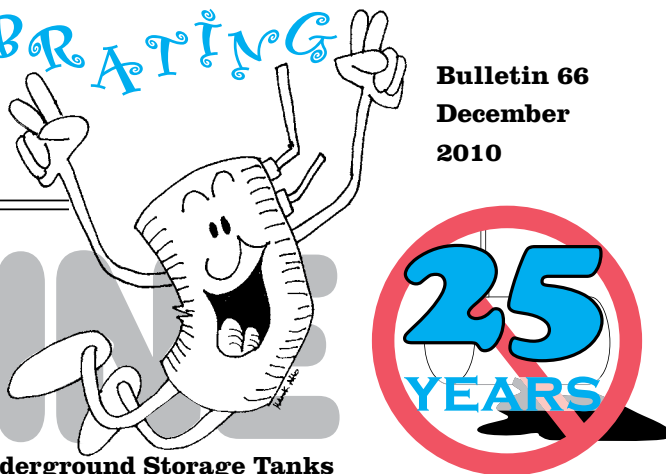


L.U.S.T. LINE

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



Hold Yer Horses!

USEPA's Partial E15 Waiver Still Has Some Ifs, Ands, or Buts

by Patricia Ellis

Prologue

One of the goals of the Energy Policy Act of 2005 (EPA 2005) was to expand the use of renewable fuels in the transportation sector. This legislation required the establishment of a Renewable Fuels Standard (RFS). In December 2007, Congress passed the Energy Independence and Security Act of 2007 (EISA), which revised the RFS, and, in effect, greatly increased the volumes of renewable fuels required. EISA required that 15.2 billion gallons of renewable fuel be used in the transportation sector in 2012, and at least 36 billion gallons per year by 2022. (See page 6.)

Current USEPA regulations allow a maximum of 10 percent ethanol, by volume, to be blended into gasoline. The total quantity of ethanol being blended into gasoline today is nearing 10 percent of the volume of gasoline consumption, which means that ethanol is about to hit its upper limit, or "blend wall." There are two ways we can use ethanol to meet the renewable fuel targets set by EISA: either we have to use more E85 (which can only legally be used in flex-fuel vehicles), or we need to be using more than 10 percent, by volume, of ethanol in conventional and reformulated fuels.

On October 13, 2010, USEPA granted a partial waiver for the use of gasoline containing up to 15 percent by volume ethanol (Federal Register: Nov. 4, 2010, Vol. 75, No. 213). The waiver applies only to model year 2007 and newer light-duty motor vehicles, which includes passenger cars, light-duty trucks, and medium-duty passenger vehicles. A decision on the use of E15 in vehicle model years 2001 through 2006 will be made after USEPA reviews the results of additional testing by the Department of Energy, which was recently completed. (See "NREL's Study on Testing Mid-Level Ethanol/Gasoline in Dispensing Equipment" on page 7.)

No waiver is being granted for the use of E15 in model year 2000 and older cars and light trucks or in any motorcycles,



heavy-duty vehicles, or non-road engines, because currently there is no testing data to support such a waiver. You can find all documents relating to the Waiver Request at <http://www.epa.gov/otaq/regs/fuels/additive/e15/>. During the comment period on the waiver request about 78,000 comments were submitted to the USEPA docket. Only a handful of these comments mentioned UST-system infrastructure issues.

■ continued on page 2

Inside

- 7 NREL Study—Mid-Level Ethanol in Dispensing Equipment
- 8 It's the Compatibility Thing—Iowa
- 12 Ferreting Out the Identity of Gasoline Additives
- 14 Predicting Impact of Biofuels on BTEX Plumes
- 18 Vapor Intrusion: Petroleum Hydrocarbon Issues
- 23 In Situ Chemical Oxidation
- 26 National LUST Cleanup Backlog
- 27 New ASTM Release Investigation Standard
- 29 Class C Operator Saves the Day
- 30 RP100 UST Installation Document
- 31 FAQs: Unsupported Leak Detection Methods

■ Partial E15 Waiver from page 1

Because of the confusing nature of all of this, USEPA is taking several steps to help consumers easily identify the correct fuel for their vehicles and equipment. First, the agency is proposing pump-labeling requirements, including a requirement that the fuel industry specify the ethanol content of gasoline sold to retailers. There would also be a quarterly survey of retail stations in most areas across the country. The proposed rule is a "Regulation to Mitigate the Misfueling of Vehicles and Engines with Gasoline Containing Greater than Ten Percent Ethanol and Modifications to the Reformulated and Conventional Gasoline Programs," which has a comment period that ends on January 3, 2011.

The API Report

With the granting of the partial waiver request, many changes will have to be made in rules and regulations before E15 can be sold legally. An August 2010 report, *Identification and Review of State/Federal Legislative and Regulatory Changes Required for the Introduction of New Transporta-*

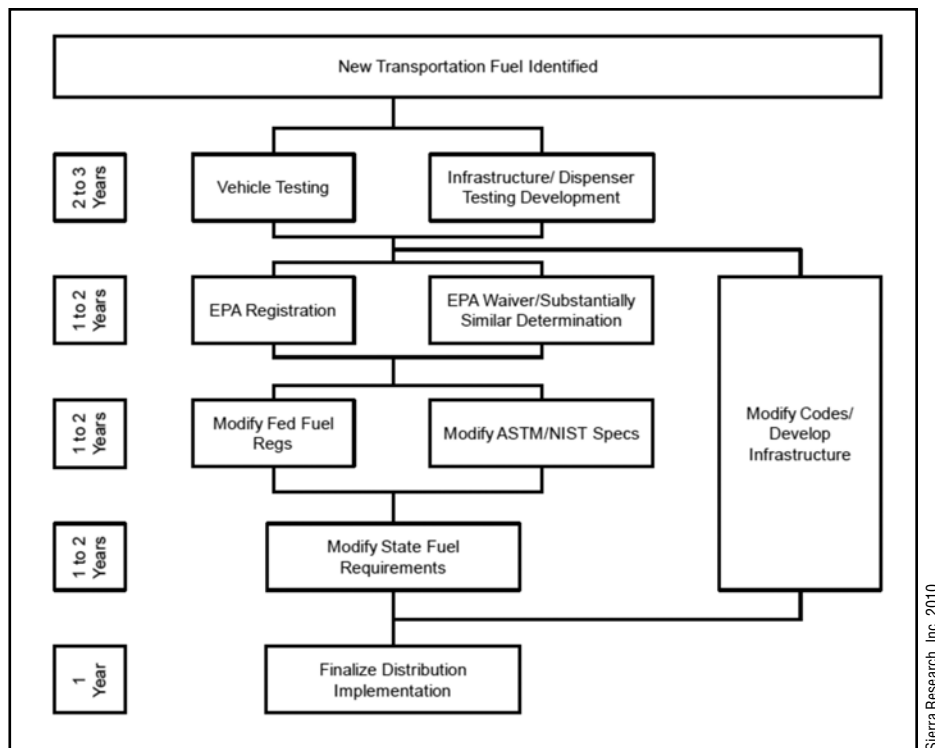


FIGURE 1. Generic schematic of the process for introduction of new transportation fuels.

tion Fuels, prepared for the American Petroleum Institute by Sierra Research, Inc., details what needs to be done before E15 can be introduced into the marketplace (http://www.api.org/aboutoilgas/otherfuels/upload/Sierra_Final_Alt_Trans_Fuel_Report_080410.pdf).

The introduction of a new transportation fuel into the marketplace is not simple or straightforward; it requires numerous changes to federal and state laws, regulations, and standards. The time required to make all of the required changes listed by Sierra is estimated to be as much as several years. Figure 1 shows a generic schematic of the required process, along with estimated time frames needed to complete the various tasks. At the time that the partial waiver was announced, some news articles claimed that E15 would be available for sale as soon as a few months from now. Evidently a few states plan on skipping a few steps in the process!

The API report includes an appendix summarizing the anticipated changes that will be required for each state in order to introduce ethanol blends greater than 10 percent into commerce. In this article, I will attempt to provide some essential hurdles discussed in this report—federal requirements, state

requirements, warranties, fuel storage, marketing and distribution, and liabilities.

Federal Fuels Requirements

■ **New Transportation Fuels Must be "Substantially Similar" to Existing Fuels** Since E15 contains more than 2.7 percent oxygen, by weight, it does not qualify to be "substantially similar" to existing fuels; therefore a waiver must be issued before it can be used as a transportation fuel.

■ **Fuel Registration and Health Effects** Part 79 of the Title 40 Code of Federal Regulations requires that any manufacturer of a motor-vehicle gasoline or diesel fuel or an additive used in either, must register with USEPA prior to introduction of the fuel or additive into commerce. A rule was later added requiring health effects information and additional air-related research. In addition to basic registration information about product composition, concentration, and production volume, information must be provided about combustion emissions, evaporative emissions, and potential adverse health effects related to inhalation of these emissions. The health-effects testing usually involves exposing laboratory test animals to the emissions. USEPA evaluates the results of these



L.U.S.T.Line

Ellen Frye, Editor
Ricki Pappo, Layout

Marcel Moreau, Technical Adviser
Patricia Ellis, PhD, Technical Adviser
Ronald Poltak, NEIWPCC Executive Director
Deb Steckley, USEPA Project Officer

LUSTLine is a product of the New England Interstate Water Pollution Control Commission (NEIWPCC). It is produced through cooperative agreements (US-83384301 and US-83384401) between NEIWPCC and the U.S. Environmental Protection Agency.

LUSTLine is issued as a communication service for the Subtitle I RCRA Hazardous & Solid Waste Amendments rule promulgation process.

LUSTLine is produced to promote information exchange on UST/LUST issues. The opinions and information stated herein are those of the authors and do not necessarily reflect the opinions of NEIWPCC.

This publication may be copied.
Please give credit to NEIWPCC.

NEIWPCC was established by an Act of Congress in 1947 and remains the oldest agency in the Northeast United States concerned with coordination of the multimedia environmental activities of the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

NEIWPCC
116 John Street
Lowell, MA 01852-1124
Telephone: (978) 323-7929
Fax: (978) 323-7919
lustline@neiwpcc.org



LUSTLine is printed on recycled paper.

submissions and makes a determination as to whether additional testing is required. Only when all testing has been submitted and evaluated by USEPA can the fuel or fuel additive be registered and introduced into commerce.

■ **Fuel Rating and Labeling** Since USEPA issued a “partial waiver,” allowing blends with ethanol greater than 10 percent only in vehicles newer than a specific model year, additional labeling requirements may be necessary, either by the FTC or USEPA. If more aggressive means than pump labeling are required to prevent misfueling with higher-level ethanol blends, implementation could take several years and could be quite costly. The announcement of proposed rulemaking was issued the same day that the partial waiver was granted.

The Federal Trade Commission (FTC) administers requirements for gasoline and diesel-fuel ratings and labeling. Existing regulations cover ethanol blends up to E10 and fuels with at least 70 percent ethanol, but blends between E10 and E70 are not currently covered. The FTC has initiated a rulemaking for blends greater than E10, which would require either identification of the precise concentration of ethanol in the blend or disclosure of the range of ethanol in the blend. In addition, the proposal would change labeling requirements for all gasoline-ethanol blends to warn that blends with more than 10 percent ethanol may harm some conventional vehicles. Since both agencies are simultaneously proposing rules for the same thing, let’s hope their efforts will be collaborative.

■ **Gasoline Detergent Certification** The Clean Air Act mandated that USEPA adopt regulations requiring the use of additives in gasoline to prevent the buildup of deposits in engines or fuel-supply systems. Since existing certifications were made using fuels containing no more than 10 percent ethanol, changes to USEPA gasoline detergency regulations with ethanol blends greater than 10 percent will need to be made to assure that additives are effective in preventing buildup in engines using blends with more than 10 percent ethanol.

■ **Volatility Exemption for Ethanol Blends Greater Than 10 Percent** The addition of ethanol to a gasoline blendstock increases the volatility of the blend relative to neat gasoline; therefore, USEPA created a one-psi exemption for gasoline-ethanol blends sold in the summer months in non-reformulated gas (RFG) areas. The exemption does not apply to gasoline with greater than 10 percent ethanol. Without an exemption, a lower-volatility blendstock would need to be used. A USEPA rulemaking to extend the exemption to higher ethanol concentrations could take six to twelve months. The federal Reid vapor pressure (RVP) exemption is not an issue in RFG areas, because the same VOC requirements would apply for blends with more than 10 percent ethanol as for other RFG blends, including E10.

The USEPA partial waiver decision document includes a discussion by USEPA that it is believed that E15 blends with higher volatility would cause vehicles to violate their evaporative emissions standards. Therefore, the partial waiver is for E15 blends that meet the summertime gasoline volatility standards for conventional gasoline without any 1.0 psi RVP waiver. In order to introduce a fuel that both meets the federal summertime RVP standards and contains between 10 and 15 percent ethanol, fuel refiners would have to create a fuel or blendstock that has approximately 1.0 psi lower RVP than a fuel or blendstock intended for E10 due to the interaction between gasoline volatility and ethanol when blended.

■ **RFG** Federal RFG requirements are still in effect along most of the northern Atlantic seaboard, most of California, and in a number of other major urban areas. A Complex Model is used to determine where RFG is required. The Model estimates the impacts of changes in eight specific gasoline properties relative to a 1990 baseline. The proposed rule includes changing the Complex Model for ethanol blends greater than E10, because the limit for oxygen content in the Model was 4.0 percent by weight (approximately E11.5). The length of time required to revise these regulations will depend on whether sufficient emissions

data exists for vehicles representative of 2007 vehicle fleets. EPA 2005 required some of this testing.

State Fuels Requirements

In addition to the federal fuel requirements, most states and some regions have enacted their own requirements for transportation fuels.

■ ASTM and NIST Specifications

Many states have adopted American Society for Testing and Materials (ASTM) specifications for gasoline (ASTM D4814) or specifications established by National Conference on Weights and Measures (NCWM) under the National Institute of Standards and Technology (NIST). While the scope of the ASTM standard applies to ethanol blends greater than E10, it is unlikely that ethanol blends greater than 10 percent could meet the T50 limits of the current version of the standard without modification (the T50 limit is the temperature at which 50% of the gasoline would evaporate). The current lower T50 limit applies only to ethanol blends from 1 to 10 percent by volume. Most states have adopted some version of the ASTM standard, but some adopt the most recent version and others adopted the version of a specific year. Some states have adopted the NIST volatility limits for ethanol blends, and similar problems will exist for those states.

■ Blending Restrictions and Blending Caps

Various states have specified a blending cap of 10 percent ethanol, by volume, in state fuel specifications, state biofuels mandates, and tax incentives for renewable fuels. Other states have adopted the most recent version of NIST Handbook 130, which specifies a blending cap of 10 percent. These states would require either a change in state legislation or regulations to permit ethanol concentrations greater than 10 percent, or a modification by National Conference on Weights and Measures to the NIST handbook to raise the blending cap.

■ **Waivers from Gasoline Vapor-Pressure Requirements** In addition to the federal RVP exemption for E10, many states have adopted gasoline

■ *continued on page 4*

■ **Partial E15 Waiver** *from page 3*

volatility limits, either by adopting ASTM D4814 or NIST Handbook 130, or by establishing state vapor-pressure limits. A large number of states would have to make changes to expand RVP waivers to ethanol blends greater than 10 percent.

■ **T50 Minimum Offsets and Vapor-Lock Protection (T@V/L=20)** Many states have adopted their own allowances for offsets for T50 minimum distillation temperatures and vapor-lock protection either by adopting ASTM D4814 or NIST Handbook 130, or by independently establishing limits through legislation and/or regulation. Where their allowances are limited to E10 blends, changes would have to be made to apply them to ethanol blends greater than 10 percent.

■ **California** To introduce any new fuel in California, a multimedia assessment must first be conducted. The second step involves the establishment of fuel specifications by the California Air Resources Board to ensure that the new fuel does not result in increases in air pollutant emissions. In addition, all fuel must comply with the California Air Resources Board's (CARB's) Phase 3 RFG regulations, which currently include a blend cap of 10 percent ethanol. The California Predictive Model (similar in concept to the USEPA Complex Model) must be used to analyze data from an extensive vehicle-testing program. The predictive Model indicates increases in NO_x emissions with higher levels of ethanol, therefore other changes would have to be made to the RFG 3 requirements to mitigate this increase, such as further restrictions on sulfur content.

■ **State Implementation Plans** For states that are ozone non-attainment areas, introducing ethanol blends greater than 10 percent may require changes to state implementation plans under the Clean Air Act. If changes are necessary, they require USEPA approval.

Vehicle and Engine Warranties

■ **Light-Duty Gasoline Vehicles** Use of ethanol blends greater than 10 percent in light-duty gasoline vehicles

may void vehicle warranties, creating potential liabilities for vehicle owners. A review of owner's manuals for ethanol usage in non-flex-fuel vehicles for model years 1999, 2000, 2003, 2006, 2009, and 2010 shows that 10 percent ethanol is the maximum concentration allowed by any manufacturer. Manufacturers may take the position that they are not required to address adverse impacts caused by the use of higher blends of ethanol in existing vehicles that are in the model years covered by the waiver.

■ **Other Gasoline-Fueled Equipment** Non-road products with gasoline engines include lawn mowers, chain-saws, forklifts, boats, personal watercraft, and all-terrain vehicles. USEPA did not approve the Growth Energy waiver request for non-road engines, vehicles, and equipment for two primary reasons: (1) Growth Energy did not provide enough information to assess the potential impacts of E15 on the compliance of non-road engines with applicable emission standards, and (2) concerns expressed by non-automotive engine manufacturers such as ALLSAFE (Alliance for a Safe Fuels Environment). These concerns include the following: (1) engine operability problems, including loss of power, stalling, and overheating; (2) substantially shortened engine life due to enrichment of air-fuel ratios; (3) catastrophic engine failures; (4) incompatibility with fuel-system materials; and (5) increases in exhaust and evaporative emission levels.

Fuel Storage, Marketing, and Distribution

It is possible that many extensive, time-consuming, and costly changes may also be needed in the areas of storing, marketing, and distributing ethanol blends greater than 10 percent. Numerous standards exist regarding the installation and operation of the fueling infrastructure. Most of these standards require that the equipment be "compatible" with the product being stored and dispensed and that the equipment be "listed" by independent organizations such as Underwriters Laboratories (UL).

Organizations and regulatory agencies with jurisdiction over or standards that apply to fuel-dispensing facilities include the follow-

ing: Occupational Safety and Health Administration (OSHA), National Fire Protection Association (NFPA), International Code Council (ICC), UL, USEPA, and American National Standards Institute. Many states also have regulatory agencies with jurisdiction over fueling facilities and fuel-dispenser and product labeling.

■ **Pipelines and Terminals** If E10 and ethanol blends greater than 10 percent use the same blendstocks, minimal changes are expected with regard to transportation and storage infrastructure. With a partial waiver, the amount of change that may be required will depend on whether different blendstocks are required. Different blendstocks would need to be transported separately and stored separately at terminals. Currently, most ethanol is transported by barge, rail, and truck, separately from gasoline. As larger and larger volumes of ethanol are transported, pipelines will become more attractive for ethanol and gasoline-ethanol blend transport. This generates concerns over water entrainment and phase separation of gasoline and ethanol; degradation of materials used in pipelines and storage tanks by ethanol and gasoline-ethanol blends; and stress corrosion cracking of pipelines.

■ **Retail Fuel Outlets** The main concerns with respect to increasing ethanol concentrations in gasoline are similar to those for existing vehicles—materials compatibility with components of the fuel storage and dispensing systems. These concerns raise liability issues for fueling outlets, and the marketing of ethanol blends greater than 10 percent could be a violation of some local building or fire codes. As the API report mentions, the following equipment may need to be replaced or modified to accommodate ethanol blends greater than 10 percent:

- Handling hardware (nozzles, hoses, breakaways, and swivels)
- Dispensers
- Product pumps
- Underground storage tanks
- Leak detection systems
- Vapor-recovery systems
- All associated piping

Research is currently underway on E15 retail infrastructure. (See NREL study on page 7.) Three million dollars is being spent on infrastructure compatibility testing, including work underway by:

- U.S. Department of Energy
 - National Renewable Energy Laboratory: Dispensers, piping, Stage II equipment, STPs
 - Oak Ridge National Laboratory: Component materials, UST coupons
- USEPA Office of Underground Storage Tanks and Office of Research and Development
 - Leak detection systems
- American Petroleum Institute
 - Misfueling mitigation measures
 - Flame arrestors
 - Stage I Recovery Equipment

All national fire codes specify that gasoline dispensers and associated dispensing equipment must be “listed” by a nationally recognized third-party testing laboratory, the most well known being Underwriters Laboratories. In terms of current UL dispenser and hanging hardware listings, UL says “dispensing systems and hanging hardware have been certified by UL for use with E15 and higher blends of ethanol. Legacy dispensers, the type presently installed in most stations, have been tested and certified for a maximum blend of E10 only.”

The problem for tank owners who want to dispense E15 is that they may have to replace perfectly good legacy (E10) equipment for dispensers that UL approves for E15.

So the larger problem lies with existing equipment, which has not been evaluated with respect to E15, and UL does not list equipment without required testing. UL says it is up to the authority having jurisdiction to determine how to proceed. In February 2009, UL announced its support for authorities having jurisdiction (AHJ) who may choose to permit legacy systems with UL approval for E10 to be used to dispense fuel blends up to a maximum of 15 percent ethanol.

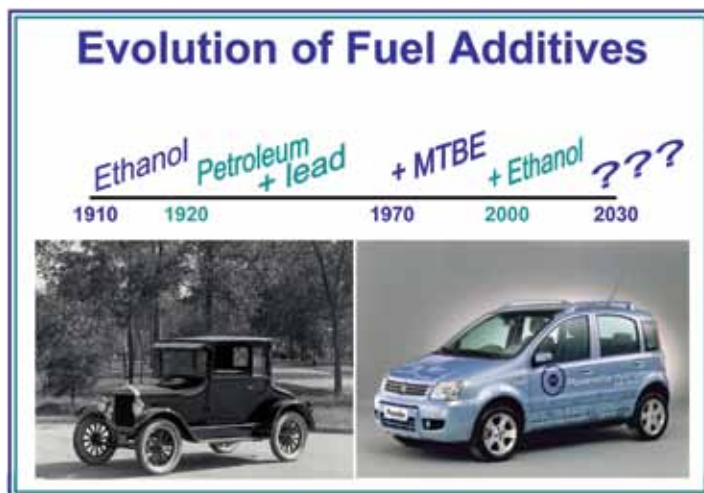
They stated that there didn’t seem to be any significant increase in risk between E10 and E15 blends but recommended that the AHJs consult

with the equipment manufacturers to confirm that the equipment is compatible with the fuel to be stored. UL recommended that the dispensers be subject to regular inspection and maintenance because the potential for degradation of the metals and other materials increases with increasing ethanol concentrations. (What, no increased risk, but increased chance of equipment degradation?)

Some states have issued workarounds that allow the use of legacy and newer dispensers, mostly by requiring periodic inspection and replacement of the unlisted equipment with listed equipment as soon it becomes available. These workarounds do not, however, exempt retailers from federal OSHA requirements for listed dispenser equipment. Also, it is unclear whether the UL announcement applied only to the dispenser itself or to all above-ground dispensing equipment, including hanging hardware, break-aways, and so on. The UL announcement and the state workarounds do not address the liability issues.

■ **Changes in Pump Labeling** State advertising and labeling requirements may require modification to accommodate ethanol blends greater than 10 percent, although many state regulations only require the posting of labels alerting consumers to the fact that the fuel contains ethanol. Other state labels include the percentage, or maximum percentage, of ethanol in the fuel. In those cases, the introduction of ethanol blends greater than 10 percent will require replacement or multiple replacements of pump labels, depending on how new transportation fuels are introduced.

As discussed above, USEPA has issued a Notice of Proposed Rulemaking to minimize the chances of misfueling vehicles. One of the parts of this rule would address dispenser labeling. Such a label consists of four



components. The *information* component of the label would inform the consumer of the maximum ethanol content that the fuel may contain. The *legal approval* component of the label would inform consumers of which vehicles and engines are approved to use E15. The technical warning component of the label would alert consumers that the use of E15 in other vehicles, engines, and equipment might cause damage to these products. The legal warning component of the label would inform consumers that using E15 in a vehicle or engine not approved for E15 use violates federal law.

If USEPA extends the waiver to include vehicles made between 2001 and 2006, the label would change accordingly. The 2007 and later vehicles represent about 20 percent of the current fleet of passenger cars and light-duty trucks, or about 42 million vehicles.

Scott Merritt, executive director of the Nebraska Corn Growers Association, cautioned that a warning label for E15 would be the wrong approach. “It will not be positive to retail sales. We have had discussions with retailers, and they are reluctant to put warning labels on pumps. From a consumer standpoint, it sends a bad message. Consumer confidence is high on ethanol (in Nebraska). Consumers can’t be very positive about a warning label—it sets us back 15 years.” (*DTN Progressive Farmer*, Oct. 15, 2010.)

A Real Predicament for Tank Owners!

You have to wonder how many retail UST facility owners are going

■ continued on page 6

■ Partial E15 Waiver from page 5

to want to mess with ethanol blends greater than 10 percent. Chevron has already informed their marketers that they are forbidden to market E15, unless expressly authorized. The National Association of Convenience Stores, in a release issued shortly after the USEPA partial waiver announcement, urged its members to use extreme caution when considering selling E15, stating that the USEPA approval does nothing to remove retailers' legal obligations regarding storage and sale of the fuel. "Further, limiting E15 use to only vehicles manufactured since 2007 could expose retailers to significant liability risk if a consumer were to fill a non-approved engine with E15," stated John Eichberger, NACS vice president of government relations (<http://www.ethanolproducer.com>, October 19, 2010).

USEPA stated in its proposed E15 label rule that it would not typically hold a fuel retailer liable for consumer misfueling into a non-approved engine, provided that a station's pumps were properly labeled. NACS claims that the Clean Air Act includes a provision that allows for citizens to sue retailers for misfuelings, and that the labels do not provide them with enough litigation protection. Valero Energy Corporation is expanding E85 availability at many of its retail stations, but Bill Day, corporate communications director, indicated that the company will not be as supportive of E15. "Valero is one of the nation's leading ethanol producers, and generally supports pro-ethanol policies," he said. "But in this case, it's hard to imagine any retailer, including Valero, selling the E15 blend at its sites without liability or warranty protection."

Representative Ross from Arkansas and Representative Shimkus from Illinois introduced H.R. 5778, the Renewable Fuels Marketing Act of 2010 in July 2010. One of the provisions of this legislation would require the USEPA Administrator, within one year of passage of the bill, to issue guidelines for determining whether USTs and associated dispensing equipment are compatible with any fuel or fuel additive authorized by the Administrator or

by statute for use in a motor vehicle, non-road vehicle, or engine.

An additional provision of the legislation attempts to alleviate liability issues stemming from the introduction of higher ethanol blends. It requires that the USEPA Administrator issue regulations for labeling within one year that prevent the introduction and transportation of fuel into an engine that is not compatible with the fuel, and if the seller complies with the labeling requirements, they will not be liable under the provisions of this act or any other provision of federal or state law for "(1) a self-service purchaser's introduction of such a transportation fuel into a motor vehicle, non-road vehicle, or engine that is not compatible with such transportation fuel; or (2) the voiding of the manufacturer's warranty of such vehicle or engine from the introduction of such a transportation fuel."

On October 21, Secretary of Agriculture Tom Vilsack announced that the U.S. Department of Agriculture would use existing funds to assist in the installation of 10,000 blender pumps across the U.S. within the next five years (less than 5 percent of gas stations in the country). He sees USEPA's approval for E15 use in vehicle models 2007 and newer as a "momentum builder" for the ethanol industry, and it should help boost demand for ethanol. He urged USEPA to approve E15 for vehicle model years 2001 to 2006 as soon as possible.

"It's already convinced NASCAR to use E15, and if it's good enough

for Jimmie Johnson, I remain hopeful that it will also be good enough for earlier model vehicles," Vilsack said. In response to the reluctance of retail station owners to invest in additional dispensers and storage tanks for E15, Vilsack has instructed rural development officials to provide matching funds for installing the blender pumps. He was unable to provide an exact cost for the initiative, but said the agency has estimated that a complete blender-pump system ranges in price from \$25,000 to \$50,000, and that work on the blender-pump program will commence "immediately" (<http://www.ethanolproducer.com>, October 21, 2010).

Hmmmmmm.... So which UL-approved blender pumps will be installed? And testing hasn't begun yet on the functionality of leak detection systems for use with ethanol blends. I continue to hope that we have learned from our past experience with MtBE that changes in our fuel composition have to be done carefully and our decisions need to include evaluation of all of the potential pitfalls, including compatibility with our existing fuel distribution system. ■

Pat Ellis, Ph.D., is a hydrologist with the Delaware Department of Natural Resources and Environmental Control, Tank Management Branch. She writes the LUSTLine column "Wander-LUST," and can be reached at Patricia.Ellis@state.de.us.

USEPA Finalizes 2011 Renewable Fuel Standards

USEPA has finalized the 2011 percentage standards for the four categories of fuel under the agency's renewable fuel standard program, known as RFS2. The Energy Independence and Security Act (EISA) amended the Clean Air Act to greatly increase the total required volume of renewable fuels each year, reaching a level of 36 billion gallons in 2022. To achieve these volumes, USEPA calculates percentage-based standards for the following year. Based on the standards, each producer and importer of gasoline and diesel determines the minimum volume of renewable fuel that it must ensure is used in its transportation fuel.

The final 2011 overall volume and standards are:

- Cellulosic biofuel: 6.6 million gallons; 0.003 percent
- Biomass-based diesel: 800 million gallons; 0.69 percent
- Advanced biofuel: 1.35 billion gallons; 0.78 percent
- Renewable fuel: 13.95 billion gallons; 8.01 percent

Based on an analysis of expected market availability, USEPA is finalizing a lower 2011 cellulosic volume than the statutory target. Overall, USEPA remains optimistic that the commercial availability of cellulosic biofuel will continue to grow in the years ahead. For more information, go to: <http://www.epa.gov/otaq/fuels/renewablefuels/regulations.htm>. ■

USEPA Proposed Guidance on Compatibility of UST Systems with Biofuel Blends Is Now Available

In the November 17, 2010 Federal Register (<http://www.gpo.gov/fdsys/pkg/FR-2010-11-17/pdf/2010-28968.pdf>), USEPA published proposed guidance that will clarify how underground storage tank owners and operators can comply with the Agency's compatibility requirement (in 40 CFR §280.32) when storing certain biofuels, such as ethanol-blended fuels greater than 10 percent ethanol and biodiesel-blended fuels containing an amount of biodiesel to be determined.

USEPA solicited comments (due on December 17, 2010) on the proposed guidance, which will provide underground storage tank owners and operators with greater clarity in demonstrating compatibility of their tank systems with these fuels.

Contact Andrea Barbary (barbary.andrea@epa.gov) of USEPA's Office of Underground Storage Tanks for more information.

NREL's Study on Testing Mid-Level Ethanol/Gasoline in Dispensing Equipment Now Online

The National Renewable Energy Laboratory's (NREL) Non-petroleum-Based Fuel Task is responsible for addressing the hurdles to commercializing fuels and fuel blends such as ethanol that are derived from biomass. One such hurdle is the unknown compatibility of new fuels with legacy infrastructure components at fuel-dispensing facilities. The U.S. Department of Energy's (DOE) Vehicle Technology Program and the NREL biomass program engaged in a joint project to evaluate the potential for blending ethanol into gasoline at levels higher than E10.

The project, carried out by Underwriters Laboratories Inc. (UL), was initiated to help DOE and NREL [and, by the way, UST regulators] better understand potentially adverse impacts caused by any dispensing equipment incompatibility with ethanol blends higher than equipment design specs. UL's November 2010 report, *Dispensing Equipment Testing with Mid-Level Ethanol/Gasoline Test Fluid*, provides data on the impact of introducing gasoline with a higher volumetric ethanol content into dispensing equipment from both a safety and a performance perspective. Safety of the equipment focuses on "loss of fuel containment and other safety-critical performance such as loss of ability to stop fuel flow or failure of breakaway couplings to separate at appropriate forces."

As detailed in the report, the project consisted of testing new and used dispensers harvested from the field (all equipment UL-listed for

up to E10). Testing was performed according to requirements in the UL's *Outline of Investigation for Power-Operated Dispensing Devices for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0-E85)*, Subject 87A, except using a CE17a test fluid based on the scope of this program.

As reported in the UL's executive summary, "the overall results of the project were inconclusive insofar as no clear trends in the overall performance of all equipment could be established. New and used equipment such as shear valves, flow limiters, submersible turbine pumps, and hoses generally performed well. Some new and used equipment demonstrated reduced levels of safety or performance, or both, during either

long-term exposure or performance tests. Dispenser meter/manifold/valve assemblies in particular demonstrated largely noncompliant results. Nozzles, breakaways, and swivels, both new and used, experienced noncompliant results during performance testing. Responses of nonmetals, primarily gaskets and seals, were involved with these non-compliances."

The report summarizes the performance of different types of equipment in the testing program (Table 1). The report is available at: <http://www.nrel.gov/docs/fy11osti/49187.pdf>.

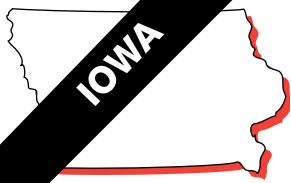
Note: This report documents the noncompliance (i.e., failure) of certain nonmetallic materials that may be found in UST equipment. ■

TABLE 1. SUMMARY OF TEST RESULTS ON DIFFERENT TYPES OF EQUIPMENT

Equipment	Compliant Test Results on New Samples ^a	Compliant Test Results on Used Samples ^a	Overall Compliant Test Results ^a
Breakaways	2 of 5	1 of 4	3 of 9
Flow Limiters	1 of 1	—	1 of 1
Hoses/Hose Assemblies	8 of 9	4 of 6	12 of 15
Meter/Manifold/Valve Assemblies	0 of 2	0 of 4	0 of 6
Nozzles	3 of 6	1 of 4	4 of 10
Shear Valves	3 of 3	—	3 of 3
Submersible Turbine Pumps	1 of 1	—	1 of 1
Swivels ^b	3 of 4	3 of 5	6 of 9

a. In the context this table, "compliant results" is used to include fully compliant test results and inconclusive test results that did not directly manifest a hazard, such as leakage, during the testing that was able to be performed as a part of this research program.

b. Includes swivels integral to hose assemblies.



It's the Compatibility Thing

How Two UST Regulators in the Land of Ethanol Addressed Ethanol Compatibility

by Ellen Frye

"From the very beginning, we made sure we talked about compatibility, about what we are regulating, and why," said Paul Nelson, Senior Environmental Specialist with the Iowa Department of Natural Resources (DNR), in a recent interview with Marcel Moreau (author of the *LUSTLine* column "Tank-nically Speaking"). "We stayed away from expressing opinions for or against ethanol to avoid alienating somebody," Paul explained. "The regulatory issue is very straightforward. It's about compatibility and preventing a release into the environment. The federal rules, which Iowa has adopted, say the UST-system components have to be compatible with the fuel being stored."

But compatibility is not only a fuels issue. As Marcel is quick to point out, both Paul and his co-worker Tom Collins, Senior Environmental Specialist, have a personal style that is instinctively compatible with their various stakeholders—tank owners and operators, installers, equipment manufacturers and distributors, fuel associations, and the state legislature. The two of them are a team and have been an effective force in piloting the state's UST program since the program began 20 years ago. Their strategy is deceptively simple: identify the issues, research them, and present them to stakeholders along with a reasonable plan. A key component of the strategy is to involve the stakeholders each step of the way.

Iowa is the number one ethanol-producing state in the nation. According to the Iowa Renewable Fuels Association (IRFA), the state has the ability to produce 3.3 billion gallons of ethanol per year. Wikipedia states that in 2008, the 92,600 farms in Iowa produced 19 percent of the nation's corn and 17 percent of the soybeans. Living in the heart of corn country, it was a given that

motor fuel would contain ethanol. One of Tom and Paul's big challenges was to find a way to ensure that fuels containing ethanol and soy-based diesel fuels are compatible with the UST systems in which they are stored.

The use of ethanol in fuels is complicated and can be downright frustrating for UST regulators, the automobile industry, tank owners, installers, and equipment manufacturers alike. The Iowa tanks program epitomizes the tangled web of competing economic and environmental interests surrounding growing, marketing, and retailing corn and soybean motor fuels.

Yet in all of this, UST systems seem to be the forgotten step children—children that can play havoc with our groundwater resources if they are not up to the task of storing and dispensing the fuel put into them without leaking their contents into the environment. It is the compatibility thing. With lower ethanol percentage levels (e.g., E10), gaskets and seals tend to be the primary problems. At the other end of the spectrum (e.g., E85), soft metals such as brass and aluminum are affected. The mid ranges (e.g., 25–30 percent ethanol) are the most difficult because they can experience both sets of problems.

Tom and Paul have become the "Who ya gonna call?" guys if you have questions about ethanol-blend motor fuels. As Marcel noted, "When I first started looking into ethanol on the Web several years ago, I ended up pretty quickly at the Iowa web-



Paul Nelson (left) and Tom Collins with the Iowa DNR Tank Program.

site." For regulators like Tom and Paul, the big question is, "Is UST equipment ready for ethanol blends beyond E10?" The solution they landed on tries to answer the questions that need to be asked for storing ethanol fuels—from E10 to E85.

As I heard their names repeatedly invoked, I knew it was high time to tell their story in *LUSTLine*. So when Marcel offered to interview Tom and Paul while doing some training in Iowa, I gave him a hearty thumbs-up. So here's the skinny.

Well, We've Got Trouble...

It was 2003, Paul and Tom had been pulling together information on E85 for a year or so in anticipation of undertaking some kind of compatibility initiative for the introduction of E85. But when a just-filled 6,000 gallon stiP3® UST, 1988 vintage, emptied out overnight, their inter-

est in ethanol compatibility with tank systems reached new heights, particularly when they learned that the owner had just filled the tank with E85. "That's when we decided we should be doing some serious research and talking to people who knew," said Tom.

Around that time, Paul had occasion to talk to a fuel marketer who called him about some other issues. Paul took the opportunity to inquire about ethanol. "He had C stores, and he also delivered fuel. He told me about the first time he was going to deliver E85. He was going to make the delivery early in the morning, so he filled the truck the night before. When he went out the next morning to deliver the load, he knew something was wrong because he could smell fuel. There were little puddles under his truck. The rubber gaskets were just dripping with fuel. He ruined a delivery hose too. So that's when he discovered that E85 was not normal gasoline," said Paul. "It was a whole learning process for him, and we figured we had some learning to do too."

"We knew there were UST issues with E85," said Tom, "but we hadn't even thought about trucks and vehicles. From talking with our marketers and service techs we realized that we didn't have to convince these people that there were issues. But there were other stakeholders who didn't know much about UST issues that we had to address as well."

E10 has been in Iowa's gasoline since the late 1970s, back when ethanol and UST-system compatibility weren't on anyone's radar. But there had been issues back then, too. "We were talking to one tank owner," recalled Paul, "and he said 'well yeah, back when we switched to E10 we had a lot of dispenser leaks.' And they usually happened within the first 24 hours...didn't take too long. All of sudden they started leaking, because it was all just a little bit different, it wasn't compatible. When we talked with the dispenser manufacturers while researching compatibility, their concern was the gaskets shrinking or growing due to a change in fuel with different characteristics."

The Road to the Big Meeting

Predictably, there was considerable

industry interest when the DNR invited the ethanol stakeholders to attend some preliminary meetings addressing E85 compatibility with UST systems. "Some legislators heard about this initiative and sat in on some of our early meetings with the renewable fuels people, even though we weren't planning any additional rulemaking," said Paul.

Tom and Paul have become the "Who ya gonna call?" guys if you have questions about ethanol-blend motor fuels.

"We didn't want anybody to be surprised by what we were doing, so we explained the reasons why we had to do something about compatibility. As we were doing our presentation, I noticed some legislators were nodding their heads up and down," recalled Paul. "And when we went over to the statehouse and met more legislators, they seemed to understand. Some of them were fairly receptive right from the start."

There was a big reason why the legislature was receptive: they'd already gone through one round of discovering and cleaning up leaking underground storage tanks, and they didn't want to go through it again. In the late 1980s, at the start-up of the state's cleanup fund, there was a decision to identify pre-existing conditions at UST facilities through invasive sampling, in an attempt to get all facilities back to a clean slate. It was a real eye-opener. There was a lot of contamination.

But the legislature was just part of the work that Tom and Paul needed to do. "The ethanol interests did not want to see us restricting the use of ethanol," explained Tom. "The national Renewable Fuels Association (RFA) was pretty emphatic about that."

When they first determined that they needed to do something about compatibility, Paul and Tom contacted the tank installers association for help in researching the issues. They called around the states to see what they were doing. They talked to equipment manufacturers, includ-

ing everyone from the tank manufacturers to the people that make pipe dope.

"I mean we contacted everybody," said Paul. "We tried to get a timeline on when various ethanol-compatible components were being manufactured and installed."

With the information they had amassed in hand, they drafted a plan for what they thought needed to happen. "Underlying our proposal was our own recognition that we are not the experts," said Tom, "and we don't have time to review all the tank systems in the state...there's only two of us. So we thought the best route to go was to have the installers check over the UST systems."

"At first, when we ran that idea by the installers," continued Tom, "they kind of went 'ehhh,' because they didn't really want to do it. They didn't want the liability of declaring a storage system compatible. So we explained that all they'd be doing was determining whether the equipment at a facility was or was not on the manufacturer's list of compatible models and serial numbers. That was a lot easier for them to swallow. Once we were at the point where we finally had our proposal, we were ready for the big meeting."

The Big Meeting

At the time (2005), the DNR had an energy section (now its own Office of Energy Independence) that was actively promoting renewable fuels. Tom and Paul asked them to identify and invite key players to the big meeting. Energy made the contacts and set up the meeting for them. It would be held at the Farm Bureau's executive meeting room in West Des Moines. "It was a very fancy meeting room, a little intimidating relative to what we were used to, but we thought it would be a good idea to hold the meeting on their home turf rather than at our offices," said Tom.

"We had a huge representation," said Paul. "The major state UST insurance company (PMMIC) and other insurance reps, petroleum marketers, weights and measures, the national and state renewable fuels people, the state fire marshal, the corn growers association, the soybean association, ethanol refinery people, the co-ops—the ones that

■ *continued on page 10*

■ Ethanol Compatibility

from page 9

store the corn and are most interested in selling the fuel—were there, and more. We presented our information and what we thought we needed to do.

"We figured there'd be push back from renewable fuels and other concerns, which there was," said Paul. "So we were just trying to get everyone together and let them know what direction we were going. We told the soy people we couldn't find any problem with B2, which is what they were concerned about. So that was easy.

"The national RFA guy kept insisting there wasn't a compatibility problem. He made a strong pitch for ethanol, saying how our information was not researched or not proven," Paul said. "Well many of the people in the room knew that we had done our research because we had talked to them directly. We knew we were on solid ground because we'd gotten our information from the manufacturers and the people who made the equipment and the people who installed and operated it.

"We weren't about to sit there and say, 'oh, let's just ignore the people who know their equipment.' So we listened politely, but we weren't about to back off," Paul asserted. "And we knew the marketers and installers were behind us because they were the ones who were going to be liable for the leaks, not the farmers, refiners, or the RFA. We were regulators doing our job to protect the environment, but this was one time when we were protecting the marketers and installers too. They didn't want leaks either."

"Paul and Tom made sure they talked to the people who had the real-world experience and could give them real-world information," said Marcel. "They already had a remarkable level of trust with the industry and the regulated community and saw each other as allies in the quest to store ethanol safely."

Connecting, and More Connecting

So that was the first meeting and soon Paul and Tom were being asked to speak at other places around the state about what ethanol might mean

for owners, operators, and installers. "The marketers don't like being pushed to do anything," said Tom. "In this case, they figured they had everything to lose and not much to gain by storing E85 in incompatible storage systems. And so they were supportive of making sure that what was going to happen made sense for them and not just for the farmers.

"Same thing with the people installing the equipment," he added. "They had the most skin in the game. Even though they were initially a little leery of our proposal to have

"Our drumbeat was, 'Look, we have some 8,000 tanks at 2,800 sites, and we don't want the public put at risk. We don't know for sure what could happen with E85, so we're looking at a worst-case scenario.' And one thing good too, we already had federal rules that said the fuel has to be compatible."

—Tom Collins

them be the ones to go out there and inspect to see what needed to be done to make the UST systems compatible, we eventually ended up getting to a win-win solution."

Tom and Paul had other meetings at their office and at legislative offices. Eventually, Tom gave a presentation to the Environment Committee.

"That was kind of a turning point," said Tom. "After that they kind of let us alone. They said, okay, it looks like you guys know what you are doing, so we'll let you go ahead. We met with a few other legislators afterwards, but their concern was mostly that they don't want to have leaks anymore. Our drumbeat was, 'Look, we have some 8,000 tanks at 2,800 sites, and we don't want the public put at risk. We don't know for sure what could happen with E85, so we're looking at a worst-case scenario.' And one thing good too, we already had federal rules that said the fuel has to be compatible."

The Pre-Ethanol System Check

Because the rules already required compatibility, Paul and Tom figured

they didn't need to do any rulemaking. Their task was to figure out a way to establish whether a storage facility was compatible or not. The centerpiece of the guidance that they developed was a storage system ethanol-compatibility checklist. The checklist is a meticulously honed mechanism for ensuring that all UST-system components are compatible with the product being stored—in this case, any fuel containing ethanol blends higher than E10. It is a checklist that must be filled out and signed by a licensed Iowa installer. (All of this information and more can be found at www.iowadnr.gov/land/ust/technicalresources/ethanol.html.)

"The beauty of this list," explained Marcel, "is that all the installer needs to do is check serial numbers and model numbers for the UST-system components to make sure they are compatible. They aren't saying this equipment is fine, they're saying, this equipment is on the manufacturer's list as being acceptable. Parts that aren't compatible need to be replaced before ethanol can be stored."

Tom and Paul enlisted the experts to help them define compatibility. Installers Al Hilgren with Seneca Petroleum and Terry Cooper with Acterra Group got very involved in developing the list, essentially taking the lead in researching equipment. Once they had the checklist and all that went with it, many in the industry, including the state renewable fuels people, were given the opportunity to comment.

"We didn't do anything in secret or private," said Tom. "Everything was out there from the very beginning. Tom Vilsack was governor at the time and was very supportive. He just wanted us to solve the problem. He wanted to make sure that if he was asked questions about it he knew what to say. We gave him talking points. He did his homework and became knowledgeable about the requirements."

An Iowa Renewable Fuels Board was created, and they set up a Renewable Fuels Infrastructure Program. They could see that replacing certain equipment was going to be costly and lobbied the legislature for funding mechanisms (reimbursements, grants, incentives) to help convert existing systems.

Tom and Paul sent a letter to the regulated community, letting them know about the ethanol guidance document and the checklist. The Iowa Renewable Fuels Board got behind the checklist and became very supportive. Tom and Paul pulled in installers and other stakeholders to figure out ways to help the Board spend the money the legislature put aside to upgrade E85 equipment infrastructure. "We could help identify the equipment that needed replacement, and the Board had the money to help pay for the new equipment, so it was a great combination," said Tom.

The fire marshal's office was concerned with dispensers and crash valves, some of which might still have brass components. The DNR had jurisdiction over the dispensers from the ground down; the fire marshal's office ruled from the ground up. There were no dispensers listed by UL for E85 service, so the fire marshal liked the idea of the checklist as a backup measure. For their part, the DNR required E85 dispensers to have under-dispenser containment that was to be checked daily until such time as the dispenser was UL-listed. Tom and Paul were uncomfortable with the fact that they were allowing this and that it could have been a public safety issue.

"You try to come up with something that works for everybody—and the environment," said Paul. "We hashed out issues, like, what if you don't know what kind of piping dope and glue was used when the system was installed? So how are we supposed to determine that? We covered these things in the checklist, but sometimes with cautionary notes rather than hard and fast answers."

Moving Forward with What You Know

Right now, there are about 135 facilities in Iowa that sell E85. You would think that Tom and Paul went to an awful lot of trouble to pave the way for a relatively few facilities, but, in fact, their running the gauntlet provided the legwork and a jumping off point for many other states and the USEPA.

Tom and Paul worked hard to create a mechanism to prevent UST-system releases brought about by

vulnerable UST-system components. In the end, they laid out what they knew in black and white, with a few gray areas still remaining. "You can only go with the information you have," says Paul, and he and Tom remain cautious.

"We read a lot of Society of Automotive Engineers (SAE) reports," noted Tom. "Man the stuff they found. No wonder they are cautious with E15. There are a lot more things to look for in an engine than we look at in underground storage systems."

Tom and Paul are not aware of any major releases in the state due to ethanol, but they are aware that ethanol is having an effect on some equipment. (See Paul's note in From Our Readers below.) "Things we didn't anticipate," said Tom, "like the surface corrosion that we're seeing on a lot of components. We still have our ear to the ground in case something pops up, but so far, things seem to be okay."

The E15 Question

"Now that E15 looks like it will be playing a role in our fuel future, do you have any thoughts on E15 compatibility?" asked Marcel.

"Well, a great deal of the equipment in the ground is only listed for E10," says Tom, "so our thought right now is to tweak the checklist a

bit so it can be applied to any storage system that is to be used for E15 or any other blend above E10."

"We still would rather be safe than sorry," adds Paul.

Postscript

"Last question," said Marcel as he wrapped up the interview, "are you pleased with the results?"

"I think it worked out," said Paul.

"It seems to have worked out well," echoed Tom.

"At first blush, I would have thought that attempting to regulate ethanol in a corn state like Iowa was a recipe for disaster. I think that things have worked out well because of who these guys are," said Marcel. "They not only understand the technical issues, they have a deep understanding and respect for their fuel marketers and tank workers. This shows in the ease with which Tom and Paul, and the people they regulate, communicate with each other. Tom and Paul listen and come across as very non-threatening. They are not know-it-alls, but they do their homework, they know what they are talking about, and they seek common-sense solutions. The industry people respect that. And that mutual respect creates an environment where things can get done." ■

Reminder:

If you are seeing unusual corrosion in E10 or E85 sumps, please contact Andrea Barbary at OUST (barbary.andrea@epa.gov) and she will coordinate with you and USEPA's Office of Research and Development to arrange for a sump sampling kit to be sent to you. Data from these sampling kits will be collected and analyzed to understand what is causing this corrosion.

From Our Readers

I found the article in *LUSTLine* ("Not for the Squeamish," *LUSTLine* #65) interesting since we noted the corrosion problem in the sumps with ethanol several years ago at the National Tanks Conference. Our hypothesis at the time was that it was caused by vapors, though we did not pursue an explanation. We had been seeing it for years with the most severe having huge flakes coming off. No releases can be attributed to the corrosion though. Evidently no one was listening or paying attention at the time. The discussion was mainly about E85 and most people had yet to see the problem in E10.

Paul Nelson
Underground Storage Tank Section
Iowa Department of Natural Resources

Ferreting Out the Identity of Gasoline Additives

by Jim Weaver and David Spidle

Chemical dispersing agents for oil spills, hydraulic fracturing fluids for natural-gas production, and chemicals serving as gasoline additives share a common characteristic—for the most part, they are proprietary compounds. In the name of competitive advantage, companies carefully guard the chemical recipes of these products and are allowed by the federal government to claim “confidential business information” (CBI) status for them. As a consequence, there could be additives in released fuels that cause future heartburn for the LUST program.

The word “could” must be emphasized because, for a compound to cause a problem, it would have to be present in sufficient concentration in a fuel, have high enough water solubility to enter an aquifer, have low enough degradation to persist, and be toxic at the concentration where a receptor would encounter it. Although these criteria present a high bar to pass, we can look to the lead scavenger ethylene dibromide (EDB) as a past example of an additive that is indeed a continuing problem (see *LUSTLine* #47).

The complexity of additives can be seen in USEPA’s additive registration form, which lists 50 purposes for gasoline additives (<http://www.epa.gov/oms/regs/fuels/forms/3520-13.pdf>). These include detergents, antioxidants, metal deactivators, corrosion inhibitors, and anti-icing agents, among many others. The concentrations of these additives in gasolines can range from low parts per million (ppm) to low percent levels. For comparison, benzene in reformulated gasoline is currently limited to less than 1 percent or 7,500 ppm, much higher than the majority of additives.

The chemical classes of additives include petroleum fractions, low molecular-weight alcohols, complex binders, organometallic compounds, surfactants, and polymers (VFJ, 2006). “Classic” additives, as defined by VFJ, are those with known chemi-

cal, toxicological, and environmental risk properties, which tend to be compounds that have been used in gasolines over a long period of time. Newer compounds tend to be surfactants, polymers, and organometallics (VFJ, 2006).

Chemical Analysis

Some additives have been identified in fuel handbooks, automotive industry conference proceedings, and journal papers, but many are publicly unknown. Lack of chemical identification coupled with the variety and complexity of these compounds, makes chemical analysis a daunting task. Despite the difficulties, two approaches have been tried.

The first approach is to equilibrate gasoline with water and analyze the extracts by liquid chromatography/mass spectroscopy. This was done for a set of Swiss gasolines by Torsten Schmidt and colleagues at the Swiss Federal Institute of Technology in Zurich (Schmidt et al., 2002). The work resulted in a list of 17 polar compounds that have a high tendency to partition to groundwater. Assessment of the partitioning behavior of these compounds led to an approximate approach for estimating their concentrations in groundwater. The results showed that many of these chemicals have high water solubility and would be released from their source gasolines relatively rapidly. Thus, they may not persist in the gasoline itself.

In a roughly similar hunt for compounds, Weaver et al. (2009) analyzed fuel-grade ethanol and looked for impurities. A number of higher molecular-weight alcohols were found and are listed in Table 1, along with Schmidt’s set of compounds and a number of additives identified in other literature. Notably for both of these projects, the focus was on identifying constituents, but not their toxicity.

A second approach looks from the top down. In Denmark, five major petroleum companies revealed

the identity of additives they were using to a consulting firm, which agreed to keep the identities of the compounds confidential unless a simplified screening determined that they might cause ill effects (VFJ, 2006). The companies identified around 100 compounds and of these, eight were identified as potentially harmful. These compounds are listed in Table 1 alongside the chemicals identified from the “bottom up.”

Questions from LUSTland

In the United States, all gasoline and diesel motor-vehicle fuel additives are required to be registered in accordance with the regulations in 40 CFR 79. USEPA requires that the producer provide information on the chemical composition and methods of analysis for determining the presence of each compound and impurities. The manufacturer is also asked to submit any information it has on “the effects of this fuel additive on all emissions; the toxicity and any other public health or welfare effects of the emission products of this fuel additive.” In a few cases, USEPA has required that these fuels and fuel additives be tested for possible health effects, notably ethanol, ethers, MMT, and cerium-based additives for diesel fuel.

However, the manufacturer can assert that the product information is CBI, and, presumably, many do. So although USEPA holds composition information on registered additives, CBI information cannot be disclosed to the public, including LUST program managers, and besides that, the health effects from ingestion of water are likely to be unknown unless well-studied chemicals are involved.

USEPA and/or outside groups have questioned the need for CBI claims for oil spill dispersants, hydrofracking fluids, and chemicals in commerce (Hogue, 2010). These increased concerns might indicate a future move toward more disclosure of proprietary chemicals. In the meantime, research is needed on pos-

sible impacts of additives in groundwater at LUST sites. We suggest a program of research on these chemicals that would begin to identify additives in U.S. gasolines. Publicly identified additives as in Table 1 form a starting point for a study of impacts to groundwater. If these chemicals are found, then attention can be focused on their health effects. Both of these factors—the exposure and the effects—need to figure into decisions concerning site management, and we are only at the beginning stage of investigating these chemicals. ■

Jim Weaver is a Hydrologist with USEPA and can be reached at weaver.jim@epa.gov. David Spidle is a Research Chemist and can be reached at spidle.david@epa.gov.

Disclaimer

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for publication.

References

- Hogue, C., 2010, Naming names, *Chemical and Engineering News*, Volume 88, Number 16, 28-31.
- Landells, R. G. In Motor Gasoline; Marshall, E. L., Owen, K., Eds.; RSC: Cambridge, UK, 1995; pp 170-200.
- Owen, K., 1989, *Gasoline and Diesel Fuel Additives*, Wiley.
- Quimby, B.D., Giarrocco, V., Sullivan, J.J., McCleary, K.A., 1992, Fast analysis of oxygen and sulfur compounds in gasoline, *J. High Resolution Chromatography*, 15, 705-709.
- Schmidt, T. C., Peter Kleinert, Caroline Stengel, Kai-Uwe Goss and Stefan B. Haderlein. Polar fuel constituents: compound identification and equilibrium partitioning between nonaqueous phase liquids and water, 2002, *Environmental Science and Technology*, 36, 4074-4080.
- Videncenter for Jordforurening (VFJ), 2006, Fuel additives: A risk screening of additives to gasoline and diesel, Teknik og Administration Nr. 3. 2006. http://www.avjinfo.dk/filer/udgivelser/rapporter/37/Teknik_og_Administration_Nr_3_2006.pdf.
- Weaver, J.W., S. A. Skaggs, D. L. Spidle, G. C. Stone, 2009, Composition and Behavior of Fuel Ethanol, EPA/600/R-09/037. http://www.epa.gov/athens/publications/reports/Weaver_EPA600R09037_Composition_Fuel_Ethanol.pdf.

Class	Chemical	CAS* No	Note	Source
Aromatic Amines	aniline	62-53-3	Water equilibrated with gasoline	Schmidt et al., 2002
	p-toluidine	106-49-0	Water equilibrated with gasoline	Schmidt et al., 2002
	o-toluidine	95-53-4	Water equilibrated with gasoline	Schmidt et al., 2002
	3,4-dimethylaniline	95-64-7	Water equilibrated with gasoline	Schmidt et al., 2002
	2,6-dimethylaniline	87-62-7	Water equilibrated with gasoline	Schmidt et al., 2002
Aliphatic Amines	diethanolamine	111-42-2	Potential environmental impact	VFJ, 2006
	triethanolamine	102-71-6	Potential environmental impact	VFJ, 2006
Phenols	phenol	108-95-2	Water equilibrated with gasoline	Schmidt et al., 2002
	p-cresol	106-44-5	Water equilibrated with gasoline	Schmidt et al., 2002
	o-cresol	95-48-7	Water equilibrated with gasoline	Schmidt et al., 2002
	3,4-dimethylphenol	95-65-8	Water equilibrated with gasoline	Schmidt et al., 2002
	2,6-dimethylphenol	576-26-1	Water equilibrated with gasoline	Schmidt et al., 2002
	3,4,5-trimethylphenol	527-54-8	Water equilibrated with gasoline	Schmidt et al., 2002
	2,6-di-tert-butylphenol	128-39-2	Identified additive	Landells, 1995
Benzotriazoles	benzotriazole	95-14-7	Water equilibrated with gasoline	Schmidt et al., 2002
	1-methylbenzotriazole	13351-73-0	Water equilibrated with gasoline	Schmidt et al., 2002
Poly phenol (schiff base)	N,N-disalicylidene-1,2-diaminopropane	94-91-7	Water equilibrated with gasoline	Schmidt et al., 2002
Thiophenes	thiophene	110-02-1	Identified additive	Quimby et al, 1992
	benzothiophene	95-15-8	Water equilibrated with gasoline Identified additive	Quimby et al, 1992, Schmidt et al., 2002
Alcohols	methanol	67-56-1	Fuel ethanol analysis	Weaver et al., 2009
	ethanol	64-17-5	Fuel ethanol analysis	Weaver et al., 2009
	1-propanol	71-23-8	Fuel ethanol analysis	Weaver et al., 2009
	2-propanol	67-63-0	Potential environmental impact	VFJ, 2006
	isobutyl alcohol	78-83-1	Fuel ethanol analysis	Weaver et al., 2009
	2-methyl 1-butanol	137-32-6	Fuel ethanol analysis	Weaver et al., 2009
	3-methyl 1-butanol	123-41-3	Fuel ethanol analysis	Weaver et al., 2009
	2-ethyl 1-hexanol	104-76-7	Potential environmental impact	VFJ, 2006
	2-butoxy ethanol	111-76-2	Potential environmental impact	VFJ, 2006
Ester	ethyl acetate	141-78-6	Fuel ethanol analysis	Weaver et al., 2009
Ester-Acid	1,2-bis(2-ethylhexyloxy-carbonyl) ethanesulphonate potassium salt	7491-09-0	Potential environmental impact	VFJ, 2006
Neutral organics	1,1-diethoxyethane	105-57-7	Fuel ethanol analysis	Weaver et al., 2009
	2-ethylhexyl nitrate	27247-96-7	Potential environmental impact	VFJ, 2006
	tetrapropylenebutanedioic acid	27859-58-1	Potential environmental impact	VFJ, 2006
Undesignated	di-sec-butyl-p-phenylene-diamine	101-96-2	Identified additive	Owen, 1989
	1-propene, 2-methyl-homopolymer, hydro-formylation products, reaction products with ammonia	68891-84-9	Potential environmental impact	VFJ, 2006
	(Z)-4-oxo-4-(tridecylamino)-2-butenic acid	84583-68-6	Potential environmental impact	VFJ, 2006
	polyolefin mannich base	--	Potential environmental impact	VFJ, 2006

* CAS = Chemical Abstracts Service.

FOOTPRINT

A New Tool to Predict the Potential Impact of Biofuels on BTEX Plumes

by John Wilson

Most of us know that BTEX compounds can biodegrade in groundwater, and many of us incorporate this natural biodegradation into our strategy to manage risk at sites where there has been a gasoline release. In the absence of natural biodegradation, many BTEX plumes would be much larger than they are. Unfortunately, biofuels can interact with BTEX and inhibit this natural biodegradation, further complicating an already complex picture.

A Bit of History

More than a decade ago, groundwater scientists and engineers raised the possibility that ethanol could inhibit natural biodegradation of benzene, toluene, ethylbenzene, xylenes (BTEX) compounds (Corseuil et al., 1996, Powers et al., 2001). If this is true, a spill of E10 should have a longer BTEX plume than a spill of conventional petroleum gasoline. To see if this really happened at gasoline station sites, Ruiz et al. (2003) compared the lengths of benzene plumes at 217 sites in Iowa, where gasoline releases did not have ethanol, to the length of benzene plumes at 29 sites in Kansas, where the releases had E10. On average, the benzene plumes were 39 percent longer at the E10 sites.

To further evaluate this potential impact of ethanol on the size of BTEX plumes, Mackay et al. (2006) did a side-by-side experiment to compare the effects of ethanol at the same release site. They constructed artificial plumes of BT and X. Both had approximately 1 to 3 mg/L of benzene, toluene and *o*-xylene. One plume had 500 mg/L ethanol, while the other had none. After the plumes reached a steady state, the BTX plume in the presence of ethanol was four times longer than the plume without ethanol.

A Conceptual Model to Predict the Impact of Ethanol

Deeb et al. (2002) developed a conceptual model that can be used to make quantitative predictions of the effect of ethanol on the length of the BTEX plume. In contaminated groundwater there is very little oxygen available, and anaerobic bacteria

carry out almost all of the natural biodegradation. After all the soluble electron acceptors such as nitrate or sulfate are exhausted, the only processes assumed to attenuate BTEX concentrations are physical, such as dispersion and sorption, and anaerobic biodegradation, which proceeds through a fermentation reaction that produces acetate and molecular hydrogen. If the concentration of hydrogen builds up to a critical level, the thermodynamics of the BTEX degradation becomes unfavorable, and the degradation stops. Ethanol in groundwater is also fermented to acetate and hydrogen.

When the concentrations of ethanol are above 3 mg/L, natural degradation of ethanol can produce enough molecular hydrogen to stop the natural anaerobic biodegradation of BTEX compounds. In the Deeb et al. conceptual model, whenever the concentration of ethanol is above a critical threshold (3 mg/L), the natural biodegradation of BTEX is prohibited. In the region of an aquifer where concentrations of ethanol are above the threshold, the only processes that attenuate the concentrations of BTEX are dispersion and sorption. However, ethanol degrades in the groundwater, and eventually to a concentration below the threshold. At that point along the flowpath in the aquifer, the model assumes that natural biodegradation of BTEX proceeds at the same rate that would prevail in the aquifer if ethanol had not been released.

FOOTPRINT

Ahsanuzzaman et al. (2008) used the Deeb et al. (2002) conceptual model to construct a simple screen-

ing model to estimate the area of a plume of benzene produced from a release of gasoline containing ethanol. The screening model estimates the plume area, or footprint of the plume, in addition to the plume length, because the chance that a plume will impact a monitoring well is proportional to its surface area, not its length. FOOTPRINT is built around the Dominico analytical solutions to the advection dispersion transport equation (Dominico, 1987; Martin-Hayden and Robbins, 1997). This is the same mathematics that is used in BIOSCREEN, a widely used fate-and-transport model.

Applying FOOTPRINT to a Vulnerable Site

Every plume is different. The question is: What will ethanol do to plume lengths at sites in your case load? To illustrate the potential impacts of a biofuel spill, FOOTPRINT was calibrated to a large BTEX and MtBE plume at Naval Base Ventura County, in Port Hueneme, California.

- In the first step, FOOTPRINT was calibrated without any effect of ethanol. (Note the check box labeled COC Only [No Ethanol] in the lower right of Figure 1.) If FOOTPRINT is appropriately calibrated, the simulated output should adequately mirror the real benzene plume at the site.
- In the second step, the potential impact of a new biofuel spill was simulated by assuming a relatively high concentration of ethanol and an average rate of biodegradation for ethanol.
- In the third step, a potential worst case was simulated by assuming

a slow rate of biodegradation for ethanol.

This site was chosen because it is representative of sites where groundwater is highly vulnerable to contamination from gasoline. In the mid-1980s there was a release of approximately 10,000 gallons of motor gasoline from the Navy

ethanol extends deep into the water-table aquifer.

The input menu window for FOOTPRINT accounts for these factors (Figure 1). The site has been particularly well studied, and it was possible to calibrate FOOTPRINT using input values that were externally derived. The only assumed values in the calibrations are the vertical

dispersivity (which was set at a low number) and the effective porosity.

A pumping test and a variety of slug tests in monitoring wells indicate that the hydraulic conductivity at the site is near 100 feet per day. The hydraulic gradient over nearly a mile of the flow path was 0.0028 foot per foot. A tracer study using deuterated MtBE (Amerson and Johnson, 2003) determined that the average longitudinal dispersivity was 8.8 feet and the average transverse dispersivity was 0.82 foot.

The release produced a pool of floating product that was at least 280 feet wide. The water-table aquifer is approximately 10 feet thick. It is confined by a lower layer of silt and clay. The maximum concentration of benzene at the site is 5.4 mg/L. The first-order rate of biodegradation was extracted from data on the attenuation of concentrations of benzene with distance along the flow path, using the approach of Buscheck and Alcantar (1995). The release was assumed to have occurred in 1985, making the plume 15 years old at the time of calibration.

■ continued on page 16

FIGURE 1. Input screen for FOOTPRINT, simulating the potential effect of ethanol on an existing BTEX plume at a gasoline spill site in California. In this simulation the rate of degradation of ethanol was set at 2 mg/L per day or 730 mg/L per year.

Exchange (NEX) service station. The groundwater seepage velocity at the site is high, nearly one foot per day. By 2000, the MtBE plume extended at least 4,600 feet down-gradient of the release. In August 2000, the Navy installed an aerobic biobarrier to treat both MtBE and BTEX contamination in the plume. FOOTPRINT was calibrated to conditions in the plume just prior to installation of the treatment system.

Calibration Details

The impact of ethanol on the footprint of a benzene plume will be greater under the following conditions: (1) the concentration of benzene in the source is high, (2) the concentration of ethanol is high, (3) the seepage velocity of groundwater is high, (4) the natural degradation rate of benzene is slow, (5) the natural biodegradation rate of ethanol is slow, (6) the source of ethanol to groundwater is wide in cross section to groundwater flow, and (7) the

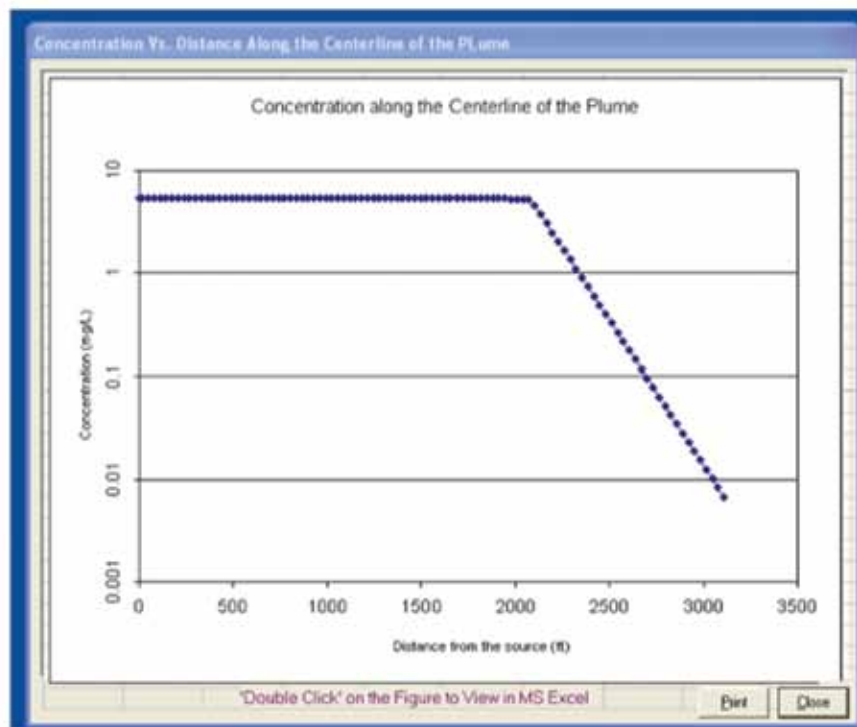


FIGURE 2. Benzene concentration vs. distance along the centerline of the plume for the FOOTPRINT simulation described in Figure 1. The simulated length where ethanol was present above the threshold and degradation of benzene was not allowed was 2,100 feet. The overall length of the benzene plume was almost 3,200 feet.

■ FOOTPRINT from page 15

Simulations for a hypothetical release of motor fuel assumed that the fuel was 10 percent ethanol. Following Deeb et al. (2002), the calibration assumed that the initial concentration of ethanol in impacted groundwater was 4,000 mg/L, and the threshold concentration was set to 3 mg/L ethanol. Based on experimental work conducted by USEPA staff at the Kerr Center in Ada, Oklahoma, ethanol degradation was assumed to be a zero-order process. FOOTPRINT was calibrated with the rate of ethanol degradation set at 20 mg/L per day and again with the rate at 2 mg/L per day. These rates reflect average rates and slow rates of ethanol degradation under anaerobic conditions respectively.

Results of the Simulations

In FOOTPRINT, the results of the simulation can be presented in two different ways. Figure 2 presents concentrations of benzene along the centerline of the plume. Figure 3 maps the surface area of the benzene plume 15 years after the release of ethanol.

Unfortunately, FOOTPRINT does not allow the user to scale the axes in the Figure 3 graphic. As a result, all the "footprints" look the same. What changes from one simulation to the next is the values plotted on the x and y axes. Figure 4 presents the actual distribution of MtBE and benzene in the aquifer in 2000, and compares that distribution to the distribution of benzene if there was no ethanol and the distribution in the presence of ethanol. The charts in Figure 3 were modified and rescaled to make the axes in the output consistent with the scale marker in Figure 4.

Notice in Figure 4 that there is reasonable agreement between the disposition and surface area of the real plume and the simulated plume without ethanol. This indicates that, for the purposes of this illustrative exercise, FOOTPRINT is sufficiently calibrated to conditions at the site. If the rate of ethanol biodegradation is 20 mg/L per day, the presence of even 4,000 mg/L of ethanol will have little effect on the size of the benzene plume. The ethanol only becomes

important if the rate of ethanol degradation is slow.

Table 1 makes the same comparisons as Figure 4 using numbers instead of shapes. If the ethanol degrades at an average rate, the simulated benzene plume is 27 percent larger with ethanol than without ethanol. The simulated effect is well

within the uncertainty in the model calibration. If the ethanol degradation is slow, the benzene plume can be up to four times larger. The MtBE plume was seven times larger than the benzene plume. If the rate of ethanol degradation is slow, the size of the benzene plume from a new spill of E10 might approach the size of the

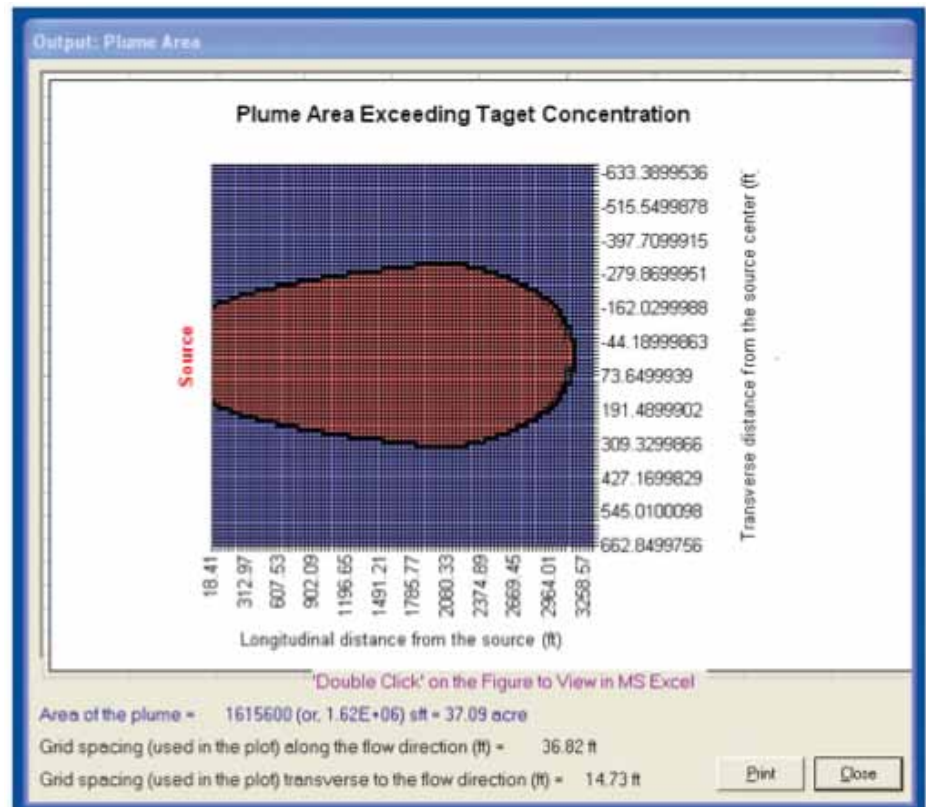


FIGURE 3. Output benzene plume area for the FOOTPRINT simulation in Figure 1. The simulated area of the benzene plume was 37 acres.

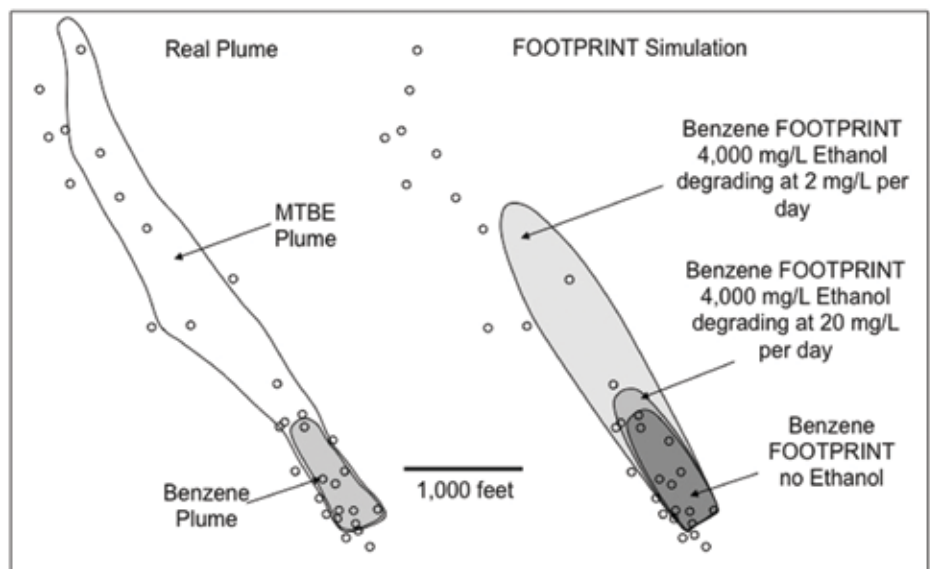


FIGURE 4. A comparison of the distribution of BTEX and MtBE in the plume at Port Hueneme, California, to the projected distribution of benzene from three separate calibrations of FOOTPRINT.

Actual Plume	FOOTPRINT Simulation	Surface Area (acres)
Benzene Plume		6.6
	Benzene Plume, no Ethanol	8.9
	Benzene Plume, 4,000 mg/L Ethanol degrading at 20 mg/L per day	11.3
	Benzene Plume, 4,000 mg/L Ethanol degrading at 2 mg/L per day	37
MtBE Plume		46

TABLE 1. Comparison of the actual surface area of MtBE and benzene plumes in an aquifer to the predicted surface areas of the benzene plume as simulated by FOOTPRINT.

MtBE plume that developed at this site.

Developments in the R&D Pipeline

Remember that FOOTPRINT is only a screening model. It is based on analytical solutions to the transport equation. As a result, it must assume uniform flow of groundwater. Notice in Figure 4 that the real plume takes a curved path through the aquifer, probably following local variations in hydraulic conductivity. FOOTPRINT cannot handle variations in aquifer properties, and in particular FOOTPRINT cannot handle the effects of a pumped well that might tend to draw in a plume.

To overcome these limitations, the groundwater flow model must be able to accommodate point-to-point variation in groundwater velocity. It will be necessary to move up to a numerical model to describe the transport of the contaminants in groundwater and their impact on water supply wells. USEPA/ORD is developing just such a model based on flow from LUST sites to water supply wells. This model builds the characteristics of LUST-site releases—gasoline volume, composition, smear zone thickness—into the aquifer-transport model and then accounts for mixing of clean and contaminated water in the well bore. Example results from the model were shown at the 2010 National Tanks conference and are due for publication in April 2011. ■

NOTE: A Problem with FOOTPRINT in Excel 2007 and higher. FOOTPRINT will run in later versions of Excel, but it runs slowly. ORD is working to bring out a new version of FOOTPRINT that will not have this problem.

John Wilson is a Research Microbiologist at the USEPA Office of Research and Development in Ada, Oklahoma.

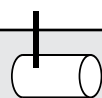
He can be reached at wilson.johnt@epa.gov for advice on anaerobic biodegradation of biofuels. For technical support for FOOTPRINT contact csmos.ada@epa.gov. Contact Jim Weaver at weaver.jim@epa.gov for details of the numerical model he has under development.

Disclaimer

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described here through in-house efforts. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document.

References

- Ahsanuzzaman, A. N. M., J. T. Wilson, M. Wang, and R. C. Earle. FOOTPRINT (a screening model for estimating the area of a plume produced from gasoline containing ethanol) Version 1.0. A. EPA/600/R-08/058 (2008).
- Amerson, I., and R. L. Johnson. Natural gradient tracer test to evaluate natural attenuation of MTBE under anaerobic conditions. *Ground Water Monitoring & Remediation* 23(1): 54–61 (2003).
- Buscheck, T.E., and C.M. Alcantar. Regression techniques and analytical solutions to demonstrate intrinsic bioremediation, in *Proceeding of the 1995 Battelle International Symposium on In Situ and On-Site*, April 1995 (1995).
- Corseuil, H. X. and P. J. J. Alvarez. Natural bioremediation perspective for BTX-contaminated groundwater in Brazil: effect of ethanol. *Water Science and Technology* 34 (7–8), 311–318 (1996).
- Deeb, R. A., J. O. Sharp, A. Stocking, S. McDonald, K. A. West, M. Laugier, P. J. Alvarez, M. C. Kavanaugh, and L. Alvarez-Cohen. Impact of ethanol on benzene plume lengths: microbial and modeling studies. *Journal of Environmental Engineering* 128 (9), 868–875 (2002).
- Domenico, P. A. An analytical method for multidimensional transport of a decaying contaminant species. *Journal of Hydrology* 91: 49–58 (1987).
- Mackay, D. M., N. R. de Sieres, M. D. Einarson, K. P. Feris, A. A. Pappas, I. A. Wood, L. Jacobson, L. G. Justice, M. N. Noske, K. M. Scow, and J. T. Wilson. Impact of ethanol on the natural attenuation of benzene, toluene, and o-xylene in a normally sulfate-reducing aquifer. *Environmental Science & Technology* 40 (19), 6123–6130 (2006).
- Martin-Hayden, J., and G. A. Robbins. Plume distortion and apparent attenuation due to concentration averaging in monitoring wells. *Ground Water* 35 (2): 339–346 (1997).
- Miller, K. D., P. C. Johnson, and C. L. Bruce. Full-scale in-situ biobarrier demonstration for containment and treatment of MTBE. *Remediation Journal* 12(1): 25–36 (2001).
- Powers, S. E., C. S. Hunt, S. E. Heermann, H. X. Corseuil, D. Rice, and P. J. J. Alvarez. The transport and fate of ethanol and BTEX in groundwater contaminated by gasoline. *Critical Reviews in Environmental Science and Technology* 31(1): 79–123. (2001).
- Ruiz-Aguilar, G. M. L., K. O'Reilly, and P. J. J. Alvarez. A comparison of benzene and toluene plume lengths for sites contaminated with regular vs. ethanol-amended gasoline. *Ground Water Monitoring & Remediation* 23 (1): 48–53 (2003).



Tank Bit.....

From PEI's Safety Letter 10/15/10

Failure to Communicate Can Be Dangerous

A service technician reported a near miss when he went to a job to fix a dispenser filter housing. Prior to the visit by the service technician, another employee had visited the site and had written "bad" on the front of the housing. The employee, however, failed to note the bad filter housing in the Dispatch Log. When the service technician was working on the dispenser, he engaged the shear valve without noticing the sign. When the shear valve was engaged, product was released. The spill was minor and no injuries incurred. However, the submitting company noted that the incident could have been prevented if the service technician and employee had engaged in better communication. The employee should have added notes to the job's Dispatch Log and thoroughly explained the situation. The dispenser should have also been properly tagged on both sides. The company noted that a red "out of order" wire tag on the Impact Valve would have saved the technician working on the site from an incident. The establishment of a lockout/tagout procedure for this scenario is also advisable. ■

The Vapor-Intrusion Pathway: Petroleum Hydrocarbon Issues

by Blayne Hartman

*I*t has been four years since my last article in LUSTline on vapor intrusion (LL#53, September 2006). Since then, the vapor-intrusion pathway has continued to be a “box-office blockbuster” throughout the environmental community. Guidance documents have been released by the Interstate Technology and Regulatory Council (ITRC), ASTM, and more than 25 states. USEPA is preparing to update its guidance. However, these documents do not have sufficient distinctions between assessing the vapor-intrusion pathway for chlorinated hydrocarbons (e.g., CHCs, solvents such as TCE, PCE) versus petroleum-related hydrocarbons (e.g., PHCs). As a result, vapor-intrusion assessments are being conducted at many PHC sites when recent evidence suggests they may not be necessary or they are being conducted in a manner that is inappropriate for PHCs. State reimbursement fund managers are concerned that the costs for unnecessary or improperly conducted vapor-intrusion assessments could drain the coffers of already cash-poor funds. So what to do?

In this article, I begin with a brief regulatory update on the vapor-intrusion pathway and then address issues specifically related to PHCs to underscore the distinction between PHCs and CHCs. I refer you to my previous articles written in LUSTline #48 and #53 for more information on some of the topics covered herein.

Regulatory Updates

■ EPA-OSWER

As of this writing, the draft 2002 EPA-OSWER vapor-intrusion guidance has yet to be updated. In 2009, the Office of Inspector General recommended that OSWER identify the portions of the 2002 guidance that need to be updated. A report released by OSWER in August 2010 summarizes the areas they feel need to be updated, including:

- Emphasis on a multiple lines of evidence approach
- Generic attenuation factors for soil gas data
- Collection time period for indoor air samples (days or longer)

(See http://www.epa.gov/oswer/vaporintrusion/documents/review_of_2002_draft_vi_guidance_final.pdf.)

In a footnote, this document states that: “The generalized statements in this document may not pertain to the more readily degradable petroleum compounds.” OSWER will be releasing a draft version of the revised guidance in late 2011, and has committed to releasing a final version by November 2012.

Go to OSWER’s vapor-intrusion website for more information: <http://www.epa.gov/oswer/vaporintrusion>.

■ EPA-OUST

Recognizing the need for vapor-intrusion guidance specific to PHCs, OUST convened a technical workgroup to prepare guidance specifically for PHCs. The workgroup consists of EPA-OUST staff, regulators from several states, and representatives from industry. The group plans to assist with the development of a series of issue papers on various topics throughout 2011, draft guidance by November 2011, and a final version by November 2012 at the same time as the revised OSWER guidance.

Fundamental Differences Between CHCs and PHCs in the Vadose Zone

PHCs behave differently than CHCs in the vadose zone for two primary reasons. First, volatile petroleum compounds biodegrade readily in the presence of oxygen and soil moisture, whereas chlorinated compounds are typically more resistant to biodegradation. The biodegradability of volatile petroleum compounds provides an effective, naturally occurring contaminant-removal mechanism that inherently limits the migration of subsurface petroleum vapors in most cases.

Second, petroleum-hydrocarbon free product is lighter than water, while chlorinated-hydrocarbon free product is denser. These two key

properties (i.e., biodegradability and density) lead to significantly different subsurface source and transport behaviors that greatly influence whether vapors reach the near surface and intrude into structures.

One final difference to keep in mind is that PHC fuel products are mixtures of many hundreds of compounds, many of which are also present in common consumer products other than fuel. Chlorinated solvents are typically only one primary compound with perhaps some degradation compounds.

Biovapor: A New Predictive Model Incorporating Bioattenuation

The most common predictive model currently used for vapor-intrusion applications is the one-dimensional Johnson-Ettinger (J-E) model that USEPA and some states have formulated into Excel spreadsheets (http://www.epa.gov/oswer/riskassessment/airmodell/johnson_ettinger.htm). However, for PHCs this model tends to significantly overpredict the vapor-intrusion risk, primarily because there is no allowance for bioattenuation. Recently, the American Petroleum Institute (API) funded the creation of a new Excel version of the J-E model that incorporates bioattenuation, named Biovapor. Dr. George DeVaul of the Shell Development Company developed the original for-

mulation of this spreadsheet and the new Excel version was developed by GSI Environmental Inc.

Bio vapor is a user-friendly spreadsheet that allows prediction of indoor air concentrations and associated risk from soil-gas or groundwater data (a version for soil-phase data is being contemplated). It also performs the back calculation of calculating allowable soil-gas and groundwater concentrations from indoor-air screening levels.

The model does the calculations for the individual aromatic compounds (i.e., BTEX, naphthalene), as well as for aliphatic hydrocarbons. The model applies bioattenuation only when sufficient oxygen is present in the vadose zone (i.e., aerobic bioattenuation). It uses a mass-balance approach to ensure that the amount of bioattenuation does not exceed the amount of available oxygen.

Shaw Environmental reviewed the model formulations in January 2010 under contract to USEPA ORD. The formulations were found to be correct. EPA-ORD is planning to do its own evaluation of the model. Meanwhile, Robin Davis of the Utah Department of Environmental Quality has compared the model's predictions to actual field data at a number of sites and found the model's results to be slightly on the conservative side (in other words, the model often underpredicts the amount of attenuation and hence overpredicts the risk). (See Robin Davis's presentation at <http://www.neiwpcc.org/lustline/supplements.asp>.)

The model is currently available on the API website (www.api.org). Instructional classes/webinars are being planned and will be listed on the website.

Exclusion (Screen-Out Sites) Criteria

A primary problem we are facing with petroleum hydrocarbon sites is what criteria to use to decide if a site needs a vapor-intrusion assessment if there is not an obvious situation (e.g., fuel in a basement, petroleum odor in a structure). If existing OSWER Tier 1 screening distances of 100 feet are applied both vertically and spatially, combined with extremely low Tier 2 screening concentration, then the vast majority of

sites will be screened in for further investigation, and few sites will be screened out. While these criteria may be appropriate for recalcitrant compounds, they are not appropriate for PHCs in most scenarios.

Robin Davis has analyzed a database of about 170 sites from the United States, Canada, and Australia in an effort to determine screening criteria for PHCs sites (see *LUSTLine* # 61). Her primary goal was to determine what thickness of clean soil is necessary for various source concentrations to decrease to levels below

LNAPL on groundwater are also completely attenuated with as little as eight feet of clean soil between the source and the receptor, based on a more limited data set of 76 vapor samples collected at 16 different sites (Figure 2).

For soil vapor concentrations, Robin has previously written in two prior PHCs articles (*LUSTLine* #49 and #52) that if three to five feet of clean, aerobic soil (oxygen $\geq 5\%$) exist, vapors are completely attenuated and the vapor-intrusion pathway will not be complete.

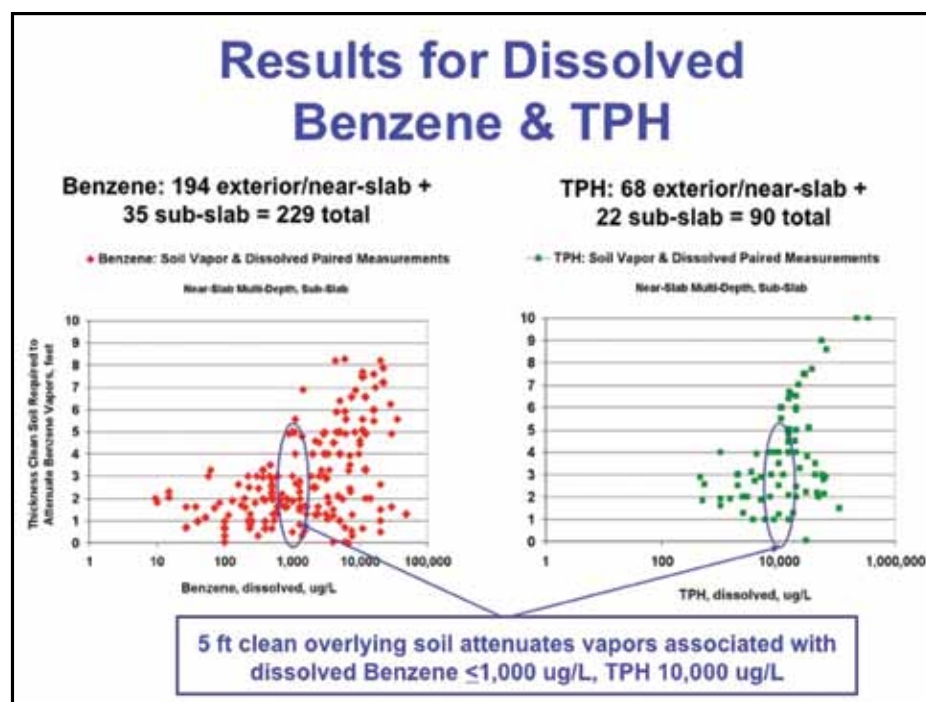


FIGURE 1. Thickness of clean soil required to attenuate benzene vapors from dissolved benzene in groundwater and to attenuate TPH vapors from dissolved TPH in groundwater (Robin Davis, 2010).

accepted risk thresholds due to bioattenuation.

She concluded that five feet of clean soil is all that is required between source and receptor to fully attenuate benzene vapors for dissolved concentrations of benzene up to 1,000 $\mu\text{g/L}$ and TPH vapors for dissolved TPH concentrations of up to 10,000 $\mu\text{g/L}$ (Figure 1), although the latter value is based on a smaller number of data points. Compare her benzene screening value of 1,000 $\mu\text{g/L}$ to the value that you would get from the current USEPA Tier 2 screening value of 1.5 $\mu\text{g/L}$: the difference is a factor of nearly 700 times!

Robin's database also shows that benzene vapors volatilizing from

These exclusion criteria for dissolved groundwater concentrations, free product, and soil-vapor concentrations are being discussed to screen out PHC sites from further vapor-intrusion assessment. California recently included some of them as screening criteria in their new draft *Leaking Underground Fuel Tanks (LUFT) Manual*.

Sampling Issues for PHC Sites

Indoor Air Sampling

The August 2010 OSWER review document mentioned previously discusses possibly collecting indoor air samples at the beginning of a vapor-

■ continued on page 20

■ Vapor-Intrusion Pathway *from page 19*

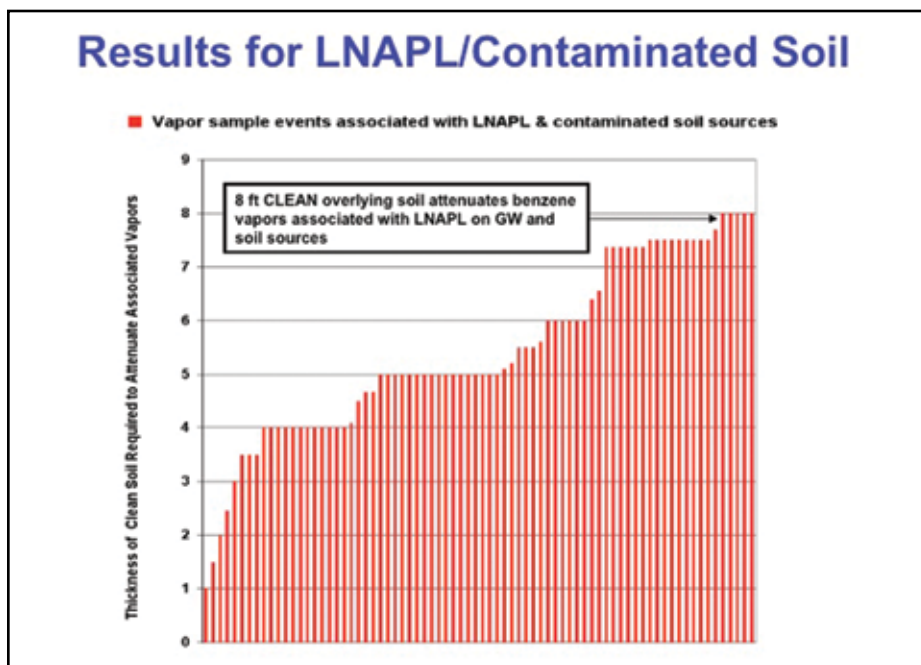


FIGURE 2. Thickness of clean soil required to attenuate benzene vapors from sites with LNAPL (Robin Davis, 2010).

intrusion investigation. Indoor air sampling for PHCs will likely be problematic and confuse, not clarify, the vapor-intrusion pathway for two primary reasons:

- Ambient (outdoor air) levels of benzene exceed the screening levels in most urban areas and can exceed the one in one million residential risk levels in many non-urban areas. Try explaining to the resident why his or her indoor air exceeds the allowable cancer risk value by 10 times, but that it is okay because the air is coming from the outside.
- The indoor sources for benzene and other PHC compounds are ubiquitous and nearly impossible to identify. My favorite recent example that demonstrates this point is Bloonie®, a balloon-making toy for kids. It contains obscene amounts of acetone, ethanol, benzene, and other goodies, and you would never think to remove it from a house if it was lying on the counter. (Read on for another example of a ubiquitous source of benzene in homes.)

In recent presentations at vapor-intrusion-related conferences, USEPA-OSWER is recommending longer indoor air sample-collection

periods, for periods as long as 7 to 30 days, based on lessons-learned from the radon literature. This is not a good idea for PHC sites because of the many potential indoor air sources. The procedure will result in numerous false positives, which will require a lot of time and expense to decipher the actual source of the detections.

For the above reasons, I rarely recommend collecting indoor air samples for PHCs at residences. For commercial/industrial receptors, collection of indoor air samples might be more suitable depending on the allowable indoor levels (allowable indoor levels can be 10 to 50 times higher than residential levels in some states).

■ Groundwater Sampling

Since the existing models and default attenuation factors do not account for bioattenuation, you can expect groundwater data to overpredict the risk for PHC compounds if there are no sources in the vadose zone. Hence, I rarely recommend that groundwater samples be collected for PHC vapor-intrusion assessment if soil-gas data can be collected (sometimes a shallow water table precludes the collection of soil-gas data). However, if groundwater data

already exist and indicate there is no risk, then it is probably a safe bet that the pathway is not of concern, and no further assessment is needed.

■ Soil-Gas Sampling

Sample Depth

PHC soil-gas sampling locations differ from those for CHCs owing to their different fate and transport behavior. For PHCs, if samples at deeper depths (>5ft bgs) exceed allowable values, shallower samples (<5ft bgs) should be collected for slab-on-grade structures, since bioattenuation may be active in the upper few feet and reduce values below acceptable levels. If on-site analysis is available, this decision can be made in real time. However, if on-site analysis is not available, I recommend that my clients collect a sample shallower than five feet bgs in the event that the deeper sample exceeds allowable levels.

The incremental cost of collecting the additional samples is negligible. You can withhold analyzing the shallower sample to see if results from the deeper sample indicate there is a need to analyze it. As far as the representativeness of shallow soil-gas concentrations, EPA-ORD has finished two studies documenting that the temporal variation of soil-gas concentrations as shallow as two feet bgs are less than 50 percent (Figure 3). (See <http://www.epa.gov/nerlesd1/cmb/pdf/270cmb07.pdf>.)

Oxygen data should always be collected to document the presence of the aerobic zone. Carbon dioxide and methane are also useful to confirm the presence of bioattenuation. Soil-phase data may also be needed to document the presence of clean soil.

Sub-slab vs. Near-slab Samples

For CHCs, the current thinking is that shallow soil-gas data (5 to 10 ft bgs) collected outside the building slab may not adequately represent sub-slab soil-gas concentrations in many situations. This thinking is based on modeling simulations as well as data from many CHC sites. But for PHCs, field data currently being presented by Robin Davis and Todd Ririe (BP-Arco) at many conferences (<http://www.neiwpcc.org/tanks-conference/pre-workshops.asp>) and from

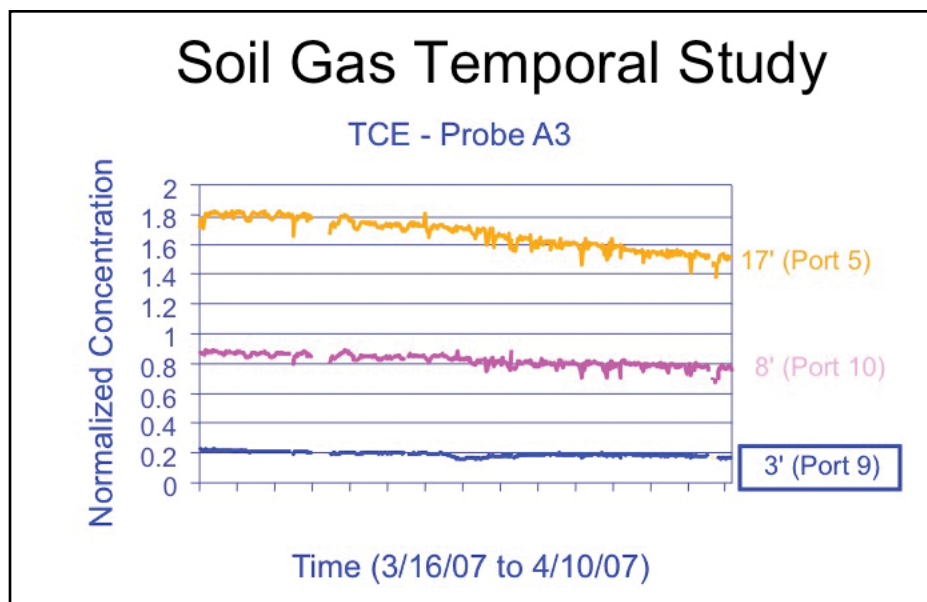


FIGURE 3. TCE concentrations in soil gas for a period of four weeks for three probes at 3' bgs, 7' bgs, and 17' bgs (EPA 2007).

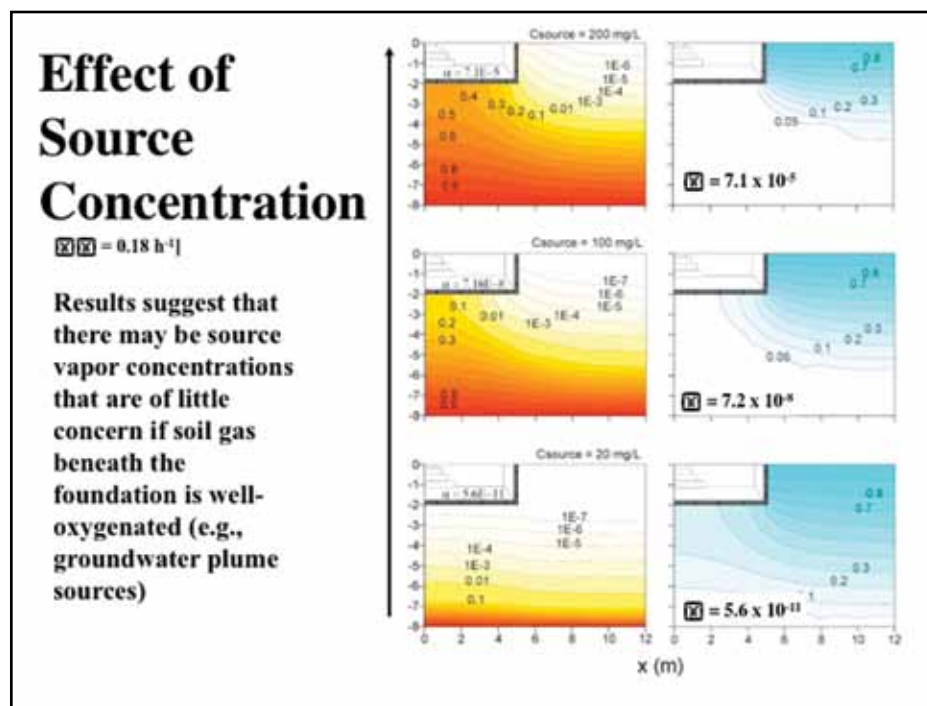


FIGURE 4. 3-D modeling of hydrocarbon vapors showing the effects of bioattenuation (Abreu & Johnson, 2006).

modeling simulations suggest that exterior shallow soil-gas samples are representative, so long as sufficient oxygen is present ($\geq 4\%$) and three to five feet of clean soil exist under the receptor (Figure 4). So, near-slab sampling for PHCs should be a viable approach at most sites, unless contaminated soils or low oxygen is suspected under the structure.

Including Petroleum Aliphatics as a Compound of Concern?

Some states (e.g., MA, CA, WA, HI) have published indoor air screening levels for the petroleum aliphatic range and require that they be included as a compound of concern (COC) for the vapor-intrusion pathway at PHC sites. There is currently considerable debate as to whether

this compound group does represent a potential health threat. I am not a regulator making policy, but I will caution those that do—if aliphatics are included as a COC, it is likely that many more sites will require a vapor-intrusion assessment. The reason for this is that the aliphatics have much higher Henry's constants and higher vapor pressures than the aromatics, resulting in much higher concentrations in the soil gas (by 10x to 50x) over free product, near dirty soil, and even near dissolved contamination.

The fundamental problem is that petroleum is made up of many different aliphatic compounds, but the toxicity data exist for very few of them. Hence, applying the limited existing toxicity data to the total aliphatic fraction is an extrapolation. To better understand the true risk of these compounds, it is necessary that the toxicity of the individual aliphatics be reviewed so that the risk-driving compounds, or compound groups, are identified and appropriate chemical-specific screening levels (meaning not too conservative) are determined.

If you are going to measure the aliphatics, be sure that the laboratory does the appropriate compound-group speciation and that it uses calibration standards for those compounds. Some labs are quantifying all the aliphatics using one or two compounds, such as hexane, rather than purchasing the expensive aliphatic mixture standards.

Beware Natural Gas

Earlier this year, while on a vapor-intrusion investigation, we discovered 90 percent methane and benzene in the thousands of $\mu\text{g}/\text{m}^3$ under a garage at a home far removed from the suspected service station source. Using real-time analysis, we collected additional soil-gas samples and honed in toward the culprit—a built-in barbeque in the adjoining courtyard plumbed directly to the public natural gas. We next collected and analyzed a sample of the natural gas itself and were astonished to find benzene concentrations exceeding $1,000 \mu\text{g}/\text{m}^3$!

All of the houses in the community had natural gas fireplaces in the living rooms, gas furnaces, and

■ continued on page 22

■ Vapor-Intrusion Pathway from page 21

many had gas ovens/stoves. It turns out that most natural gas supplied by gas companies across the country has 0.1 to 1 percent "impurities," meaning hydrocarbons other than methane. Take-home lesson: if the receptor has natural gas, analyze a sample of the natural gas for the target compounds. This should be done if indoor-air, sub-slab soil-gas, or exterior soil-gas data are being collected, since underground gas lines can also leak.

Parting Thoughts

■ The Two Most Common Errors in Vapor Intrusion

Vapors and vapor intrusion are an unfamiliar territory for many practitioners in this field (i.e., regulators, stakeholders, consultants, subcontractors, attorneys). Here are two of the most common errors that I see being made in this subject area:

• Confusion with Units

One common error that people make with soil-gas data is thinking a ppbv is equivalent to a $\mu\text{g}/\text{L}$ or a $\mu\text{g}/\text{m}^3$. The units are not equivalent, and the conversion depends on the molecular weight of the compound. Converting between units (e.g., $\mu\text{g}/\text{L}$ to $\mu\text{g}/\text{m}^3$, percent to ppmv) is also causing headaches. Make your life simpler by:

- Instructing your lab in which units and detection levels you want the data reported.
- Going to www.handpmsg.com for a handy-dandy and easy-to-use unit conversion spreadsheet.

• Required Soil-Gas Target Levels

The other error I see too often is the regulator or consultant using incorrect soil-gas target levels. Residential values are erroneously applied at commercial sites, incorrect attenuation factors are being used to determine target values, or values determined from predictive models are incorrect. The soil-gas target level ultimately determines the required analytical method and the need for additional assessment. Determining the proper value is often an unfam-

iliar exercise for both regulator and consultant. So, consultants need to ensure that regulators are asking for the proper values, and regulators need to ensure that consultants are proposing the proper values.

Vapor-intrusion assessments are being conducted at many PHC sites when recent evidence suggests they may not be necessary or they are being conducted in a manner that is inappropriate for PHCs. State reimbursement fund managers are concerned that the costs for unnecessary or improperly conducted vapor-intrusion assessments could drain the coffers of already cash-poor funds.

■ Experience: The Key Ingredient for Vapor-Intrusion Solutions

The most important ingredient needed for cost effective, and cost-efficient vapor-intrusion investigations is the experience of the consultant and the subcontractors (e.g., sampling firm, laboratory). This is a growing problem as many practitioners are jumping into vapor intrusion due to the opportunities that exist.

Sampling errors include such basics as not opening containers, incorrect seals, over-tightening swage lock fittings, wrong tubing, using contaminated parts and sealants, and more. Laboratory issues consist of sending out incorrect or faulty hardware, using the wrong method for the required detection levels (typically at higher cost), and more. These mistakes result in bad data that only further confound the interpretation.

I advise responsible parties to use consultants experienced with this pathway. In turn, I advise consultants to use firms experienced in soil-gas collection and use labs experienced in indoor-air/soil-gas analysis. The stakes are simply too high with vapor intrusion to do anything else.

Want to Know More?

- The Nielsen Field School will be giving a course on "Soil Gas Sampling for Vapor Intrusion Applications" in January 2011 in San Diego. Go to: <http://www.envirofieldconference.com>.
- API is offering free training entitled "Assessing Vapor Intrusion at Petroleum Hydrocarbon Sites" covering the topics discussed in this article and more at the AEHS conference in San Diego in March 2011.
- As mentioned previously, API will be offering training on the Biovapor model throughout 2010 and 2011. Go to www.api.org to find dates or e-mail me if you are interested in such training.
- ITRC continues to offer a two-day vapor intrusion course. San Antonio in January 2011, and three other locations (TBA) in 2011. Go to www.itrcweb.org for details.
- EPA-OSWER will be holding a 1-day workshop on vapor intrusion at the AEHS conference in San Diego in March 2011. Go to: <http://www.aehsfoundation.org>. ■

References

- Abreau & Johnson (2006). Simulating the effect of aerobic bioattenuation on soil vapor intrusion into buildings: Influence of degradation rate, source concentration, and depth. *Env. Sci. Tech.*, 40, 2304–2315
- LUSTLine articles referenced in this article can be found at www.netwpc.org/lustline.
- Robin Davis (2010). Slides from her most recent presentations at API's "Assessing Vapor Intrusion at Petroleum Hydrocarbon Sites" training course.
- USEPA (2007). Final project report for investigation of the influence of temporal variation on active soil gas/vapor sampling. EPA/600/R-07/141, December 2007.

I wish to thank the following reviewers of this article for their constructive comments: Robin Davis, George DeVaul, Larry Froebe, Tom McHugh, and Todd Ririe.

Blayne Hartman, Ph.D., is an independent consultant offering vapor-intrusion, soil-gas, and analytical support services. He has provided training on soil-gas methods and vapor intrusion to over 30 state agencies, several U.S. EPA regions, ASTSWMO, the DOD, and numerous consultants and stakeholders. He is a trainer in vapor intrusion courses offered by EPA-OUST, ITRC, API, and previously ASTM. For more information, contact Blayne at Blayne@hartmaneg.com.

Using In-Situ Chemical Oxidation to Clean Up Contamination at a Shallow-Groundwater/Fine-Grained Soils Site

by Samar J. Bhuyan and Michael R. Latin

The Arizona Department of Environmental Quality (ADEQ) developed and implemented a successful remediation approach to address a challenging set of site-contamination conditions at a leaking underground storage tank (LUST) site in Somerton, Arizona. The challenges at the site involved shallow groundwater, fine-grained soils, and gasoline contamination in the groundwater, smear zone, and in free-product phase. The remediation approach combined in-situ chemical oxidation (ozone injection) with soil-vapor-extraction (SVE) technology. The cleanup was implemented through the ADEQ's State Lead Unit (SLU), Corrective Action Section, Waste Programs Division. The project was initially funded by state funding and was completed and closed utilizing federal stimulus money provided under the American Recovery and Reinvestment Act (ARRA). Timely completion of this project prevented the spread of contamination to nearby residential properties and a school.

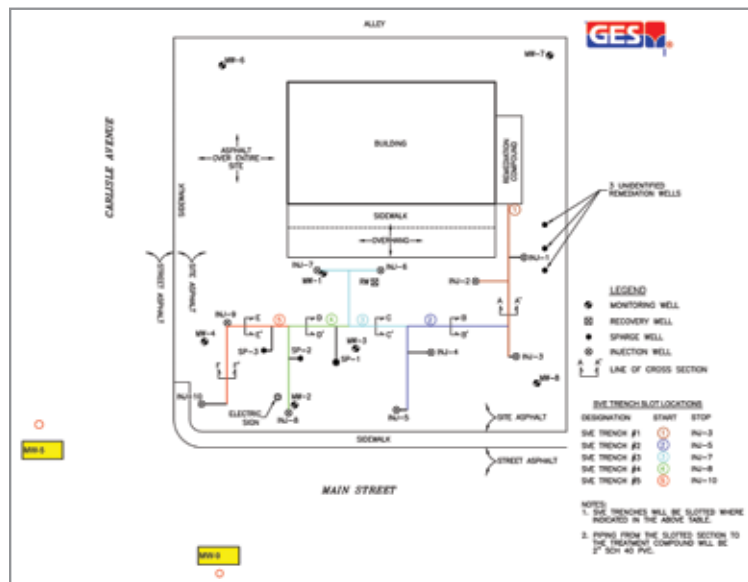


FIGURE 1. Somerton, Arizona, LUST-site map.

The Setting

The previous owner used the property as a retail gasoline station during the 1980s. In 1987, an unknown quantity of gasoline escaped from the UST system into the soil and groundwater. Of particular concern was the residential property and the Desert Sonora Elementary School located just north and down gradient of the property. Pump-and-treat and SVE systems were implemented by the responsible party in the 1990s and then terminated without successful completion. The responsible party declared bankruptcy and the property was sold to the current property owner.

In 2006, the property owner requested state-lead program assistance to complete the corrective-action work. The site lithology consisted of mostly clay from the surface to depths ranging between 7 and 11 feet below ground surface (bgs). Below the clay layer to a depth of at least 25 feet bgs, a fine-grained, unconsolidated, and uniform river sandy layer was observed. The groundwater level at this site is generally about 10 or 11 feet bgs.

Due to the shallow nature of the groundwater, soil contamination

was not the primary remediation concern. The groundwater had very high levels of benzene, toluene, ethylbenzene, and xylene (BTEX). Arizona's Aquifer Water Quality Standard (AWQS) for BTEX cleanup is 5.0, 1,000, 7,000, and 10,000 $\mu\text{g/L}$ (ADEQ, 2002), respectively.

Groundwater fluctuation, corresponding to nearby irrigation scheduling, resulted in a smear zone of contamination. Nine groundwater-monitoring wells, as shown in the site map (Figure 1, extracted from ADEQ's LUST file), were installed at the site to delineate the groundwater plume. This contaminated mass was estimated to have spread to an area of approximately 8,200 square feet.

The Methods

The objective of our remediation approach was to be as effective and aggressive as possible due to the presence of the down-gradient school and residential properties. To do this, we used, primarily, the in-situ chemical oxidation technology, reported to be effective in reducing contaminants in a short time frame from both the groundwater and the smear zone (USEPA, May 2004).

We injected air containing up to 5 percent ozone into the groundwater

for this purpose. Ozone has a very high chemical oxidation potential of 2.1 V, which is useful for attacking petroleum contamination aggressively in-situ (ITRC, 2005). The ozone was injected at a low pressure and flow so that the contaminated mass would be less likely to be pushed underneath the building on the site. It also helped minimize the potential for generating volatiles through the vadose zone and causing groundwater mounding. The ozone also dissolves readily in groundwater, which can significantly increase dissolved oxygen (DO) and enhance biodegradation (USEPA, May 2004).

Under this approach, developed by the SLU in 2007, ten 2-inch-diameter injection wells were installed to 25 feet bgs. They were constructed with chlorinated poly vinyl chloride (CPVC) materials and three feet of stainless-steel screen at the bottom. The wells were installed in the more highly contaminated source area. Injection wells were then connected through subsurface teflon tubing to the ozone-injection equipment. Teflon tubings were inserted through larger diameter (6-inch) PVC pipe installed in a horizontal trench at about 4 feet bgs.

■ continued on page 24

■ In-Situ Chemical Oxidation from page 23

Due to the shallow depth to groundwater, a horizontal SVE system was implemented. With this system, we extracted contaminated hydrocarbon vapors (using a smaller blower with a 100 standard cubic feet per minute [scfm] capacity) from the vadose and smear zones and treated it through a catalytic oxidizer.

The horizontal subsurface perforated piping consisted of five different legs, each constructed of 2-inch-diameter PVC perforated pipe, approximately 40 feet long (Figure 1). During this period, groundwater dropped about 3 feet

to approximately 13 feet bgs, resulting in the appearance of free product in three monitoring wells (MW-2, MW-3, and MW-4; see Figure 2) and exposure of the smear zone in the site. These three wells were retrofitted to vapor extraction (VE) wells and connected to the SVE equipment through subsurface piping, in order to extract free-product and smear-zone contamination. The free product from the wells was also hand-bailed prior to system start-up.

Start-Up

The SVE system was started on May 31, 2007, utilizing three vertical VE wells and all five horizontal perforated legs. The flow rate was initially

98 scfm and later reduced to 40 scfm due to low hydrocarbon recovery rate and groundwater mounding concerns. The ozone injection system was then brought into operation at 2 pounds per day with a flow rate range of 3.6–4.5 scfm and at a pressure range of 9–12 pounds per square inch (psi) through individual injectors. This ozone injection equipment was programmed to inject a mixture of ozone and air through one injection well at a time for one hour, known as pulsing or cycling. Each injection well was injecting at least once per 24-hour cycle. This pulsing of airflow is reported to be effective in remediating contamination (NAVFEC, 2001).

The Outcome

We monitored the progress of this remediation by periodically sampling the groundwater in nine monitoring wells (MW-1 through MW-9) as well as the influent and effluent to the catalytic oxidizer. During each groundwater-sampling event, the remediation systems were turned off three days prior to sampling to allow the groundwater to stabilize and to collect a homogenized sample. Wells that showed free product were not sampled. Atmospheric vapor readings across the site did not show any unusual readings.

The ozone injection system was equipped with an ambient ozone sensor that detects and measures concentration of ozone emission. The equipment shuts down automatically if an ozone leak is detected. Approximately, 670 pounds of ozone were injected into the groundwater. Based on the influent vapor sampling, the SVE system was recovering approximately 10 pounds/day of petroleum hydrocarbons in the initial four months of operation, which was reduced to 4 pounds/day, and then to 0.4 pounds/day toward the end of the remediation.

The baseline DO measured at the site prior to the system installation was in the range of 0.4 through 1.1 parts per million (ppm). DO levels measured during the remediation period were as high as 8.9 ppm. This demonstrated a significant increase in DO as a result of ozone and air injections. Four boundary monitoring wells (MW-5, MW-6, MW-7, MW-9), which were away from the



Remediation system installation and groundwater-monitoring activity.

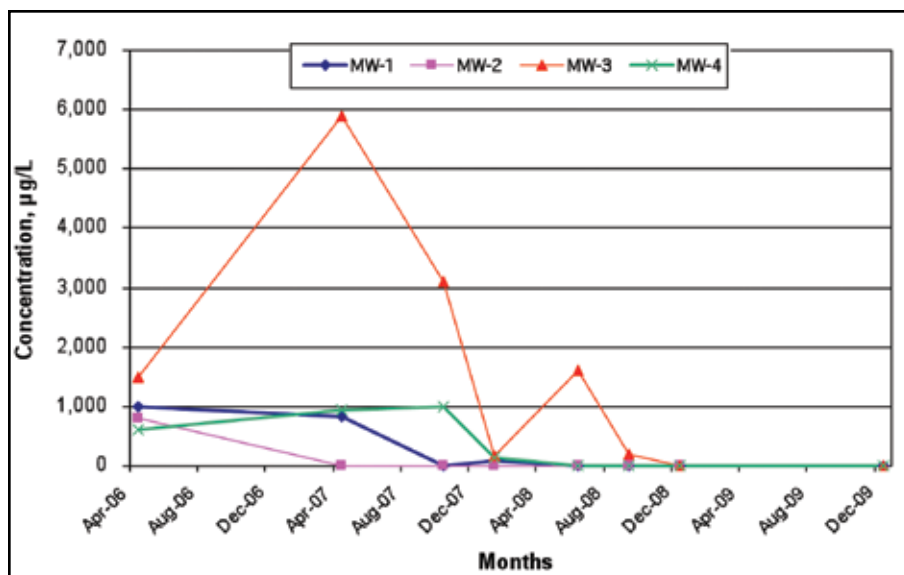


FIGURE 2. Benzene concentration data in a few selected wells. Note: Free product was detected in MW-2, MW-3, and MW-4 in early 2007.

ozone injection area, also showed increased DO levels. These wells were between 40 and 80 feet away from their nearest ozone injection well. The location of the boundary injection wells enhanced bioremediation in the outer edge of the plume.

Groundwater elevation during the remediation period remained at approximately 13 feet bgs, which helped expedite free-product recovery and smear-zone remediation. The free product contamination disappeared after three months of operation. Free product was not analyzed for contaminants of concern (COC). Sampling below the free-phase area would have provided us with a better understanding of the total contaminant mass. Therefore, the concentration data shown in Figure 2 cannot be used to estimate this mass.

Benzene concentrations in most contaminated wells are shown in Figure 2. The COCs from most of the wells dropped significantly within 8 months of system operation. After 18 months of system operation, results from the December 2008 groundwater-sampling event showed that COCs in all wells except one, MW-3, were below AWQS. Active remediation on the site was terminated following this sampling event.

Two rounds of post remediation groundwater sampling were performed approximately one year after the termination of active remediation to test for any rebound of contaminants. Confirmatory soil sampling at two locations was also performed

to test for residual soil contamination across the vadose zone. All COCs were measured below AWQS and soil cleanup levels. The site was closed in February 2010.

It should be noted that bioremediation (natural attenuation) may have occurred during the post-active remediation period to address residual contamination. This remediation phase helped reduce remediation costs as a result of system operation and maintenance, generation of remediation wastes, and associated costs for treating residual levels of contamination. Recently, the remaining infrastructures were abandoned and the site was restored as close as possible to its original condition.

The successful results of this remediation approach, however,

should not be taken as endorsement for this application in similar site conditions. Detailed site-specific condition and feasibility tests should be carefully evaluated before developing any remediation approach. ■

Samar J. Bhuyan, Ph.D., is an Environmental Engineer and Michael R. Latin is the Manager of State Lead Program, Corrective Action Section, Waste Programs Division with the Arizona Department of Environmental Quality. Samar J. Bhuyan can be reached at bhuyan.samar@azdeq.gov.

Acknowledgement: Funding for this project was provided under Arizona's State Assurance Fund and American Recovery and Reinvestment Act (ARRA). The remediation approach was implemented through Groundwater and Environmental Services, and post-active remediation activities were performed through Blaes Environmental Management, Inc., State Environmental Contractors contracted with State of Arizona. Comments from Eric Magnan, P.E., Underground Storage Tank Program Office, U.S. EPA Region 9 were much appreciated.

References

- Arizona Department of Environmental Quality (ADEQ). 2002. Release Reporting and Corrective Action Guidance. Underground Storage Tank Program.
- The Interstate Technology & Regulatory Council (ITRC). January 2005. *Technical and Regulatory Guidance for In-Situ Chemical Oxidation of Contaminated Soil and Groundwater*. Second Edition, January 2005.
- Naval Facilities Engineering Command (NAVFEC). August 2001. Technical Report. Final Air Sparging Guidance Document. TR-2193-ENV.
- United States Environmental Protection Agency (USEPA). May 2004. How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers. EPA 510-R-04-002.

Maine DEP Receives National Award for Online Operator Training

The Maine Department of Environmental Protection received an award for its *TankSmart* online service from the Center for Digital Government's annual "Best of the Web" program—Government-to-business category. The awards given for online state government services are chosen for their innovation and effectiveness. *TankSmart* (www.Maine.gov/online/tanksmart) is a free online service that provides training and certification for Class A/B operators of underground storage tank facilities. Congrats to the Maine UST program folks.



A MESSAGE FROM CAROLYN HOSKINSON

Director, USEPA's Office of Underground Storage Tanks

Move Over Sisyphus, Here's a Real Challenge: Reducing the National LUST Cleanup Backlog

In Greek mythology, Sisyphus was a king who angered the gods so much that they punished him with a difficult and never-ending task. He was made to roll a huge rock up a steep hill, but before he could reach the top of the hill, the rock would always roll back down, forcing him to begin again. At times, cleaning up the nation's LUST cleanup backlog seems like a sisyphian task. We continually clean up sites, but the pace of cleanups has slowed, some sites remain open for decades, some are not addressed, and all the while new releases add to the workload. There doesn't seem to be an end in sight.



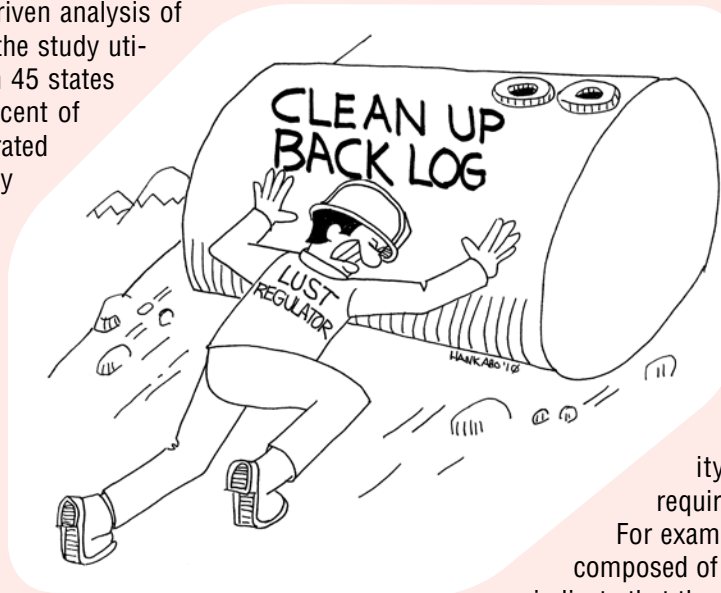
A Unique Analysis of the Cleanup Backlog

As of March 2010, more than 491,000 releases from USTs had occurred nationwide. The states (with a few done by EPA in Indian Country) have made tremendous progress addressing these releases by cleaning up 395,000 (80%) of them. This achievement represents an enormous amount of work and resources. However, a national backlog of over 96,000 releases remains, and the annual number of cleanups completed nationally has declined steadily since FY 2000. To understand the makeup of the backlog of releases and why the pace of cleanups is slowing, EPA undertook a two-phase data-driven analysis of the backlog. Phase 1 of the study utilized summary data from 45 states to determine that 60 percent of the backlog was concentrated in ten states, that many releases in the backlog were old, and that there were more groundwater than soil-only sites, although many soil-only sites remain in the backlog.

In Phase 2, EPA invited 14 states to participate in a more in-depth analysis of their LUST backlogs. We were interested in isolating several attributes of the sites in the backlog (e.g., age, media affected, prioritization) and looking closer at how state cleanup programs functioned. EPA selected those 14 states because they are responsible for approximately 67 percent of the national LUST cleanup backlog and provide participants from all ten EPA Regions. EPA worked with the states to ensure it used the correct data elements for analysis, and the states provided EPA with the data from their LUST cleanup programs.

By the end of FY 2009, the cleanup programs in the participating states had closed 71 percent of their cumula-

tive releases but had over 71,000 releases remaining in their cleanup backlogs. EPA was able to identify patterns and trends within the state backlogs that could provide potential opportunities to reduce the state and national cleanup backlogs and improve cleanup progress. The report on Phase 2 will consist of 14 individual state reports and one national summary report. EPA will use the results of the study to set the groundwork for discussions with states and tribes and other stakeholders to develop targeted backlog reduction strategies.



Some Disconcerting Findings

Many of the states' open releases looked at in Phase 2 are very old and still in the early stages of cleanup. Over 50,000 of the releases are ten years old or older, and over half of the releases did not have a completed site assessment.

Many factors affect the pace of cleaning up releases, including funding availability and mechanisms, statutory requirements, and program structure. For example, the current backlog is likely composed of difficult-to-remediate sites. Data indicate that the majority of releases in the backlog contaminate groundwater resources. In general, remediating groundwater contamination is more technically complex, longer-term, and more expensive than remediating soil contamination. Therefore, larger numbers of releases affecting groundwater could be a major reason for the persistence of the LUST cleanup backlog.

In addition to the prevalence of groundwater contamination, the states lacked the resources to fully address all of these expensive cleanups in the near term. EPA is aware that state cleanup programs face obstacles to reducing their backlogs and that the recent economic downturn has also had a tremendous impact on the states' ability to make

MESSAGE FROM CAROLYN HOSKINSON *continued from page 26*

progress on cleanups. State cleanup funds and staff are often stretched thin and cleanup costs are increasing. Furthermore, many cleanups have uncertain financing.

Is all the low-hanging fruit already picked? Our data say, No! But, many of the low-hanging fruit are low-priority fruit, and we're not picking those. State programs use various strategies to address limited resources, such as prioritizing releases to focus on the worst sites first. These practices have positive benefits: they address the highest risks to human health and the environment and protect state environmental resources. However, they also can contribute to the backlog, especially where statutory requirements prevent some state programs from completing easy, lower-priority closures. Consequently, there are many sites in the backlog that are very old, low priority, and will likely remain unaddressed for many more years to come.

Opportunities to Reduce the Backlog

EPA acknowledges that many state programs have initiated their own backlog reduction strategies. Such efforts have included data and file reviews and the use of temporary staff (e.g., interns, contractors) to close more releases. Other strategies being implemented include using multi-site agreements to encourage responsible party activity, utilizing pay-for-performance and other incentives for contractors

to reach closure, and referring releases to brownfields programs or other programs like voluntary cleanup programs. EPA wants to highlight these efforts, encourage sharing best practices, and continue to build on states' successes.

The Phase 2 report analyzes and presents additional factors related to backlog releases. Throughout the national study, EPA identifies potential opportunities for improved backlog reduction. The opportunities presented are related to three main categories: accelerating corrective action, pursuing targeted initiatives, and improving program implementation. These opportunities are not intended as specific recommendations. They are meant to open dialogue with the states and other stakeholders on all opportunities to reduce the national cleanup backlog and to serve as the basis for the backlog reduction strategies that EPA intends to develop jointly with the states and tribes.

Next steps for EPA include working with the states and tribes to identify and begin to implement backlog reduction strategies, explore further questions about the existing backlog, examine funding issues for LUST cleanups, look at cleanup goals and milestones, and support the states and tribes in improving LUST program management. Our role as Sisyphus is more illusion than reality, and by retooling our approaches we can reach the top of the hill. Our work is important to the nation's health and safety, and we must find ways to improve our efforts. ■

Investigating Petroleum UST-Equipment Problems and Releases (ASTM E2733-10)

by Thomas Schruben

Since the 1980s, significant strides have been made in preventing releases. By all reports, the frequency of releases is down, and the size of releases is typically smaller than the bad old days of USTs. But releases still happen, even in systems that are in full compliance with current regulations. In fact, when viewed as a fraction of the active tank population, the rate of release discovery is now only about half the rate in the 90s (Figure 1).

One can argue that the current rate of releases is actually much lower than that indicated by this graph, because this statistic includes new discoveries of old releases and only a fraction of these discoveries are from new failures. While there is probably some truth in this argument, it brings me to the point of this article—we don't really know

enough to make definitive statements about the rates of releases or the sources and causes of releases.

Congress tucked a provision into the Energy Policy Act of 2005 that tasked USEPA with gathering data on the sources and causes of releases, but by all accounts, the data gathered so far does not provide the insight needed to focus prevention efforts on the weak links in UST systems in the ground today.

Carol Eighmey, Executive Director of the Petroleum Storage Tank

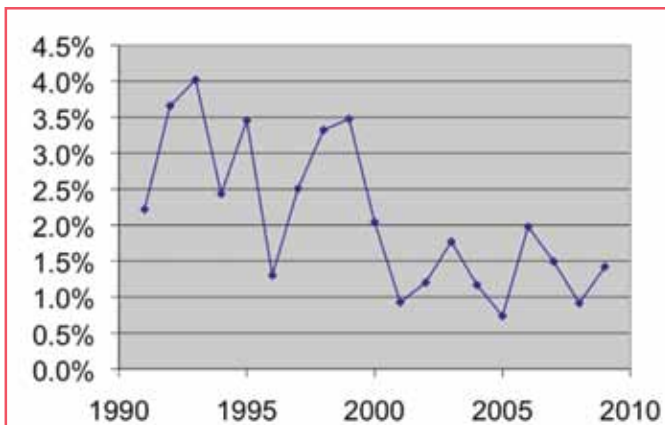


FIGURE 1. New-release reports nationally as a % of number of active tanks. Data from 1990 through 2010 EPA OUST Semiannual Report of UST Performance Measures.

Insurance Fund, compiled Annual "Source and Cause Reports" from 47 state UST programs. (For more information, contact Carol Eighmey at pstif@sprintmail.com.) Eighmey has concluded that the data pres-

■ *continued on page 28*

■ ASTM E2733-10 from page 27

ent “a largely meaningless picture in which the vast majority of releases are catalogued with ‘other’ or ‘unknown’ as the source or cause of the release, providing little insight into what equipment is failing or which regulations need strengthening or increased enforcement.”

And So, a Standard Guide

Gathering data that can be analyzed for sources and causes of failure requires investigation and uniformity—some kind of standardized data-gathering method. Creating this kind of standard sounded like a job for the American Society of Testing Materials (ASTM), so Dennis Rounds, Director of Risk Management for South Dakota and Past Chair of the E50.04 Subcommittee on Environmental Corrective Action, asked me and the ASTM E50.04 Subcommittee to develop what has now been published as the ASTM E2733-10 *Standard Guide for Investigation of Equipment Problems and Releases for Petroleum Underground Storage Tank Systems*.

Several years ago Dennis conducted an UST autopsy study for South Dakota’s Petroleum Release Compensation Fund. The information from that study has been very useful to the UST community in South Dakota. Dennis would like to make it easier for states to collect this type of information routinely during tank closures. He believes that states would benefit from greater detail and uniformity in sources and causes of release data. Both Dennis and I believe that this data can be collected by inspectors, tank removal contractors, and tank maintenance contractors with little additional expense.

E2733 is intended to assist in the development of protocols for the investigation of a malfunction or failure of storage tank systems and the implementation of said protocols. The guide outlines steps that may be necessary, including but not limited to: initial evaluation of the UST system to determine the malfunction(s); preparation of samples of failed equipment for laboratory analysis; and documentation of the investigation.

The guide provides a series of investigation options the user may employ to design failure investiga-

tion protocols. It describes common investigation techniques in the order in which they might be employed in an investigation. In other words, it puts some meat on the bones of collecting data on the sources and causes of releases.

A user may elect to utilize this guide for a number of reasons, including but not limited to:

- Differentiating new releases from new discovery of old releases
- Establishing malfunction and failure rates of various storage tank equipment components
- Determining expected life spans of various storage tank equipment components
- Identifying opportunities for improving the performance and reliability of storage tank equipment
- Focusing inspection and maintenance efforts on portions of the tank system most prone to malfunction and failure
- Identifying components of the storage tank system that require more frequent maintenance
- Reducing remediation and equipment replacement costs
- Preventing petroleum releases
- Identifying conditions that may cause or contribute to the deterioration or cause the malfunction and failure of various components of the UST system
- Complying with environmental regulations that require the investigation of release-detection alarms and the source of releases.

The guide may be used to establish a framework that pulls together the common approaches to UST system investigation and allows users to establish an investigation protocol to meet their specific requirements. Specific user requirements will vary depending on the purposes of the data collection and the decisions that the investigation is intended to support.

While the guide focuses on identifying and documenting UST system equipment problems and preserving problem equipment and does not provide guidance on establishing root causes of equipment malfunction or failure, it does provide the first, necessary steps in a root-causes investigation. Identifying the root causes

of equipment malfunction or failure may require further expert analysis of the data and equipment collected during the failure investigation.

The guide includes information on methods of investigation, documentation, taking samples of problem equipment, preserving equipment samples, chain of custody, storage, shipping, working with equipment manufacturers, and notifying regulators and listing laboratories. It provides techniques for documenting problems while the tank system is operating, while it is being removed, and after the equipment has been removed.

Working with equipment manufacturers is particularly important because they need to know about problems in the field if they are to improve their equipment and provide effective instructions to the installers, maintenance contractors, and owners of tank systems. Similarly, notifying listing laboratories like UL provides valuable real-life information they can use to improve the testing and listing procedures for the equipment they list.

Implementation Pilot Project?

As wonderful and useful you may think this guide is, publishing a guide is only the first step to a better world. As is oft-repeated in the pages of *LUSTLine*, implementation is the key. To that end, Dennis Rounds and I would be happy to work with states where there is interest in doing a pilot project on incorporating this guide, first, into their inspector training program and eventually into their installer or tank-removal training programs. We feel that a pilot project would help refine the guide and bring in the knowledge needed to start compiling useful statistics. If you are interested contact Dennis Rounds (dennis.rounds@state.sd.us) or me. If you would like a copy of the standard, it can be purchased at ASTM.org or contact Dan Smith (dsmith@astm.org) for more information on obtaining this standard for regulators. ■

Tom Schruben is an independent environmental risk-management consultant and UST-equipment failure investigator. He can be reached at environmentalguy@aol.com.

Class C Operator Saves the Day When Dogs Drive Van into Dispenser

by Ben Thomas

As a trainer you want to think all your hard work pays off and that the folks you train are actually putting into practice what they've learned. And sometimes you get a small reward as a reminder that what you are doing matters. This story is about such a reminder.

When we used to do more classes live and in person, I would sometimes get an operator who had to take an emergency call on his or her cell phone and step out of the room to respond to an alarm or spill. And because the operator was in a classroom and off-site—usually in some city halfway across the state—response was limited to delegating action to an on-site coworker.

With Web training, people can be attending from anywhere. When we do Class A/B webinars, people often take the class in an office and sometimes even in the back room of a C-store.

In December 2009, I received an email at lunch break during an online Class A/B Operator class I was conducting:

"Sorry I had to scramble out of class today. A customer parked his van while he was having lunch in my deli, his 'dogs' jumped on the steering wheel/dash board and put it into gear! [The engine was on.] Rolled into the pump, smashed it. Fuel started flowing. THANK GOODNESS for my responsible certified 'C' Operators!!!! They did everything right. One person shut off the emerg. switch and breakers while the other one contained the flow of the spill with the socks, pads, etc. and the 3rd one called me! WHEW! Fire dept. wasn't necessary.

I will be in class tomorrow while all the 'certified' workers are trying to get my business running again."

When I emailed back for details, the operator told me they had certified their Class C operators two months ago, and all the store employees had attended a safety



Damaged dispenser.

meeting a couple of weeks prior. When I asked what happened at the dispenser she replied:

"The shear valve did not shear. The impact of the van crashing into the dispenser broke the connection between the filter housing and the delivery piping, even breaking off the bolts! The electrical conduit got displaced and opened also. I did take several pictures. I will try and download and send them to you by class tomorrow."

The second day of class, the operator very generously allowed me to share the photos. The cool thing about the webinar as a learning platform is that we were able to look at the pictures, discuss what happened, sleuth out the causes, and have an interactive study case—all in nearly real time. The students really appreciated using the incident as a learning exercise to make the training material more relevant and meaningful.

Lessons Learned:

- ❑ Even with training, accidents can and do happen, sometimes where you least expect it.
- ❑ Training compliance can be measured by certificates or response actions. We like the latter.
- ❑ Training can result in a significant savings of time, money, and petroleum.
- ❑ Using real, live incidents as case studies can be a very informative learning tool.
- ❑ When you're at a C-store, don't leave the engine on when you go inside! ■



The shear that didn't shear.

Ben Thomas is an online trainer for class A, B, and C operators. A former UST regulator in Alaska, he has been training operators since 2004. He can be reached at ben@USTtraining.com.

Field Notes

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

PEI Revises RP100 UST Installation Document

The 2011 edition of the Petroleum Equipment Institute's (PEI's) *Recommended Practices for Installation of Underground Liquid Storage Systems* (PEI/RP100) is now available. This eighth edition of RP100 supersedes the previous recommended practices of the same name that were published in 2005. PEI revises RP100, when warranted, to ensure that users of its documents receive the latest guidance on the proper methods and techniques for installing underground storage tank (UST) systems.

PEI's Tank Installation Committee, which includes installers and federal and state UST regulators, reviewed over 70 suggestions submitted by various individuals and groups to revise the previous edition of PEI/RP100. The committee accepted more than 50 percent of these comments in some manner. I won't go through all of the changes here for several reasons. First, we don't have enough space in *LUSTLine* to list them all. And second, I'm afraid it would put all but the most avid tank installer/regulator to sleep. Having said that, however, several of the changes are worth noting and will provide you with a sense of the kinds of issues the committee addressed and how they dealt with them.

- Recognizing that ballasting underground tanks with water may promote problems with microbial contamination that may lead to subsequent fuel-quality issues, the document now recommends that the installation of submersible pump motors be postponed until after the water ballast has been completely removed (Section 5.3).
- The committee confirmed that the UST has to be tight for flapper valves to be used as overfill prevention by requiring that all risers above the flow shut-off device be properly sealed to prevent product from being discharged when the overfill shut-off device closes (Section 7.3.2).
- The warning that prohibited vent-restriction devices on emergency-generator or heating-oil supply tanks has been removed (Section 7.3.3) because it was considered to be redundant with another warning in the same section.
- Language reflecting the secondary containment provisions of The Energy Act of 2005 was incorporated in the secondary-containment chapter (Section 8).
- A new section for transition sumps was added. New Section 8.6 now states: "Transition sumps may be required for reasons of extending existing piping systems, extending from underground piping to aboveground apparatus, or creating branches in

piping. Transition sumps have similar requirements as other sumps, but, additionally, should always be continuously monitored and installed in conjunction with a raised concrete apron not less than 24 inches all around the grade opening for durability reasons."

- A new warning was added to the groundwater monitoring section, admonishing installers never to use fill caps or similar-appearing covers for observation-well service (Section 9.2.2).
- The committee noted that many truck stops and other large facilities have been installed with line leak detection that does not function properly. A new warning has been added to the automatic line leak detection section, explaining that mechanical line leak detectors may be insufficient to detect leaks quickly in high-throughput systems or systems with submersible pumps operating in tandem. The warning goes on to suggest that additional means of leak detection may be required (Section 9.3.1).
- If a piping manufacturer permits a shallower piping installation depth than recommended in RP/100, the document will now allow those shallower depths, provided the installation is thoroughly compliant with the manufacturer's specifications for configuration and quality (Section 10.4).
- RP/100 has long maintained, as a general rule, that product piping maintain a minimum slope of 1/8 inch per foot toward the tank, a dispenser sump, or a collection sump. The committee elaborated on that statement by adding the following language to the third paragraph of Section 10.4: "In pressure systems, slope may not be necessary on supply lines. Rather, communication between the interstitial space of secondarily contained pressure supply lines and collection sumps should be maintained so that released product can enter a sump and be visually observed or detected by sensors. For safe suction-piping configurations, the entire piping run must slope down to the tank, allowing product to drain safely if air should enter."

The committee also made changes in the sections of the recommended practices dealing with piping trenches (tracer tape), threaded joints, flexible connectors, fuel compatibility, and vent piping. New sections on shear valves and manhole identification were added. All the drawings were updated.

The 2011 PEI/RP100 is copyrighted and may not be photocopied or otherwise reproduced. Order copies online at www.pei.org/rp100. ■

FAQs from the NWGLDE

...All you ever wanted to know about leak detection, but were afraid to ask.

Unsupported Leak Detection Methods

In this LUSTLine FAQs from the National Work Group on Leak Detection Evaluations (NWGLDE), we discuss leak detection methods that are no longer supported by the company that markets them. Note: The views expressed in this column represent those of the work group and not necessarily those of any implementing agency.

Q. According to the NWGLDE website, [a certain company] is out of business. Given this circumstance, is this method still approved by the NWGLDE?

A. Before answering this question, we need to make it clear that the NWGLDE list is not a list of "approved" leak detection methods. Please review the disclaimer on our website at <http://www.nwglde.org/disclaimer.html>. The NWGLDE list is a compilation of methods that meet the criteria for being listed on our list; namely, a successfully completed third-party evaluation that is properly performed in accordance with a protocol that has been found to be acceptable to the NWGLDE.

Now, the answer to the question: Once a leak detection method has met the criteria for being listed, it remains on the list, even if the company is out of business or the company no longer provides support for the method. We do this because those who have purchased the leak detection method may still be using that method. To remove such a method from the NWGLDE list could create problems in states where the method is still in use, and only leak detection methods that are listed by the NWGLDE are allowed.

If a state has concerns about tank owners using listed leak detection methods that may no longer have support from the manufacturer, we suggest that the state develop a policy or regulation that would preclude tank owners from using such methods. (Please note: the NWGLDE does not get involved with the development of implementing agency policy or regulation.)

The NWGLDE depends on the company that markets a leak detection method to notify us of any changes. As we are made aware of corporate changes (e.g., companies being acquired by other companies, ceasing operation), this information is added to the NWGLDE list. However, this information will not always be on the listings, because we don't always receive this information. Even if we do receive the information, we may not be able to verify its accuracy.

Please be aware that even though a NWGLDE leak detection method listing indicates that a company is out of business, or that the equipment is no longer supported by the manufacturer, the method still has the potential to perform well without further support. Theoretically these unsupported methods could function indefinitely. However, as technology advances, some of these methods may encounter compatibility issues (new computer operating systems that will not run certain software, unavailability of replacement parts). In these scenarios, even though a leak detection method is still listed by the NWGLDE, the method will become obsolete, and another leak detection method will need to be used. ■

About the NWGLDE

The NWGLDE is an independent work group comprising ten members, including nine state and one USEPA member. This column provides answers to frequently asked questions (FAQs) the NWGLDE receives from regulators and people in the industry on leak detection. If you have questions for the group, please contact them at questions@nwglde.org.



L.U.S.T.LINE Subscription Form

Name _____

Company/Agency _____

Mailing Address _____

E-mail Address _____

☐ One-year subscription: \$18.00

☐ Federal, state, or local government: Exempt from fee. (For home delivery, include request on agency letterhead.)

Please enclose a check or money order (drawn on a U.S. bank) made payable to NEIWPCC.

Send to: **New England Interstate Water Pollution Control Commission** 116 John Street, Lowell, MA 01852-1124

Phone: (978) 323-7929 ■ Fax: (978) 323-7919 ■ lustline@neiwpcc.org ■ www.neiwpcc.org

L.U.S.T.LINE

New England Interstate Water
Pollution Control Commission
116 John Street
Lowell, MA 01852-1124

Non-Profit Org.
U.S. Postage
PAID
Wilmington, MA
Permit No.
200

Ellis and Frye Receive LUST Poster Session Lifetime Achievement Awards at the National Tanks Conference

The LUST Poster Session Lifetime Achievement Award was presented this year to Pat Ellis of Delaware, DNREC, and Ellen Frye, Editor of *LUSTLine*. Pat was recognized for her many years of dedication, leadership, and significant contributions to the science of site assessment, risk evaluation, and cleanup for LUST sites. Ellen was recognized for her dedication and tireless efforts to ensure that the latest information on operating and cleaning up underground storage tank sites is disseminated and documented in *LUSTLine*, the “bible” of the UST/LUST program. The award was presented from their friends and colleagues with many thanks for years of dedication and significant contributions. Previous award recipients include John Wilson, USEPA Kerr Lab, Bruce Bauman, American Petroleum Institute, and Robin Davis, Utah DEQ. ■



Pat Ellis and Ellen Frye receive the 2010 LUST Poster Session Lifetime Achievement Award. From left to right: Pat Ellis, DE, DNREC, John Wilson, USEPA ORD, 2007 award recipient, Ellen Frye, LUSTLine Editor, Robin Davis, Utah DEQ, 2009 award recipient, and Bruce Bauman, API, 2008 award recipient.