THINK TANK

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ASTM to Tackle Risk-Based Approach for Evaluating Non-Aqueous Phase Liquids

by Tripp Fischer and G.D. Beckett

In the summer 2002 edition of the National Ground Water Association's *Ground Water Monitoring & Remediation Journal*, there was an editorial written by Don A. Lundy, PG entitled "There Are Better Ways to Regulate Free Product". In it, the author argued that inconsistent interpretation of the USEPA's requirements of removing free product "to the greatest extent practicable" (U.S. EPA 1988) has lead to potentially responsible parties spending "disproportionate funds" on sites where free product recovery can not meet cleanup criteria with conventional remedial technologies.

The article also pointed out that whereas allowable concentrations of chemicals of concern in soil, ground water and air are risk-based, free product recovery is based solely on thickness in a well; concluding that a better way to regulate free product would be a risk-based approach as well. Finally, Mr. Lundy suggested that in order for states to adopt risk-based NAPL programs, the backing of organizations such as the USEPA, American Petroleum Institute (API), and the American Society of Testing and Materials (ASTM) was necessary.

As a result, in the fall of 2002, the Corrective Action subcommittee (E50.04) of ASTM's Environmental Assessment committee (E50) conducted a brainstorming session in an attempt to address a Risk-Based approach for evaluating NAPL. One year later in Tampa, Florida, the first "official" meeting of the "NAPL Task Group" took place.

The proposed goal of the standard is to help guide users through the technical rigor of NAPL risk-based decision-making by enabling the user to make sound decisions based on answers to applicable questions. The standard will not necessarily be a training document for multiphase science, but rather focus on the aspects of NAPL mechanics and chemistry that affect risk-based and practicability decisions. The end result will be a simple-to-use guidance document to assist all parties in their day-to-day decisions around environmental NAPL management irrespective of the location or jurisdiction of those sites. Some of the complexities of NAPL mechanics and chemistry may be highlighted in appendices to the guidance as determined by the participants in the task group.

A key distinction for this task group is that the focus will be primarily on building NAPL site conceptual models and on using that understanding to develop consistent metrics than can be applied to remediation attempts that have non-risk-based goals. The conceptual models will contain stages of technical evaluation and decision making for sites where NAPL is present. Aspects of these stages include: a) NAPL identification and delineation; b) addressing immediate threats; c) formulation of a representative or conservative site conceptual model on which estimates plume state, risk, and other evaluations may be based; d) determination of the risk-status of present and future site conditions; e) and in the absence of

Continued on p. 5 – ASTM

Free Phase Petroleum and Risk Assessment

by Emil Onuschak, Jr., PG

When federal underground storage tank regulations were first promulgated in 1988, it was recognized that free phase petroleum ("free product") has to be removed from the ground at a release site because its mobility presents a potential adverse risk to surrounding soil, ground water and air: "Use abatement of free product *migration* [added emphasis] as a minimum objective for the design of the free product removal system;..." (40 CFR 280.64).

This federal requirement is reflected in Delaware's regulations that state "...the responsible party must remove the free product to the maximum extent practicable..." (Department of Natural Resources and Environmental Control, 1994).

Implicit in these regulations is the separate consideration of the *presence* of free product versus the *migration* of free product.

Risk Assessment

The more-recently-developed risk-based corrective action (RBCA) procedure maintains this two-fold view and does not address free phase liquid petroleum except to say that it should be recovered "...until product recovery ceases." Then, "after some period of operation, when hydrocarbon removal rates decline, a soil and ground water assessment plan will be instituted..." (ASTM, 1995, p. 47).

Delaware's adaptation of RBCA, the Delaware Risk-Based Corrective Action Program, or DERBCAP, uses the same approach by declaring, as a policy decision, that "All free-phase product must be removed to the maximum extent technologically feasible" (Delaware Department of Natural Resources and Environmental Control, 2000, p. 74).

Neither RBCA nor DERBCAP attempt to quantify how much decline in the removal rate is enough to qualify as the "maximum extent technologically feasible."

Mobility of Free Phase Petroleum

Free product, by its mere *presence,* can serve as a "secondary source" of contamination apart from a leaking aboveground or underground storage tank (the primary source) and adversely impact adjoining soils, ground water and air by processes of adsorption (to soils), dissolution (into ground water) and volatilization (to the air). But depending on the characteristics of the released product and the contacted soil (including depth to ground water), these processes are comparatively slow.

In contrast, movement of mobile free product on the surface or in permeable soils is fast and can quickly affect an ever-larger area until the product's mobility is controlled.

Somewhere between the first drop of released petroleum that contacts the soil and is held immobile and the release of an indeterminate larger volume is the point where immobility changes to mobility and the attendant potential risks of the release and the costs of remediation escalate dramatically.

Remediation of Free Phase Petroleum

When remediating a free phase petroleum site, the challenge is to consider the release process in reverse: How much free product must be removed to change mobile free phase petroleum to *immobile* residual petroleum—still free phase—whose associated potential risks are dramatically less?

When does this point occur? That is, how can the *residual saturation* value for a given free product/soil combination be recognized?

The answer to how much free phase petroleum can be left behind at a release site is a site-specific exercise in multiphase fluid mechanics that is largely influenced by the characteristics of the soil into which the petroleum is released and the specific product that is released (US EPA 1997). Much research, both theoretical and experimental, has been devoted to a rigorous consideration of the topic (e.g., Higinbotham, Parcher and Johnson, 2003; Adamski and Kremesec, 2003; Adamski, Kremesec and Charbeneau, 2003; Brubaker, Meyers and Fantone, 2003; Huntley and Beckett, 2002; Fetter, 1993). Recently, attention has focused on "rules of thumb" that can be applied on-site in the field (Sale, 2001; Sale, 2003). The advantage of this latter approach is that it provides site-specific data without the time and cost required to apply more rigorous methods. The purpose of this paper is to provide practical guidance that has been or can be applied to petroleum releases in Delaware.

Neither RBCA nor DERBCAP attempt to quantify how much decline in the removal rate is enough to qualify as the "maximum extent technologically feasible."

Historic Closure Criteria for Free Phase Petroleum in Delaware

Free phase petroleum in the subsurface is recognized by its ability to flow into wells or excavations (US EPA, 1997). It follows then that when free phase petroleum is no longer recognized in wells or excavations, its mobility is eliminated, or at least greatly diminished.

However, removal of free phase petroleum from the subsurface typically follows an exponential decline curve that strictly speaking never ends—a fact well-known to petroleum production engineers whose responsibility is to get as much as possible out of the ground.

But whereas a petroleum production engineer can apply a readily-defined economic criterion to call an "end" to the removal process—when the cost of production equals the value of the recovered petroleum—a scientist performing a risk assessment at a release site is obliged to define an end point when potential risks associated with the release are a *minimum*. This end point can be defined as when free phase petroleum loses its mobility.

Historically, leaking underground storage tank sites with free phase petroleum present in Delaware have been considered for closure when the mobility of the free product has been minimized, as indicated by:

- Free phase petroleum is reduced to "an irreducible sheen" for a minimum of four consecutive calendar quarters.

  This is the "tail-end" of the exponential decline curve. The sheen does not have a measurable thickness. Remediation with appropriate technology may be continued at selected sites because the sheen may escape to the surface of the land or a water body and cause a visible, aesthetic impact.

- Free phase petroleum shows a trend of decreasing thickness measured in monitoring wells (starting from a small but undefined initial thickness).
  Trends can be shown by simple line graphs, sometimes with set limits on the amount of point-to-point fluctuation that is allowed.

  Trends can also be shown by tabulating the percentage of data points that show decreases in thickness from the preceding values versus those that show increases; the points showing decreases must attain a specified majority of the total number of data points.

- A specified small maximum volume of free phase petroleum is recovered each quarter for one year from each monitoring well on-site.

  For example, an instrumental measuring limit of 0.05 ft in a four-inch diameter monitoring well represents a volume in the monitoring well of 0.26 pints.

- Scattered "hot spots"—individual monitoring wells with small volumes of free phase petroleum that does not migrate to other wells—may be defined as a ground-water management zone, with a prohibition against new wells drawing from the impacted aquifer inside the zone.

  The perimeter of the zone is defined by monitoring wells where periodic sampling shows that no free phase petroleum is migrating beyond the perimeter.

- Another criterion, not known to have been used in Delaware, specifies a maximum recovery *rate* of < 2 gallons per month at a site (US EPA 1997).

- Decline curve analysis (Sale, 2001), also not known to have been used in Delaware, plots recovery rate in gallons per day against the cumulative production of free product in gallons. If total liquid production is constant, or nearly so, the later plotted points will tend to fall along a straight line that can be extrapolated to predict the maximum free product recoverable.

The justifying assumptions in these instances are (a) the volume of free phase petroleum has been reduced to a small volume of immobile, discontinuous ("pendular") droplets of petroleum in the intergranular pore spaces of soils or (b) the volume of free phase petroleum is changing toward immobile status by volatilization, dissolution or adsorption onto additional soil grains.

A Case History

A 500,000-gallon release of diesel fuel in Coastal Plain sands in Delaware has been recovering free product for about four years. Applying the preceding criteria yields the following results:

Irreducible sheen. Field observations indicate this condition will not be attained in the main area of the release in a reasonable time. Isolated peripheral wells do show a reduction of free product thickness to a sheen.

Decreasing thickness. Free product thickness is not measured in several main recovery wells. Some isolated peripheral wells attained a thickness of “sheen.”

Small maximum volume. A free product thickness of 0.05 foot (an instrumental limit) equals a theoretical maximum volume of 16,291 gallons per acre upon “completion” of recovery when free product mobility is minimized (the actual value will be less depending upon soil porosity). Assigning a prorata share of the original release volume to each of four recovery wells yields a starting volume of 125,000 gallons per well. After four years of pumping, the free product remaining is about 33,844 gallons per well, a 73 percent reduction. The slope of a graph showing recovery flattens with time and makes it necessary to assess potential risks of low-level residual drainage, including aesthetic impacts, to site-specific potential receptors. High percentage recoveries are possible.

“Hot spot” reduction. A ground-water management zone is not being considered for this site at this time.

Maximum recovery rate < 2 gallons per month. After four years of recovering free product, this site still recovers about 250 gallons per month.

Decline curve analysis. The following figure that shows daily production in gallons per day plotted against cumulative production in gallons suggests the maximum recoverable volume of free product for this site is 340,000–360,000 gallons. Total recovery to date is 360,000+ gallons, which indicates the remainder is close to immobile residual status.

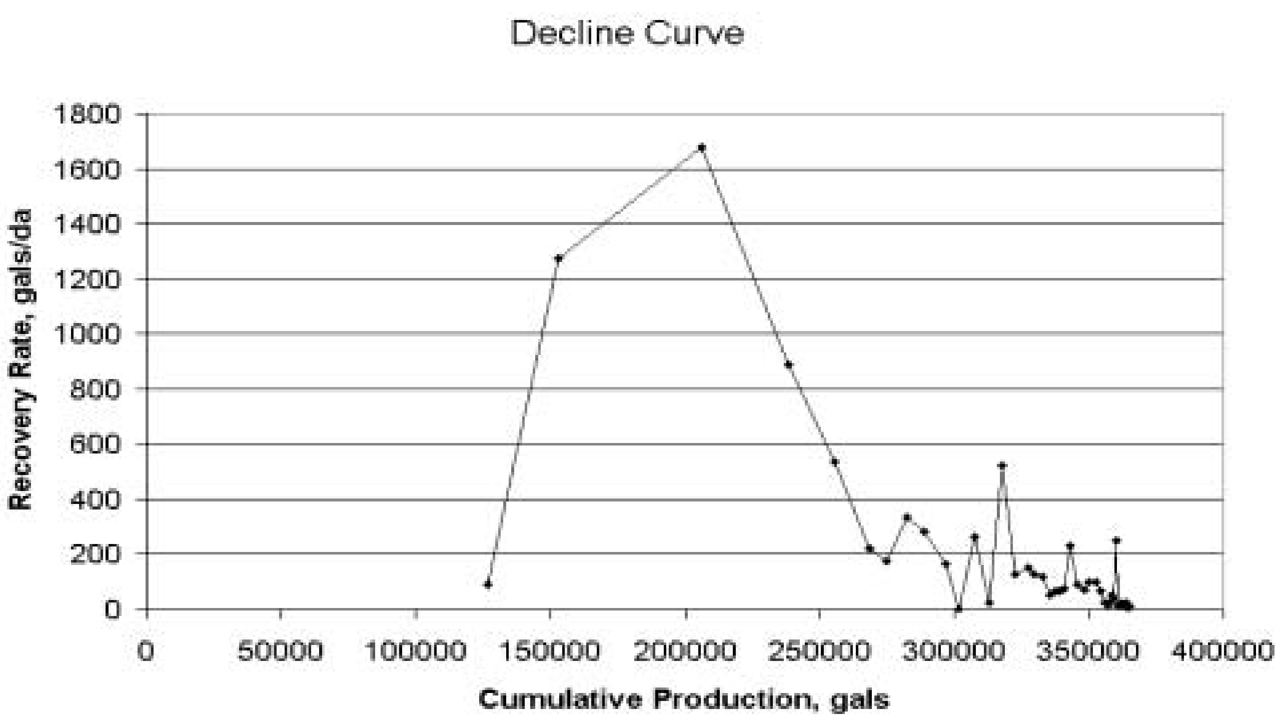
Conclusions

1. A small volume of *immobile* free product can be present at a petroleum release site without presenting unacceptable environmental risks.
2. When residual free product can be shown to be immobile—or nearly so—it can be incorporated into a standard site risk assessment as a secondary source. This is the same approach that would be used at a site where a tank contains a small volume of free product and is abandoned rather than removed because the tank is not physically accessible.
3. The immobility of free product can be shown by site-specific pragmatic means:

a. The “reduction-to-sheen” criterion is best applied at the periphery of free product plumes or to free product plumes that are thin (< 1 ft).

b. “Trends of decreasing thickness” are considered demonstrated if quarterly measurements over a maximum two-year period show a distinct downward trend and point-to-point measurements show no more than a +100 percent fluctuation. Tabulated point-to-point values must show *decreases* for at least 60 percent of the points.

c. The “*small maximum volume*” that may be allowed to remain is a function of site-specific geol-



ogy, petroleum product hydrology and the nature of any potential receptors.

d. "*Hot spot reduction*" can be implemented best by excavation at petroleum release sites where the free product is shallow (< 10 feet) and its areal extent limited. Deeper or more extensive "hot spots" are best addressed by ground-water management zones.

e. "*Recovery rate*" and "*decline curve analysis*" have not been used in Delaware, so no judgement of their usefulness can be made.

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risk, methods of describing specific attributes of non-risk-based remediation to assist in defining a site specific assessment of the practicability of NAPL cleanup.

The intent of the standard is to fold seamlessly into those other standards and guidance documents that currently exist. The basis for the standard is that irrespective of the local, regional, or national policies, a sound site conceptual model is needed in order to make sound, cost effective, and environmentally valuable decisions.

AST Update

by Jill Hall

The draft *Regulations Governing Aboveground Storage Tanks* are now complete. The Aboveground Storage Tank Technical Advisory Committee (ASTTAC) voted unanimously to release the draft *Regulations Governing Aboveground Storage Tanks* at a meeting on February 11, 2004. The Department is required to promulgate the Regulations pursuant to Title 7 Del. C., Chapter 74A, *The Jeffrey Davis Aboveground Storage Tank Act*.

The first step in regulation preparation was the formation of a technical advisory group, the Aboveground Storage Tank Technical Advisory Committee (ASTTAC), to assist the Department. The ASTTAC includes aboveground storage tank experts in the fields of leak detection, corrosion protection, secondary containment, tank installation, and engineering, as well as representatives of civic and environmental protection organizations, other state agencies, and tank owners and operators. The first meeting of the ASTTAC took place in August 2002, with subsequent bimonthly meetings. The ASTTAC created three subcommittees to develop the Regulations. The subcommittee membership included experts in the specific disciplines related to the subcommittee topic. Created were the Installation/Modification Subcommittee, the Financial Responsibility/Corrective Action Subcommittee and the Inspection/Monitoring Subcommittee.

The *Regulations Governing Aboveground Storage Tanks* are intended to address existing and potential sources of pollution that may result from ASTs. To ensure the prevention and early detection of a release of a regulated substance should one occur, new ASTs are required to meet acceptable design and installation criteria, and existing ASTs are required to upgrade to comparable standards on a schedule. Regulated ASTs are required to conduct internal and external inspections on a prescribed schedule to ensure the integrity of the AST. AST design criteria promulgated under these Regulations will minimize the risk of regulated substances being released and impacting the environment. Release confirmation and remediation standards are set forth to require the clean-up of any release that does occur. Financial responsibility requirements ensure that AST owners show proof of the ability to pay should a clean-up be required.

The Regulations are divided into five sections. The first section, Part A, includes registration requirements including fees, a list of standards referenced in the Regulations, alternative procedures approval requirements, release preparedness plans, release indication and reporting requirements, and specifications for confidentiality claims.

Part B details the specific requirements governing the design and construction of new ASTs, including requirements for secondary containment, overfill and spill prevention, leak detection and inerting for ullage volumes of new ASTs containing flammable substances and without a floating roof. Requirements for the upgrade of existing aboveground storage tanks, requirements for out of service ASTs and requirements for removal, permanent closure in place and permanent change in contents are included in this Part.

Part C details requirements for the inspection, monitoring, testing and record keeping for all ASTs.

Part D details requirements for showing proof of financial responsibility by owners and operators of ASTs.

Part E details requirements for conducting site assessments and remediation of sites with contamination resulting from a release of a regulated substance from an AST.

The draft Regulations may be viewed at http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/ast/

Promulgation Schedule

Public Hearing
March 30, 2004 – 6:00 pm
DNREC, 391 Lukens Drive
New Castle, DE 19720

Comment Period (Ends April 6, 2004)
Written comments may be sent to:
Jill Hall – DNREC/TMB
391 Lukens Drive
New Castle, DE 19720

Final Regulations Published in the Delaware Register – June 1, 2004

Regulations become effective – June 11, 2004

Summary Table of AST Requirements		Registration	New Construction Fee	Annual Fee	Release Remediation	Enforcement	Subject to Technical Regulations	Subject to Best Management Practice
1	ASTs >250 gal. and <12,499 gal. containing a Regulated Substance and not otherwise exempt	X			X	X		
2	ASTs >12,499 gal. and <40,000 gal. containing a Regulated Substance other than Heating Fuel, Kerosene, and Diesel	X	$1500	$300	X	X	X	
3	ASTs >12,499 gal. and <40,000 gal. containing Heating Fuel, Diesel, and Kerosene	X			X	X		
4	ASTs >40,000 gal. containing any Regulated Substance	X	$3750	$750	X	X	X	
5	ASTs less than 1,100 gal. containing: Heating Fuel for consumptive use on the premises where stored; or Motor Fuel or Motor Oil used for non-commercial purposes.				X	X		
6	Agricultural/Farm AST less than 1,100 gal.				X	X		
7	Agricultural/Farm AST >12,499 gal. and <40,000 gal.	X	$1500	$300	X	X		X
8	ASTs installed on a temporary basis not to exceed six months (any size, any substance)				X	X		
9	ASTs regulated pursuant to Title 29 Del. C. Ch. 80 Section 8028 (Boiler Safety Program)				X	X		
10	ASTs and associated equipment regulated as part of a process regulated by Title 7 Del. C. Ch. 77 (Accidental Release Prevention Program)				X	X		
11	ASTs containing Propane				X	X		
	ASTs do NOT include: flow through process tanks, wastewater treatment works containment vessels, transformers, septic tanks, or pipelines							
	Regulated Substance: 1% CERCLA substance; 0.1% IRIS substance; Petroleum Product; Any other substance deemed by the Secretary to pose a risk to human health, safety, or the environment							

Notes from the Field – Vapor Shear Valve Installation

by Brian Churchill

Now that the well publicized May 1, 2003 deadline has come and gone, all gasoline dispensers with Stage II vapor recovery must have vapor shear valves installed. Like product shear valves, vapor shear valves are designed to reduce the chances of a flammable condition under gasoline dispensers and protect underground piping in the event of a severe impact involving a gasoline dispenser. While at this time vapor shear valves have been installed at virtually all facilities requiring them, a large number have been installed improperly. Vapor shear valves should be installed per manufacturer's specifications. Any deviation from these requirements may result in improper functioning of the shear valve in the event of an accident as well as costly repairs, loss of business from downtime during repairs and possibly enforcement action.

The TMB is increasing the inspection frequency of each facility and it is only a matter of time before improperly installed shear valves are found and owners are required to take corrective action. Most importantly, the base of the valve *must* be anchored to a structural member within the island (depending on the model, the top of the valve may be required to be secured to the dispenser) and secured in such a way that in the event of an accident, breakage at the shear groove is insured. If installed properly, vapor shear valves should stop vapors from being released while protecting the vapor line.

Owners should do their homework to ensure they understand manufacturer's installation instructions. This will allow an owner to determine if their selected contractor has installed the vapor shear valves properly or verify if a repair on an improperly installed vapor shear valve has been conducted per manufacturer's specifications. For more information or clarification on proper vapor shear valve installation, please contact the TMB at (302) 395-2500.

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Announcements

Rebecca Keyser – was hired in October 2003 as an Environmental Scientist for the UST program. Becky previously worked for an environmental consulting firm and graduated from the University of Delaware with a bachelor's degree in chemistry.

Rajesh Khanna – was hired in September 2003 as an Environmental Engineer for the AST program. Raj has a Masters of Environmental Engineering and was previously a consultant in New Jersey.

Deybra Chapman – was hired in December 2003 as an Administrative Specialist. Monkeys are her favorite animal. Her home is full of stuffed monkeys, monkey mugs, and other assorted monkey items.

Boiler Safety Program now part of TMB

Boiler Safety started out as the "Board of Boiler Rules" in 1919. In 1971, it then became the Division of Boiler Safety when it was moved into the Department of Public Safety. In July 2003 it was moved to DNREC and placed with the TMB. Boiler Safety has jurisdiction over boilers and pressure vessels located in "places of public assembly" with some restrictions due to size limitations. This includes churches, schools, nursing homes, apartment buildings of 7 or more units, processing plants, dry cleaners, and more.

Boiler Safety's mission is to promote public safety through inspection of boilers and pressure vessels, and to provide education on the operation, maintenance and repair of boilers and pressure vessels in the State of Delaware.

Boiler Safety also conducts "Shop Reviews" for manufacturers of boilers and pressure vessels.

Safety training is provided to all school districts in the state as well as to contractors and owners in each county once each year.

And we oversee 17 insurance companies that do boiler inspections within the state or perform shop inspections at manufacturing plants within the state.

TMB web site — http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/ust/

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