ENHANCING THE EPRI GENERIC WORK PLAN TO ASSESS DENSE NON-AQUEOUS PHASE LIQUID MOBILITY IN THE SUBSURFACE AT MANUFACTURED GAS PLANT SITES

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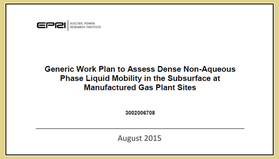
ABSTRACT

Research has shown that when dense non-aqueous phase liquid (DNAPL) is present in the subsurface at a manufactured gas plant (MGP) site, a principal issue related to site closure is an assessment of its mobility and potential for migration. In the absence of a quantitative approach for differentiating between mobile and immobile DNAPL, environmental regulators are prone to the conservative assumption that all DNAPL identified in the subsurface is mobile with the potential to migrate; thereby, precluding environmental closure of the Site until the subsurface DNAPL is removed or otherwise managed. Expanding on earlier Electric Power Research Institute (EPRI)-sponsored research, the DNAPL mobility assessment approach within the **Generic Work Plan to Assess DNAPL Mobility in the Subsurface at MGP Sites** (EPRI, 2015; see Figure 1) provides a standardized and reproducible characterization protocol using a combination of conventional and high resolution site characterization (HRSC) field-based and laboratory-based methods for conducting a site-specific subsurface DNAPL mobility assessment. To further enhance the EPRI protocol, the Precision Recoverability Evaluation for DNAPL via Transmissivity, PREDiCT™ (patent pending) is a new in situ process for areas of known pooled MGP DNAPL to best understand the lithological units that are the primary focus of concern and define if these fingers of mobile MGP DNAPL are recoverable based upon transmissivity. The use of PREDiCT™ aids in bettering understanding of areas of mobile DNAPL that may have the potential to migrate, and how to best address these zones within the subsurface; and further, as a leading, lagging, progress, and design remediation metric for MGP DNAPL removal technologies like hydraulic recovery. The results can also be utilized to determine if the transmissivity of the MGP DNAPL is nearing a quantifiable endpoint, and support risk-based site closure evaluations. The EPRI protocol uses methods that are acceptable to the regulatory community and provide responsible parties with the data necessary for informed, defensible evaluations of the potential for subsurface MGP DNAPL to migrate under anticipated site conditions. In addition to supporting site closure, the EPRI protocol may also be used to target areas of mobile DNAPL at a site for active remediation, where PREDiCT™ provides critical design information for hydraulic remedies, enhances conceptual site models (CSMs) with high resolution mobile non-aqueous phase liquid (NAPL) interval data, and aids in defining the endpoint metrics for remediation through quantified levels of transmissivity, a metric gaining nation-wide regulatory approval for ceasing hydraulic recovery remedies.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Generic Work Plan to Assess Dense Non-Aqueous Phase Liquid Mobility in the Subsurface at Manufactured Gas Plant Sites

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FIGURE 1: Generic Work Plan to Assess DNAPL Mobility in the Subsurface at MGP Sites, August 2015. Free download: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002006708

OVERVIEW OF EPRI GENERIC WORK PLAN TO ASSESS DNAPL MOBILITY IN THE SUBSURFACE AT MGP SITES

An overview of the current science of subsurface DNAPL mobility at MGP sites is provided, and the technical protocol describes it in the context of a DNAPL management framework for achieving site closure. Expanding on earlier EPRI-sponsored research, the DNAPL mobility assessment approach is a combination of conventional and HRSC fieldbased and laboratory-based measurements for conducting a site-specific subsurface DNAPL mobility assessment.

FIGURE 2: Example soil core collected via split-spoon sampler. Note the layering of silty clay, and the DNAPL-impacted medium sand lenses.

DNAPL MOBILITY FIELD ASSESSMENT

- TarGOST®, soil borings, and other field screening methods for delineating the areal and vertical extent of DNAPL in the subsurface (Figures 2 and 5)
- Collection of discrete DNAPL-impacted soil samples for API / ASTM laboratory DNAPL mobility testing
- Analysis of DNAPL field recovery data to assess whether DNAPL is at, or approaching, the residual saturation point
- Collection of additional site geology and hydrogeology information to assess the presence of migration pathways for the potentially mobile DNAPL
- Addition of PREDiCT™ to confirm and quantify the transmissivity prior to DNAPL recovery and to confirm when hydraulic recovery has achieved a saturation-based risk objective.
- Addition of PREDiCT™ to identify high resolution mobile NAPL intervals

DNAPL MOBILITY LABORATORY ASSESSMENT

Offsite laboratory analysis of soil cores includes core photography to select the depth intervals, centrifugation/water drive (ASTM D425 Modified), and pore fluid saturation via Dean Stark (API RP 40), and others (Figures 3 and 4)

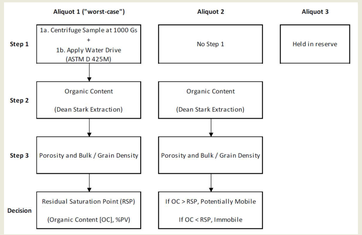

FIGURE 3: Laboratory protocol to determine presence of potentially mobile DNAPL in a DNAPL-impacted MGP site soil using API and ASTM methods.

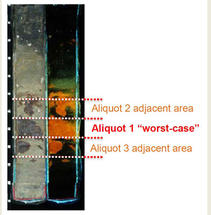

FIGURE 4: Use of white light (left) and ultraviolet light (right) profiles for identification of field samples for laboratory determination of potential DNAPL mobility

DNAPL MOBILITY: REMEDIAL DESIGN CRITICAL INPUT

Reliable delineation of mobile DNAPL in the subsurface is an important objective for site characterization informing the remedial design. Targeting active remediation in areas of the site with mobile DNAPL (i.e., above residual saturations) will increase the likelihood of remedy success and promote more cost-effective remedial design. Thus the protocols outlined serve a dual purpose of both supporting site closure and site characterization for cost-effective remedial design, which the PREDiCT™ process further enhances.

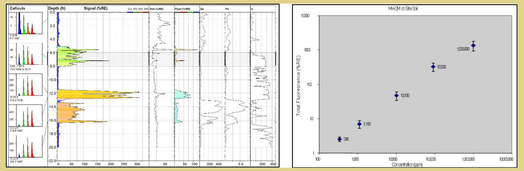

FIGURE 5: Correlation of TarGOST® profiles with DNAPL concentrations in soil from soil samples analyzed for PAHs, and DNAPL saturations for soil samples analyzed for saturation (EPRI, 2006; API RP40).

OVERVIEW OF THE PREDICT™ PROCESS

Transmissivity is an established universal metric for the recoverability of groundwater from aquifers, essentially measuring the rate at which groundwater can flow through a one-foot wide strip of an aquifer under a unit gradient in a unit amount of time. However, transmissivity is not limited to groundwater. It can be used to measure the flow potential for any liquid in the subsurface that exhibits Darcian flow. As documented in ASTM E2856, transmissivity may be measured for LNAPL via multiple methods, and accounts for the different density and viscosity of the LNAPL, as well as the relative permeability resulting from two liquids (groundwater and LNAPL) competing to flow through an aquifer. Transmissivity may also be calculated for MGP DNAPL using a modification of the methods identified in ASTM E2856.

One of the common methods to measure transmissivity for groundwater and NAPLs is the baildown test. For MGP DNAPL within unconsolidated formations, the identification of mobile NAPL intervals (MNI) are identified as the extracted NAPL recovers back into the well. The PREDiCT™ method identifies these through a patent-pending method but simply uses the drawdown versus discharge (DvD) responses following NAPL evacuation to identify multiple MNIs perched on finer grained soil or fractured bedrock intervals.

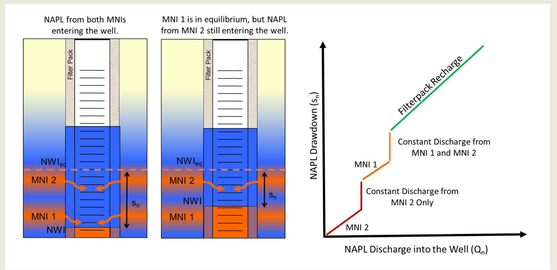

FIGURE 6. Discharge versus drawdown interpretation of baildown testing using the PREDiCT™ process.

The well acts as a sump and MGP DNAPL enters the well from all MNIs causing an exaggeration of the NAPL thickness relative to where the NAPL is actually present within the formation; thus, exaggerating the height of MGP DNAPL in the well versus the impacted portion of the formation (Figure 6). If the well is evacuated of NAPL, then the well will fill from all MNIs initially and as each MNI is reached then the transmissivity of that given MNI can be calculated from the resulting measures (modified ASTM E2856 method). An idealized DvD is shown on Figure 6 with respect to the MGP DNAPL recovering into the well. For highly transmissive MGP DNAPL the testing may take hours; whereas, testing for sites with NAPL reaching the threshold of recoverability may take weeks to months to have the MGP DNAPL thickness within the well return to pre-testing equilibrium conditions.

PREDICT™ ENHANCEMENTS TO EPRI DNAPL MOBILITY ASSESSMENT PROTOCOL

Generic subsurface DNAPL management framework consists of three primary field characterization units as follows (Figure 7):

1. DNAPL delineation (Red Box)
2. DNAPL mobility assessment (Blue Box)
3. DNAPL migration assessment (Green Box)

PREDiCT™ enhancements are noted with the numbered stars.

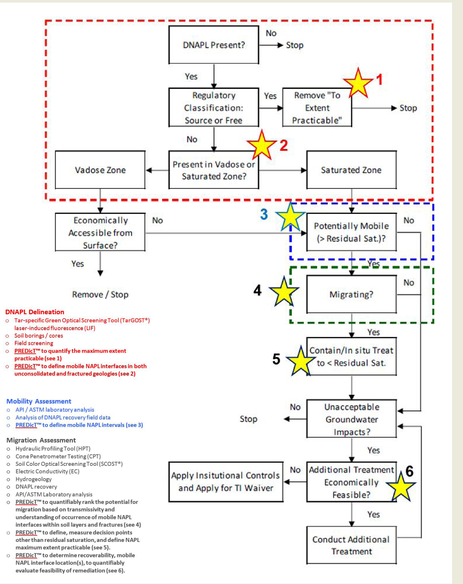

FIGURE 7: PREDiCT™ Enhancements to EPRI DNAPL Mobility Assessment Protocol, which aid in DNAPL delineation, mobility and migration assessment at MGP sites.

CLOSING

The methods outlined in the protocol can be used to quantitatively differentiate between mobile and immobile DNAPL at MGP sites, and to better understand areas of mobile DNAPL that may have the potential to migrate. PREDiCT™ provides a quantified method to define the mobile NAPL intervals, and to quantify the transmissivity of those intervals individually and in the aggregate. The EPRI protocol with PREDiCT™ uses methods that are acceptable to the regulatory community and provide responsible parties with the data necessary for informed, defensible evaluations of the potential for subsurface DNAPL to migrate under anticipated site conditions. In addition to supporting site closure, the EPRI protocol may also be used to target areas of mobile DNAPL at a site for active remediation and the use of PREDiCT™ will aid in both identifying if these mobile NAPL intervals require recovery and when hydraulic recovery can be ceased based upon transmissivity, a metric gaining national acceptance as a closure metric.