



**ITRC PROJECT PROPOSAL:**  
**Methods to Evaluate LNAPL Recoverability**  
**For Optimization of Recovery System Design**  
**and Operation in Tidal-Coastal Environments**

**PROPOSAL DATE: March 9, 2009**  
**Proposal Contact:**

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**Call for Proposals Topical Area**

- Site characterization and remediation (CHAR/REM)  
*Technologies and approaches for site characterization and remediation of soil and groundwater; preference given to proposals involving advanced diagnostics for site characterization.*

**Problem Statement (why is this project necessary and relevant to ITRC's purpose & mission<sup>1</sup>?)**

ITRC's purpose and mission is to:

- Provide guidance and training to the environmental community, and
- Promote the implementation of promising new technologies within state environmental regulatory programs.

ITRC is currently developing technical guidance and webinar training related to characterizing sites with light non-aqueous phase liquids (LNAPL) floating on the water table. ITRC helps practitioners and regulators understand the benefits of developing an LNAPL Conceptual Site Model (LCSM), to better

<sup>1</sup> **ITRC Purpose:** To advance innovative environmental decision making  
**ITRC Mission:** Develop information resources and help break down barriers to the acceptance and use of technically sound innovative solutions to environmental challenges through an active network of diverse professionals.

evaluate practical LNAPL recovery endpoints and risk-based remedial options at these sites. However, these may not adequately cover the issue of LNAPL mobility and design/cyclic operation of LNAPL recovery systems in tidal-coastal environments.

Unique LNAPL and groundwater recovery system operational issues arise in a tidal environment. For example, perhaps the recovery system should only be run when the tide is receding (or the water table is falling), as that is when LNAPL mobility and migration into the surface water would be peaking.

Operating the system 24/7 allows the recovery of more LNAPL and groundwater, but may be less cost effective. A cyclic operation may appear optimal but will require costly controls and greater oversight.

We propose to develop tools and analytical methods for evaluating LNAPL recoverability at sites where cyclic water table fluctuations control LNAPL mobility and recoverability – specifically, sites in tidal-coastal settings. In these settings, tidal fluctuations in the surface water propagate as a wave along the water table creating fluctuating water levels in wells. This causes cyclic smearing and un-smearing the LNAPL body and fluctuations with in-well LNAPL thickness. Because LNAPL mobility and recoverability can be related to LNAPL thickness in wells, tidal fluctuations indirectly control cyclic rates of LNAPL recovery. Understanding these processes at a study site can help identify methods for optimizing the design and operation of LNAPL recovery systems in this environment. Our study will form the basis for developing supplemental guidance and training materials to enhance existing LNAPL guidance and training materials.

#### **Proposed Scope to Address Problem (what is the approach for this project?)**

In cooperation with one of our petroleum-industry clients, we will select one or more study sites in a tidal setting and perform the following tasks as part of our scope of work:

- Use electronic and manual instrumentation to monitor fluid levels in the surface and groundwater systems, and track cyclic variations in LNAPL thickness at wells located various distances from the shoreline under non-pumping conditions for approximately one (1) month.
- Infer a range of hydraulic diffusivity values for the aquifer based on the lag time between water table and LNAPL thickness fluctuations relative to tidal changes as a function of distance from the shoreline.
- Collect soil cores from the LNAPL-bearing strata near selected wells, and analyze these for the occurrence of LNAPL (native-state fluid saturations) within the smear zone, and quantify the physical properties of the porous media affecting LNAPL mobility and recoverability (porosity, permeability, capillary properties, and residual saturations) using an outside petroleum core analysis laboratory.
- Perform LNAPL baildown tests on selected wells during a tide cycle to obtain field-scale hydraulic properties (LNAPL and groundwater conductivities) from which capillary properties will be estimated as a function of hydraulic conductivity and two national databases to bracket a range of property values.
- Perform LNAPL skimming and dual-phase pumping tests at selected wells during one or more tide cycles; monitor cyclic recovery rates and infer relationships to LNAPL thickness in nearby observation wells, and LNAPL mobility measured with the baildown tests.
- Identify which part of the tide cycle is better suited for LNAPL recovery (rising or falling water table) based on an evaluation of operational cost and energy efficiency for a recovery volume.
- Integrate the analyses of the fluid-level data, core analyses, and all hydraulic testing an LCSM following ASTM (2007) guidance.
- Predict the cyclic performance of a recovery wells at different distances from the shoreline with in-house and API (2004) software by modeling the cyclic LNAPL smearing and recoverability.

#### **Targeted Users (who will use products generated by this project?)**

The products of our investigation would benefit environmental contractors, owner/operators, and state and federal regulators that are managing petroleum refineries, product terminals and pipelines, and UST facilities with LNAPL plumes near tidal surface water bodies. This could include a large number of petroleum facilities in the private and public sectors of our economy. It includes numerous U.S. military bases and facilities that store and use petroleum products in coastal areas around the world.

Affected facilities and regulatory agencies include those located in 23 states bordering the Pacific and Atlantic Oceans, and the Gulf of Mexico (Alaska, Hawaii, Washington, Oregon, California, Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, New Jersey, New York, Connecticut, Massachusetts, New Hampshire, and Maine), and U.S. territories with tidal-coastal environments (e.g., Puerto Rico, U.S. Virgin Islands, and Guam).

### **Summary of Deliverables (primary project product(s))**

The products of the project case study report, to be incorporated into a written guidance document and training materials will include:

- Specifications for any new equipment developed solely for monitoring and recording (data logging) LNAPL thicknesses in wells on a use-specified time interval.
- Documentation of field and laboratory procedures for electronic data (fluid level gauging) and sample collection activities (LNAPL and groundwater fluids, and soil cores).
- Documentation of methods of analyzing the field test data for field-scale hydraulic properties that influence or control LNAPL mobility and recoverability.
- Documentation of methods for evaluating cyclic LNAPL mobility and recoverability for a typical tide cycle and distance from the shoreline for the case study site conditions.
- Documentation of methods for evaluation of the optimum conceptual design (number and spacing of wells) and operation relative to tide cycles that meets criteria consistent with applicable state environmental regulations.
- Documentation of the methods for estimating the rates of LNAPL and groundwater recovery during a tidal cycle.
- Copies of new computer software that may be developed as part of this project.
- Appendices of laboratory and field data collected for the case study site investigation.

### **Impact (how will this project result in more effective environmental decision making?)**

This project is consistent with a national trend in LNAPL policy change—that of developing site-specific risk-based endpoints to LNAPL remediation, while also optimizing the design and operation of remediation technologies needed to control risks. The ultimate goal is to derive scientifically sound and defensible strategies to evaluate and manage challenging LNAPL projects that are practical, achievable and protective of the environment.

The selection of the right remedy and system design/operation depends on a good understanding the physical and chemical processes at work at an LNAPL site. As applied here, the optimum selection, design, and operation of fluid recovery system that is influenced by the groundwater/surface water system, requires the designer to understand that natural flow system. Otherwise the system tends to be over-sized or under-sized and will over- or under-perform, hence not meet the goals at least cost. This project can make environmental decision-making more effective in two ways:

- Characterizing the natural system and its influence on the time-dependent recoverability of the LNAPL that leads to the development of the LCSM, and illustrates by example how it can be applied in a tidal environment.
- Through communication with the environmental community at large through development of guidance and training of regulators (primarily) who are in the best position to modify their policies which can drive substantive changes in how we remediate LNAPL sites.

### **Project Schedule**

Jan. – Jul. 2010: Initial meeting with ITRC team, site selection with client, work plan development and review by all parties, implementation of site investigation and characterization of the LCSM, preparation of a case study draft report.

Aug. – Sept. 2010: Meetings with ITRC team and revisions to the draft report. Planning for the guidance document and training material phase.

Oct. – Dec. 2010: Develop guidance document and training materials (slide presentations)

We assume that the guidance document can be closely related to the work performed on the study site, and that the slide presentations would cover approximately 3 to 4 hours, allowing some time for questions.

## Proposed Personnel

### Potential Team Membership/Needs

Project Manager: Don A. Lundy, PG

Don Lundy is a Principal Hydrogeologist with Environmental Systems & Technologies, a Division of Groundwater & Environmental Services, Inc. He has worked in groundwater consulting since 1978 and specializes in solving multiphase environmental problems related to releases of LNAPLs and DNAPLs. He contributed to the development of the 2004 API Interactive LNAPL Guide, and served on the subcommittee for development of the 2007 ASTM LNAPL Guide E 2531-06. Mr. Lundy has organized and led several LNAPL training courses for the National Groundwater Association (NGWA) and for the Massachusetts Licensed Site Professionals Association. He was the lead developer for the software BardownSolver, marketed by NGWA. He has published a number of technical papers on the subject of LNAPL site investigations, remediation, and regulatory policies. Mr. Lundy has a B.S. in Geology from the University of Texas at Austin, an M.S. in Geology from the University of Wyoming (groundwater thesis), and is a registered professional geologist in Georgia and Alabama. From 2004 to 2008 he served as an adjunct professor of geology at Georgia Perimeter College, a 2-year unit of the University of Georgia system.

Principal-in-Charge: Mary Ann Parcher

Mary Ann Parcher is a Site Operations Manager and Principal Scientist with 15 years of environmental consulting experience. She oversees operation of Environmental Systems and Technologies (ES&T), the technology support division of GES. Ms. Parcher specializes in the application of computer technology to aid in the assessment and remediation of sites impacted by petroleum products and solvent releases. She specializes in the modeling of multiphase flow and chemical fate and transport for NAPLs. Ms. Parcher directed the development of and coauthored the API Interactive LNAPL Guide. Her project experience encompasses retail service stations, terminals and bulk storage facilities, refinery complexes, and industrial sites. She has been involved with technical analyses for facilities across the country as well as in the Caribbean, Europe, Canada, and Australia. In addition, Ms. Parcher has provided litigation support and expert witness testimony for numerous litigation cases.

Ms. Parcher has presented at numerous technical conferences, seminars and workshops. She is active within the industry for advocacy issues as well as research and development activities. In particular, she has been involved with a variety of organizations developing training materials, guidance documents, and standards associated with the analysis and cleanup of NAPL. Ms. Parcher has received a MS in environmental science and engineering from Virginia Tech as well as a BS in natural resource management from the University of Maryland.

Other items per ITRC:

- Texas, Delaware, or New York are possible states for the case study site. The first two have risk-based LNAPL regulatory programs in place and we have working knowledge in those states, but we don't currently have a specific client/site identified. We have been working for several years in New York, on risk-based LNAPL remediation projects at which we have applied some of the field and laboratory methods proposed here. Also, we currently have an interested client that has two LNAPL sites in tidal environments in New York.
- It is possible that the Groundwater Technical Task Force of the American Petroleum Institute may have some interest in this project. We are currently in contact with them about related LNAPL issues and possible research funding; that effort is in a preliminary stage of development.
- Don Lundy and Mary Ann Parcher have expertise in hydrogeology, LNAPL CSM model studies, transport modeling, multiphase modeling, and risk assessments. We are currently working closely with several remediation engineers and project managers in GES on LNAPL sites, who would be on the project team. Resumes can be provided later.
- If a NY site is selected, the NYSDEC personnel that we and GES are currently working with should be involved.

**Related Work:**

ES&T/GES has performed contract work for API as noted above with the development of the API Interactive LNAPL Guide published in 2004.

ES&T has completed approximately 12 LNAPL mobility/recoverability projects and currently have another five (5) ongoing projects. We have developed and field-tested a number of field and laboratory methods for quantifying the parameters that control LNAPL in the shallow subsurface environment, including a broad range of hydrogeological settings and product types.

Mr. Lundy and Ms. Parcher have developed a 1-day LNAPL training course (slide presentations) for NGWA and the Licensed Site Professional Association (LSPA) in Massachusetts. This course has been very popular has been given at least twice a year for the past 3 years. We continue to update our presentations as we continue to learn more about applying multiphase principles to solve different problems and deal with a wide range of site conditions.

Mr. Lundy has performed field work, designed data collection programs, supervised pilot testing, and performed groundwater flow system and recovery system analyses at LNAPL and DNAPL sites in tide-influenced hydrogeologic settings in Texas, Louisiana, Delaware, and New York state.

ES&T/GES currently has two ongoing projects for the LNAPL site characterization and the design and construction of LNAPL recovery systems at two tidal-influenced sites in New York.