

Working with Regulators to Understand Practicable LNAPL Recovery and Gain Win-Win Site Closure

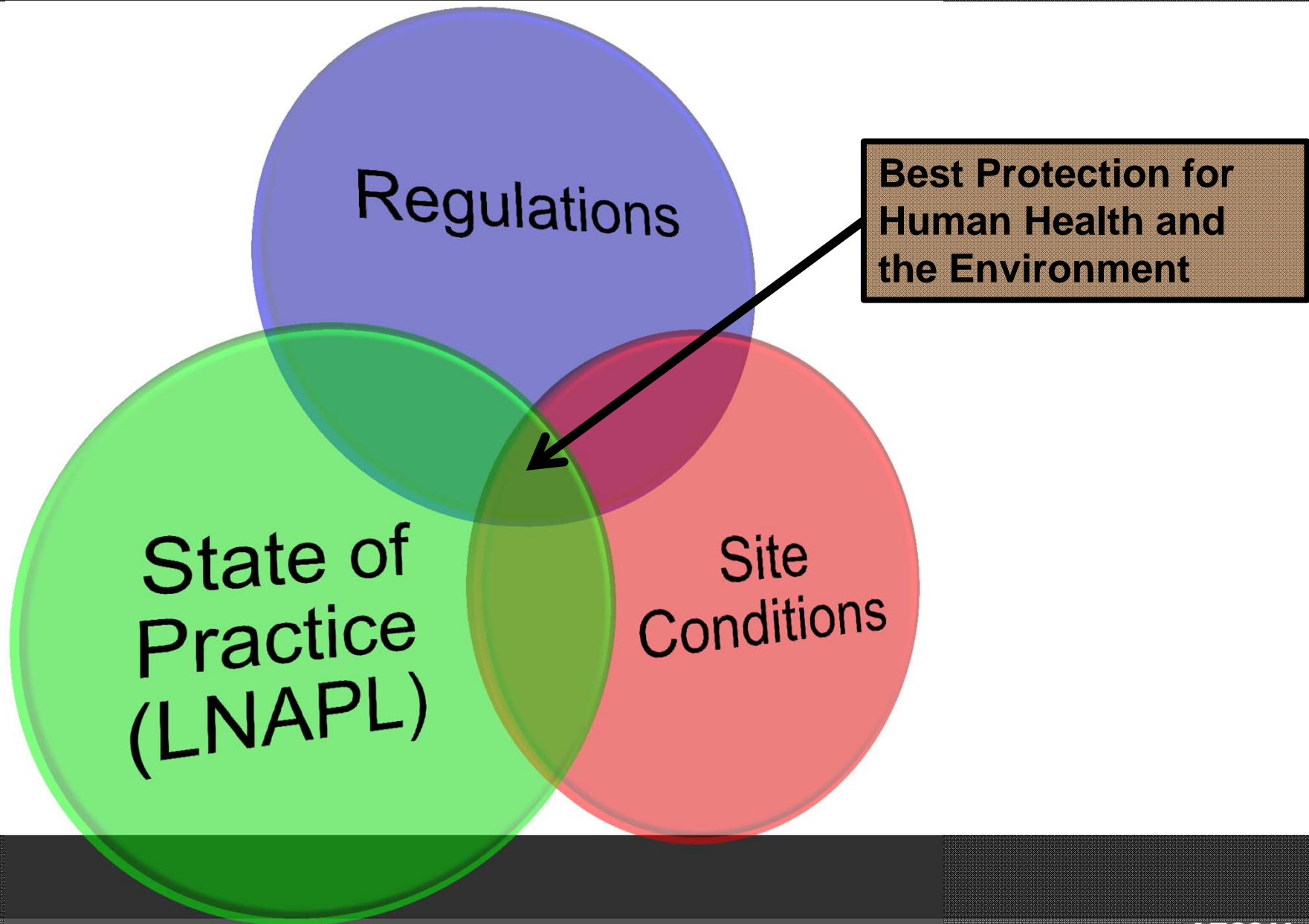


Trevre Andrews, Geophysicist
Andrew Kirkman, P.E.

Environment



The Importance of Stakeholder Communications



Site Closure

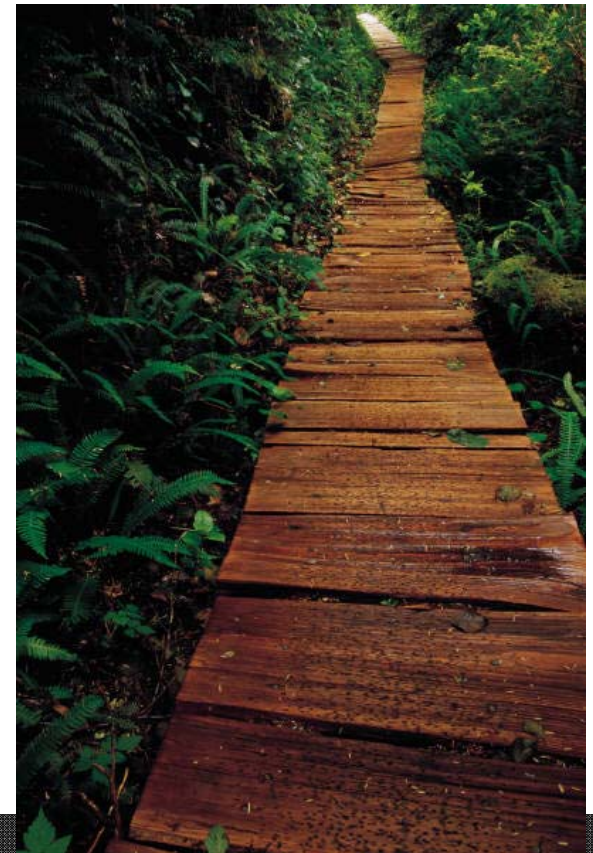
- Everybody wants it, but what do they really want?
 - NFA? Yes
 - Reduction in Monitoring? Yes
 - Acceptance of practicable investigation and remediation for each site? Yes
- It means Reasonable, practicable, and feasible investigation and remediation which assures human health and the environment is protected
- Ultimately the regulatory body decides when and if sites should be closed and under what *CONDITIONS*

IDNR LNAPL Regulatory Pathways



Which set of regulations are guiding the LNAPL sites in Iowa?

- Underground Storage Tank Section?
 - UST regulates USTs
- The Iowa Groundwater Protection Act (IGPA)?
 - The IGPA generally applies to all site where groundwater contamination is suspected or present
- The Land Recycling Program (LRP)?
 - The LRP has voluntary enrollment/unenrollment



IDNR LNAPL Regulatory Pathways Details

Current UST guidance

- Indicates that sites cannot be closed if wells contain more than **0.02 feet** of product or recover **0.1 gallons per month**, but it does stipulate the following
- “Termination of free product recovery activities. Owners and operators may propose to the department to terminate free product recovery activities when **significant** amounts of hydrocarbons are not being recovered.”
- **Significant** is not defined in the regulations

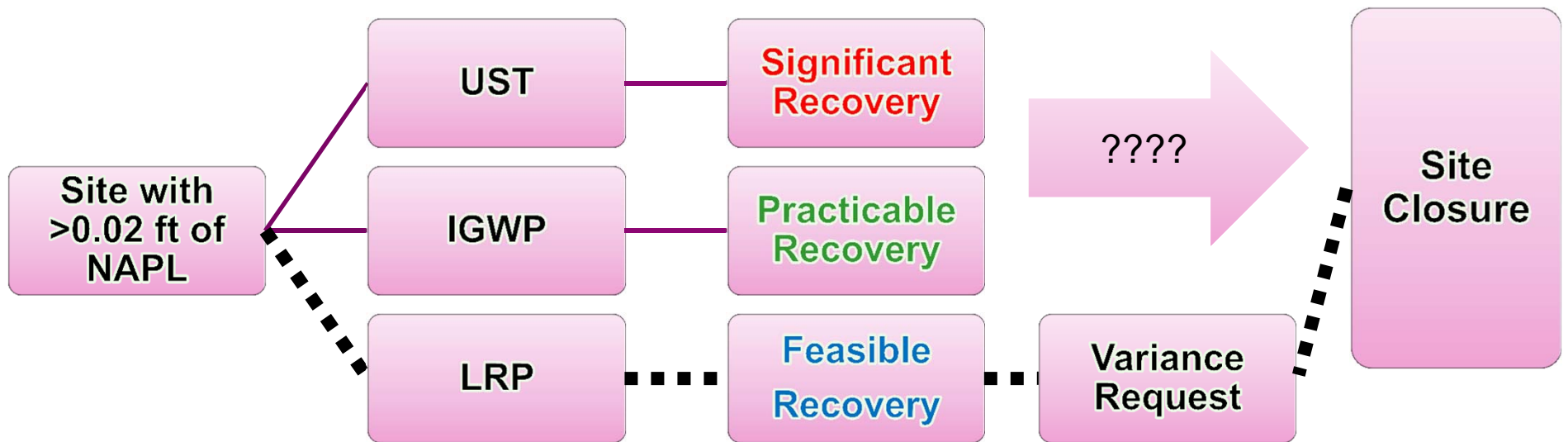
Current guidance from the (IGPA)

- Indicates removal to the extent **practicable**
- **Practicable** is not defined by the regulations

Current guidance from the LRP

- “*The department recognizes that treatment or removal of free product or gross contamination may not, in some cases, be **feasible**. In such cases the department may grant a variance to this portion of the rule.*”
- **Feasibility** is determined by the following Information in a variance request:
 - *Free Product Plume is defined and Migration Potential is limited*
 - *Contaminant Volume Estimation*
 - *Best Available Technology Demonstration*

IDNR LNAPL Regulatory Pathways



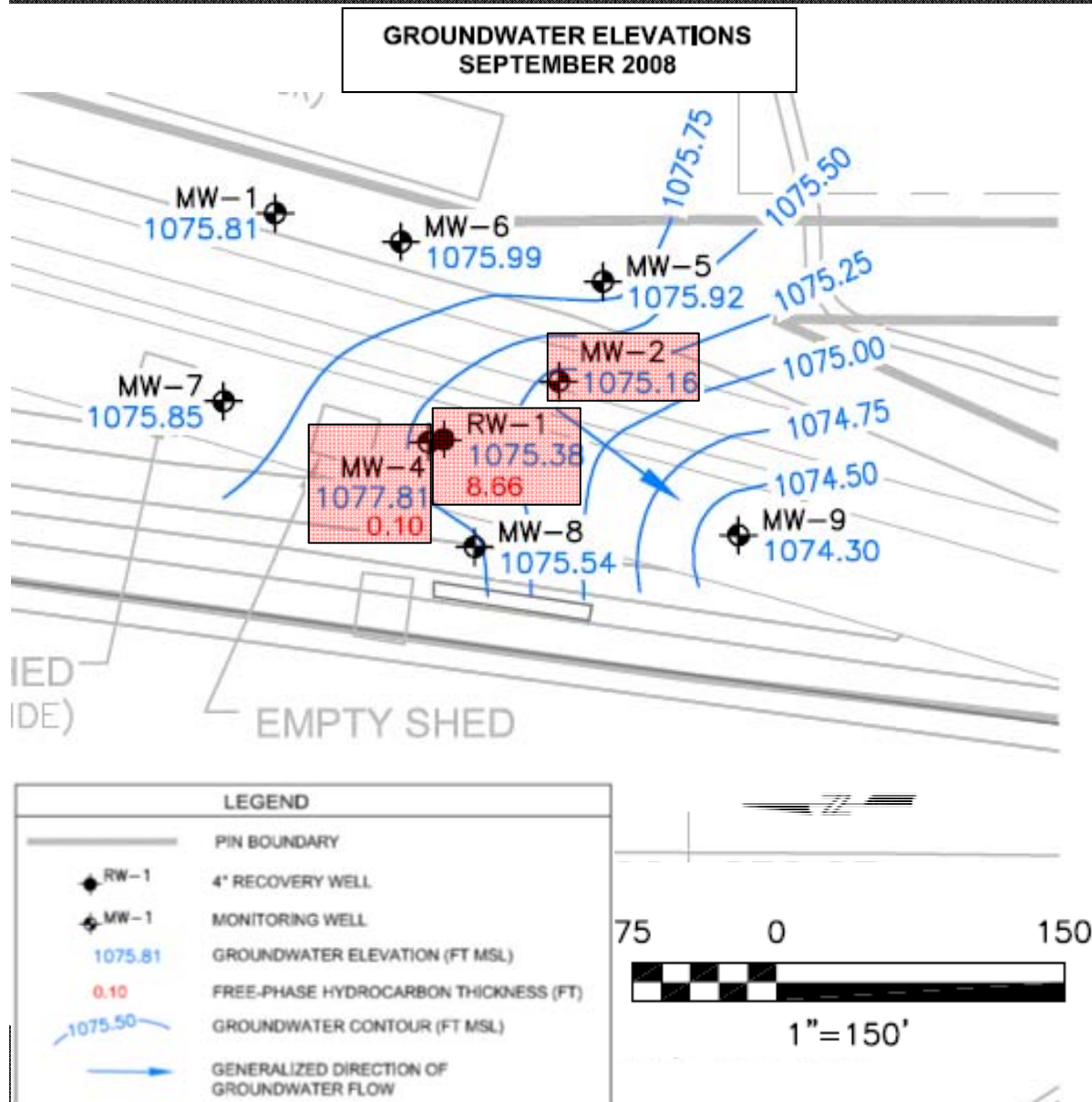
IDNR LRP Variance Criteria

The LRP is the only regulatory pathway in Iowa which specifically allows for site closure

The Variance Criteria Are Assessed:

- Primary Criteria - Variance may be granted based on one primary criteria
 - Effectiveness of Technology - Recovery is ineffective
 - Structures with free product - Free product in structures must be recovered
 - Surface conditions/accessibility – Prevent the recovery of free product
 - Volume of free product – Less than 50 gallons, Recovery less than 0.1 gallons/month, greater than 0.02 feet of product
- Secondary Criteria – only used if primary criteria yields inconclusive results
 - Cost of Recovery – Passive recovery is considered cost effective.
 - Geology/hydrogeology - difficult geology for recovery
 - Offsite impacts – not eligible for variance
 - Aquifer Value – how important is the aquifer
 - Cleanup time frame – is the time frame practicable
 - Type of Free product – product type affects product recoverability

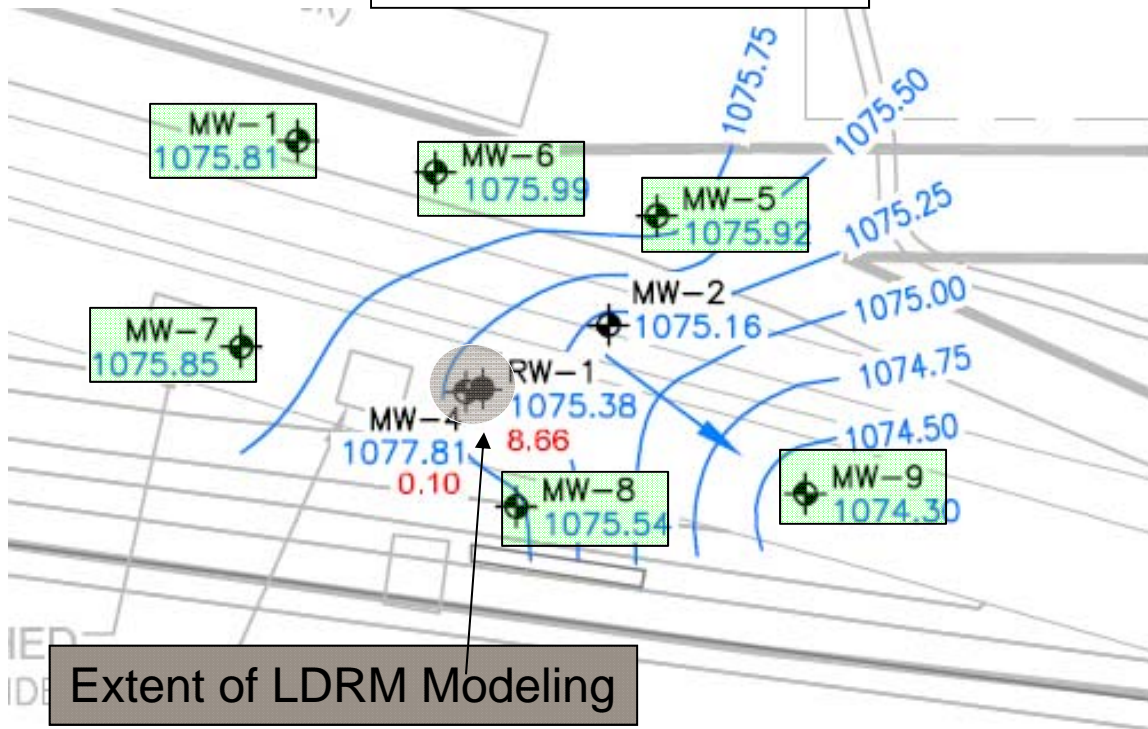
AOC Summary and Layout



- Prior to 2008 Low levels of organic parameters were detected in certain groundwater samples.
- Dibenz(a,h)anthracene, naphthalene, and OA-2 as Diesel Fuel were detected in groundwater samples collected from monitoring wells MW-2 and MW-4 at concentrations one order of magnitude greater than the applicable Iowa statewide standards for groundwater.
- Measurable LNAPL thickness has been historically detected at MW-2, MW-4, and RW-1
- Recovery and Monitoring Activities in compliance with applicable IDNR LNAPL guidance
- The transmissivity at RW-1 was assessed via baildown testing which calculated the transmissivity to be 0.008 ft²/day

AOC Summary and Layout

GROUNDWATER ELEVATIONS
SEPTEMBER 2008

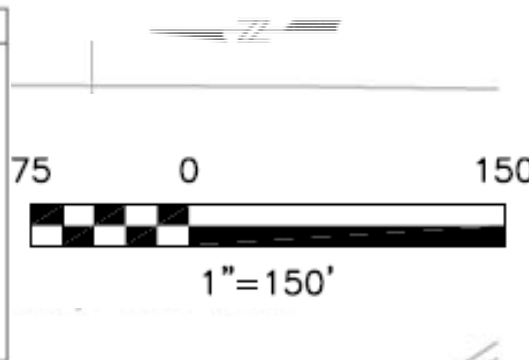


Traditional indicators at the site show the dissolved phase and LNAPL plume at the site is **stable and delineated** based on...

- The *length of time* the plume has existed and
- The length of time active operations involving hydrocarbons have *ceased*
- Low dissolved phase concentrations and lack of measureable LNAPL thickness in surrounding monitoring wells

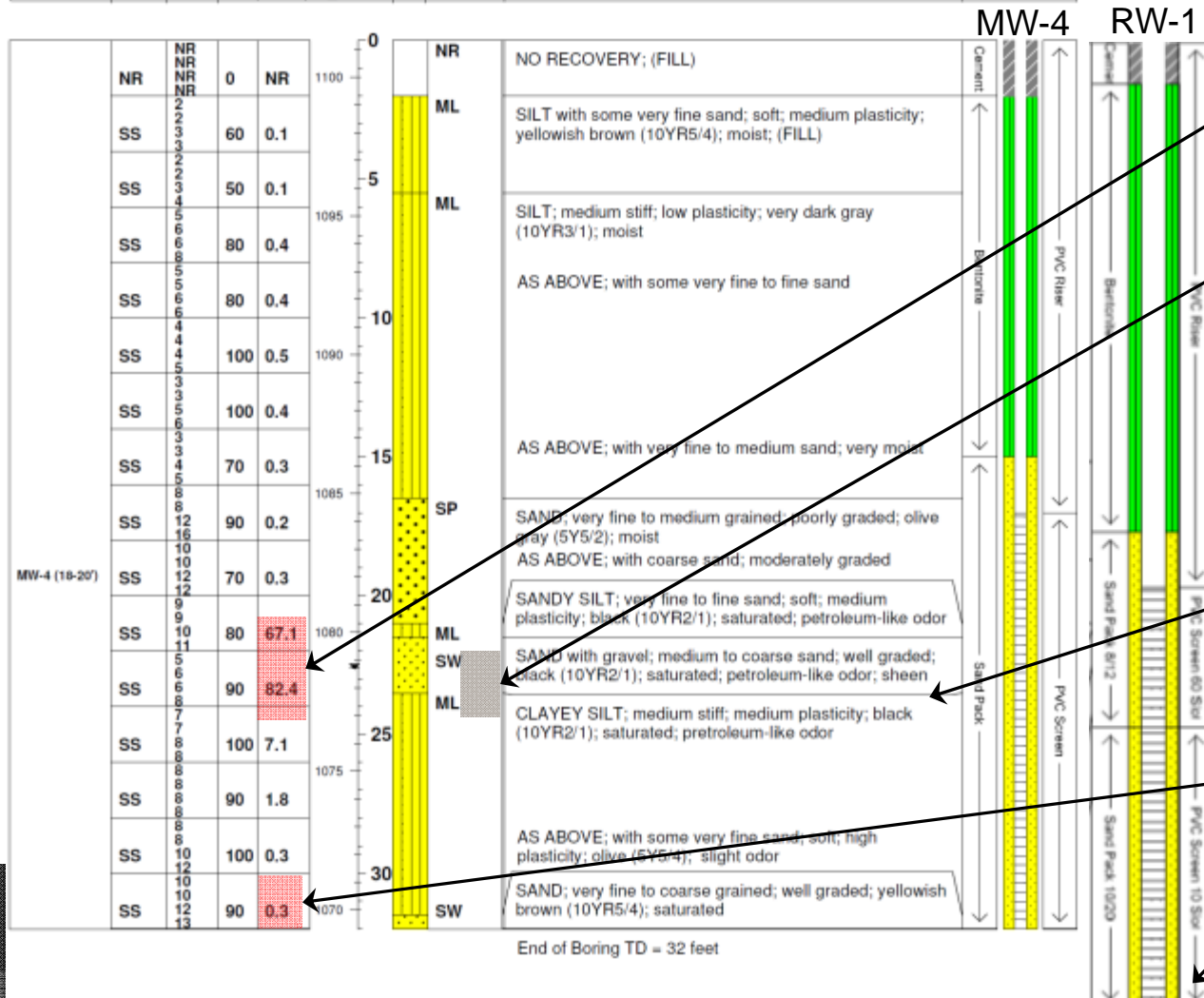
To further support these conclusion a **LNAPL distribution and Recoverability Model** was created for the site

LEGEND	
	PIN BOUNDARY
	4" RECOVERY WELL
	MONITORING WELL
1075.81	GROUNDWATER ELEVATION (FT MSL)
0.10	FREE-PHASE HYDROCARBON THICKNESS (FT)
1075.50	GROUNDWATER CONTOUR (FT MSL)
	GENERALIZED DIRECTION OF GROUNDWATER FLOW



Site Conceptual Model

AECOM - Environmental		Boring Log		Boring #:MW-4 Sheet 1 of 1	
Project: Sioux City		Contractor: Thein Well		Location: Sioux City, IA	
Project #: CNIC8-18899-200		Operator: Brian & Kurt		Northing: 3660542 Easting: 4142072	
Client: CNIC		Drill Rig Type: B-59 Truck Mounted		Surface Elevation (ft AMSL): 1101.31	
Start Date & Time: 7/20/05 725		Method: HSA		Total Depth (ft): 32	
Finish Date & Time: 7/20/05 915		Boring ID: 8"		Logged By: JJJ	



Elevated PID readings

Estimated Location of LNAPL in the formation (~1077 to 1079 ft MSL)

Sand overlying clay creates perched conditions

Low PID readings in lower sand

RW-1 is screened 3 feet below MW-4

What is the Model?

LNAPL Distribution and Recoverability (LDRM) Analysis Overview

- The American Petroleum Institute (API) LNAPL Distribution and Recovery Model (LDRM). The API LDRM has two parts:
 1. An LNAPL distribution model;
 2. and an LNAPL Recovery model
- The LNAPL distribution portion is calibrated to site saturation versus well thickness as well as fluid properties and verified with field tests (e.g., baildown or manual skimming ->Tn)
- The LNAPL Recovery model is used to simulate recovery scenarios for the following technologies
 - Skimming
 - Water-enhanced skimming
 - Vacuum Enhanced Skimming
 - Vacuum and Water Enhanced Skimming
- An LDRM model was created for the CCP site in Sioux City, IA using all available site specific data and supplemented with reference data provided by the American Petroleum Institute.
- More information about the model is available at <http://www.api.org/ehs/groundwater/lnapl/lnapl-reg.cfm>

LDRM Modeling Inputs

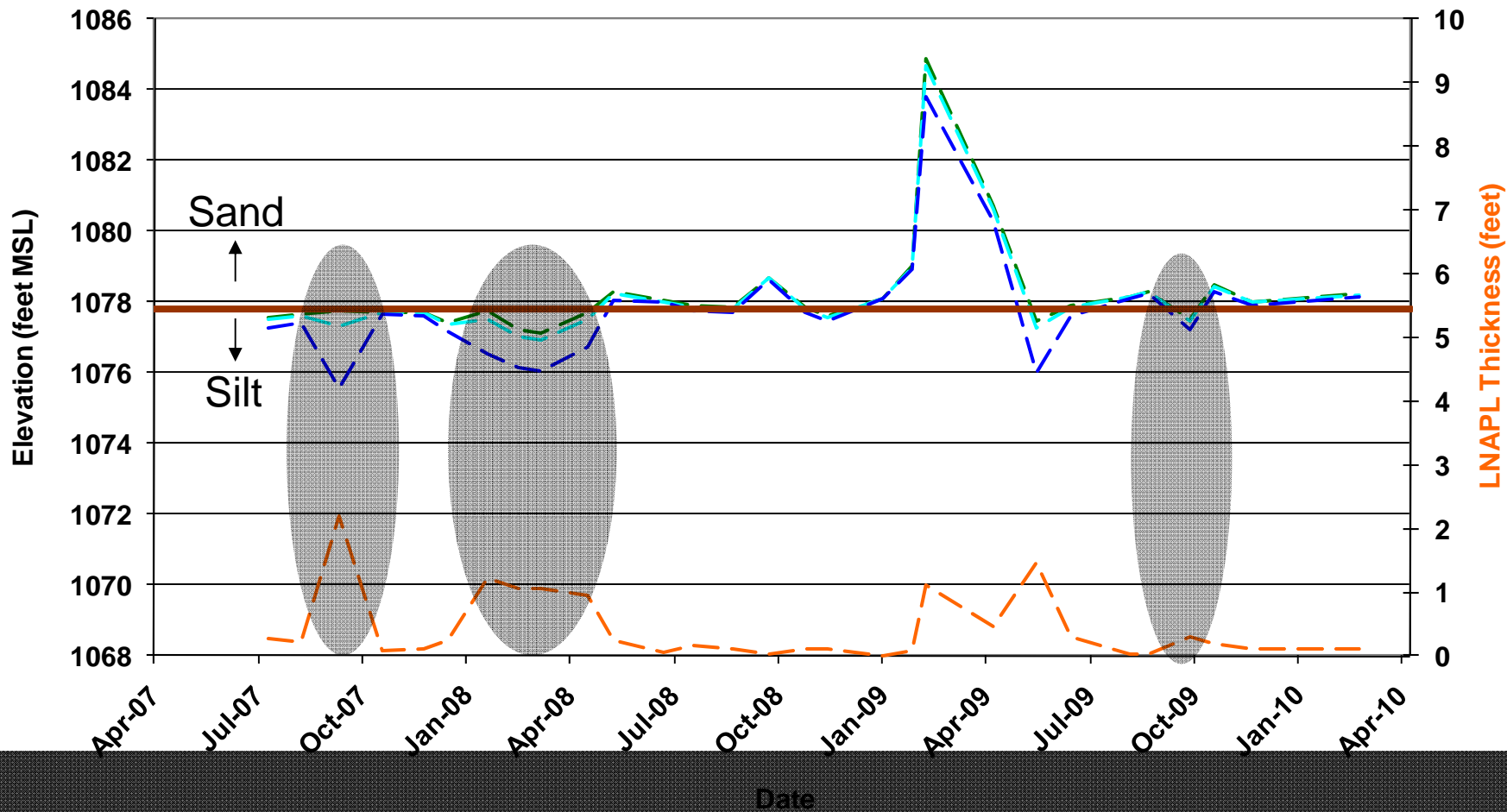
- **The following site specific data was used to calibrate the model**
 - Fluid gauging data
 - Geologic information (boring logs)
 - Baildown test transmissivity
 - Site specific grains size distribution data
 - Hydraulic conductivity from slug testing
- **The following data was used in the model based on published values and site specific calibration**
 - Soil layer properties data (Van Genuchten Parameters, porosity, and LNAPL residual saturations)
 - Recovery parameters (radius of influence, mobile LNAPL extent, and recovery system operation parameters)

RW-1 Mobility Testing

- The Interstate Technology & Regulatory Council (ITRC) has recently established LNAPL hydraulic recovery endpoints based on LNAPL transmissivity of **0.1 to 0.8 ft²/day** *Evaluating LNAPL Remedial Technologies for Achieving Project Goals*
- **Baildown testing was primarily used to calibrate the LDRM model**
 - In 2008 the maximum calculated transmissivity adjacent to MW-4 and RW-1 was **0.008 ft²/day**.
 - Based on the assumptions made for the LDRM, the model for the site was conservatively calibrated to a transmissivity
- **Ongoing gauging at RW-1 confirms low LNAPL mobility and formation thickness**

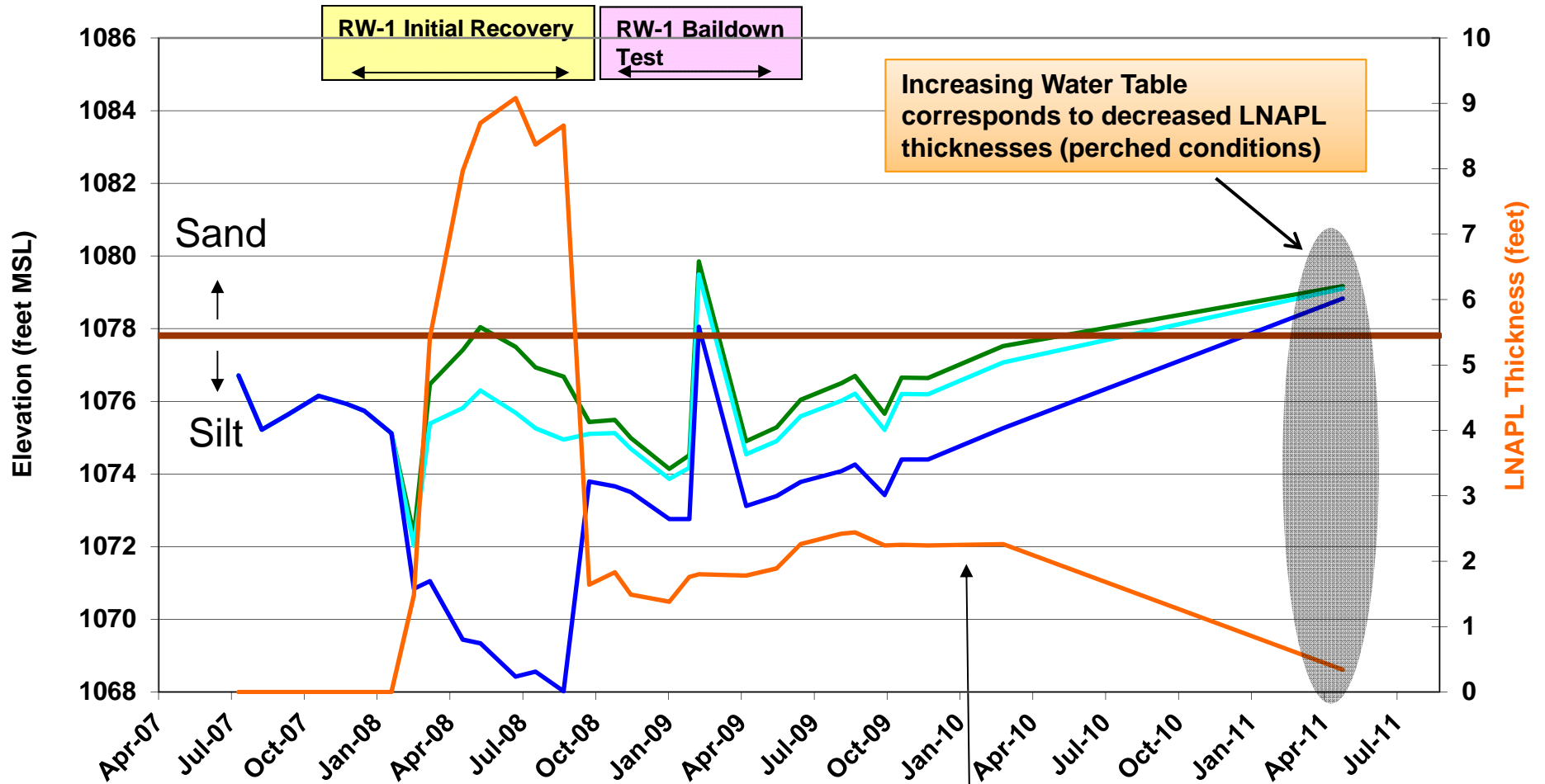
MW-4 Hydrograph

- MW-4 Free-Phase Hydrocarbon Elevation (ft MSL)
- MW-4 Adjusted Groundwater Elevation (ft MSL)*
- MW-4 Measured Groundwater Elevation (ft MSL)
- Sand/Silt Contact
- MW-4 Free-Phase Hydrocarbon Thickness (ft)



RW-1 Hydrograph

— RW-1 Free-Phase Hydrocarbon Elevation (ft MSL)
 — RW-1 Adjusted Groundwater Elevation (ft MSL)*
 — RW-1 Measured Groundwater Elevation (ft MSL)
 — Sand/Silt Contact
 — RW-1 Free-Phase Hydrocarbon Thickness (ft)



Stable and Decreasing LNAPL thickness after baildown test

PID
(ppm)

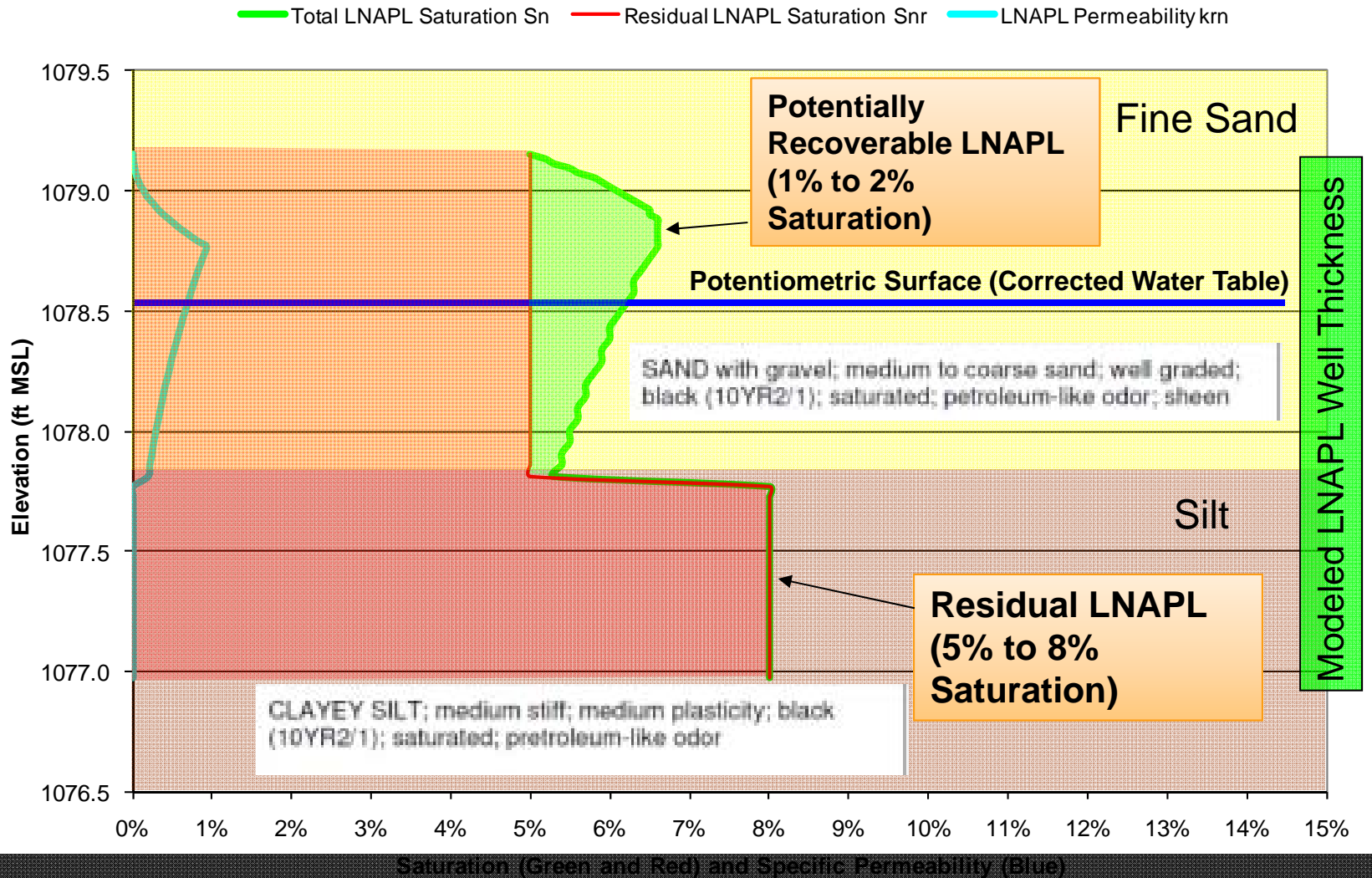
67.1

82.4

7.1

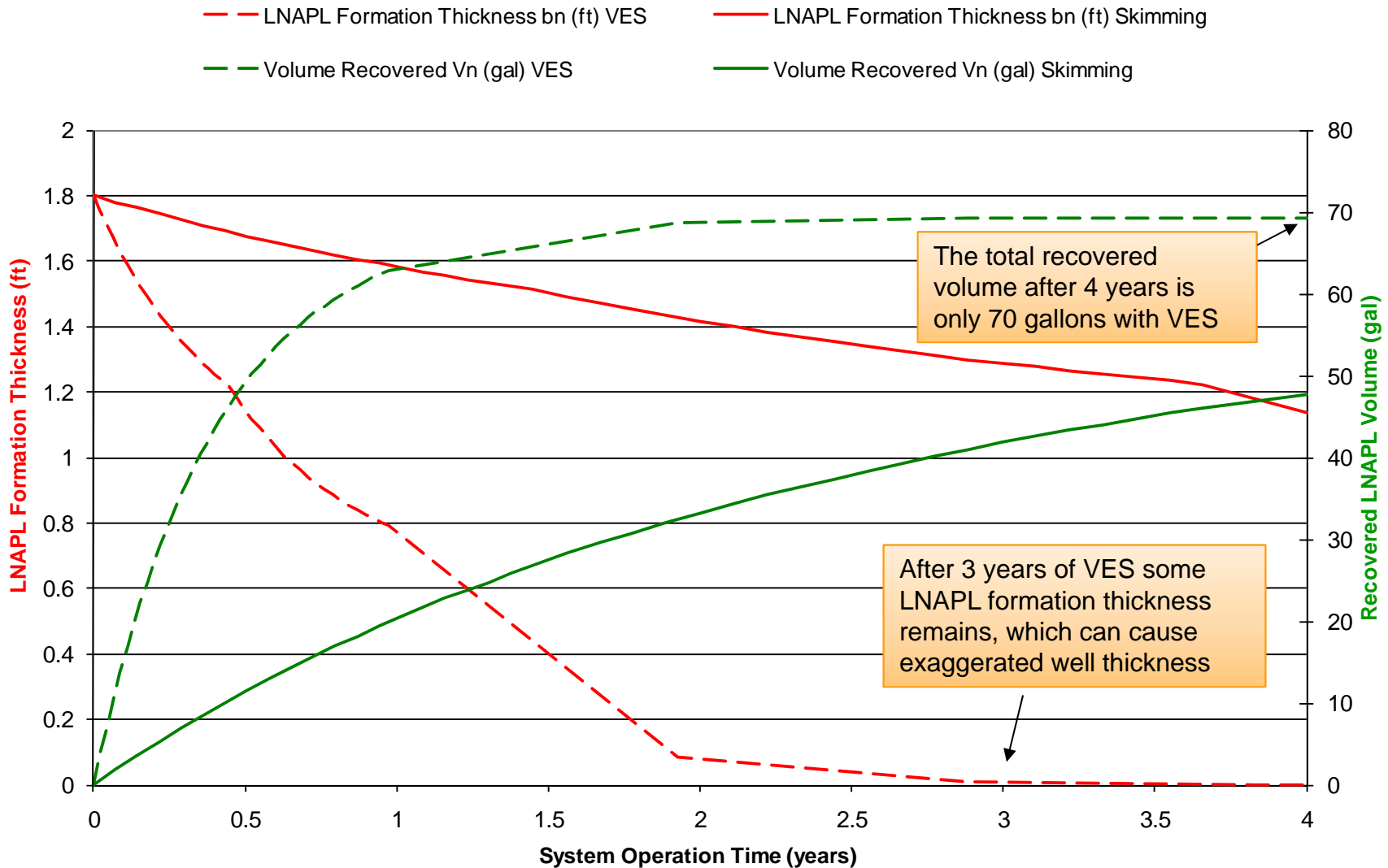


Distribution Model Results (Calibrated to Transmissivity)



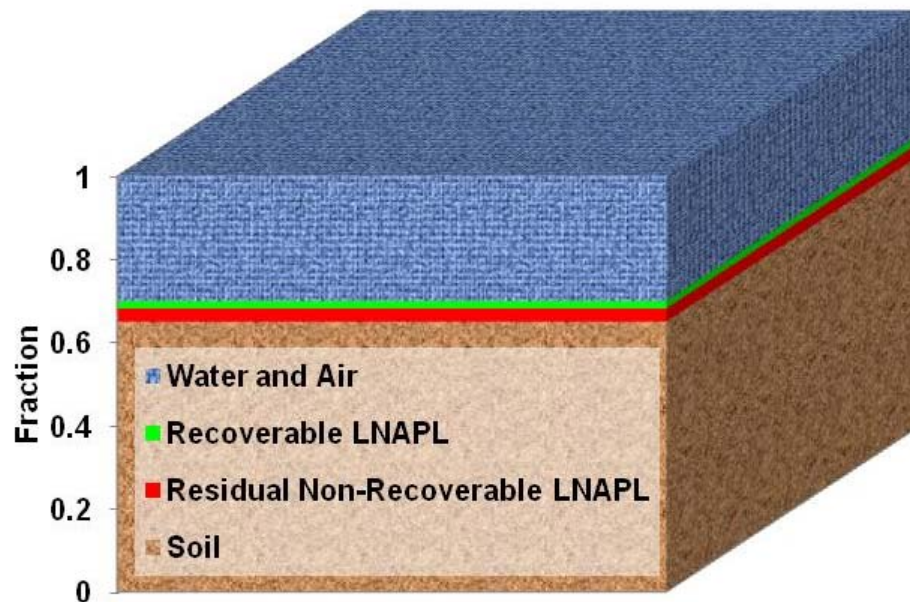
Recovery Model Results (Calibrated to Transmissivity)

Modeled LNAPL Recovery for Skimming and Vacuum Enhanced Skimming (VES) at RW-1



Estimated LNAPL Volume

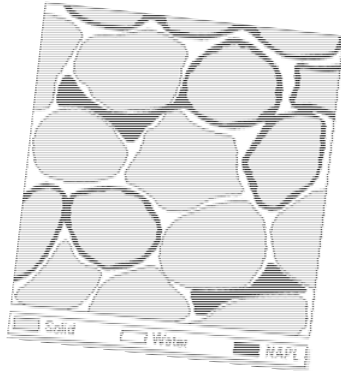
- Estimated Soil Porosity 0.35
- Estimated Residual NAPL Saturation 0.086 to 0.229 for silt to medium sand (Mercer and Cohen, 1990)
- Estimated Mobile Saturation (5% mobile saturation)
- Estimated Maximum NAPL formation thickness 2 feet



Soil Type		<i>Medium to Coarse Sand with Fuel Oil*</i>
Parameter	Unit	
Porosity	Unitless	0.35
Residual LNAPL Saturation	Fraction	0.09
Mobile LNAPL Saturation Above Residual	Fraction	0.05
Formation Thickness	ft	1
Specific LNAPL Total Thickness	gal/(ft²)	0.74
Specific LNAPL Recoverable Thickness	gal/(ft²)	0.26

Migration Potential

- The equation below accounts for the capillary pressure properties of the highest permeability formation material containing LNAPL and estimated interfacial tension values of site fluids



$$\Delta\Psi = \left[\begin{array}{cc} \frac{\sigma_{ow}}{\rho_w} & \frac{\sigma_{ao}}{\rho_o} \\ \frac{\sigma_{aw}}{\rho_w} & \frac{\sigma_{aw}}{\rho_o} \end{array} \right] \Psi_{baw}$$

$\Delta\Psi$ = Minimum LNAPL entry head pressure

σ_{ow} = LNAPL/water interfacial tension

σ_{aw} = Air/water interfacial tension

σ_{ao} = Air/LNAPL interfacial tension

ρ_o = LNAPL density

ρ_w = Water density

Ψ_{baw} = Air and water bubbling pressure head (i.e. The pressure on the capillary pressure curve at which water saturation drops below 100%)

- LNAPL formation thicknesses of more than **3 feet would be required** for the LNAPL to migrate laterally into adjacent clean soil.
- In addition the dissolved phase plume is stable which is a strong indication of a stable LNAPL plume

2010 Summary Report Results

Free-Phase Hydrocarbon

- **LNAPL Delineation** - LNAPL is limited to RW-1, MW-4, and MW-2, and bounded by wells free of LNAPL in all directions. Dissolved Phase and soil impacts at delineation boundary do not exceed regulatory standards.
- **LNAPL Migration Potential** - Multiple Factors including the age of the LNAPL plume, low LNAPL transmissivity, and low LNAPL driving heads support a stable LNAPL plume.
- **LNAPL Volumes** – limited and mostly represent residual saturation (Less than 22 gallons of recoverable LNAPL per year)

Future Land Use

- For the foreseeable future, the Site will remain classified as industrial with ongoing railroad-related activity.

Receptors

- Because the dissolved and free-phase hydrocarbon plumes are limited and well defined in extent, the potential for receptors coming into contact with either the LNAPL and dissolved plumes is remote.

Best Available Technology Demonstration

- Baildown Pilot Test Transmissivities ranged from 0.001 to 0.008 ft²/day
- For a skimming system this amounts to a maximum of 6.9 gpy
- For a Vacuum Enhanced Skimming System this amounts to a maximum of 21.8 gpy

Actual LNAPL recovery rates would likely remain much lower than these estimates due to fluctuating water tables, overly conservative recovery parameters (i.e., the highest transmissivity range, 100% operation efficiency, and limited aerial extent of recoverable LNAPL)

LRP-like Variance Evaluation

- Primary Criteria - Variance may be granted based on one primary criteria
 - Effectiveness of Technology - Recovery is ineffective
- Based on delineation data at the Site which indicates the LNAPL plume is of limited extent, is delineated, is stable, and does not threaten any known groundwater receptors the recovery of LNAPL at the Site will not further reduce risks to groundwater or the environment. In addition the limited recovery rate and recoverable volume make the recovery of LNAPL at the Site ineffective.
- As part of a variance site wells are abandoned and NFA with institutional controls is place
- Site owner is not released of future environmental liability

Questions?



- **Trevre Roys Andrews**

- Geologist/Geophysicist
- **AECOM Environment**

D: 212.798.8553 C: 651.261.7310

- One World Financial Center
 - 200 Liberty Street
 - 25th Floor
- New York, NY 10281

- **Andrew Kirkman, P.E.**

NAPL Technical Leader

AECOM Environment

Geologist and Geological Engineer

651-367-2324 (Direct)

651-270-7220 (Cell)

First National Bank Building

332 Minnesota Street, Suite E1000

St. Paul, MN 55101

Name
Title
Phone
Email