Swimm, David E - DNR
Tuesday, October 15, 2013 12:26 PM
Robinson, John H - DNR; Stoltz, Carrie R - DNR; Fassbender, Judy L - DNR
Draft LNAPL Presentation
Draft LNAPL Presentation2.pptx
Follow up
Friday, October 25, 2013 7:00 AM
Completed

Good Afternoon All,

Please find attached a draft PowerPoint slide presentation. It focuses on Doug's because the assessment there was most profound and complete in terms of what I prepared.

I purposefully left off a title slide; it can come later (titles are best that way).

Please provide your comments/thoughts. I know the presentation is heavy on visuals; it is meant to be that way – not about details of the modeling or drawdown analyses – those could be separate presentations.

It also is not about remedies, with the exception being that assessments allow one to focus better on remedy selection/location.

I envision this to be an internal presentation for staff only at this time . The figures are tedious and incorporate my hand drawn original figures. At this time it would be difficult to insert DNR logos, standardized borders, etc. (unless very small). In the longer term, clearer/cleaner figures starting from scratch on a "DNR" base that perhaps would also include Auto Stop (across the street to the south) could be developed for outside presentation. I started that, but is time consuming, so switched to my original bases to get this draft out quicker. Figures with Auto Stop would also show the implied LNAPL area beneath the Lake St. ROW.

Jennerman's would be more difficult to present since the data is more limited mostly due to the LIF survey break down.

As suggested by John, the theme is lessons learned. I could not help but add the last slide – my summary thoughts/knowledge concerning LNAPL Removal.

John and Carrie, I would love to give a live draft presentation using this slide show to folks interested in Northern......live to obtain candid feedback/discussion and develop/improve my presentation.

Thanks all for your recent and ongoing support.

David Swimm, PG

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Pre-Assessment 2006 LNAPL Distribution (one of three adjacent sites)

- 7-Well Extraction System
- Compressed Air Pumps
- Operated 2003-07
- Extracted Diesel and Gasoline
- 7K gals. LNAPL reportedly removed
- Relative water proportion uncertain (IMO)
- \$670K reimbursed (PECFA)
- MWs contain 2-4 ft. LNAPL post-remedy



LNAPL Assessments conducted during 2011-12 on all three adjacent corner PECFA sites

- Significant LNAPL volumes remained on-site (3) and beneath the ROW.
- No modern assessments attempted.
- Active treatments (2) had effectively ended 4-5 years earlier.
- Remaining product was obviously "potent" (relatively unweathered)
- Coordinated groundwater sampling showed a significant dissolved plume, including heavily impacted piezometers



LIF Survey Log results need to be *interpreted and integrated*:

- They cost >>\$
- Fluorescence results provide thickness maps independent of wells. They also distinguish between products.
- Conductivity results provide detailed smear zone geology.
- Integrated results show LNAPL distributions that are far more detailed than any prior effort using boring log data.

Additional Hint:

Well LNAPL thicknesses should be measured the same day/start of survey. LNAPL plume expression may not be obvious on LIF logs (e.g. LNAPL below water table, vadose zone contamination, plume changes over short distances, etc.).



LIF results can show disconnect between true LNAPL plume thickness/distribution and that suggested by well data.

Well data is subject to artifacts related to vertical LNAPL movement (i.e., drainage and imbibition effects in the near wellbore environment).









A′

40

LIF 10-50% RE

Α



В

B'

LIF survey-based distribution maps allow:

- Improved means to estimate in-place volumes and mobility estimates (i.e., better LNAPL h).
- Ability to focus LNAPL remedial efforts (location).
- Determine if LNAPL volumes are present below the water table.

LNAPL Assessment Reports -

Data Integration Is Necessary for Meaningful Assessments



LDRM: LNAPL Distribution and Recovery Model (API) HC: aquifer hydraulic conductivity VG: vertical gradient

Baildown Results MW3



Baildown Results EX-1



LNAPL Baildown Tests:

- As conducted, difficult to obtain accurate raw data five of six were problematic, based on inspection alone (i.e., inaccurate LNAPL/water interface measurements).
- Analyses provided relative mobility (T_n) results. Allowed comparisons between wells, but data accuracy severely limited use as a LDRM model calibration tool.
- Sufficient LNAPL must be present (> 1 foot) analysis assumes only LNAPL removed.
- Baildown analysis tool provides three T_n estimates and their associated statistical qualifications.
- Consideration needed for field techniques to improve data quality.
- Consideration needed for temporal effects on T_n.

API van Genuchten-Burdine Model of LNAPL Distribution and Realtive

Summary Table of LDRM Model Results

API van Genuchten-Mualem Model of LNAPL Distribution and Realtive Permeability (Single Layer)

	t (yr)	Rc (ft)	Ri (fl
Skimmer well: Q _w = 0	2	20	20
Vertical Gradient (site)	-0.05		
HC groundwater (ft/d) (site)	1.42		Ααι

- Aquifer Hydraulics

LNAPL Fluid Properties

		iereu			
Fluid Parametes		gas	site gas	site diesel	
LNAPL density (gm/cc)	ρο	0.73	0.754	0.79	1
LNAPL viscosity at 60°F (cP	μ	0.62	0.6	1.1	
	. 0				
air-water tension (dynes/cm	σ _{aw}	65	57.8	59.3	
air-oil tension (dynes/cm)	σ _{aw}	21	21.3	24.3	1
oil-water tension (dynes/cm)		50	15.1	15	

Individual, Site-Specific Model Run (Inputs)

Geologic Subareas

							Site - Smear Z	one (gasoline)			BWT (g	asoline)	Site -	Smear & BWT (diesel)	
	Diredel Dhaca Sail	and			Burd	ine1	V		Mu	alem	Bur	dine		Mualem		
	Saturation Para	mete	Ideal Sand	Ideal Sand w/site fluids,grad,h	>50% RE SW/GW	>50% RE SW/GW	10-50% SW/GW	10-50% SW/GW/SM	10-50% SM	10-50% SM	10-50% SW/GW - BWT	10-50% SW/GW - BWT	SM	SM	SM	
	ENAPL h	· · ·	3	1.5	1.25	0.5	0.5	0.5	1	0.5	2	0.75	4	2	1	
	vertical gradient		0	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	
	porosity	n	0.43	0.43	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
	aquifer conductivity (ft/d)	Kw	23	23	23	23	23	11	1.4	1.4	23	23	1.4	1.4	1.4	
	van Genuchten "N"	N	2.68	2.68	2.68	2.68	2.68	2.28	1.5	1.5	2.68	2.68	1.5	1.5	1.5	
	van Genuchten "α"	α	4.4	4.4	4.4	4.4	4.4	3.8	1.4	1.4	4.4	4.4	1.4	1.4	1.4	
	irreducible water saturation	Swr	0.1	0.1	0.1	0.1	0.15	0.25	0.3	0.3	0.15	0.15	0.3	0.3	0.3	
-	LNAPL Residual Saturation (f-Factor) 1		0.18	0.18	0.20	0.20	0.50	0.55	0.6	0.6	0.5	0.5	0.6	0.6	0.6	
	1.	1														
	Recovery Model Results.					-										
	in-place specific volume (ft)		0.55	0.33	0.24	0.07	0.06	0.03	0.09	0.03	0.52	0.13	0.67	0.24	0.07	
	recovery efficiency		78%	71%	67%	34%	35%	11%	20%	11%	49%	44%	31%	5 21%	12%	
	relative mobility ³ (reduction from ideal sd.	.)	-	-9%	-14%	-56%	-55%	-86%	-74%	-86%	-37%	-44%	-60%	5 -73%	-85%	
	Initial T(ft ² /d)		15.5	9.2	6.5	5.8	0.9	0.8	0.33		18.5	2.7	1.7	0.55	0.14	
	T(ft²/d) - 1yr		3.5	2.5	1.3	0.5	0.18	0.18	0.08		7.0	0.7	0.7	0.18	0.04	
	Initial Sn		0.65	0.65	0.6	0.35	0.42	0.2	0.25	0.15	0.7	0.55	0.5	0.35	0.25	

Model Outputs (next slide)

LDRM Model Outputs for Gasoline Smear Zone – Various Sub-Areas

				Site - Si	mear Zone (g	jasoline)			
Model Type		Burdine							
Geologic Subarea	Ideal Sand w/uw fluids	Ideal w/site fluids,grad,h	>50% RE SW/GW	>50% RE SW/GW	10-50% SW/GW	10-50% SW/GW/SM	10-50% SM		
LNAPL h	3	1.5	1.25	0.5	0.5	0.5	1		
Recovery Model Results:									
in-place specific volume (ft)	0.55	0.33	0.24	0.07	0.06	0.03	0.09		
recovery efficiency	78%	71%	67%	34%	35%	11%	20%		
relative mobility (reduced f/ideal)	-	-9%	-14%	-56%	-55%	-86%	-74%		
Trans./LNAPL Sat. Results:									
Initial Tn (ft²/d)	15.5	9.2	6.5	5.8	0.9	0.8	0.33		
Tn (ft²/d) - 1yr	3.5	2.5	1.3	0.5	0.18	0.18	0.08		
Initial S _n	0.65	0.65	0.6	0.35	0.42	0.2	0.25		

Recovery Efficiency can not be used in an <u>absolute</u> sense!

- No real world effects: radial drainage, anisotropy, relative permeability, vertical equilibrium, BWT access, etc.
- At a *minimum* needs pilot testing calibration, but still not real in terms of time (medium and long-term recovery)

Recovery Efficiency Relative mobility (reduced f/ideal)

78%	71%	67%	34%	35%	11%	20%
_	-9%	-14%	-56%	-55%	-86%	-74%

Hence, relative mobility measure

- a comparison metric.

In-Place LNA	PL Vo	Relative Mobility	LNAPL (gal.)					
		LNAPL In-Place Volume – O	Gasoline Related					
Total Estimated On-	Sito	Vadose	NA	300				
In-Place LNAPL:	Site,	Smear Zone >50% RE	-14% to -56%	1,600				
28,000 gallons		Smear Zone 10-50% RE	-55% to -86%	1,400				
		Below Water Table (BWT)	-37% to -44%*	3,200				
		LNAPL In-Place Volume – Diesel Related						
		Vadose	NA	2,500				
		Smear Zone	-60% to -85%	10,200				
		BWT	-60 to -85%*	9,100				
		* BWT relative mobility values only applicable at exceedingly low water levels (i.e., smear zone much deeper than 26' bgs.)						

Gasoline Related Smear Zone extents beneath ROW and likely reflects 2-5X or more volume in-place (i.e., 6-15K additional gallons in place)

We <u>can</u> integrate a wide range of site-specific, LNAPLrelated data to provide estimates of in-place LNAPL volumes (i.e., modeled specific volume factors).

We <u>can</u> use relative mobility results (from above integration/modeling) together with the in-place estimates to drive LNAPL remedial strategies.

Consideration is needed regarding dual phase flow parameters for gravel dominated soils (heterogeneous and homogeneous).

