Quantifying LNAPL Mobility in Fractured Rock

An Equivalent Porous Media Approach

Project Summary

Site Conditions

- Several historical releases reported
- Fractured/vuggy dolomite
- Stable downgradient groundwater concentrations
- LNAPL not migrating based on pumping tests and monitoring at downgradient collection drain
- Several new wells had 10-25 feet of LNAPL

Hypothesis

• LNAPL mobility/transmissivity will decrease quickly with targeted recovery efforts due to limited porosity (LNAPL movement through secondary porosity features)

Objective

 Quantify LNAPL mobility/transmissivity to demonstrate remedial performance and support remedial decision-making

Outcome

- LNAPL behavior during baildown tests at several wells with significant LNAPL accumulation was similar to equivalent porous media (EPM)
- Selected remedial approach included targeted LNAPL recovery instead of large-scale operation
- Successful demonstration of decreasing LNAPL mobility/transmissivity with targeted LNAPL removal
- Provided basis for decision-making for subsequent discovery or monitoring results with significant LNAPL

Lessons Learned

- LNAPL mobility/transmissivity at fractured rock sites can be evaluated using similar field methods to unconsolidated sites
- At sites/wells with sufficient fracture density/ connectivity and LNAPL saturation, the behavior can be modelled as EPM
- At sites/wells that don't behave like EPM (which is the majority), baildown and skimming tests provide information on distinct fracture intervals
- Quantifying equivalent LNAPL transmissivity provided context to regulators on the scale of the problem and the performance of remedies



(ft)	
L/	
× 0	
<u>v</u>	
a V	
Ď	
Ч	
A	
\leq	

		1.0		-
NN		0.9	_	
δ		0.8	_	
N N	(t)	0.7	_	
)ra	ft/i	0.6	_	
	0 (f	0.5	_	
Ze)//s	0.4	_	
ali	s(t	0.3	_	
LU		0.2	_	
20		0.1	_	
		0.0		

Baildown Test Results

LNAPL Discharge (ft³/d)



Bouwer and Rice Type Curve



LNAPL Recovery Decision Making



It's a Question of Scale

Groundwater

LNAPL

Alec Danielson, PE, PG; adanielson@barr.com Joe Berns, PE; jberns@barr.com Patrick McHugh, PE; pmchugh@psands.com

• Fracture systems can be modelled as EPM when the scale of the evaluation is greater than the scale of the controlling fractures/conduits within the study area. This allows for estimation of hydraulic conductivity and storativity for a representative elemental volume of aquifer.

• Fracture systems can be modelled as EPM when: 1) fractures are connected and distributed throughout the impacted interval, 2) the impacted interval is significantly saturated with LNAPL, and 3) the impacted interval is significantly thicker than the fracture spacing. This allows for estimation of representative equivalent LNAPL transmissivity without considering storativity.



Typical Cores

Not Suitable for EPM

Potentially Suitable for EPM





- Full recovery
- Disconnected fractures



- Incomplete recovery
- Connected fractures