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INVESTIGATION AND REMEDIATION STRATEGIES FOR A DNAPL IMPACTED SITE IN STRATIFIED SOILS

SEACOR
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Christopher Reiss

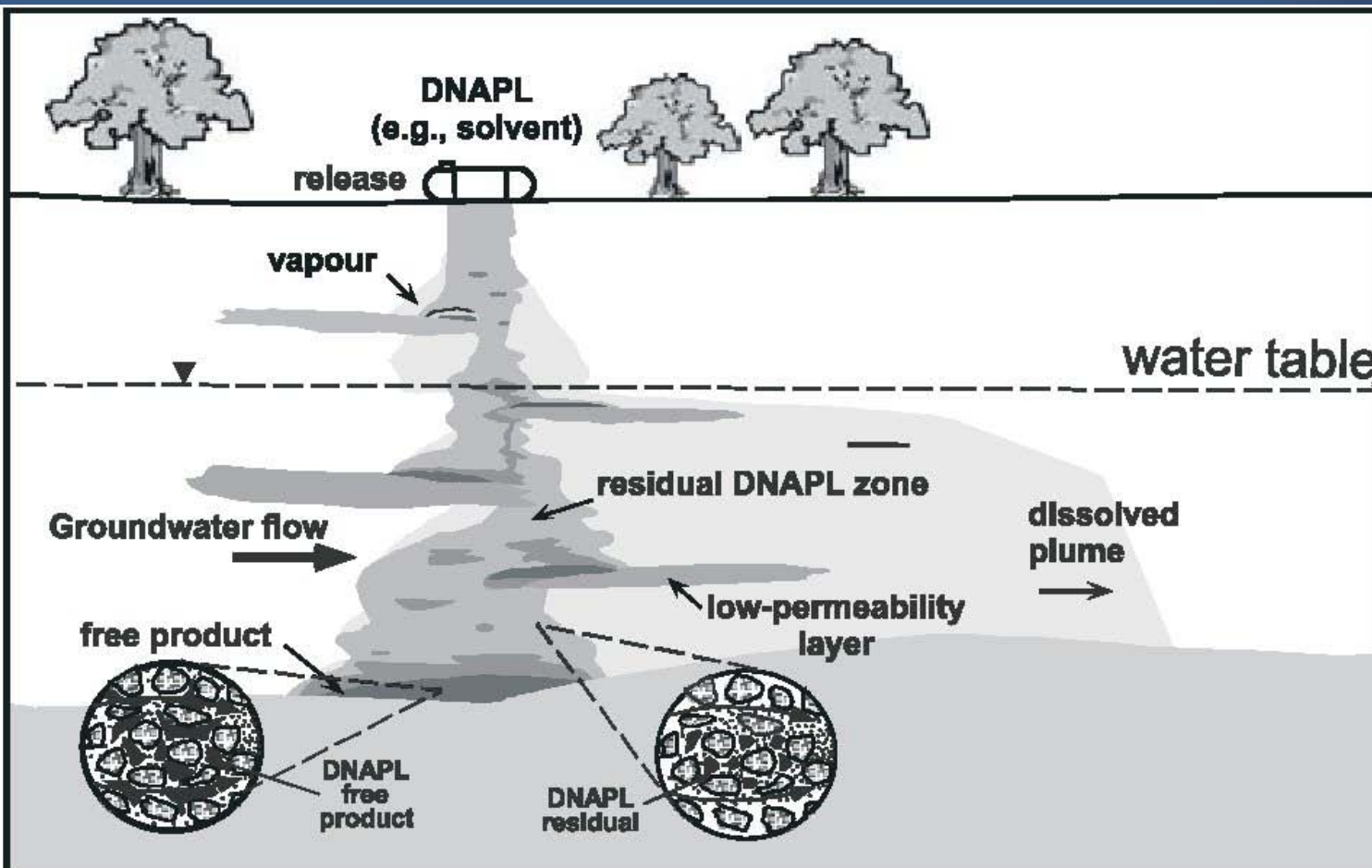
Overview

- DNAPL Intro
- Case Study: DNAPL Site History
- Field Investigation Program
- Pilot Testing program
- Results and Partial RAP
- Completed RAP
- Summary

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INTRO: DNAPL Difficulty

- Requires more complex delineation



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Case Study: Chemical Company Warehouse Facility Site



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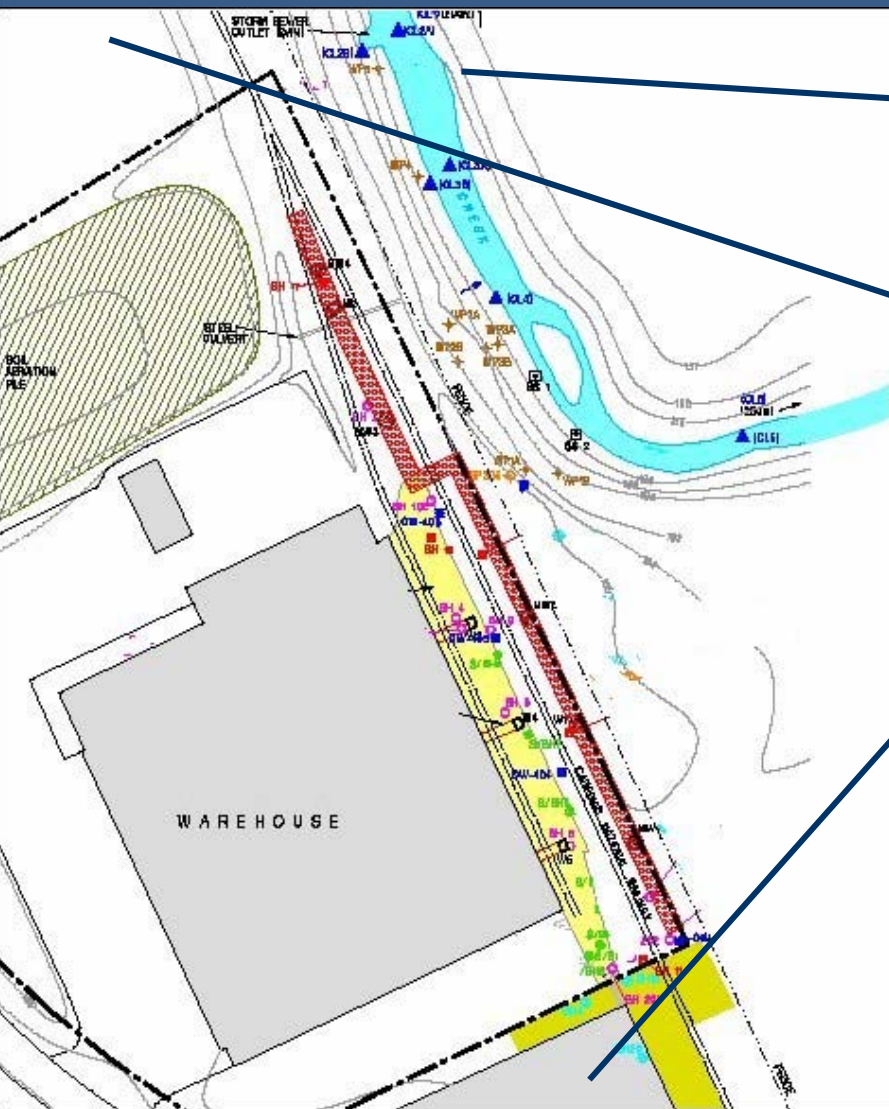
Case Study: Chemical Company Warehouse Facility Site

- Located in an industrial area
- Borders paper shredding company, warehouse, and a Creek
- Current operations include receiving, storage and shipping of chemicals, food additives and plastic pellets

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Case Study: Chemical Company Warehouse Facility Site



Creek

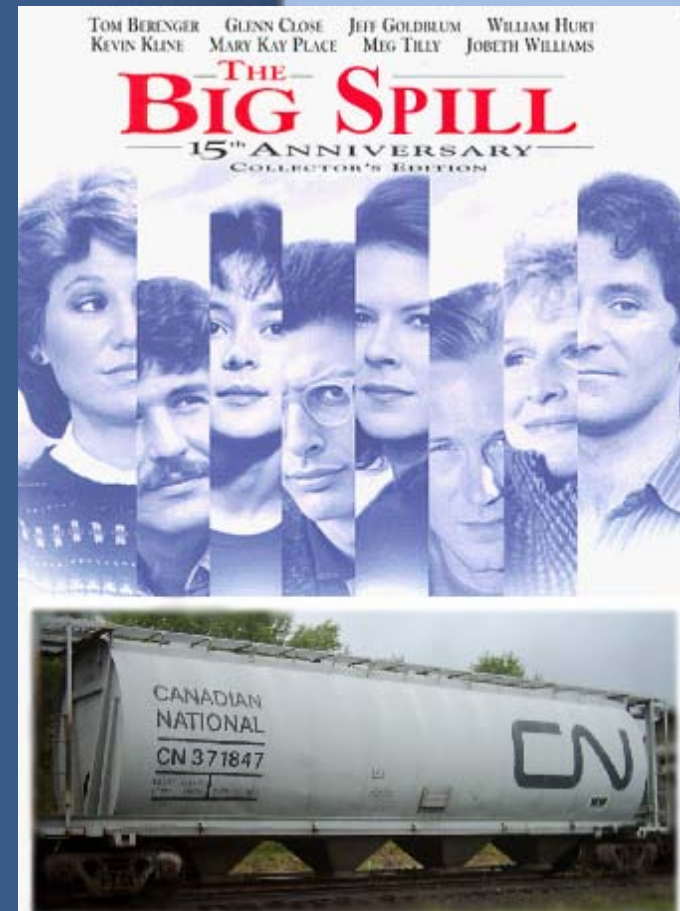
Shredding
company

Adjacent warehouse

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Case Study: Chemical Company Contamination History

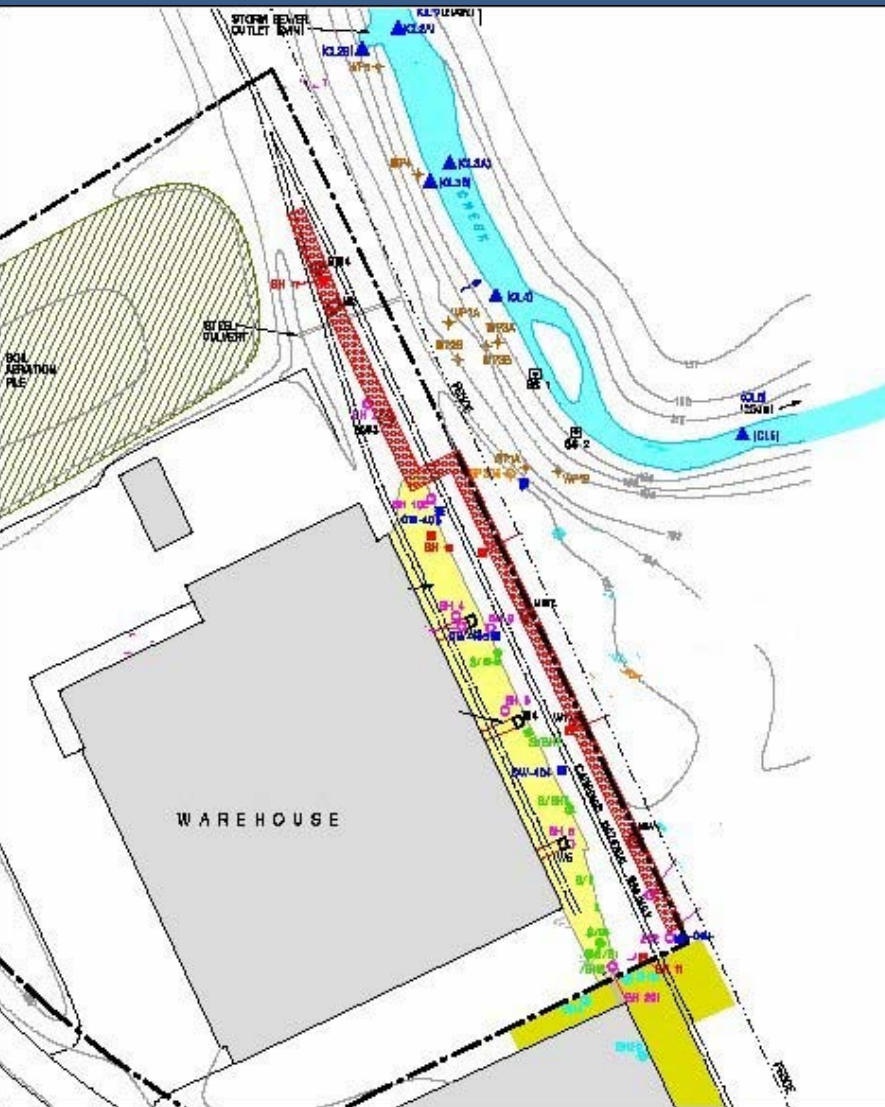
- Many gallons of PCE were released in 1984 from a sabotaged tankcar during former use as chemical handling facility
- PCE pool likely flowed into rail ballast, building footings and overland via drainage topography



Spend some time with a few good friends.

DVD
VIDEO

Case Study: Chemical Company Early Cleanup Measures



- Excavation zone
- Excavation zone II
- PCE collection trenches

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Case Study: Chemical Company

Arrival of SEACOR...

- SEACOR was retained to supervise the installation of monitor wells by Company's original consultant based out of California
- Company decides to retain local SEACOR office as service level from original consultant declines due to distance (= 'Client')

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Case Study: Chemical Company

Property Politics



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Case Study: Chemical Company

Property Politics II

- Negotiations with all parties and local Regulator proposed a 'Joint Investigation' to confirm the contaminant distribution
- Joint Investigation was performed by SEACOR and the 'Consultant' (Former Owner's consultant) in the summer of 2002



Case Study: Joint Investigation

SEACOR & Consultant

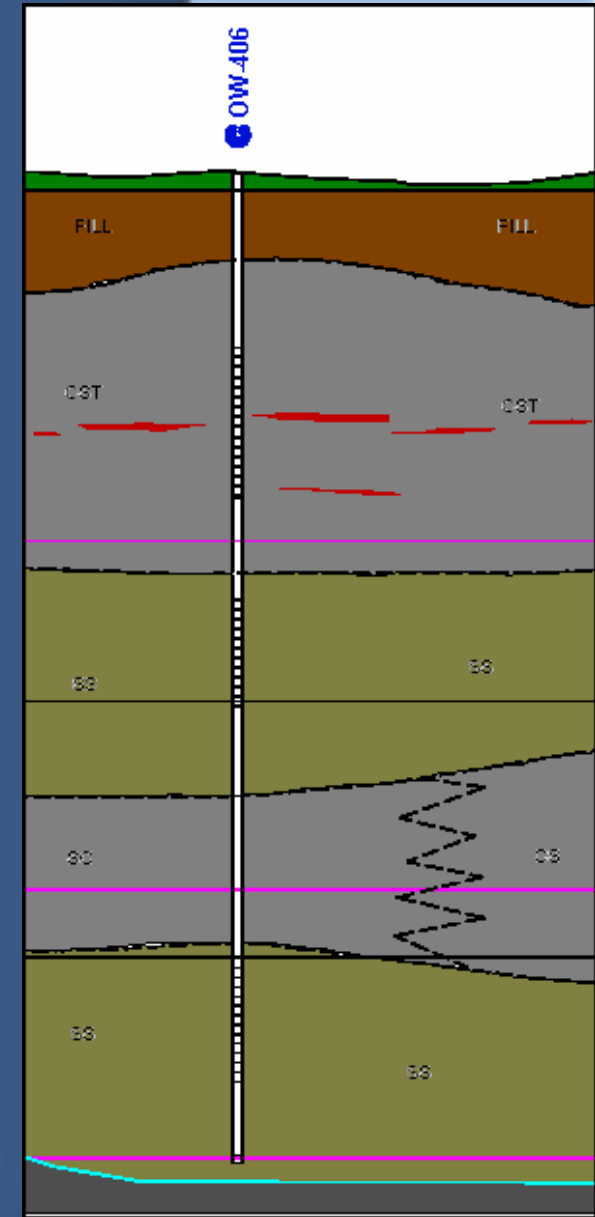
- Fourteen locations drilled in nests of three
- Consultant installed seven off site nests and SEACOR installed seven on site
- 2" PVC nests consisted of a well at 22' (7m), 45' (14m) and 65' (20m)



Case Study: Joint Investigation

Typical Site Stratigraphy

- 1-2 m of clay Silt fill
- Shallow Zone: clay Silt (to approximately 25')
- Middle Zone: sandy Silt (to approximately 45')
- Lower Zone: sandy Silt (to approximately 65')

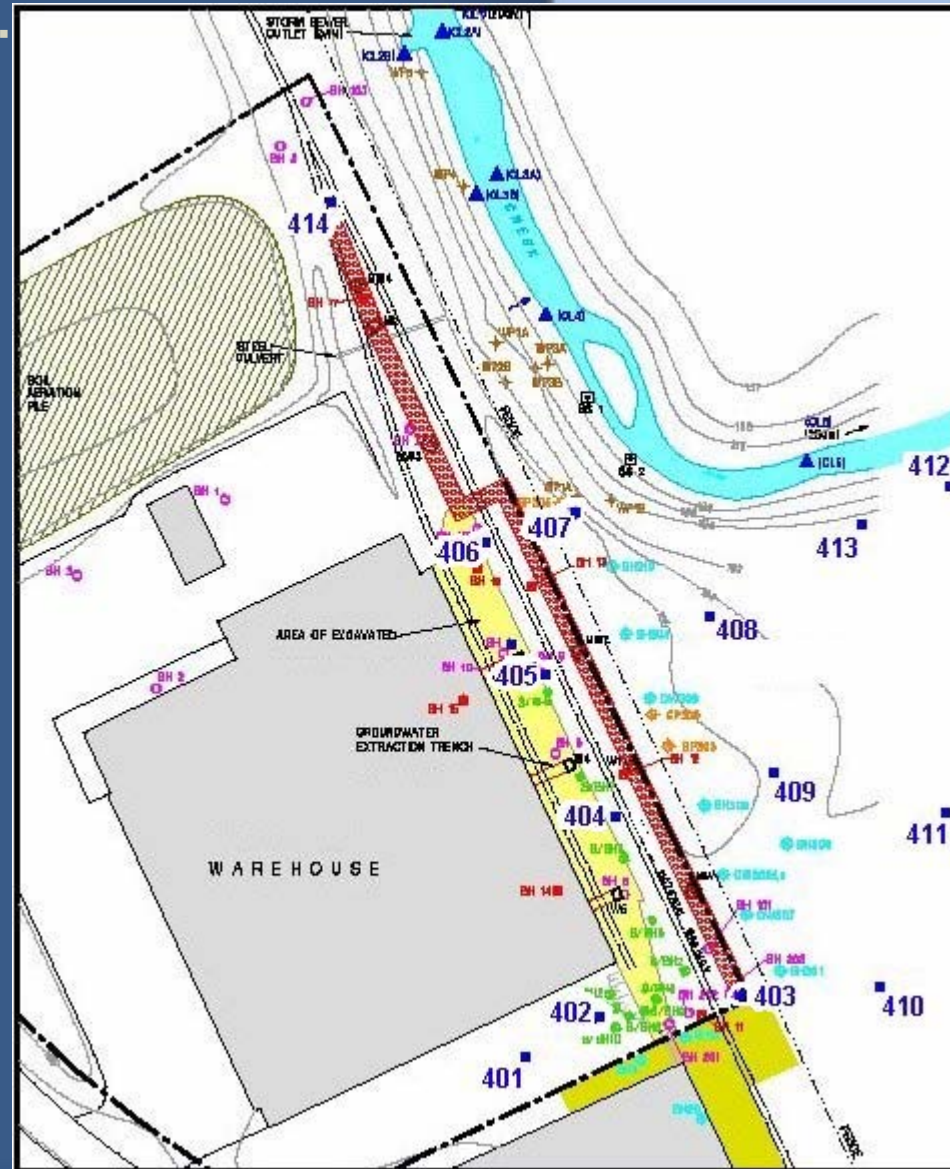


Case Study: Joint Investigation

Location, location, location...

High PCE Soil Concentrations:

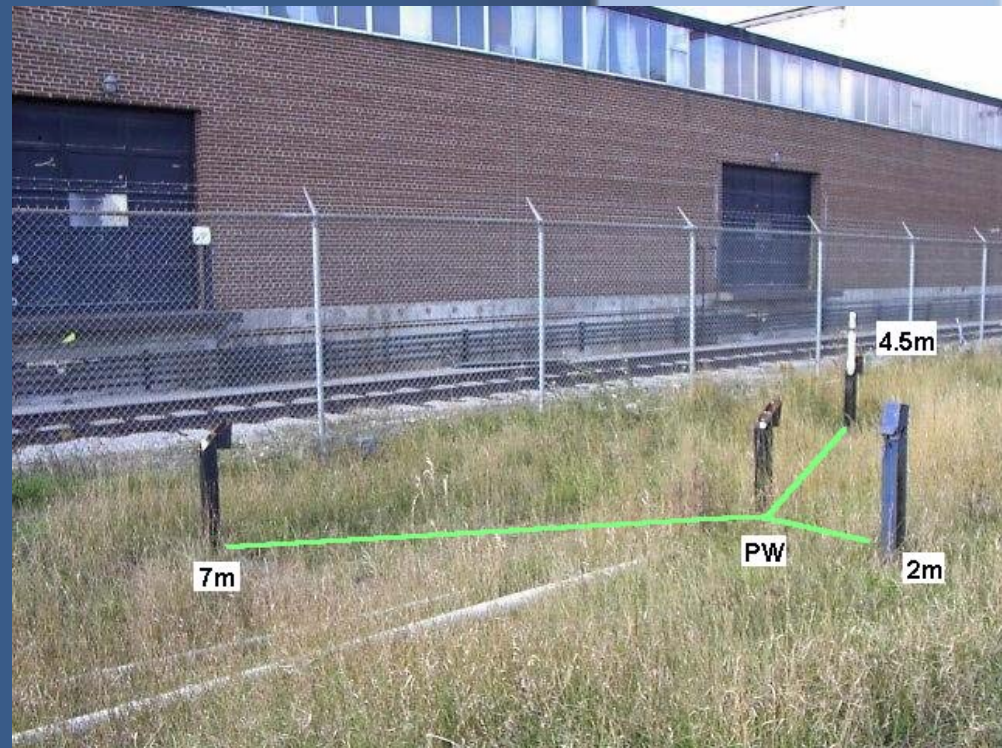
- Mainly in upper clay-silt zone, in visible silt seams at ~15-17'
- Some contamination at mid sandy silt zone
- Trace concentrations in the lower sandy silt zone
- Bad wells: 403, 404, 405, 408, 412 & 413 (up to 300 ppm)



Case Study: Pilot Test

Proposed Pilot Test

- SEACOR proposed installing 2" extraction and radius monitoring wells to test each zone's response to VEMPE in turn
- Extraction wells installed in each Zone with 2m, 4.5m and 7m radius monitoring wells



Case Study: Pilot Test

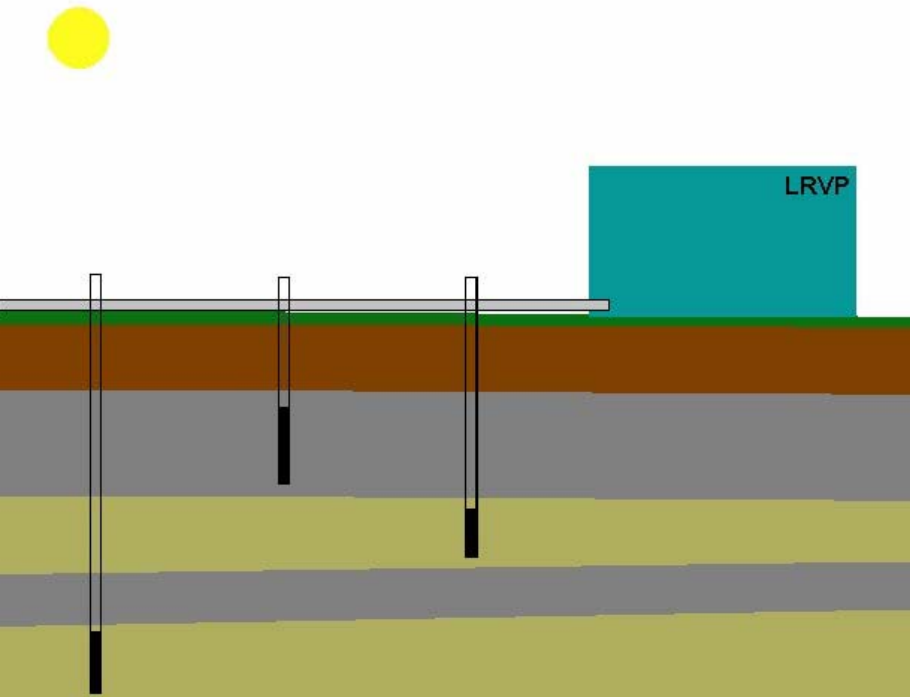
The System:

- Skid-mounted, 25 hp liquid ring vacuum pump unit
- Header line of 4" PVC ran from unit to each extraction well
- Liquid and air streams were collected and tied into existing remediation room air stripper and GAC

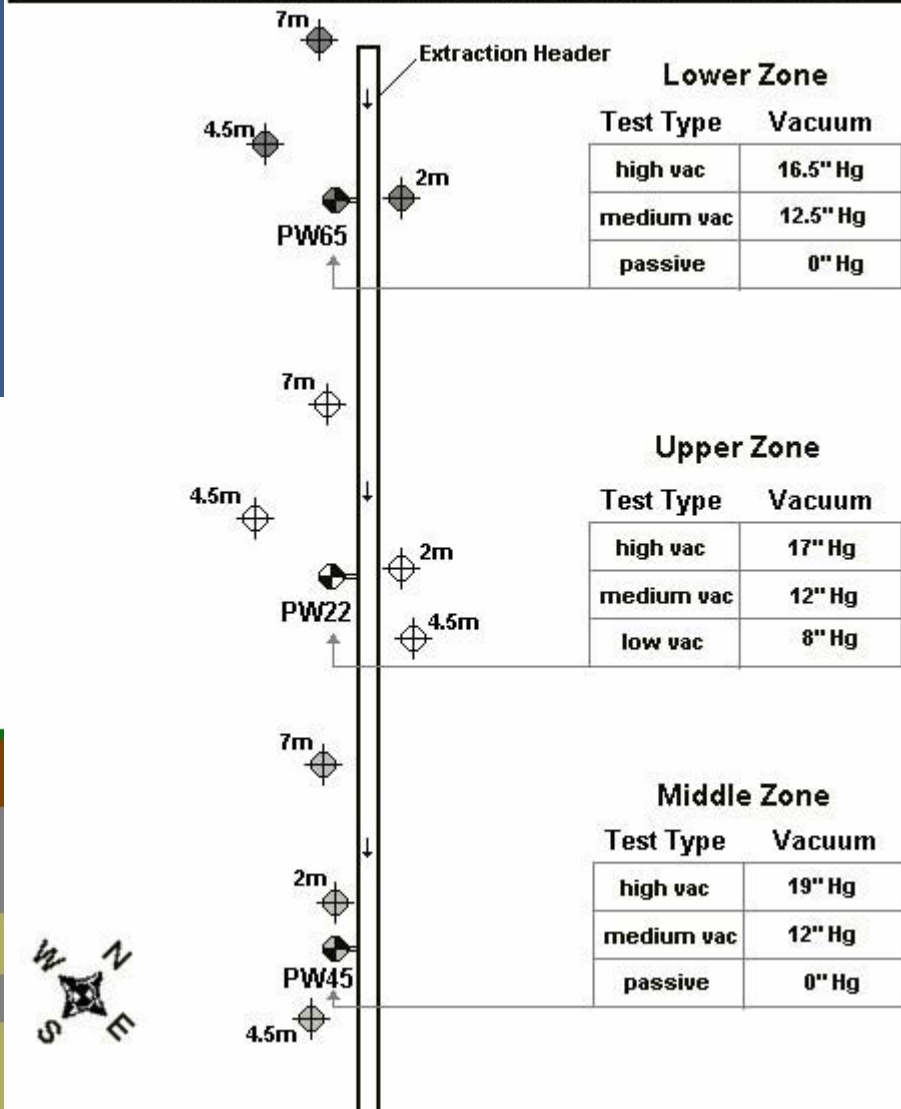


Case Study: Pilot Test

The System:



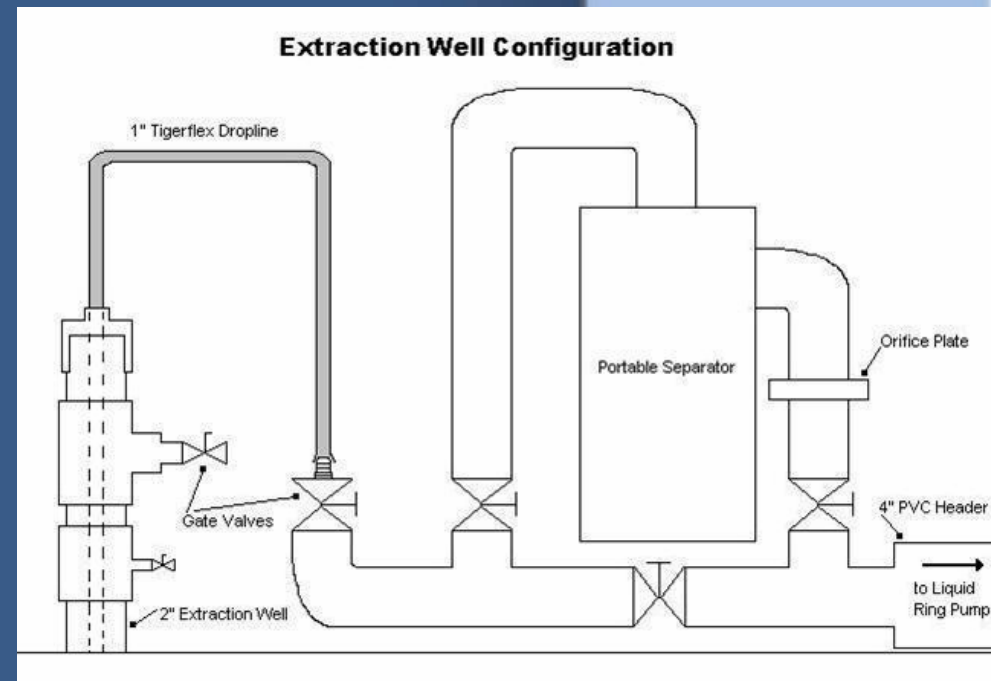
Pilot Test Well Spacing and Vacuum Schedule



Case Study: Pilot Test

The Extraction Well:

- Modular well head coupled via 2" Cam-locks and could be moved to each test location
- Portable separator to measure air and water flow at well



Case Study: Pilot Test Results

Upper Zone Results (12-22' Screen):

- High, Medium and Low vacuum (17, 12 and 8" Hg) were run at this depth with extreme cold and shut down delays
- Excellent PCE removal (product observed in drop lines during start-up)
- 2.4 kg of PCE removed in 7300 l groundwater (5 l/day average pump rate)
- 350 kg of PCE removed in the vapour stream (290 g/hour average PCE removal rate)

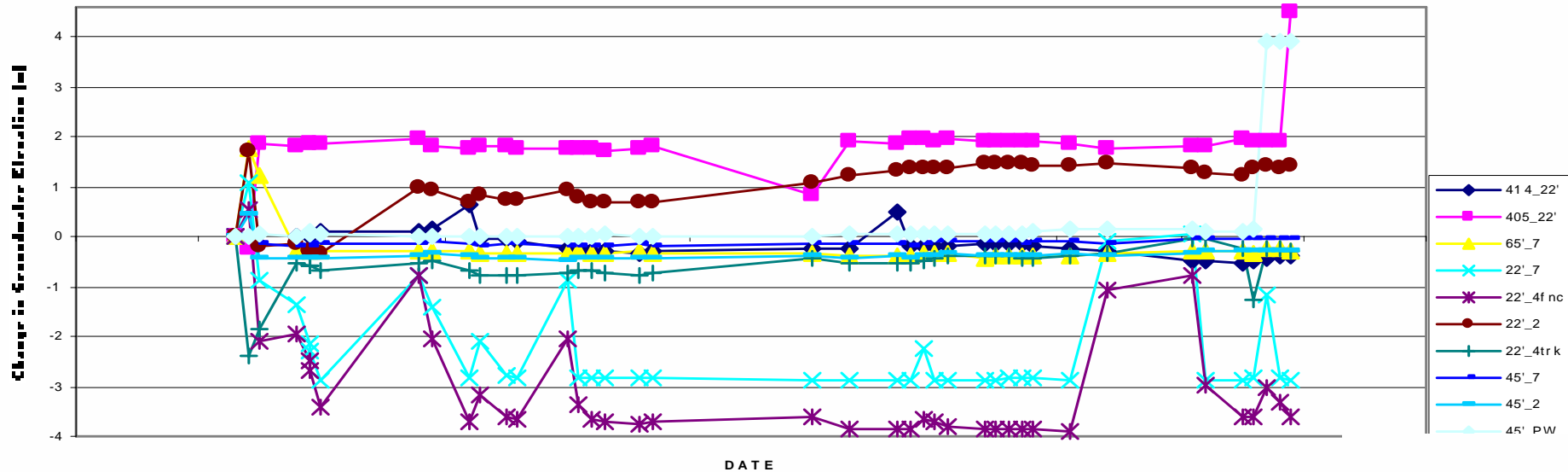
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Case Study: Pilot Test Results

Upper Zone Results (12-22' Screen):

- Overall drawdown and vacuum response was erratic due to shutdowns and a 'utility trench' nearby

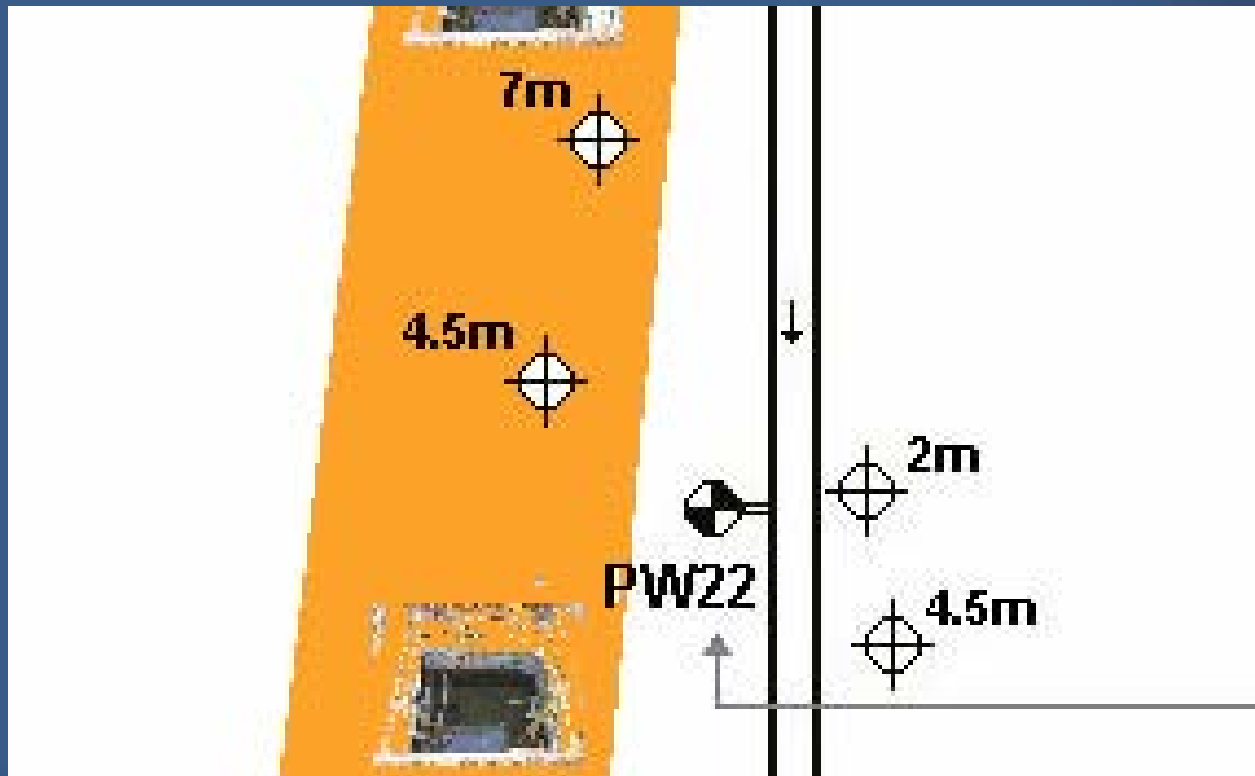
CHANGE IN GROUNDWATER ELEVATION - 22' Zone



Case Study: Pilot Test Results

Upper Zone Results (12-22' Screen):

- Initially, all local monitor wells responded
- Once vacuum reached the trench, only drawdown and vacuum were observed in 22'_4.5F and 22'_7



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Case Study: Pilot Test Results

Mid Zone Results (30-45' Screen):

- High, Medium and Passive (no vacuum) were run at this depth (19, 12 and 0" Hg)
- Minor PCE removal but smoother operation
- 1.3 g of PCE removed in 2819 l groundwater (80 l/day average pump rate)
- 57 g of PCE removed in the vapour stream (0.07 g/hour average PCE removal rate)

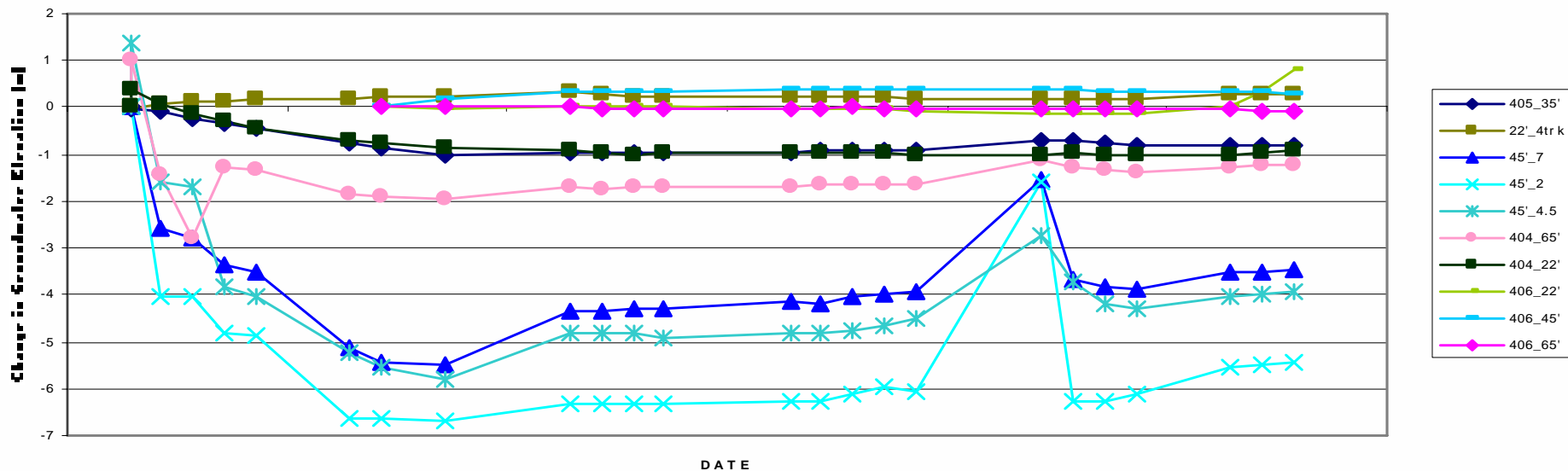
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Case Study: Pilot Test Results

Mid Zone Results (30-45' Screen):

- Drawdown response very good (over 25m)
- Vacuum response noted between 2 and 4.5m

CHANGE IN GROUNDWATER ELEVATION - BRENNTAG PILOT TEST 30-45' ZONE



Case Study: Pilot Test Results

Deep Zone Results (50-65' Screen):

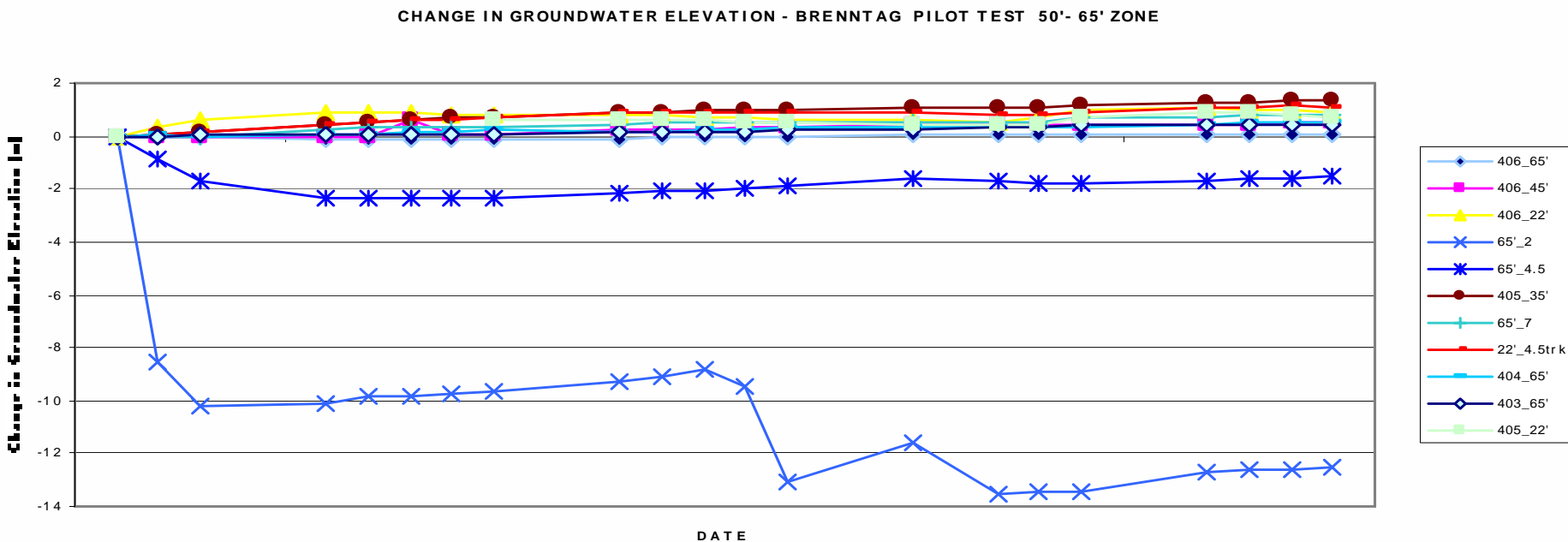
- High, Medium and Passive (no vacuum) were run at this depth (17, 12 and 0" Hg)
- Fourteen locations drilled in nests of three
- Minor PCE removal (limited analytical confirmed)
- 0.8 g of PCE removed in 1016 l groundwater (36 l/day average pump rate)
- Low mass in vapour stream similar to Mid test

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Case Study: Pilot Test Results

Deep Zone Results (50-65' Screen):

- Drawdown response between 4.5 and 7m
- Vacuum showed negligible response at 2m



Case Study: Operational Issues

1) Extreme Cold

- January 2003 had record cold weeks with the monthly average low at -22 C and windchills driving that to the -40's
- Expansion of the 2" extraction well to the 4" header under vacuum caused freezing of the wellhead to well head with additional heater
- Even with the heating panel on, the inlet separator froze in the LRVP unit if the unit shut down for any length of time

Thursday



High -42°C

Low -76°C

Flurries

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Case Study: Operational Issues

1) Solution:

- Additional heater installed in unit
- Insulated well head cover built with piped warm air from unit air-stripper blower (stripper not used) as well as tech-cable ran to well head with additional heater
- Solenoid valve installed to apply vacuum to well for 1 minute, then open and allow flow for 20 seconds (and repeat)

Thursday



High -42°C

Low -76°C

Flurries

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Case Study: Operational Issues

2) Extraction of Product

- Initial removal of high concentrations and observable separate-phase PCE ate through flow meter
- High vapour concentrations also caused H & S issue in existing Remediation Room (treatment)

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Case Study: Operational Issues

2) Solution:

- Flow meter removed until concentrations dropped in liquid stream
- Depth measurements of existing collection tank in site Remediation Room were taken and volumes calculated manually
- Overhaul of leaking components, stripper and associated piping

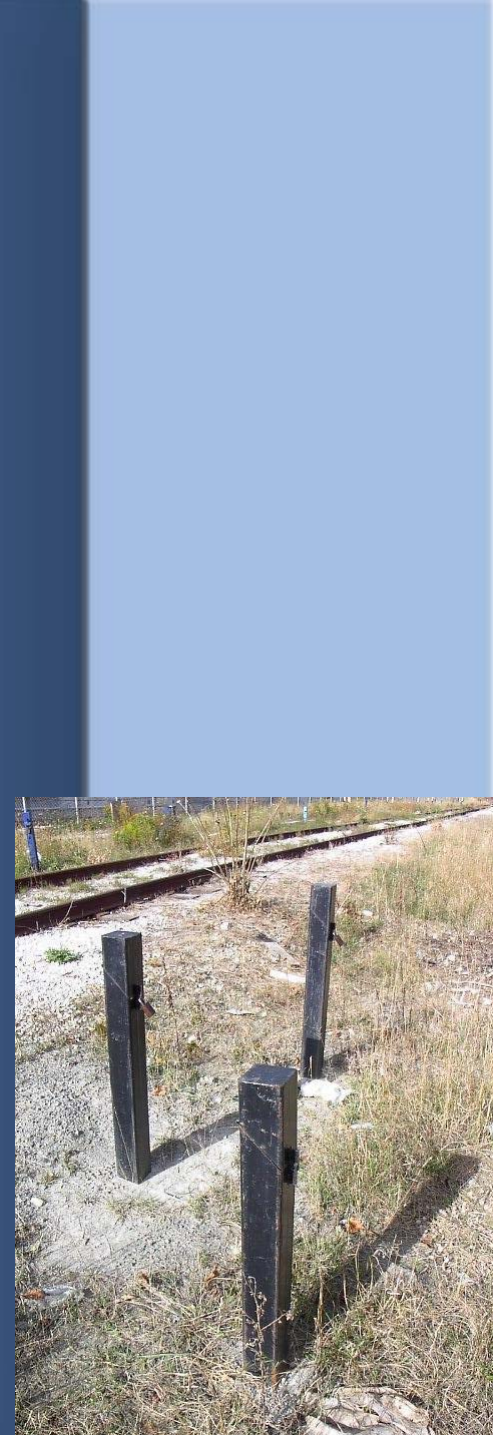
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Case Study: Partial RAP

Pilot Test Post Mortem

- The Consultant did not support the VEMPE test results in the Upper zone soils due to the lack of drawdown at 2m
- The Consultant was impressed with the Mid zone results
- Hydraulic conductivity testing of select wells was performed by both consultants to evaluate the option to control Mid zone impacts and replace the partially effective collection trenches



Case Study: Partial RAP

k Testing Results...

- k's averaged in the order of 10^{-7} m/s for Mid zone
- This appeared inconsistent with Pilot Test observations



Average Hydraulic Conductivity Measured in Well Nests (k, m/s)

	Upper Zone	Mid Zone	Lower Zone
Soil Unit:	Clayey Silt	Sandy Silt	Sandy Silt/Clay Silt
Aprx. Screen Interval:	3.5 - 6.5 m	7.5 - 10.5 m	16 - 19 m
Average k (Hvorslev):	2.08×10^{-8}	2.03×10^{-7}	2.51×10^{-7}

Case Study: Partial RAP

Hydraulic Control Well Pilot (H-well)

- Two 4" PVC H-wells were installed at the property line (H-1 and H-2)
- Pumping tests revealed low k values again, but more evidence of drawdown influence



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Case Study: Partial RAP

More k Testing...

- The Consultant requested the testing of each individual H-well for k
- Testing was performed in 2 stages, every other well and then the alternate set
- Results again showed low k values, but observed evidence of influence in H-well midpoints and well nests

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Case Study: Partial RAP

Test Results

Chart 2: Head Drawdown in Neighboring H-Wells, June 2005

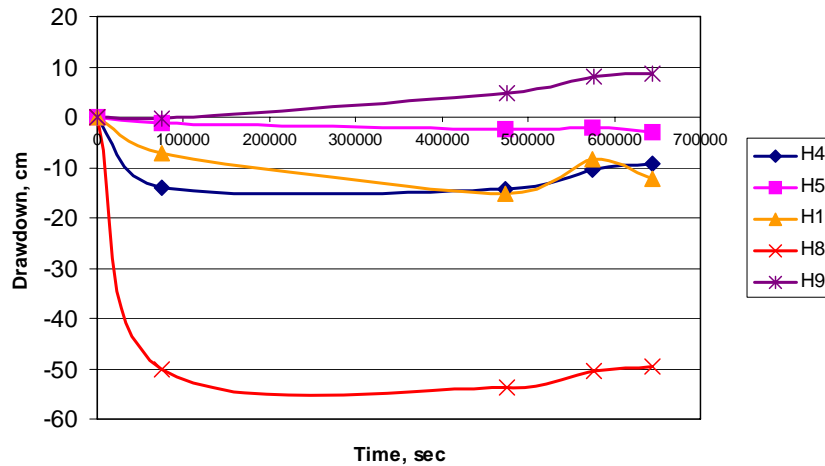
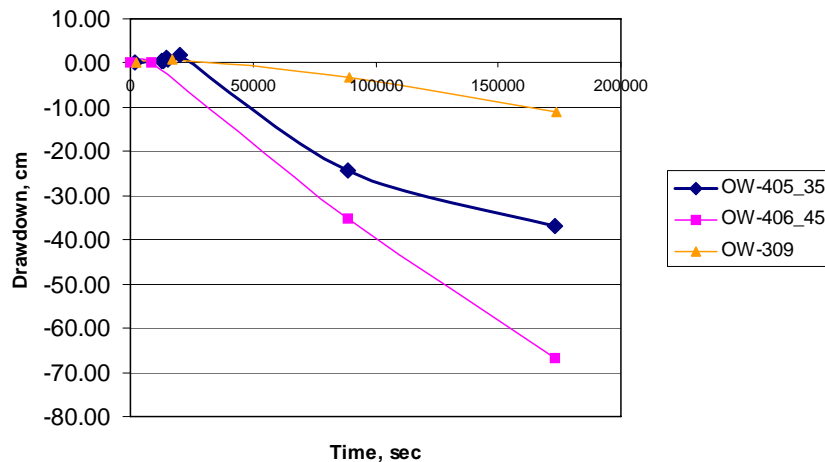


Chart 1: Head Drawdown in Neighboring Well Nests, November 2004



Summary Table

Well	K, m/s	
	2004	2005
H2		5.80E-09
H4	1.38E-08	
H3		1.75E-09
H5	1.09E-09	
H6		7.03E-09
H1	5.28E-09	
H7		3.17E-09
H8		
H9		
H10	1.02E-09	1.09E-09

Average: 4.88E-09

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Case Study: Partial RAP

- Confidence gained for dissolved phase impact control in Mid zone soils at the property line (via H-well system)
- Focus turned to perceived source areas and evidence of product migration (seams observed at OW-403)
- Additional BH's drilled between well nests confirmed more small, PCE-saturated seams between 15-18' and evidence of product

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Case Study: Complete RAP

- Former owner and Consultant required excavation as part of whole on-site RAP
- SEACOR wished to remove source zone via VEMPE
- Compromise agreed on whereby SEACOR proposed a 'strip excavation' adjacent to property line to depth of Mid zone soils (6-7m)

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Case Study: Complete RAP

RAP Objectives

- Address migration of PCE off-site in Mid zone soils
- Control and recover DNAPL in preparation for Risk strategy for dissolved phase impacts

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Case Study: Complete RAP

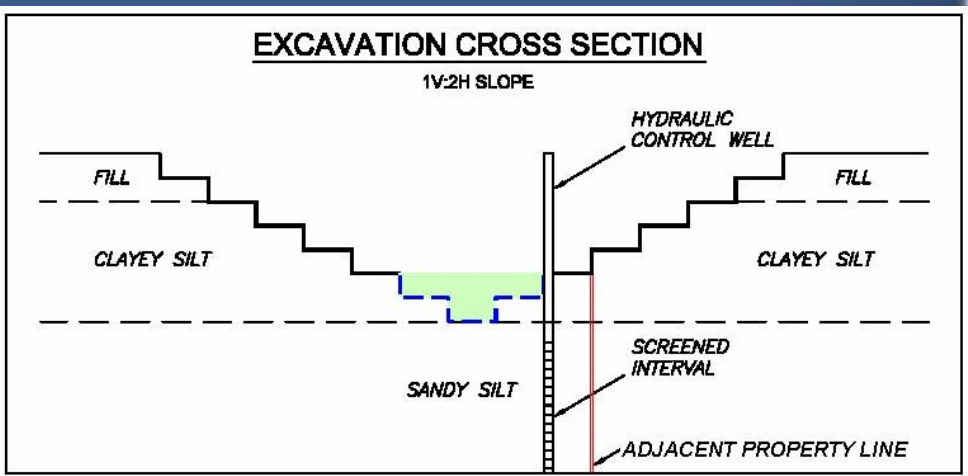
RAP Overview

- 1) Excavation of Upper Zone at Property Line
- 2) Hydraulic Control of Mid Zone at Property Line
- 3) VEMPE of Source Areas and Residual PCE in Upper Zone

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Case Study: Complete RAP

1) Excavation



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2) Hydraulic Control



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Case Study: Complete RAP

3) VEMPE Product Recovery



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Case Study: Summary

The Successful Approval

- Multiple field tests with cooperative observation
- Use of in-house and external DNAPL experts
- Made use of the excavation 'requirement' to further impede PCE migration

All components of RAP were approved by Client, Former Owner and Consultant ...

APPROVED BY LOCAL REGULATOR!

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Case Study: Summary

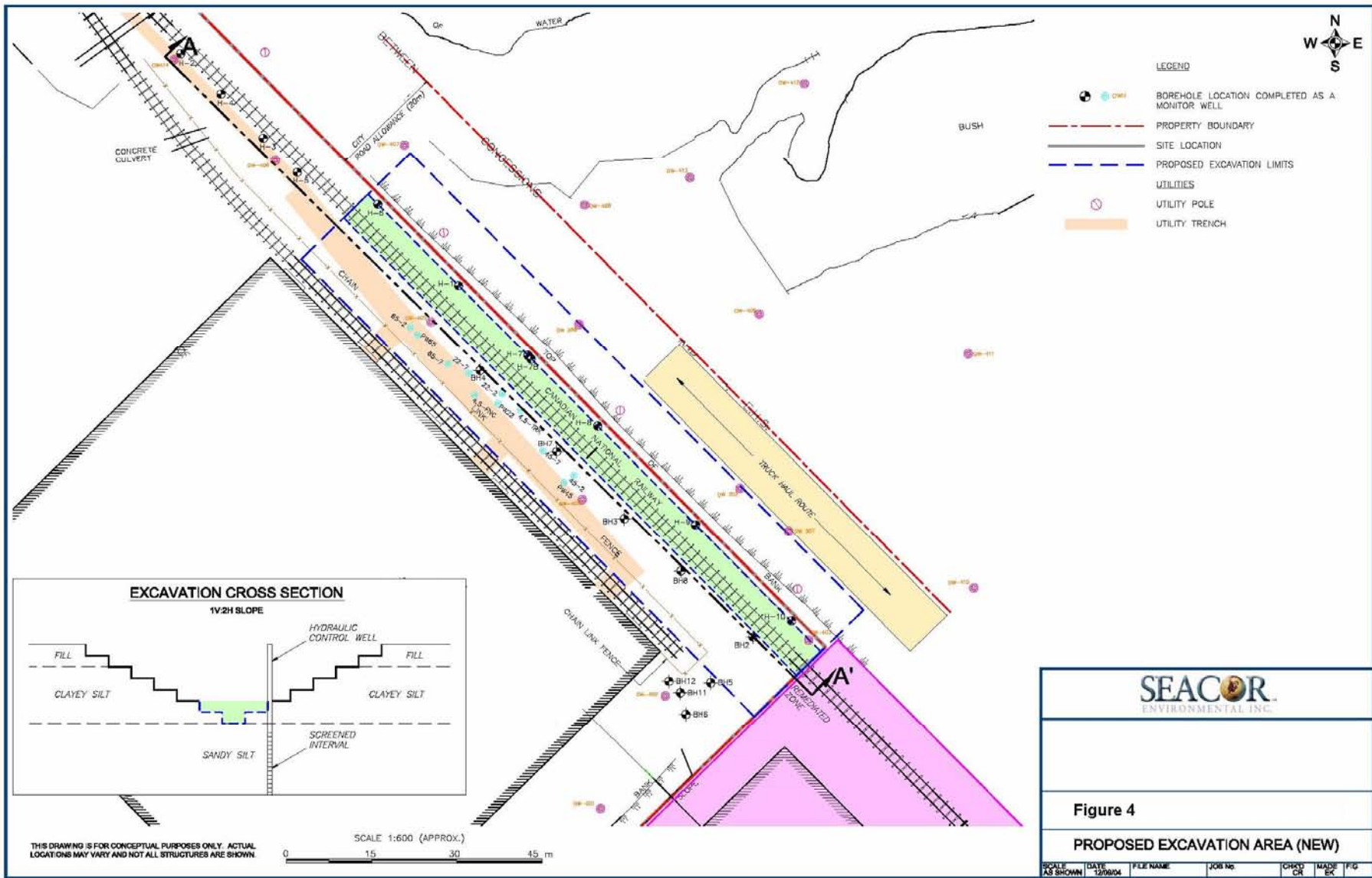
Schedule

- H-wells already installed
- Excavation phase to start winter 2005
- System I and II commissioning to follow in spring 2006

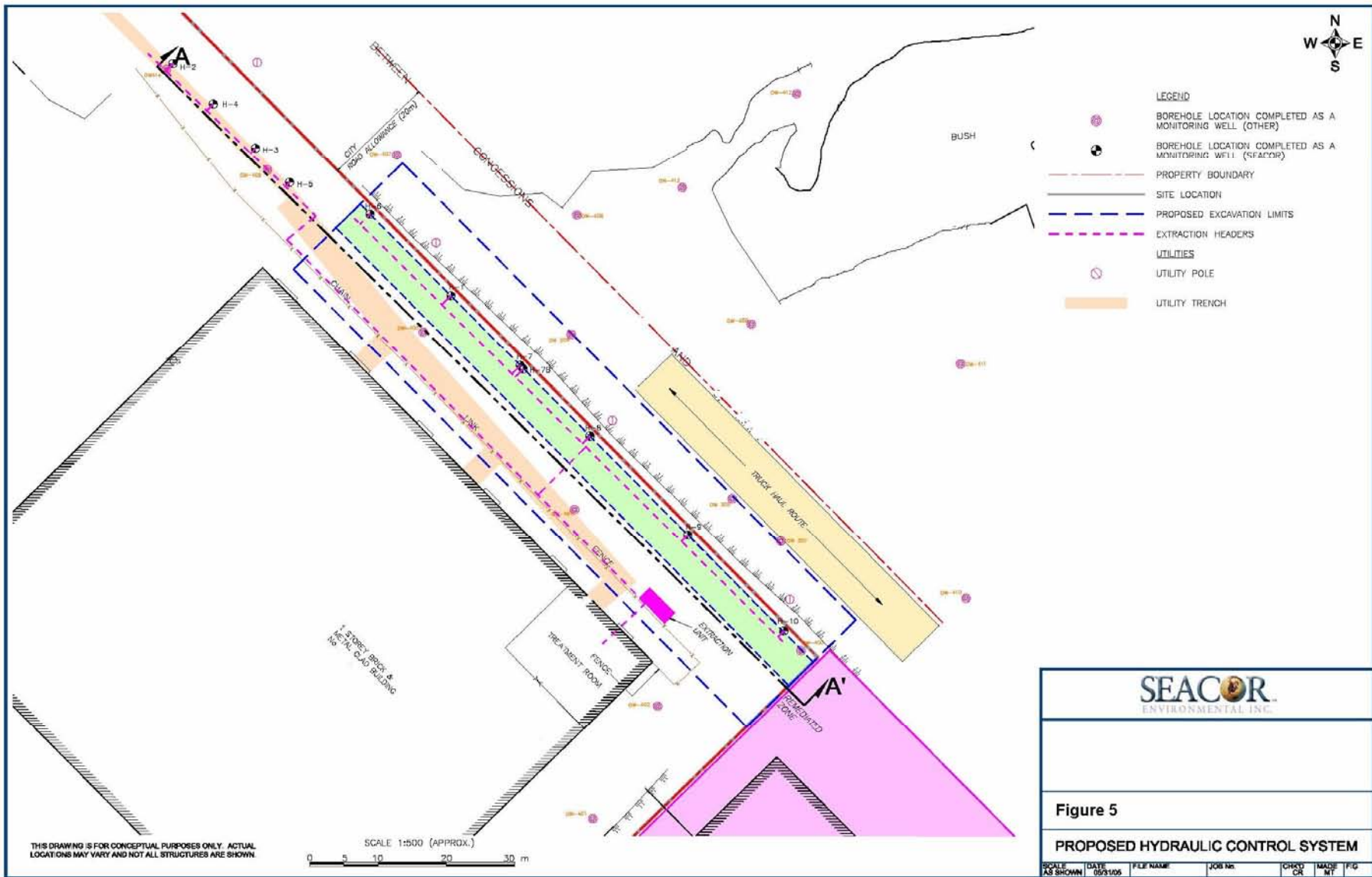
THANK YOU

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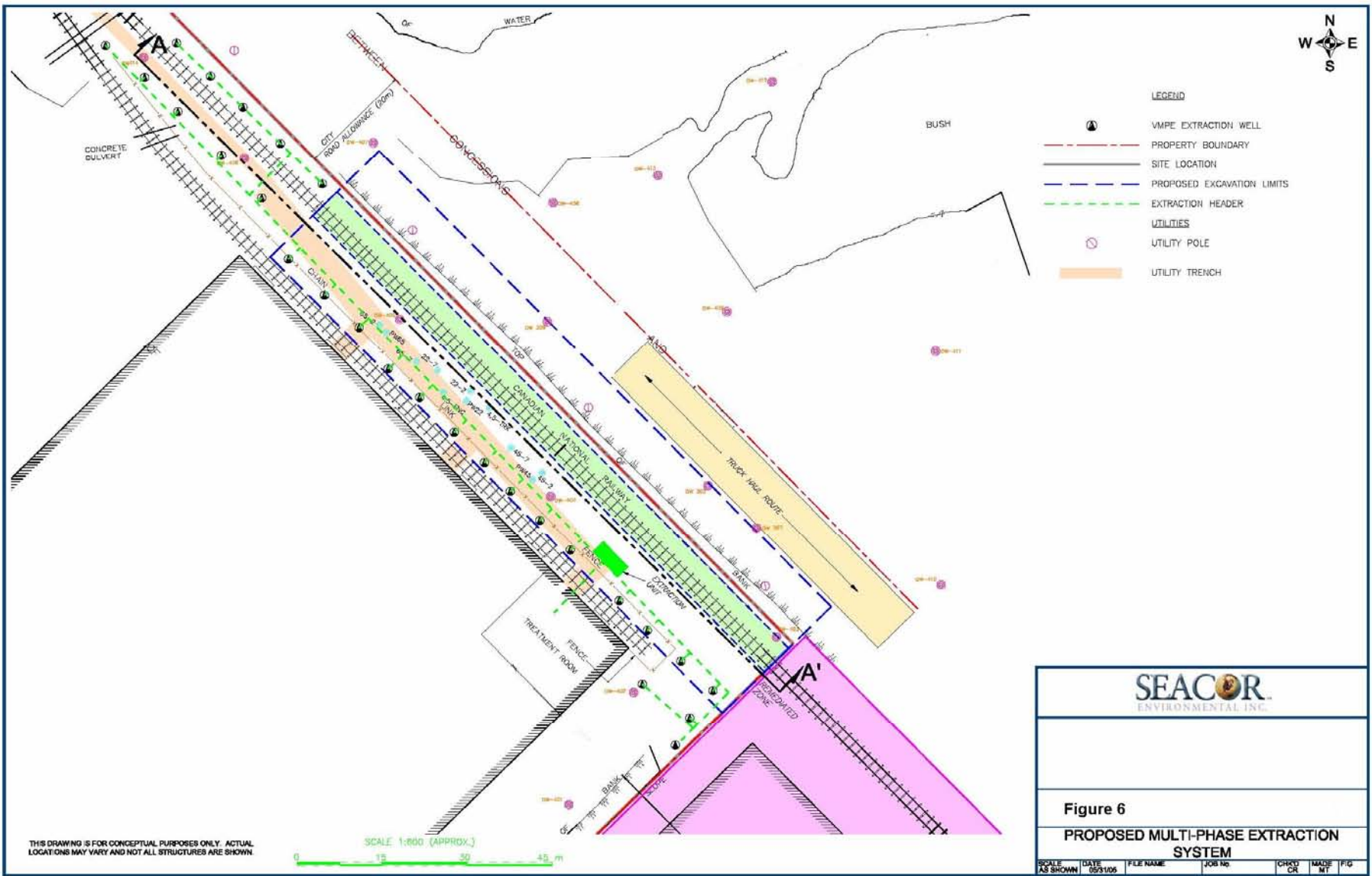
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THANK YOU



THANK YOU



THANK YOU