Permeable Reactive Barriers Can Be a Cost Effective Tool To Deal With Groundwater

SMA Environmental Forum
Ryan Riess, M.Sc. P.Eng
PINTER & Associates
October 17, 2018

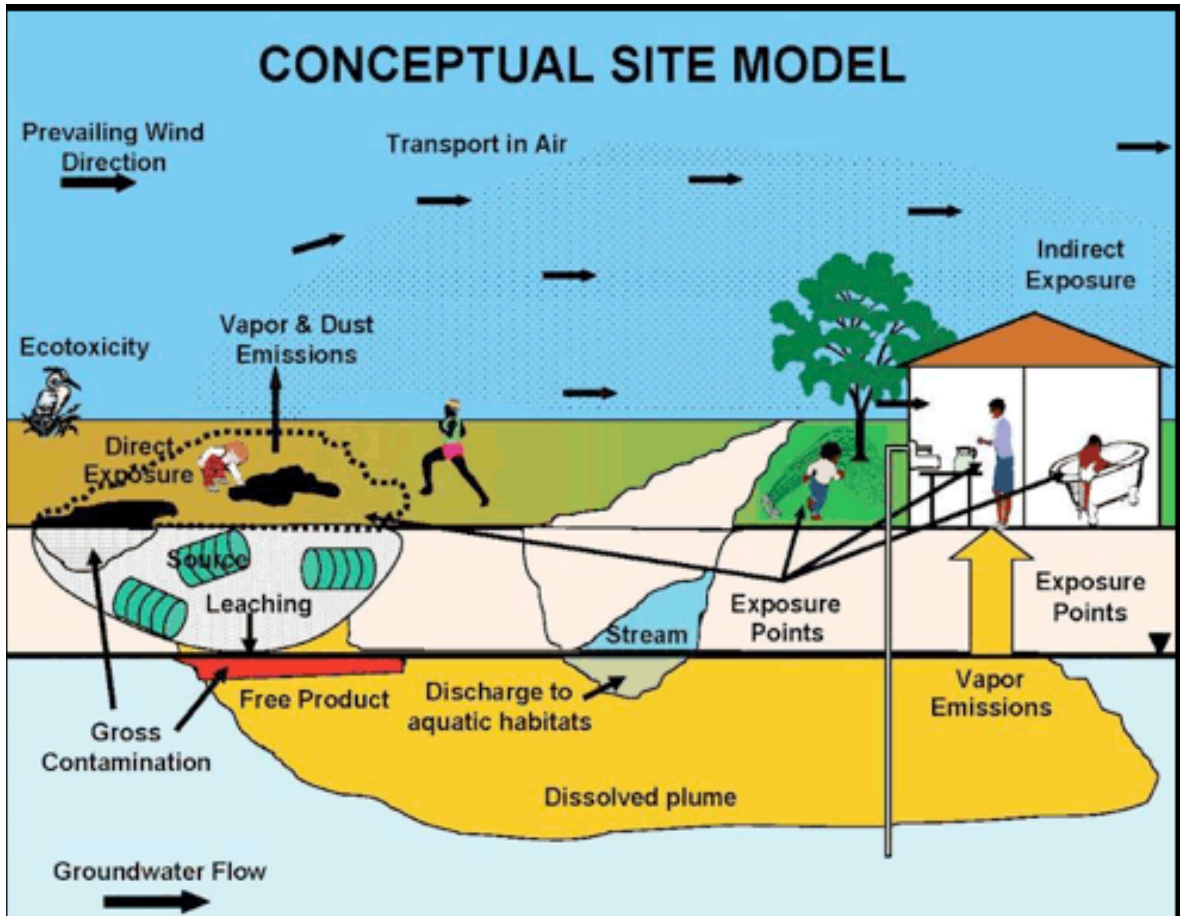
PINTER & ASSOCIATES

Overview

- Source-Pathway-Receptor Discussion
- Soil Ingestion Pathway Example
- Permeable Reactive Barrier(PRB) Basics
- Case Study 1
- Case Study 2
- Case Study 3
- Case Study 4
- Questions

PINTER & ASSOCIATES

Source-Pathway-Receptor



PINTER & ASSOCIATES

Soil Ingestion Pathway

PINTER & ASSOCIATES

PRB Basics

- Must be more permeable than surrounding soils
- Ideally tied in to an underlying impermeable layer
- Can be used to protect specific receptors, eliminate specific pathways or achieve full remediation

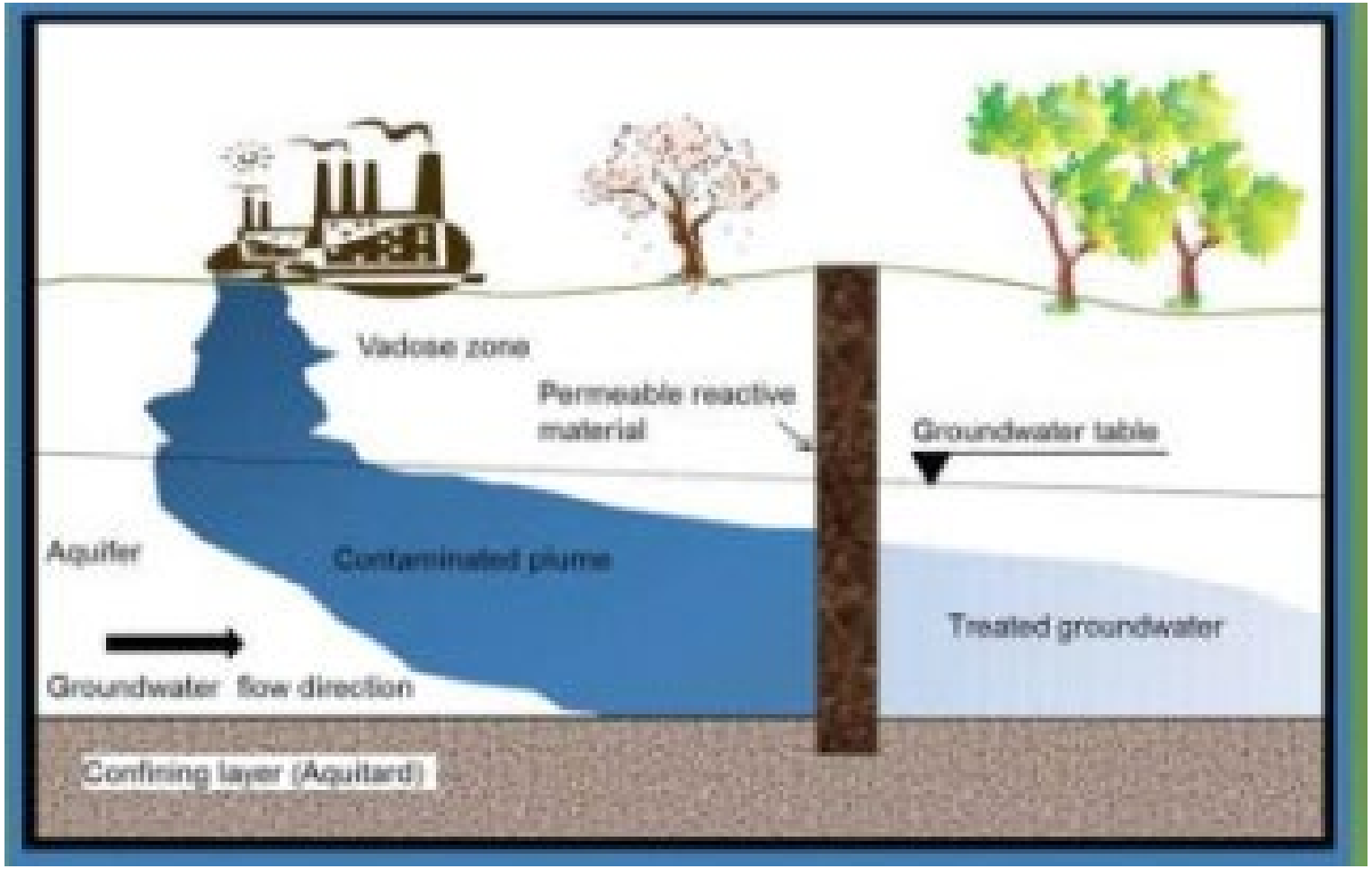
PINTER & ASSOCIATES

PRB Basics

- Reactive material can be mixed with sand or gravel
- Can be effective from months to decades
- Four main processes:
  - Stick to reactive material;
  - metal precipitation,
  - reaction directly with prb material,
  - biodegradation

PINTER & ASSOCIATES

What is a PRB?



PINTER & ASSOCIATES

Contaminants

Table 4-1. Examples of COCs treated by types of reactive materials used in PRBs

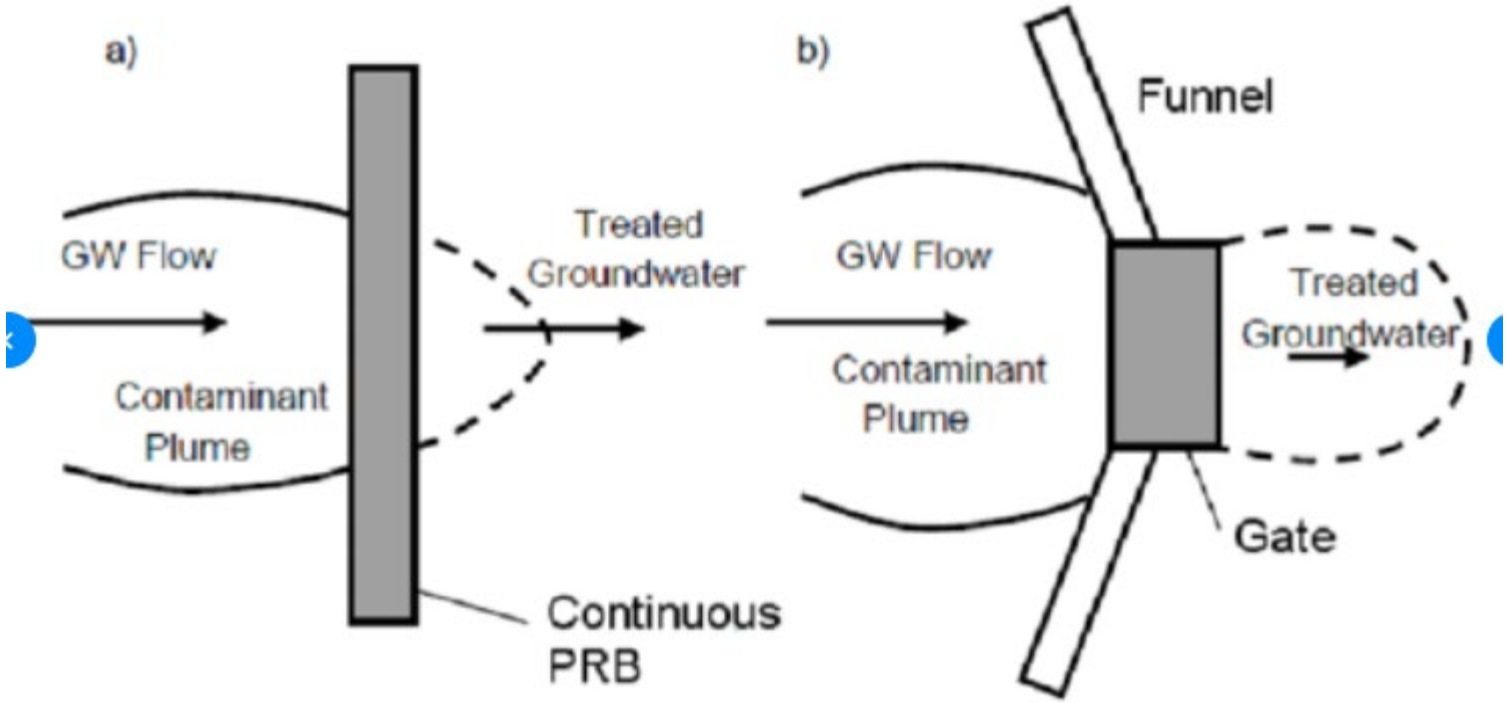
COCs	ZVI	Biobarriers	Apatite	Zeolite	Slag	ZVI-carbon combinations	Organophilic clay
Chlorinated ethenes, ethanes	F[a]	F			L	F	
Chlorinated methanes, propanes						F	
Chlorinated pesticides						P	
Freons						L	
Nitrobenzene	P						
Benzene, toluene, ethylbenzene, and xylenes (BTEX)		F					
Polycyclic aromatic hydrocarbons (PAHs)							L
Energetics	P	F				P	
Perchlorate		F	F	L		L	
NAPL							F
Creosote							F
Cationic metals (e.g., Cu, Ni, Zn)	L	F	F		L	F	
Arsenic	F			L	F	F	
Chromium(VI)	F			L	L	F	
Uranium	F	P	F			T	
Strontium-90			F	F			
Selenium	L					L	
Phosphate					P		
Nitrate		F	F			F	
Ammonium				L			
Sulfate		F				L	
Methyl tertiary butyl ether (MTBE)		F					

[a] F = full-scale application, L = laboratory evaluation, P = pilot-scale application.

- ITRC, 2011

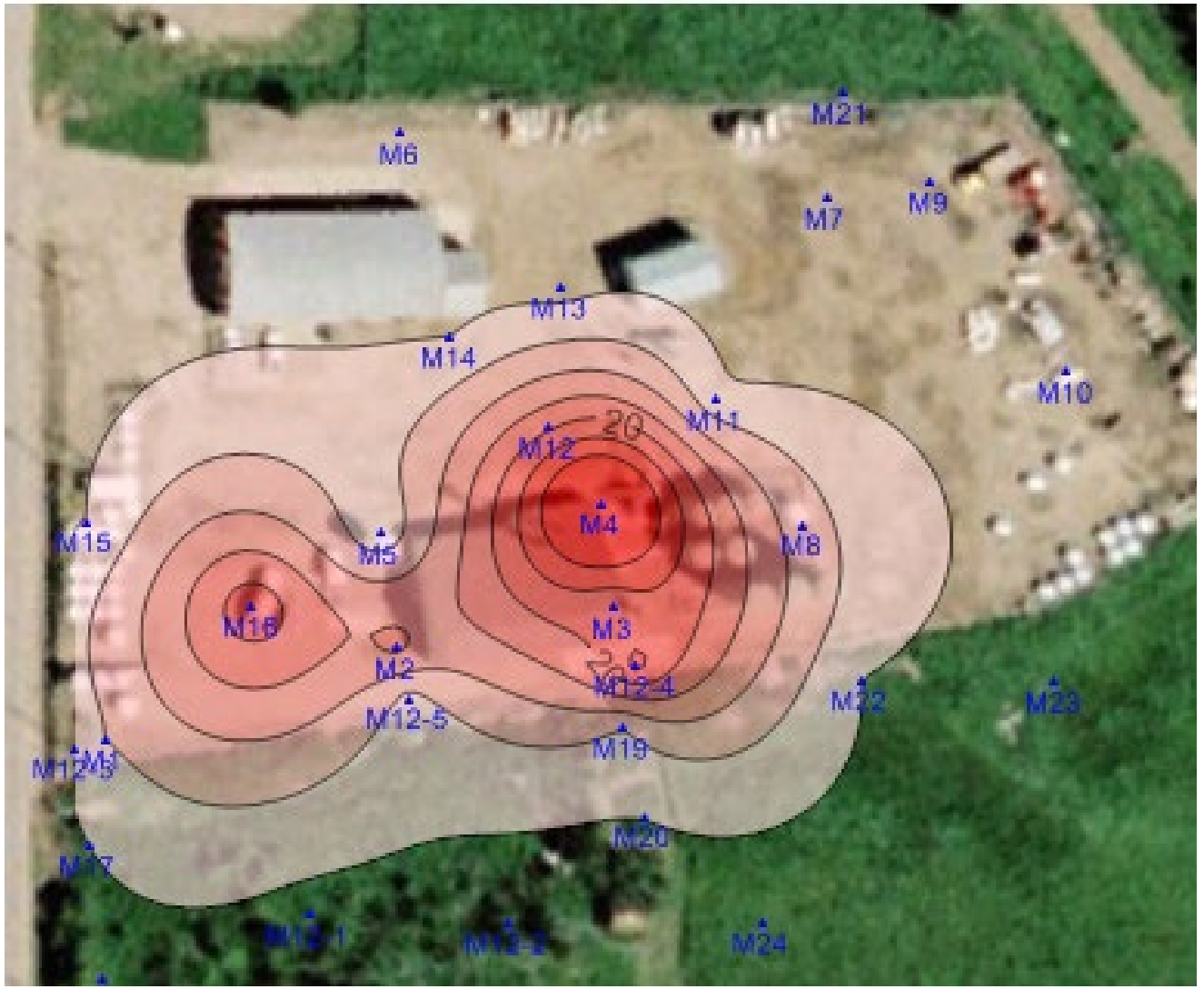
PINTER & ASSOCIATES

Continuous, Funnel and Gate



PINTER & ASSOCIATES

Case Study 1 - Viterra



PINTER & ASSOCIATES

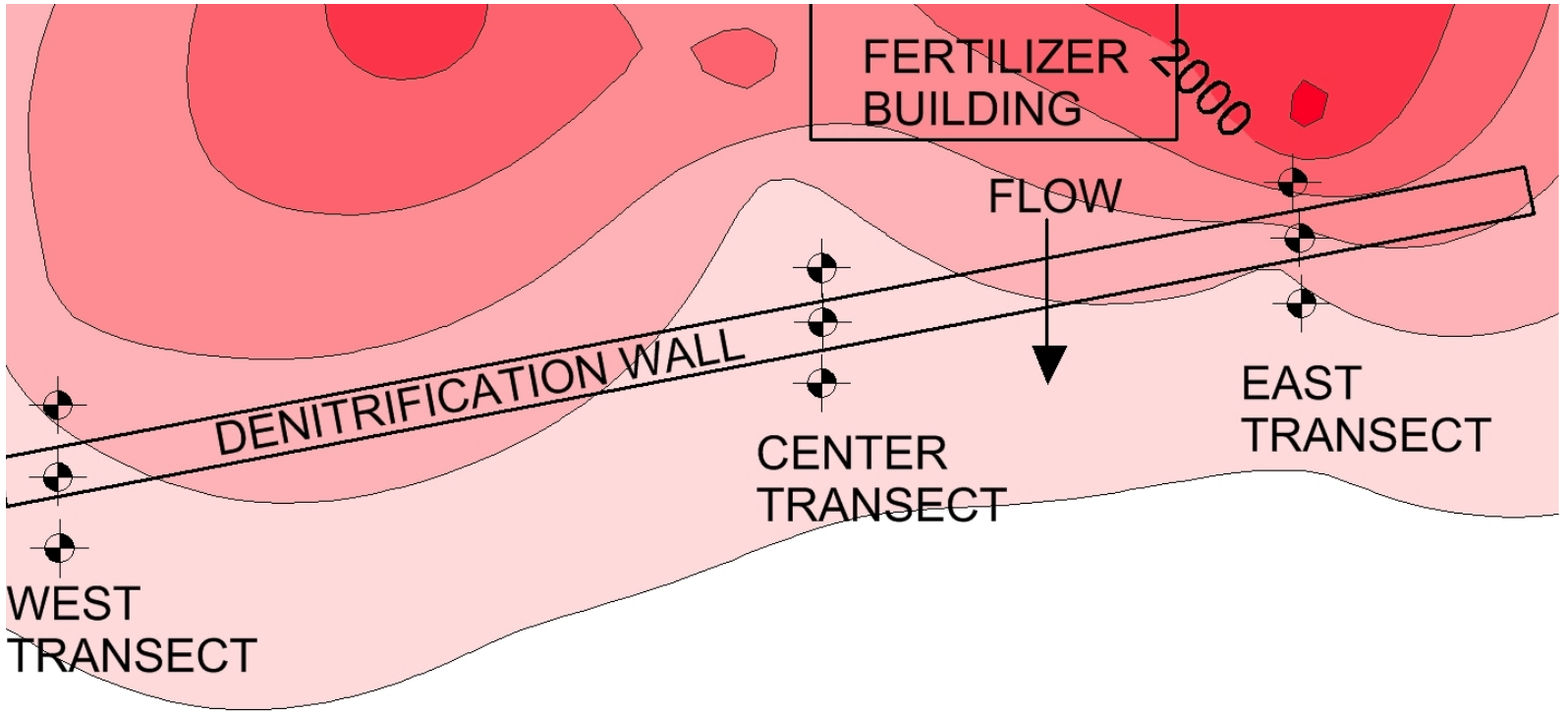
PRB Construction for Biological Denitrification

PINTER & ASSOCIATES

PRB Post Construction

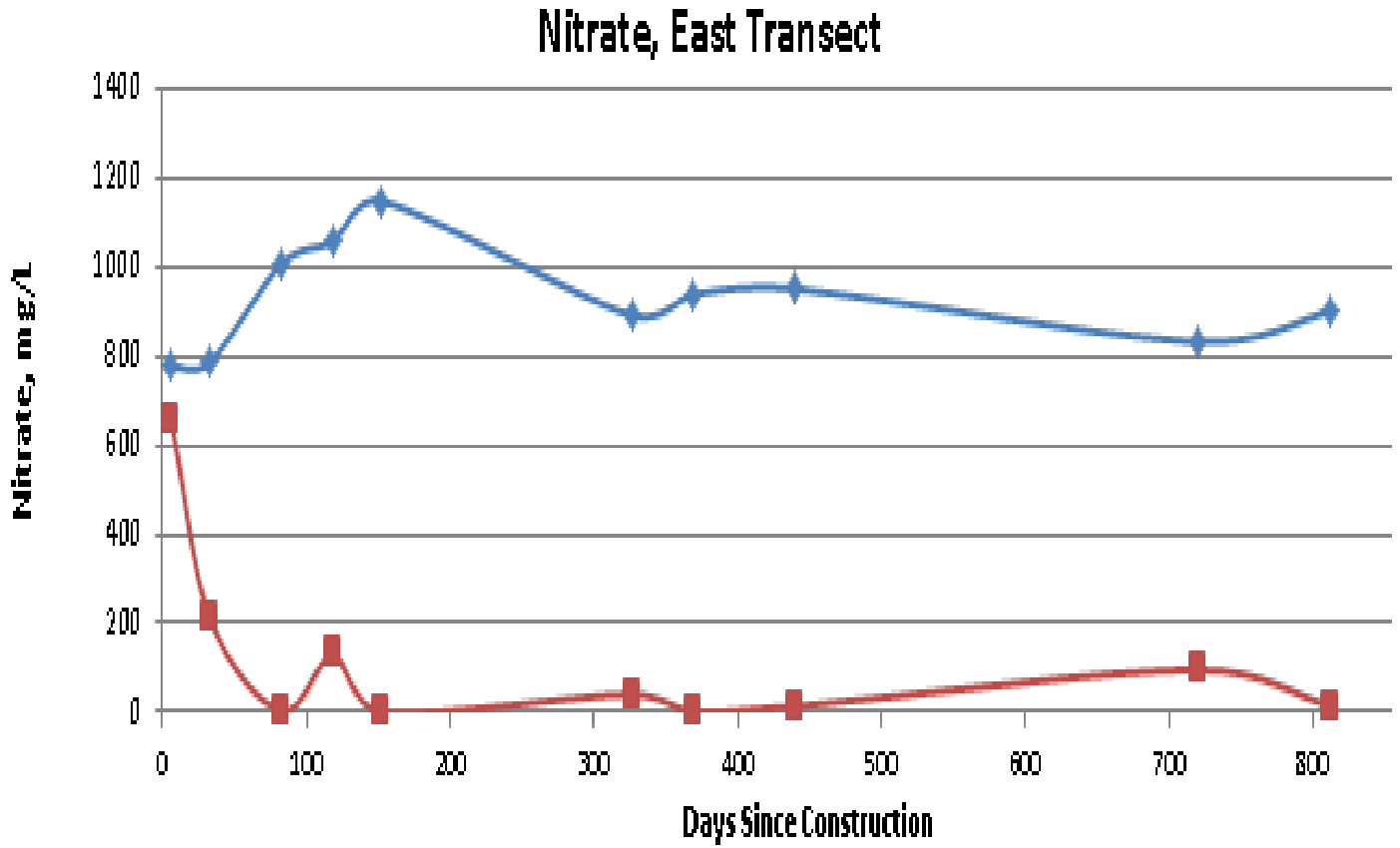
PINTER & ASSOCIATES

Results



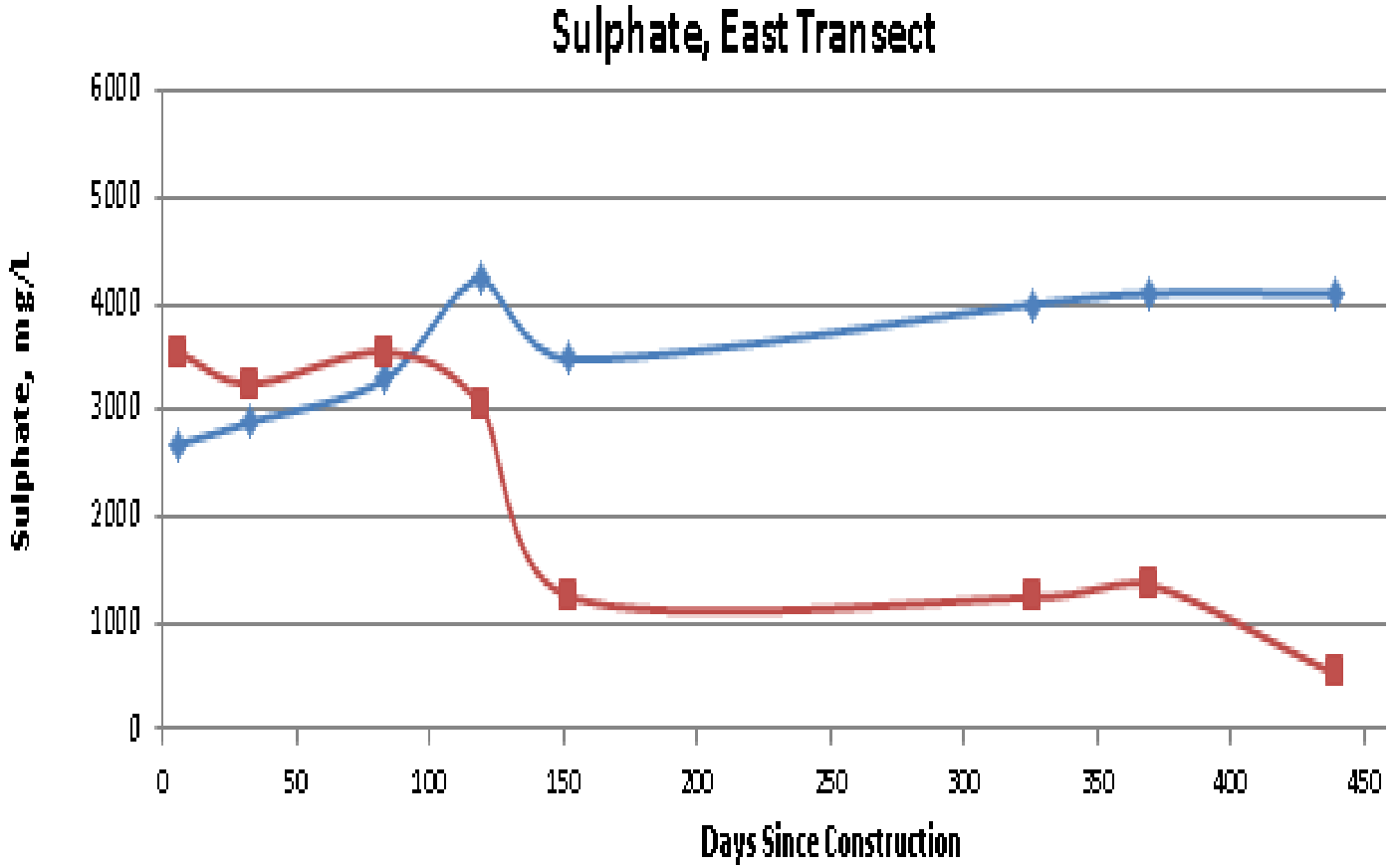
PINTER & ASSOCIATES

Results Nitrate



PINTER & ASSOCIATES

Results Sulphate



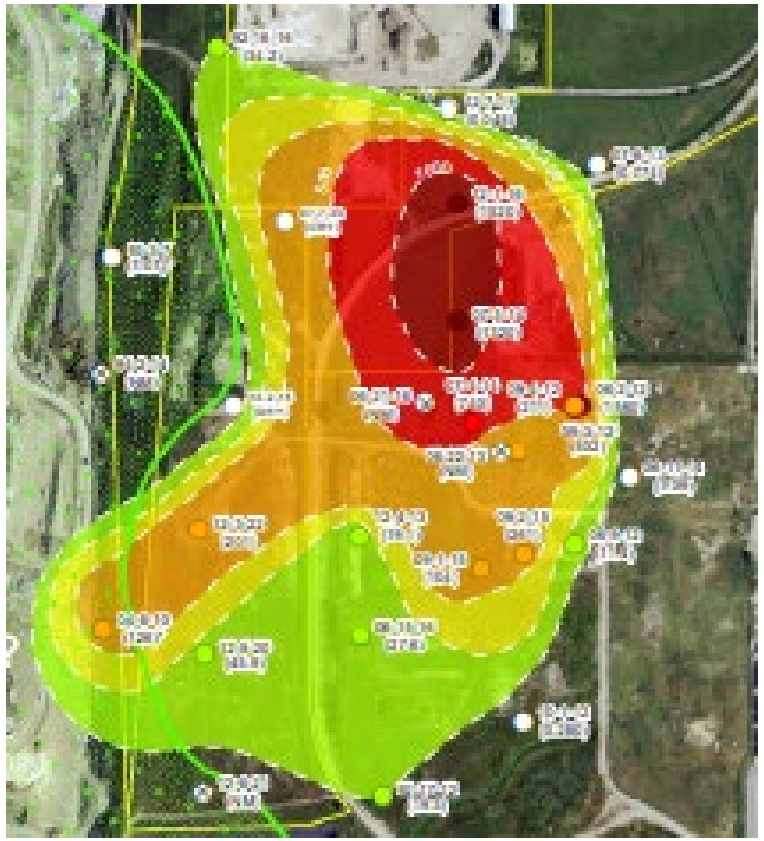
PINTER & ASSOCIATES

Conclusions Case Study 1

- Nitrate removal > 90%, Sulphate >80%
- Downstream well protected
- Installation cost of about $150,000
  - PRB design life approximately 30 years
- Conventional bids were in the 3 – 5 million range
- PINTER won provincial and national ACEC award of excellence for this project in 2014

PINTER & ASSOCIATES

Case Study 2



PINTER & ASSOCIATES

Installation

- Installed depth between 9 and 11 m

PINTER & ASSOCIATES

Results – Case Study 2

- Nitrate removal >99%
- Sulphate removal >95%
- PRB design life about 30 years
- Bow River no longer at risk
- All in costs about $350,000
- Full remediation estimates in excess of $10 million, never seriously pursued

PINTER & ASSOCIATES

Case Study 3

- Design
- Expert witness

PINTER & ASSOCIATES

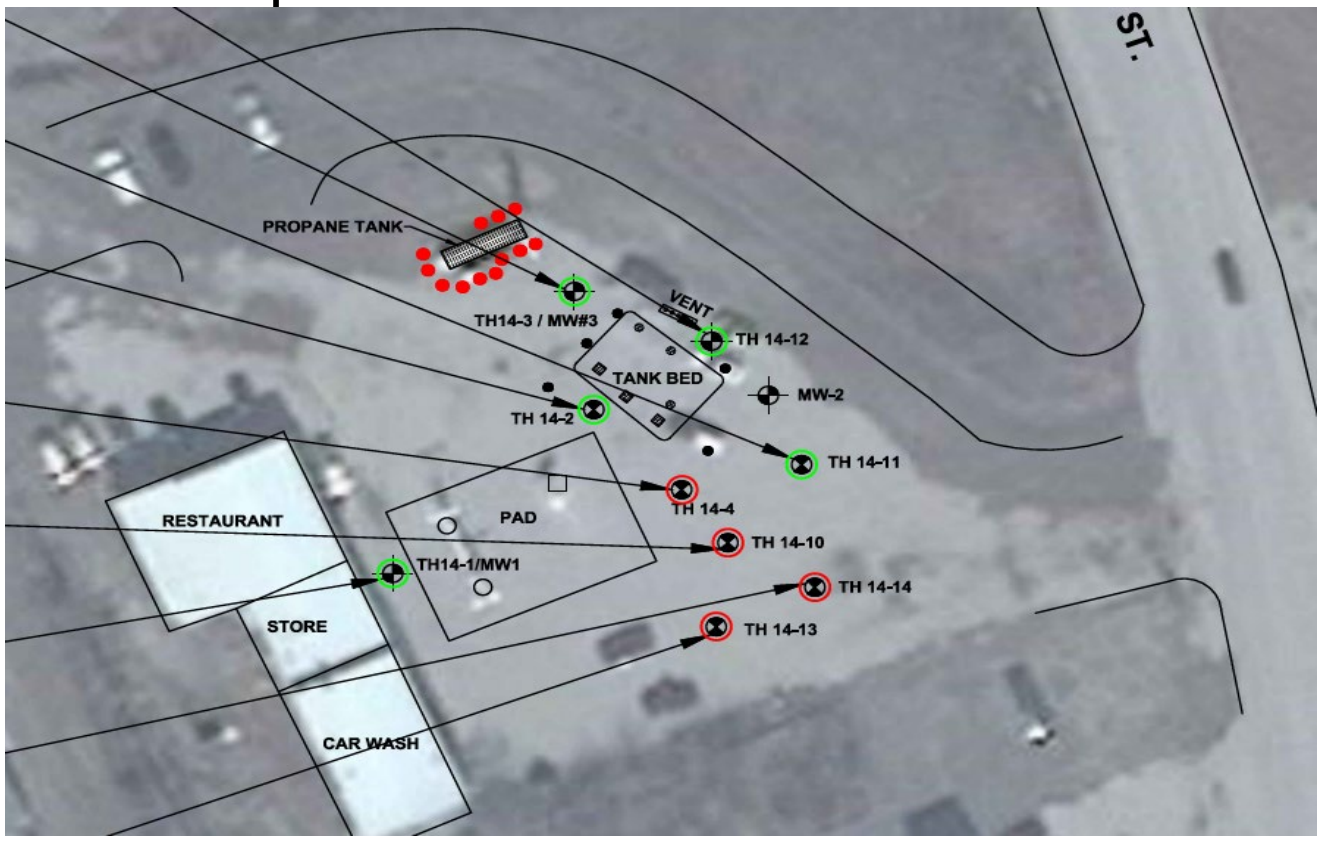
Case Study 3 results

- Current system is a wastewater plant near end of service life
- 30 year cost of current system were known, projected costs for next 30 years ~ 55 million.
- 30 year cost of a PRB installation ~7 million
- In pilot studies presently

PINTER & ASSOCIATES

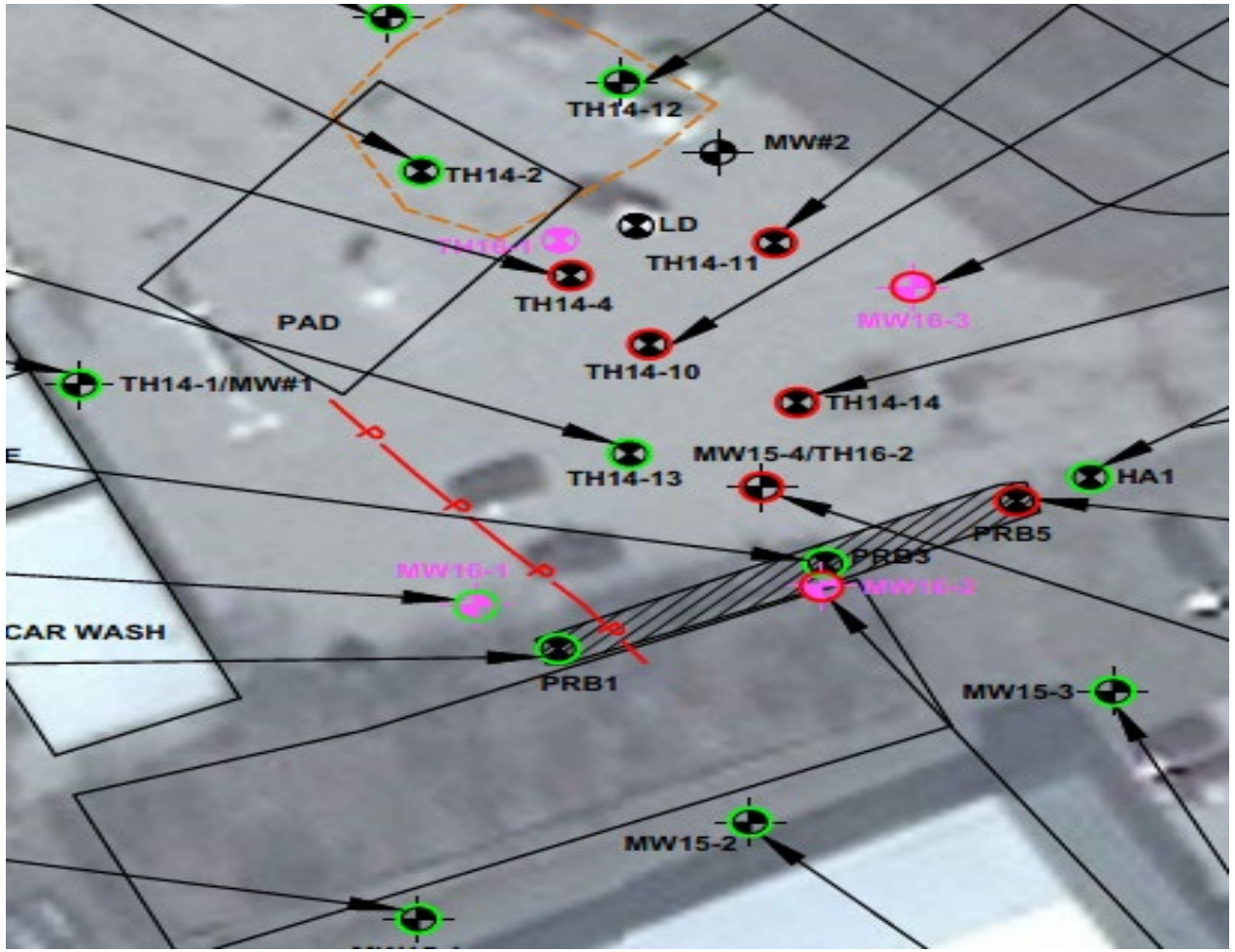
CASE STUDY 4 - PHCs FULL REMEDIATION

- BTEX, F1 - GW flow south, ~30 m/year
- Lake is present 300 m south



PINTER & ASSOCIATES

CAP – TIER 2



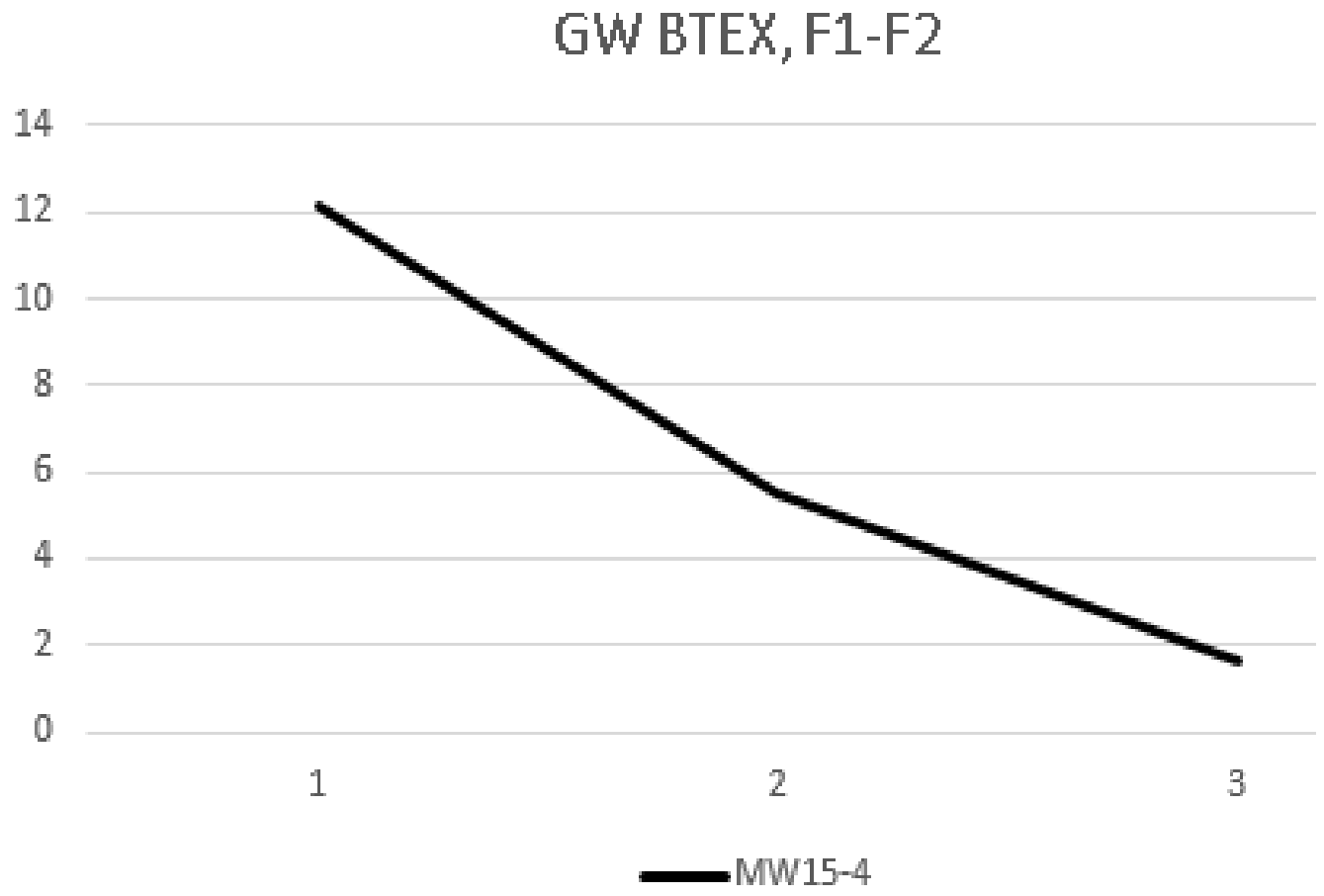
PINTER & ASSOCIATES

Installation

PINTER & ASSOCIATES

Groundwater Results

- About 86% reduction in MW15-4



PINTER & ASSOCIATES

Worst Case Soil

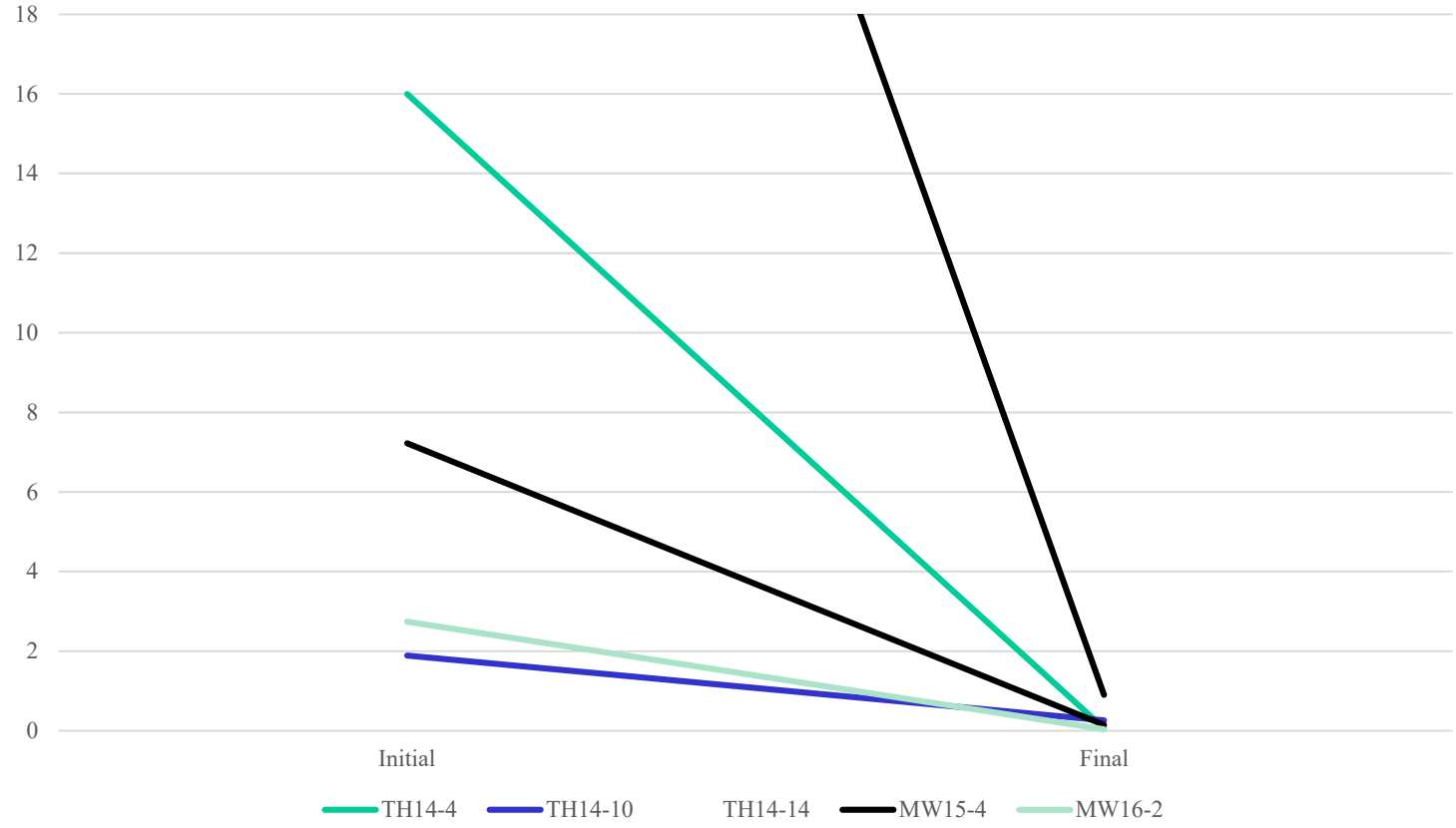
- MW15-4, just north of PRB

15-4	Date Sampled	CVC	B	T	E	X	F1	F2	F3	F4
		ppm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
15-4-4 @ 3.0m	22-Sep-15	1000	7.22	67.6	78.4	285	12500	<90	604	<90
15-4-2-4 @ 3.0m	25-Sep-17	120	0.145	<0.070	<0.023	<0.11	<40	<25	238	78

PINTER & ASSOCIATES

Results - Soil

- Average Benzene Removal – 98%



PINTER & ASSOCIATES

Case Study 4 Summary

- Site wide remediation in 2 years, Tier 2 closure from MOE
- No Site downtime
- Costs of approximately $50,000 compared to dig and dump estimates of $500,000
- Project is nominated for national and provincial ACEC awards this fall

PINTER & ASSOCIATES

Summary

- PRBs can be a cost effective tool
  - Can protect receptors
  - Can Eliminate pathways
  - Can Achieve full remediation
- Not a magic bullet and more front end information required than with other approaches

PINTER & ASSOCIATES

QUESTIONS?

306-244-1710

ryan.riess@pinter.ca

PINTER & ASSOCIATES