Vertex Environmental Inc.

Case Study:

Significant Return on Investment Achieved by Successfully Remediating a Challenging Chlorinated Solvent Site

September 28, 2023

SABCS Workshop

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Kevin French, B.A.Sc., P.Eng.

Presentation Overview

- Who Am I?
- Site Remediation Activities:
  - Before Vertex (Pre-2018)
  - In-Situ Site Work (2019 to 2021)
  - After (2021 to 2022)
  - Today (2023)
- Return on Investment
- Questions

Who Am I?

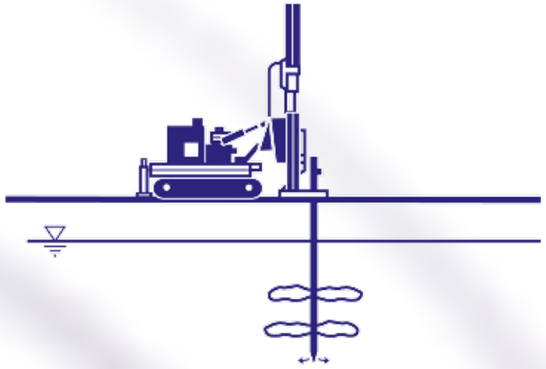
Bruce Tunnicliffe, M.A.Sc., P.Eng.

- Masters – U of Waterloo. Remediation
- Founder – Vertex Environmental Inc.
- Founder – SMART Remediation

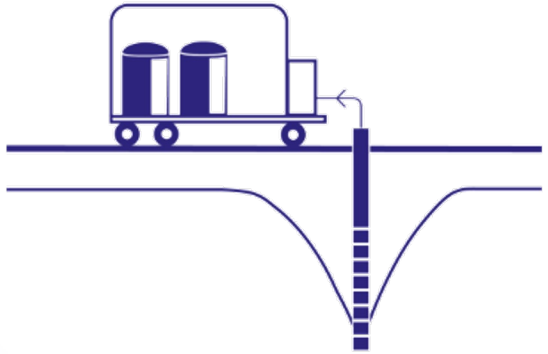
Vertex Environmental Inc.

- Started July 2003
- Environmental Contractor

Vertex Environmental Inc.

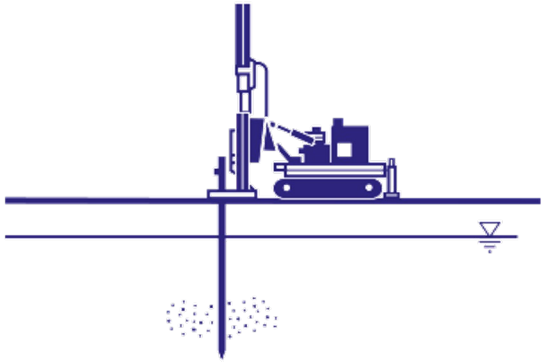


In-Situ Remediation

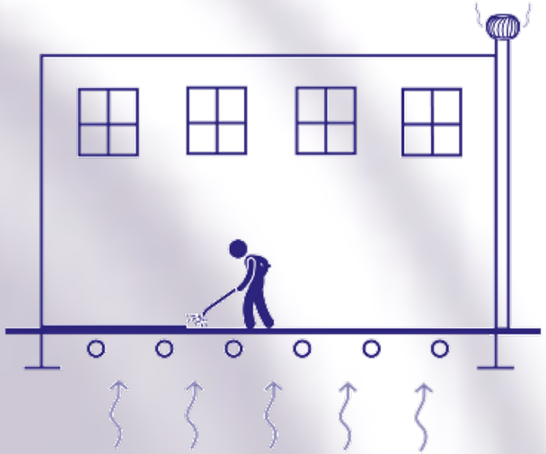


WTS & Dewatering

Ex-Situ Remediation



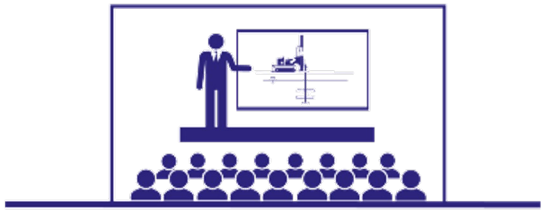
HRSC & RDC



Vapour Intrusion

Bench-Scale Testing

Remedial Design



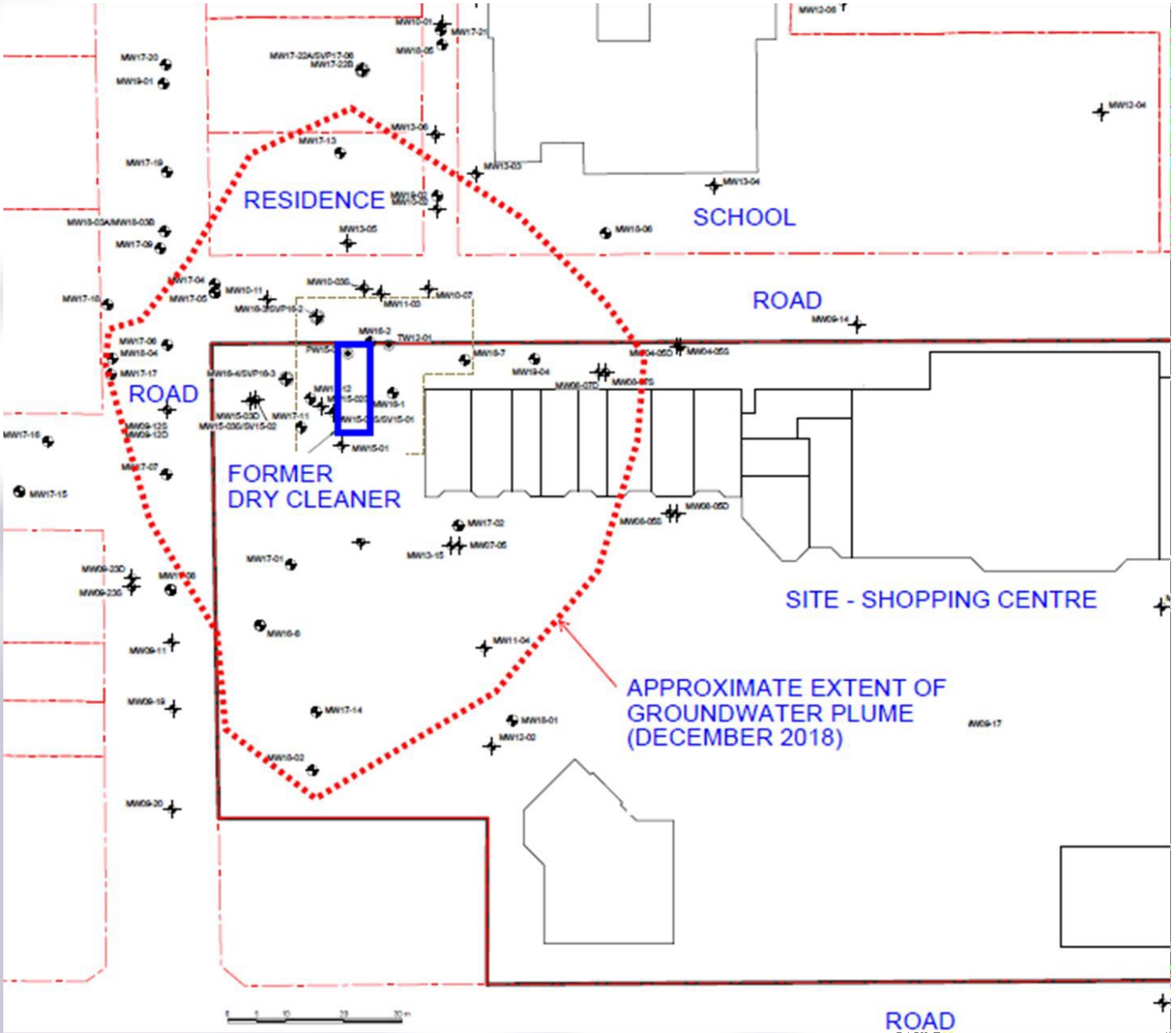
Outreach

Before Vertex (Pre-2018)

Site Description and Background

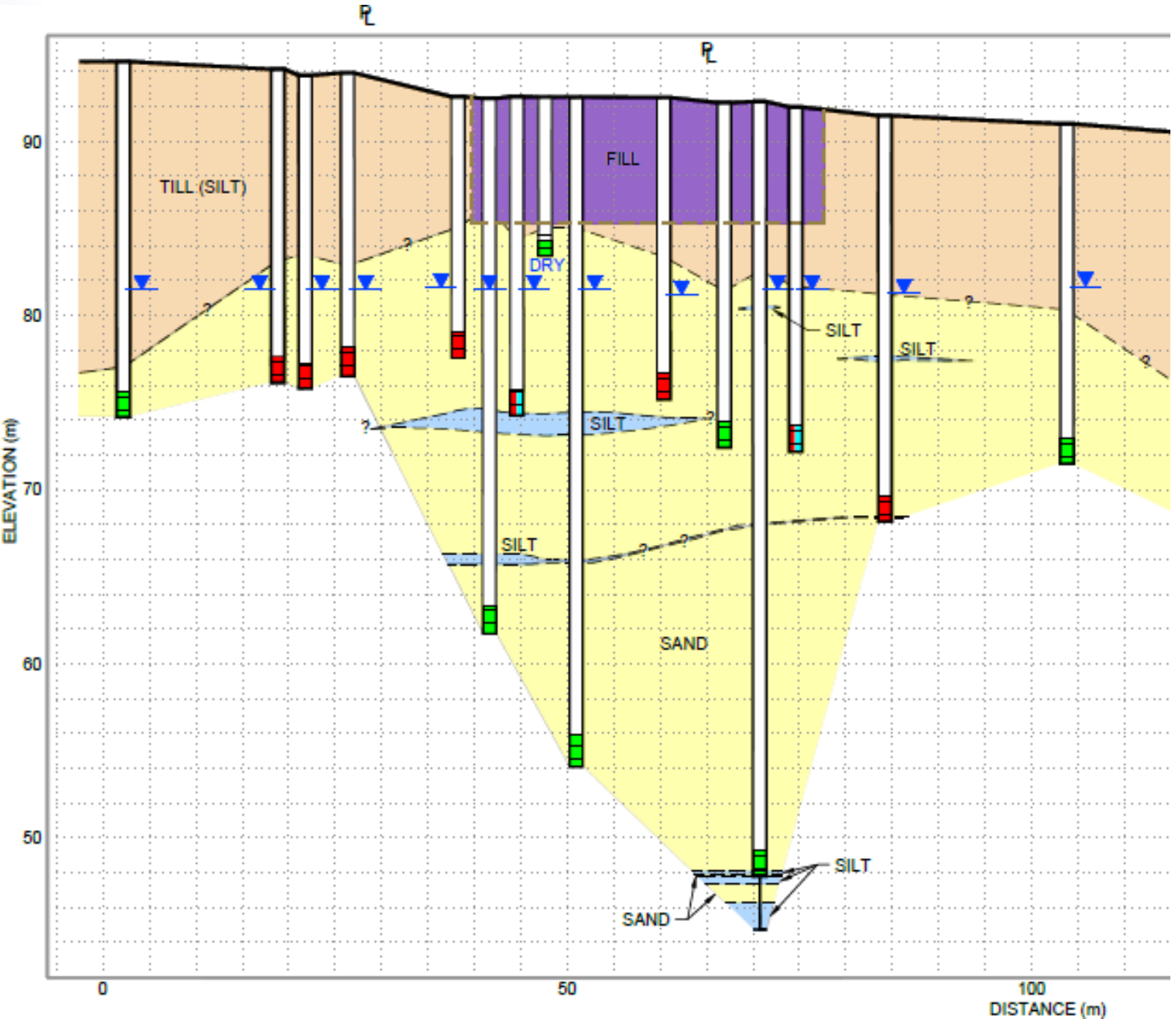
- Site is an **active shopping center** in Metro Vancouver, BC (commercial)
- **Dry cleaner** operated on the northwest corner of the site between **early 1960s and late 1980s**
- Adjacent surrounding properties include commercial, **residential and a school**
- Major river ~2 km north of the site and smaller tributaries and creeks to ~600 m north, ~900 m northwest and ~850 m southeast
- **Environmental investigation** and remediation activities at site **since 1988** by various consultants
- **Remedial excavation** of 6,000 m^3 of PCE-impacted **upper till** soil in source area on-site and off-site to north
- **Groundwater treatment system** installed on-site to extract and treat groundwater and prevent further migration of groundwater plume off-site in the **lower sand**

Environmental Condition of the Site



- **PCE and degradation products in soil, groundwater and vapour** at concentrations above applicable BC CSR standards on-site and off-site to north and west beneath roads, a residence and a school

Environmental Condition of the Site



- Soil profile in area of plume approximately:
  - **Dense silt till with cobbles to 8 mbgs** (hard - difficult to drill)
  - **Sand to 45 mbgs** (heaving – difficult to drill)
  - Lower silt confining layer
- Main groundwater plume in sand between **approx. 11 and 21 mbgs** (delineated horizontally and vertically)

Remedial Activities Completed at the Site

1990s & 2010s

Remedial excavations removed 6,000 m^3 of PCE-impacted soil in source area on-site and off-site to north, focussed on the till.

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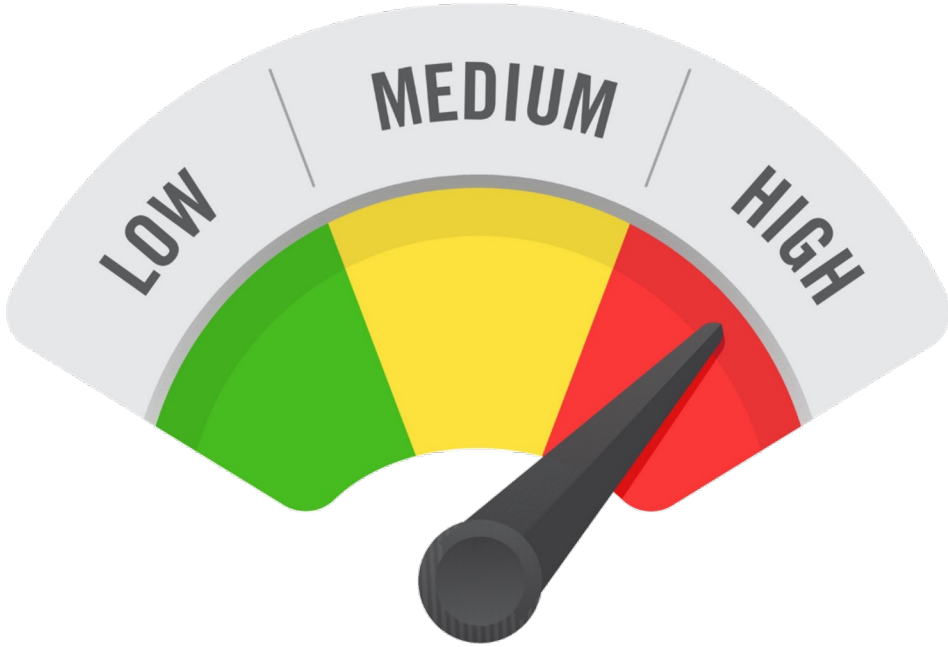
New Remedial Objective

- Overall objective: **To reduce PCE concentrations:**
  - **To remove High Risk designation**
  - To eliminate need for perimeter groundwater pump and treat system
  - To facilitate a human health and ecological risk assessment for the site
  - **To obtain risk-based Certificates of Compliance** from the BC ENV for the site and off-site affected areas



Client's Position – Before

- **Site was classified as a High Risk due to suspected mobile DNAPL presence** (i.e., >10% solubility PCE = >20,600 µg/L))
- Full-scale "dig & dump" remediation would have cost many $10s of millions!
- Perimeter groundwater treatment system expected to operate into perpetuity to protect off-site sensitive receptors
- Soil vapour monitoring requirements into perpetuity due to elevated soil concentrations
- Potential third party liability over off-site migration of impacts
- **No exit plan in sight: could not sell, finance, redevelop or densify the site**
- Even if the site could be sold (likely at a loss) there would **likely be trailing liability**
- The site was an illiquid and depreciated asset for the owner

In-Situ Site Work (2019 to 2021)

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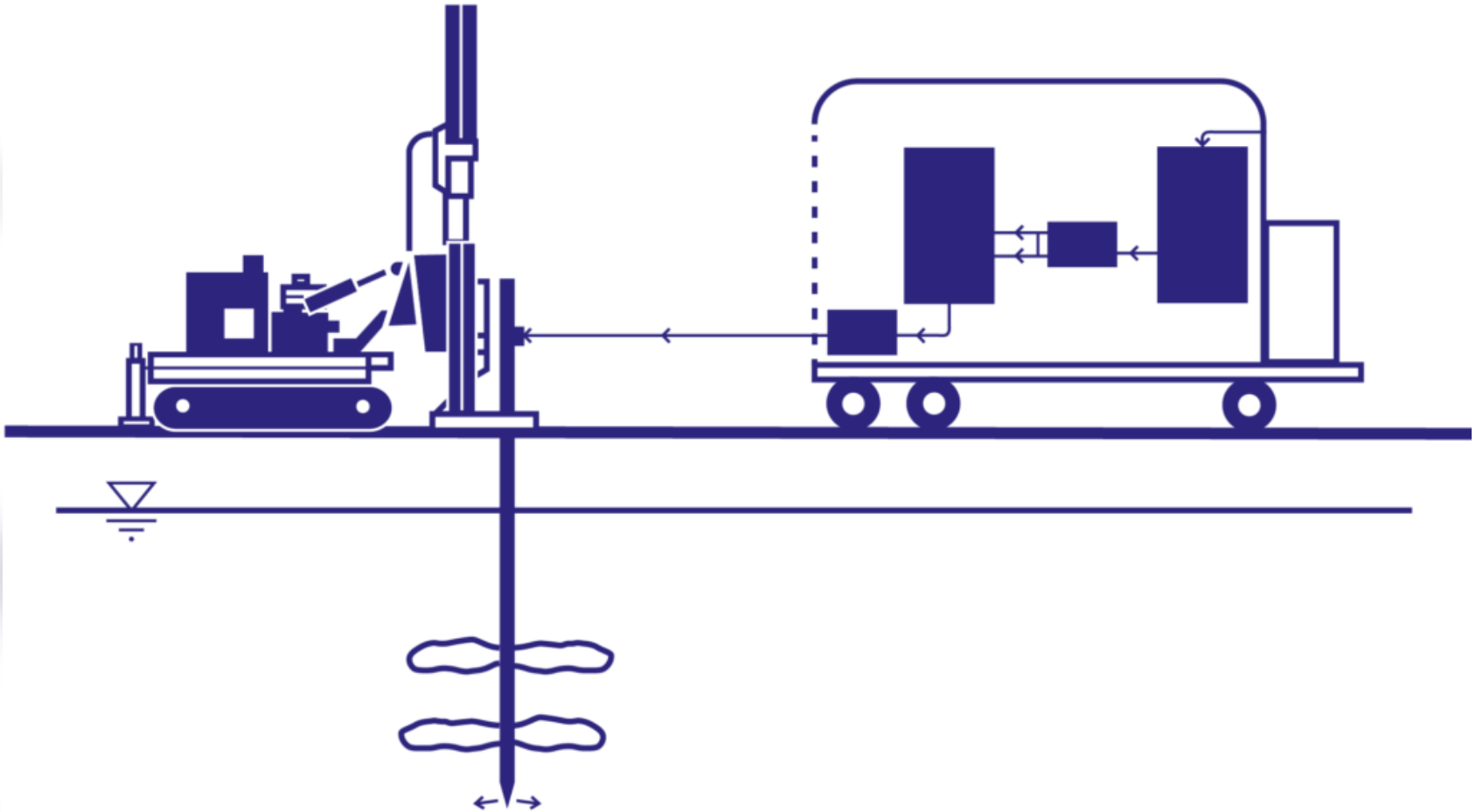
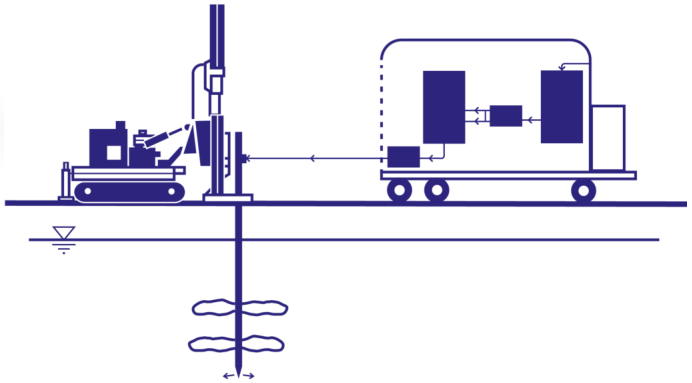
2019

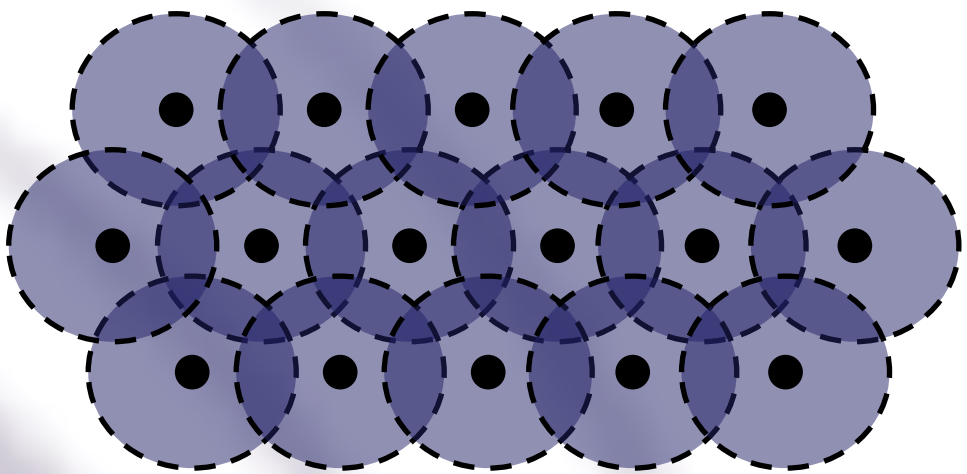
Pilot-test injection program of BOS 100® was implemented in "hot spot" on-site to treat PCE in groundwater.

In-Situ Remediation Equipment

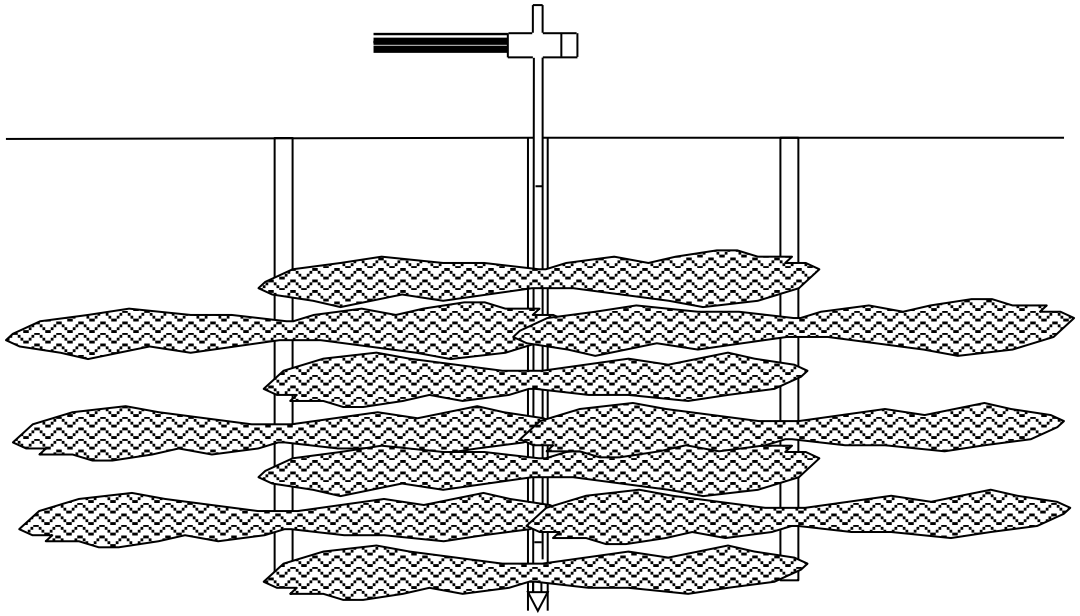


In-Situ Remediation Approach





Plan View



Profile View

In-Situ Remediation Amendment: Activated Carbon-Based

AC is produced from carbonaceous source materials
(coconut husk, wood, coal, etc.)

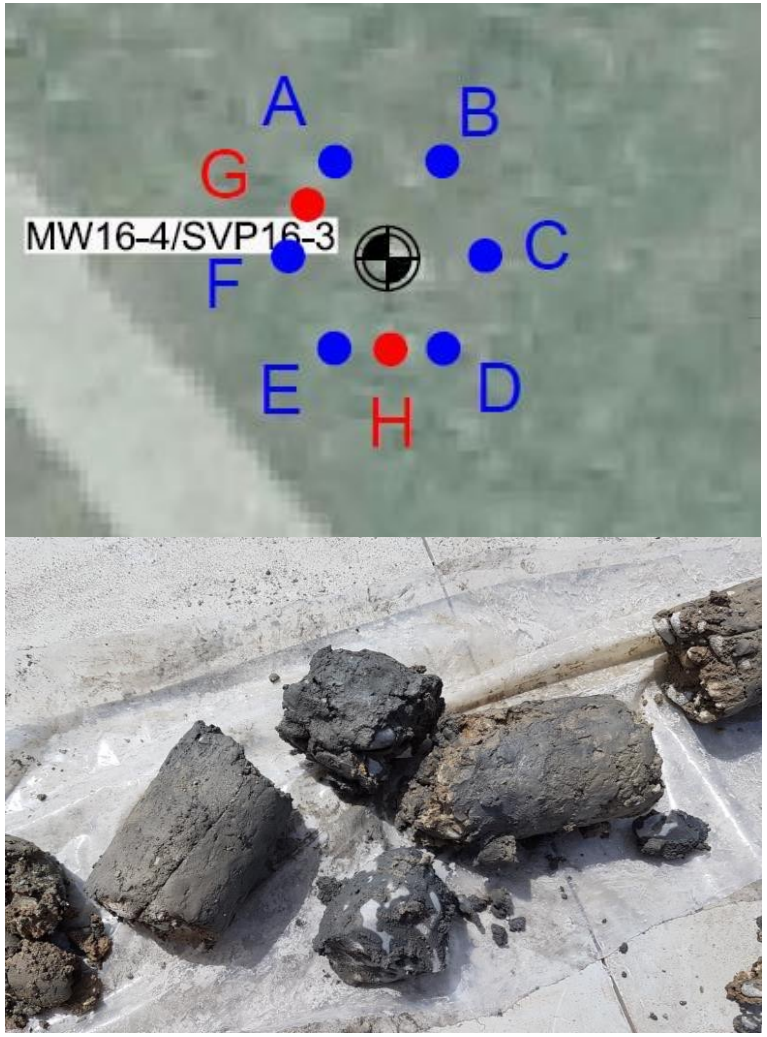
In-Situ Remediation Amendment: Trap & Treat® Technology

BOS 100® - for cVOCs

Activated Carbon & Zero Valent Iron

Pilot-Scale Injection (June 2019)

- Selected “hotspot” of groundwater plume in the source area on-site (MW16-4)
- 6 temporary IPs completed (A to F)
- Injected 12% wt. suspension (~650 kg Trap & Treat® BOS 100® in 5,500 L water suspension)
- 2 confirmatory boreholes sampled (G and H)
- Visual inspection of soil samples showed amendment well distributed within targeted injection depth ranges



Post-Pilot Injection Monitoring Results

Groundwater Concentrations at MW16-4 (µg/L)						
	PCE	TCE	C12DCE	T12DCE	11DCE	VC
"High Risk"	20,600					
BC CSR DW	30	5	8	80	14	2
Sampling Date	PCE	TCE	C12DCE	T12DCE	11DCE	VC
2018-01-22	15,500	33.8	25.5	<1	<1	0.47
2018-06-20	22,700	56.5	23.9	<1	<1	1.75
2018-10-03	25,500	60	28.4	1.3	<1	0.49
2018-12-04	26,900	74.7	33.6	1.4	<1	2.19
2018-12-04	25,300	73.9	33.8	1.4	<1	2.07
2019-05-15	17,200	64.8	44.4	1.4	<1	1.12
2019-07-02	14,400	71.8	97.1	1.5	<1	3.34
2019-07-02	13,300	68.4	90.2	1.5	<1	3.11
2019-07-25	9,890	60	214	1.4	<1	19.2
2019-07-25	9,740	56	206	1.7	<1	19.7
2019-08-08	12,600	76.7	93.5	1.9	<1	13.2
2019-08-08	12,100	76	91.1	1.8	<1	13.2
2019-08-29	11,200	43.6	37.8	1	<1	2.98

Pilot-Scale Injections

~58% Reduction after 3 months

Decision to proceed with full-scale

Remedial Activities Completed at the Site

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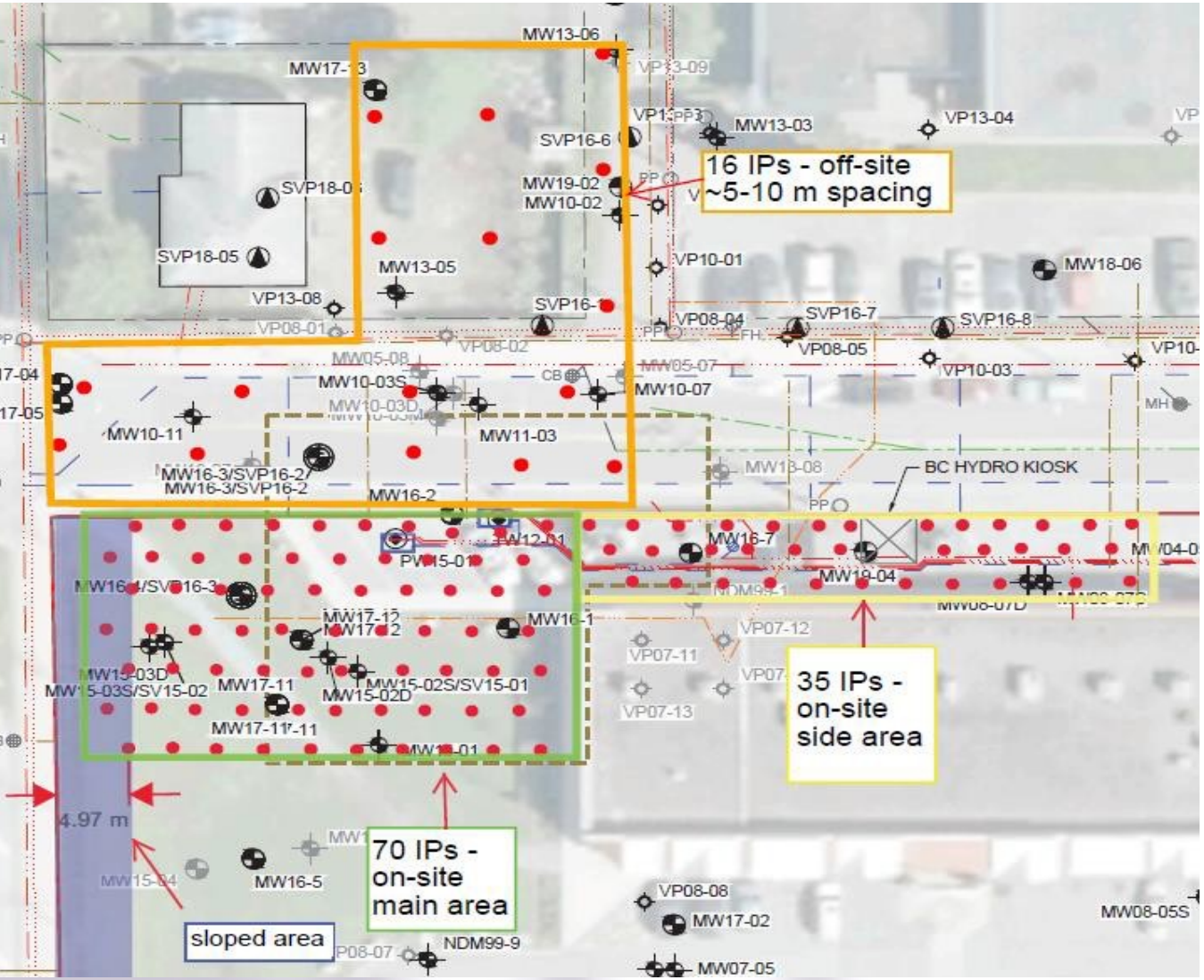
2021

Based on success of pilot-test, the full-scale BOS 100® injection program was implemented on-site and off-site.

Full-Scale Remedial Injections (June to August 2021)



- On-site injection program:
  - 105 IPs on 3 m grid
  - Injection interval 8.8 - 18.9 mbgs
  - ~21,000 kg Trap & Treat® BOS 100® in 330,000 L
- Off-site injection program:
  - 16 IPs on 5-10 m spacing
  - Injection interval 14.9 - 21.3 mbgs
  - ~2,500 kg Trap & Treat® BOS 100® in 60,000 L)
- 68 days total work

GeoTAP^{SM} (Pre-Drill) Method


BADGER


Geoprobe 7822DT


DRILLWELL

Full-Scale Remedial Injections (June to August 2021)

Challenges:

- Refusal of direct push in pre-drilled boreholes
- Injection tooling/rods clogging, lost rods

Solutions:

- Increasing diameter of pre-drilled holes from 3.5 to 6 inches
- Removing rods/tooling, cleaning and re-attempting
- Adjusting injection pressures (150-1,350 psi)
- Disconnected rods that could not be removed, left in place, cut hose and backfilled

Full-Scale Remedial Injections (June to August 2021)

Challenges:

- Daylighting of suspension through the top of pre-drilled boreholes and/or interconnecting boreholes (instead of going into the formation)

Solutions:

- Changing backfill material of pre-drilled boreholes for a better seal
- Increasing concentration of BOS 100® slurry to reduce volume and increase viscosity of injection liquid
- Adjusting injection pressures (150-1,350 psi)
- Re-alllocating to adjacent IPs

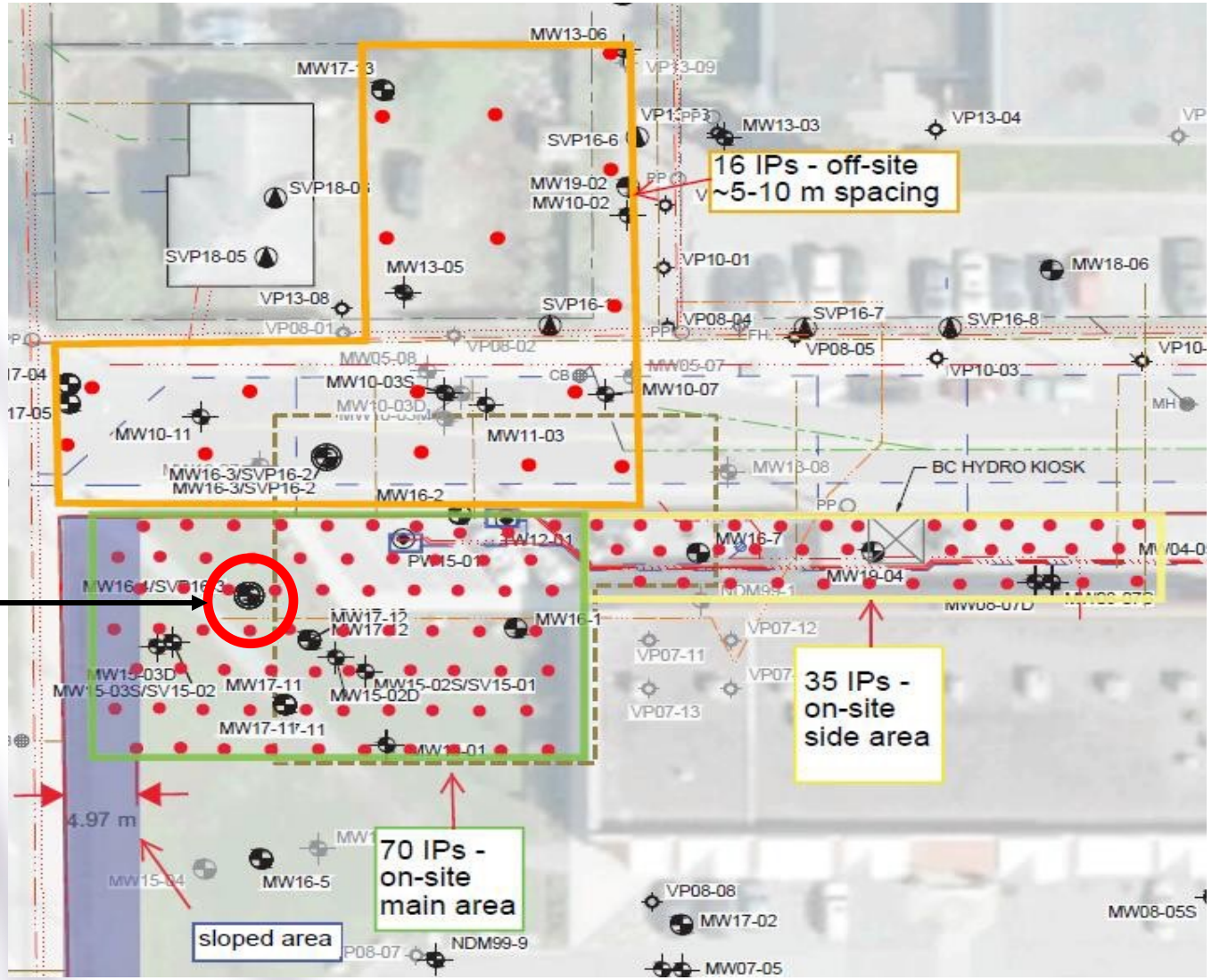
Client's Position – In-Situ Site Work

- **Results of the pilot-scale injection activities** in the worst-case area of the site (i.e., suspected mobile DNAPL) **allowed High Risk designation to eventually be removed**
  - Required one year of monitoring
  - **This was the most important objective**
- Proof-of-concept that allowed full-scale remediation to be approved by owner:
  - If only continued commercial use was possible post-remediation it would not have proceeded
  - **Real potential for upzoning of site for mixed use redevelopment** post remediation made the cost of undertaking the full-scale remediation worthwhile (i.e., a path forward)
- **In-situ remediation was much less disruptive to site operations:**
  - Allowed **continued access** to **and operation** of the shopping center
  - No tenants were displaced
  - **No loss of income during remediation; no requests for rent relief**

After (2021 and 2022)

Post-Remediation Monitoring Results

Pilot-Scale Injection Area



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2019-08-29	11,200	43.6	37.8	1	<1	2.98
2019-10-04	5,140	55.6	36.2	1	<1	3
2019-10-04	5,030	55.8	37.5	1.1	<1	3.15
2020-01-31	2,760	40.8	24	0.77	<0.5	0.55
2020-01-31	2,640	38.5	22.7	0.73	<0.5	0.52
2021-03-25	658	21.5	4.51	<0.5	<0.5	<0.4
2021-03-25	531	28.6	5.97	<0.5	<0.5	<0.4
2021-10-05	451	34.8	12.1	<0.5	<0.5	1.61
2021-10-05	357	34.5	10.9	<0.5	<0.5	1.22
2022-01-25	7	<0.5	<0.5	<0.5	<0.5	<0.4
2022-01-25	7	0.52	<0.5	<0.5	<0.5	<0.4

Pilot-Scale Injections

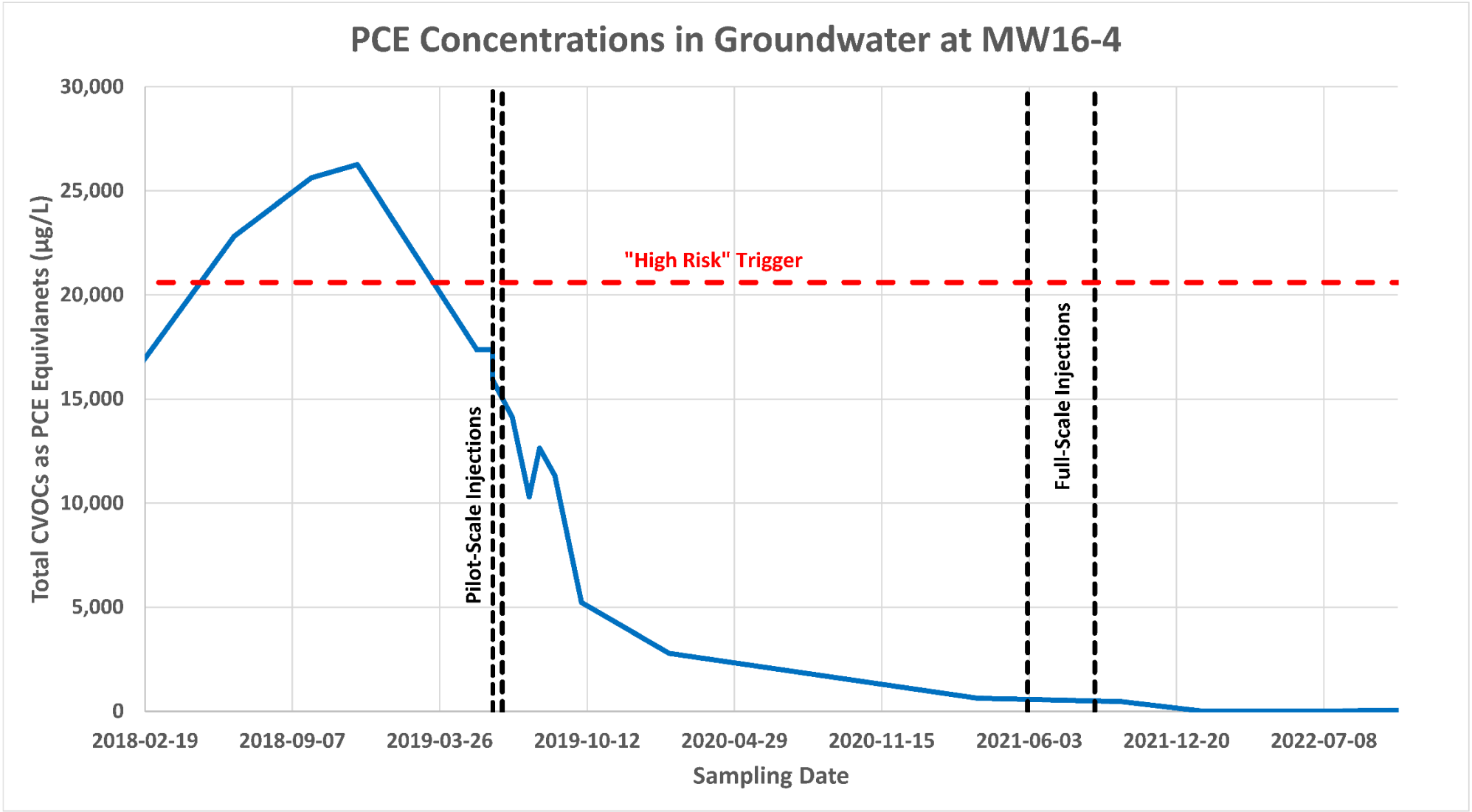
Full-Scale Injections

>99.95% Reduction!

SLR

VERTEX

Post-Remediation Monitoring Results



Site Restoration Activities

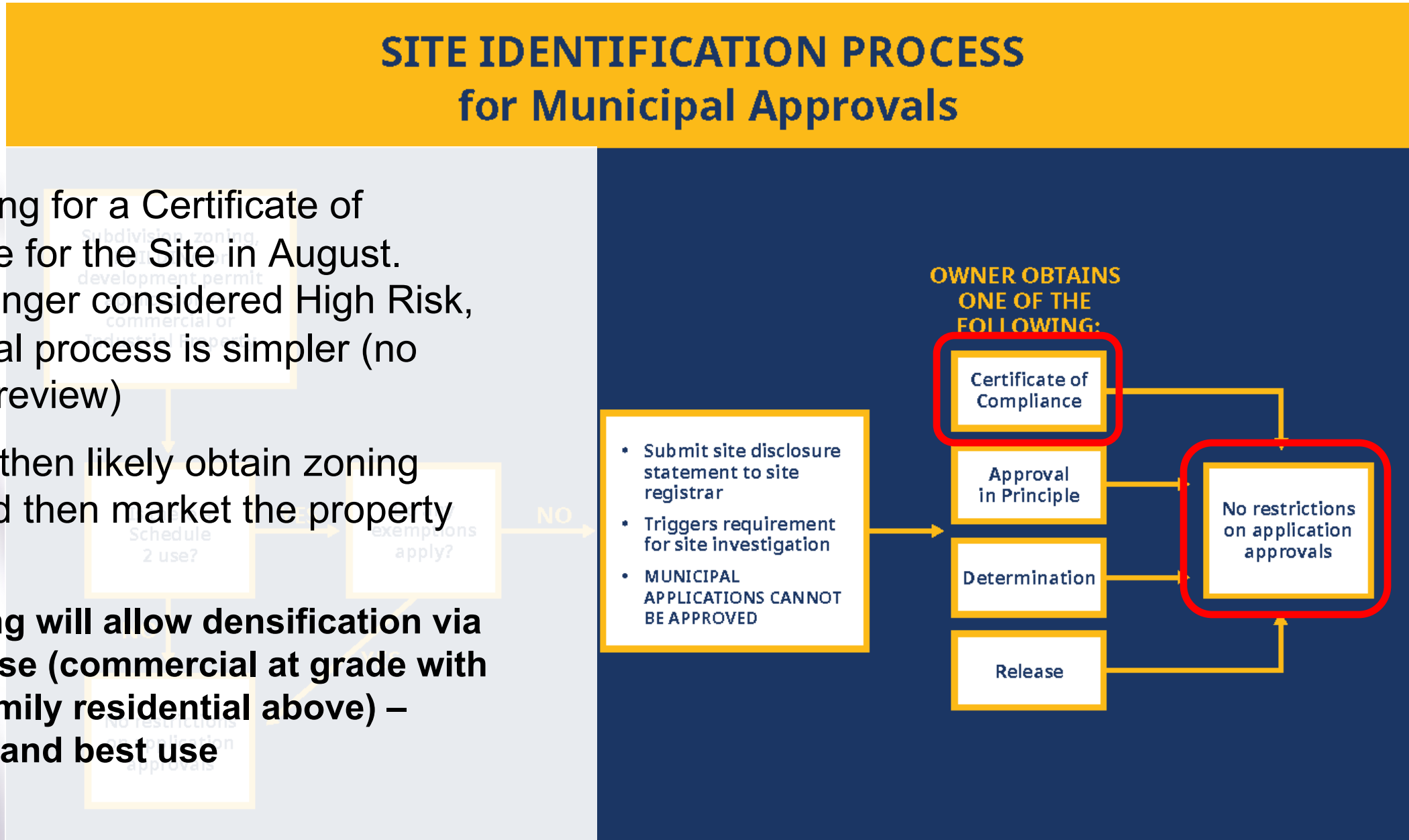
Client's Position – After

- **No perimeter groundwater treatment system required**
  - Remedial injections are protective of off-site sensitive receptors
- No long-term operation, maintenance and monitoring costs
  - **Post-remediation groundwater monitoring** ceased after five quarters **demonstrated stable / decreasing plume**
- **Some zoning changes possible now that the site is no longer considered High Risk and can be redeveloped**

Today (2023)

Remaining Activities

- SLR applying for a Certificate of Compliance for the Site in August. Since no longer considered High Risk, the approval process is simpler (no ministerial review)
- Owner will then likely obtain zoning change and then market the property for sale
  - **Upzoning will allow densification via mixed use (commercial at grade with multi-family residential above) – highest and best use**



Client's Position – Today

- **The site remediation is a huge success story internally for the owner**
- **Never expected 10 years ago that they would have an exit plan for the site without trailing liability**
- **Site is now marketable and worth full market value**
- **The owners are now looking forward to what the site could be!**

Return on Investment

Return on Investment

- **Client's Investment:**
  - Trust in SLR and Vertex
  - 4 years
  - Several million $$
- **Client's Return on Investment:**
  - Trust rewarded
  - The site is now **worth at least 2 to 3 times** the cost of the entire remediation, monitoring and risk assessment program

Thank you!

Questions?

Bruce Tunnicliffe, M.A.Sc., P.Eng.
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www.vertexenvironmental.ca

Project Team:

Consultant: SLR Consulting (Canada) Ltd.

Remediation Contractor: Vertex Environmental Inc.

Pre-Drilling: Downrite Drilling Ltd.