Achieving Site-Specific Remedial Goals for PHCs, PAHs, and VOCs through a Collaborative Multidisciplinary Approach

GeoTactical REMEDIATION

SustainTech 2025

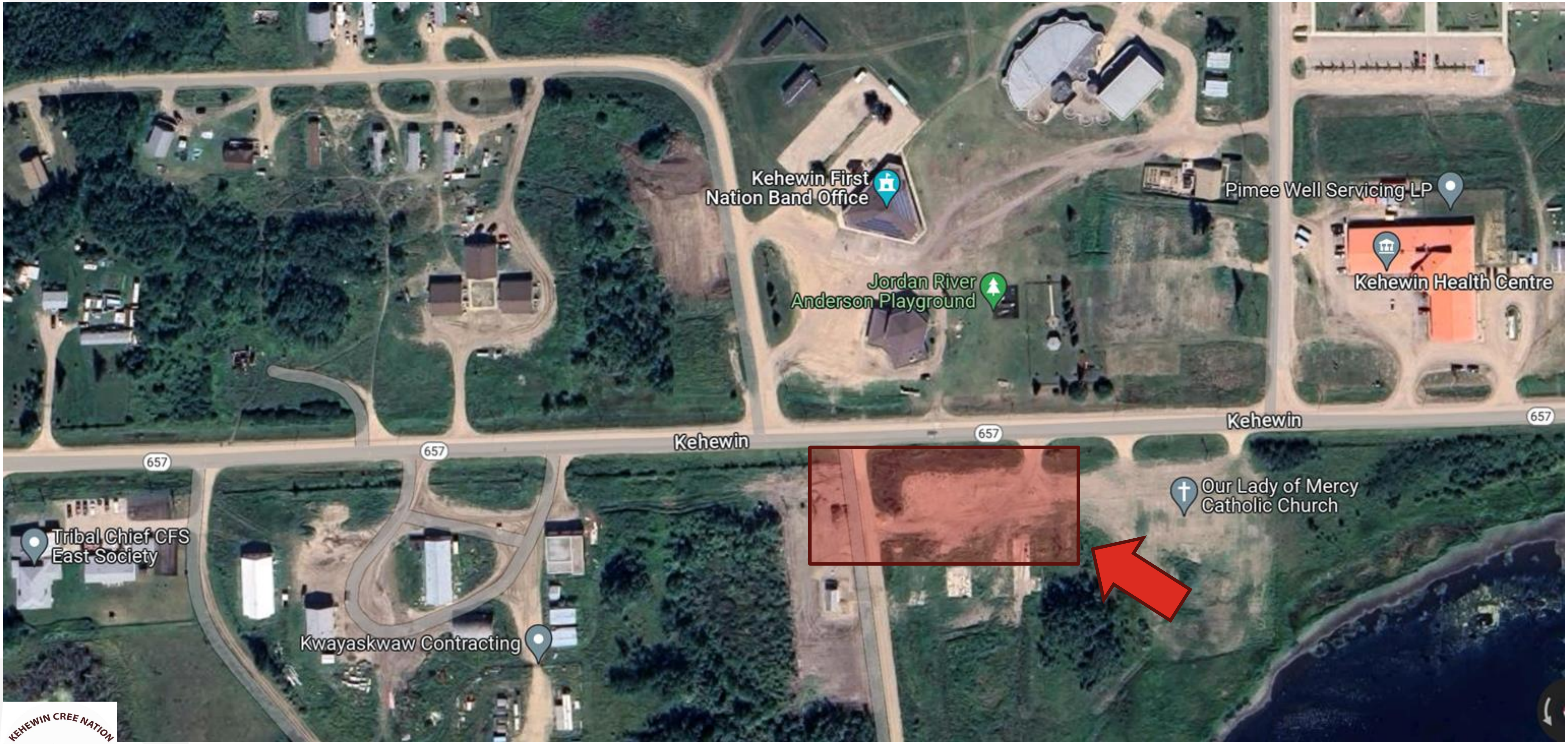
Danny Procter- Geo Tactical Remediation Ltd.

KEHEWIN CREE NATION #123

General Site Description

- Site is located on Kehewin Cree Nation No. 123
  - Former gas station, currently inactive and unoccupied
  - Site contaminated due to UST's requiring removal
  - Centrally located with several administrative facilities and schools located nearby.

Image of Area



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Project Objective

- Primary site objective for project was to advance the site in the Federal Contaminated Sites Action Plan:
  - Remediation of site to functional land use
  - Source removal and subsequent risk management

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Geo Tactical Remediation Ltd.

Who we are

- Environmental service company
  - Speciality: In-situ injection remediation
- Based in Calgary, AB
- Service backed by science

What we do

- In Situ Injection Services
  - Permeation (Matrix) Injection
  - Fracture Injection
- 3D Tiltmeter Mapping
- Assist with developing in-situ remediation programs

Kehewin Cree Nation #123

APEGA Permit Holder

Workplace Safety COR Certificate of Recognition

Energy Safety Canada

GeoTactical Remediation

Stakeholders

- **Client and Project Oversight** – Kehewin Cree Nation No. 123
- **Funding** – Indigenous Services Canada
- **Overall Project Management** – Bosgoed Project Consultants
- **Technical Project Management** – Associated Environmental Consultants
- **Injection Services** – Geo Tactical Remediation Ltd.
- **Thermal Services** - Nelson Environmental Remediation

- Site goals
  - CCME guidelines
  - Community engagement

Community Business Engagement

- Local contractors
  - Personnel to assist with injection
  - Snow clearing
  - Fuel
  - Site cleanup
  - Security
  - Aided in sourcing additional community-based services

Effective Collaboration

- Flexibility in site schedule and plan adjustments due to unexpected site conditions

- Close communication and transparency allowed for rapid site plan adjustments
  - E.g., adjustment in sampling event time to allow for clearer picture of amendment effectiveness.

- All stakeholders involved in significant site plan adjustments.
  - Allowed rapid implementation and reduced delays

Technology Disciplines Applied

- Onsite ex-situ thermal desorption by Nelson for areas with free phase and small volume near surface contamination.
- In-situ bioremediation injections selected at depths greater than 2 metres (GTR) outside and under of free phase footprint.

Why Bioremediation

- Bioremediation approach chosen for:
  - Contaminant type: BTEX, F1 and F2, naphthalene, MTBE…
  - Hydrogen peroxide highly reactive and limited longevity- geology concerns with clays
  - Alternate Oxidants: Residuals concern
- Bioamendments are safer to handle and provides longevity.
  - Safety aspect of site location and allowed for onsite local engagement (oxidant has significant training requirements)

Amendments Injected

- PTS – Biostimulation package (nutrients)
- PTBac – Microbial bioaugmentation blend of aerobic and anaerobic microbes
- iPAC – Activated Carbon
  - Adsorption, enhanced biofilm production, increased residence time
- Sand proppant – Provide permeable pathways for multiple injections without the need to re-mobilize drilling equipment.

C.E.R.E.S. Remediation Products ***supplied the Bioremediation Amendments***

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Site Geology and Contaminants

- Geology
  - GW between 1.5-2m bgs
    - No significant GW gradient
  - Soils are primarily clay and silts with some layers of sand and gravel.
  - Silty clay shale bedrock underlying contaminated site area

- Contaminants
  - GW- BTEX, PHC fractions F1 and F2, naphthalene
  - MTBE
  - Soil- BTEX, PHC fraction F1, and naphthalene

Challenges of Low Permeability Formations

- Low injection / extraction flow rates
- Low radius of distribution / radius of capture
- Limited connection with secondary porosity
  - Resulting in reduced contact with contaminants
- Limitations on injectable particle size
- Rebound

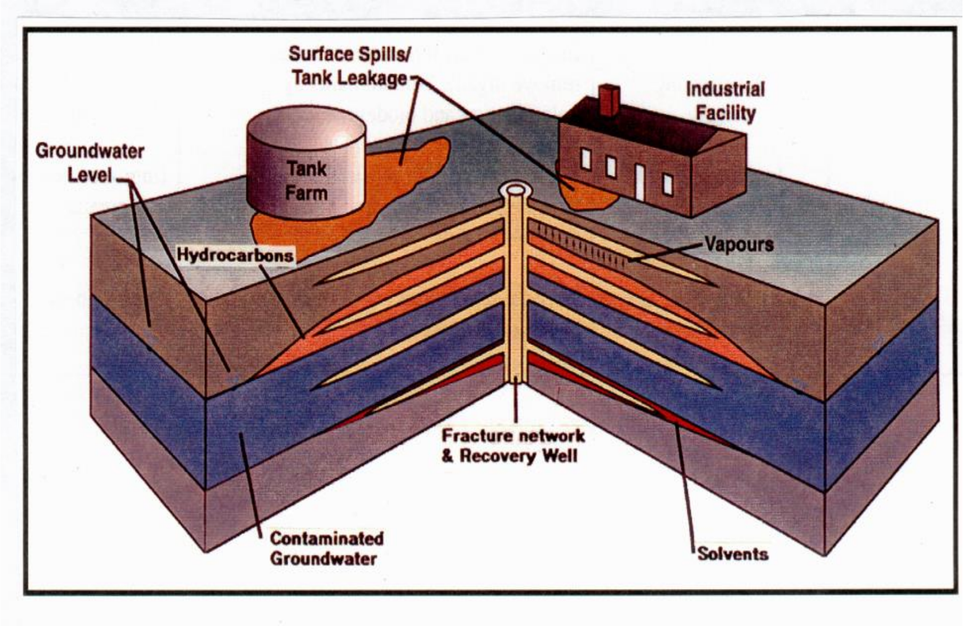
Injection: Modes of Emplacement

- Fracture Injection
  - Direct injection emplacement of remediation amendment
    - PTS, PTBac and iPAC
  - Sand propped fractures (Area B) – for multiple solution injections
    - iPAC included
- Permeation Injection
  - Into sand propped fractures through installed injection wells (Area B)
    - PTS and PTBac

Fracture Injection

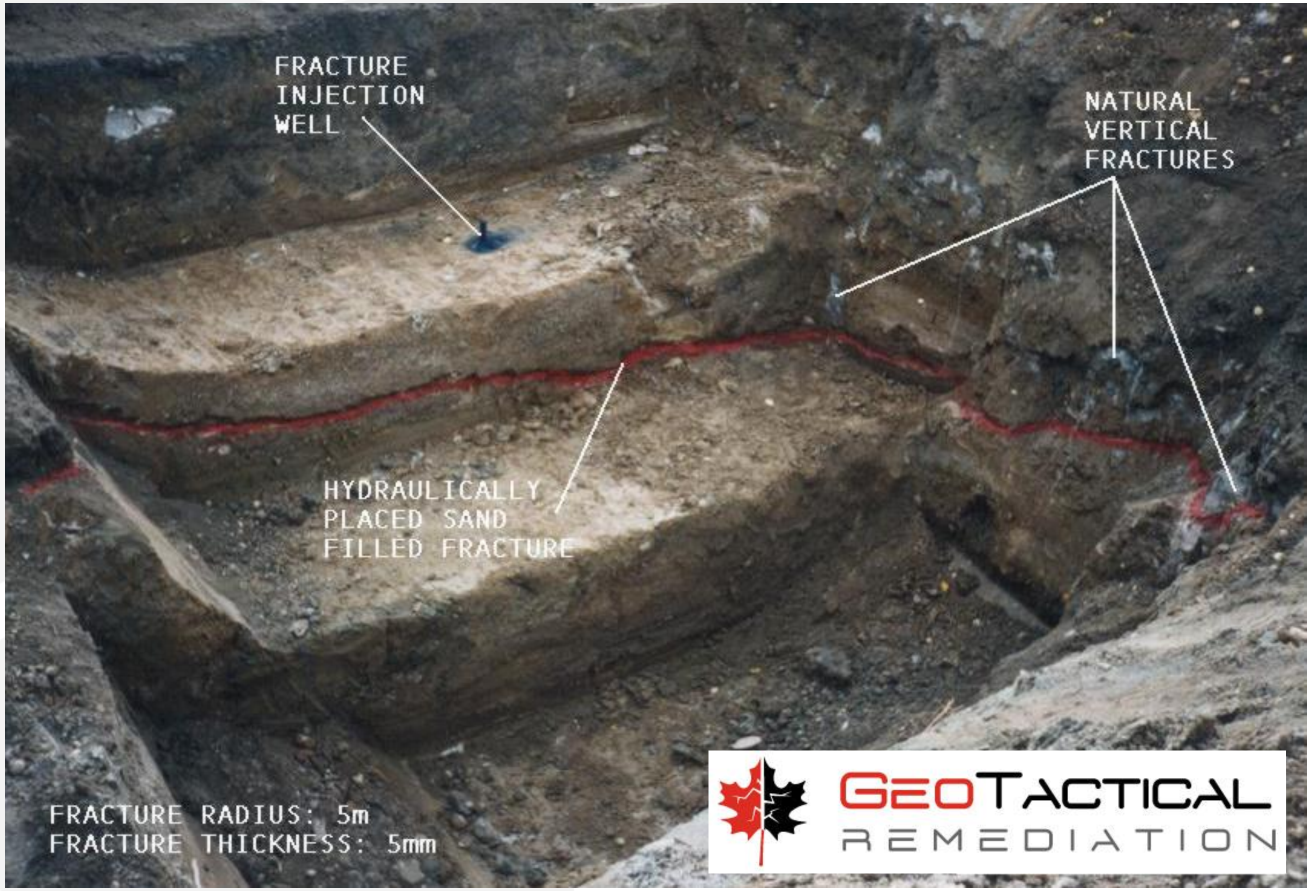
- *Fracture Injection* is a process in which a fluid is applied to a soil or rock mass until failure of the soil or rock occurs, which results in a tensile parting (i.e. fracture)

- Used for:
  - Increasing bulk permeability
  - Greater treatment area per well
  - Better contact with contaminants in matrices with secondary porosity
  - Solid phase amendments



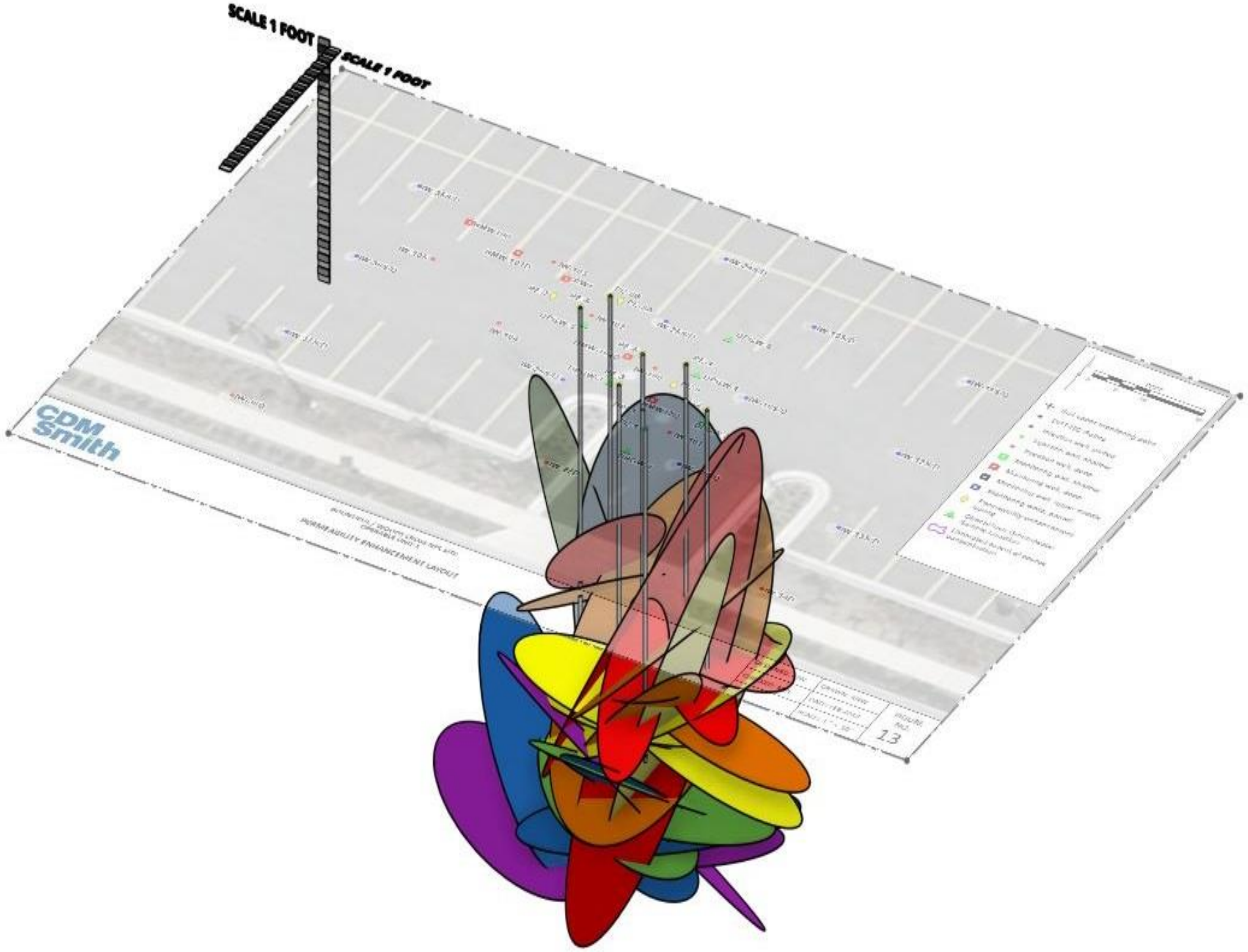
* Direct Injection- **NOT** a mode of injection, a method of drilling

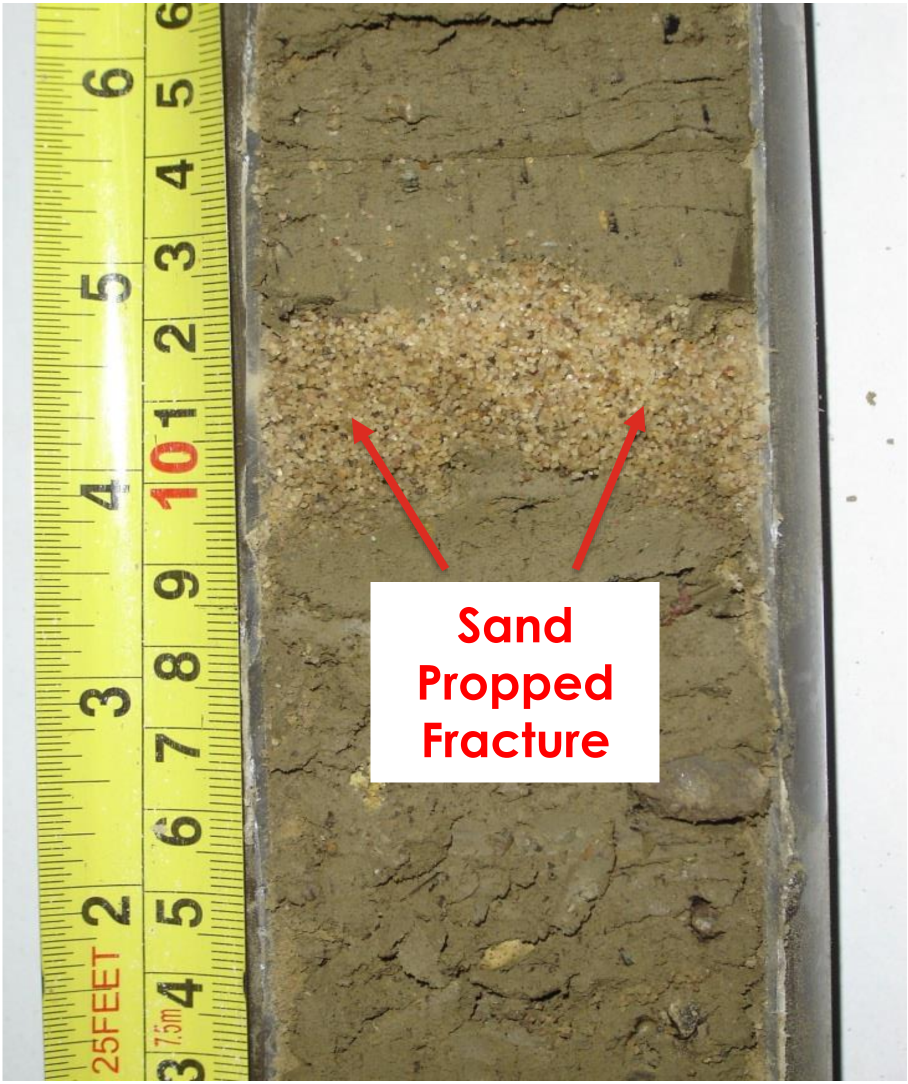
Contact Area



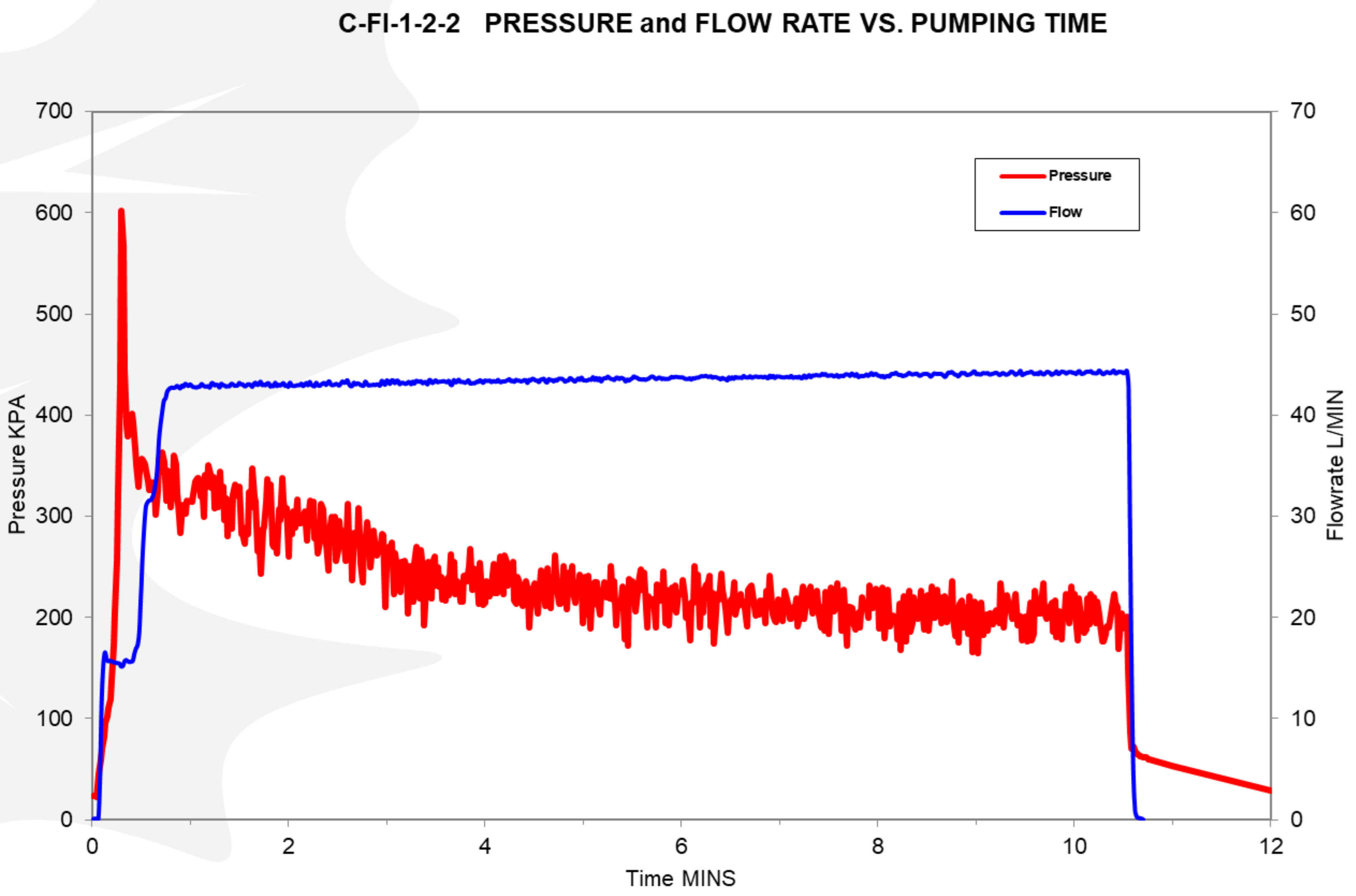
Contact Method	Unit contact Area per Injection Interval Length (m^2/m)
Direct Push Borehole from 6.4 cm OD rod	0.2
Injection Well installed in 15.2 cm OD borehole	0.5
5 m radius fractures at 0.6 m vertical spacing (80 m^2/frac)	260

Fractures Exposed





Pressure-Flow Rate – Time Plot of Fracture Injection



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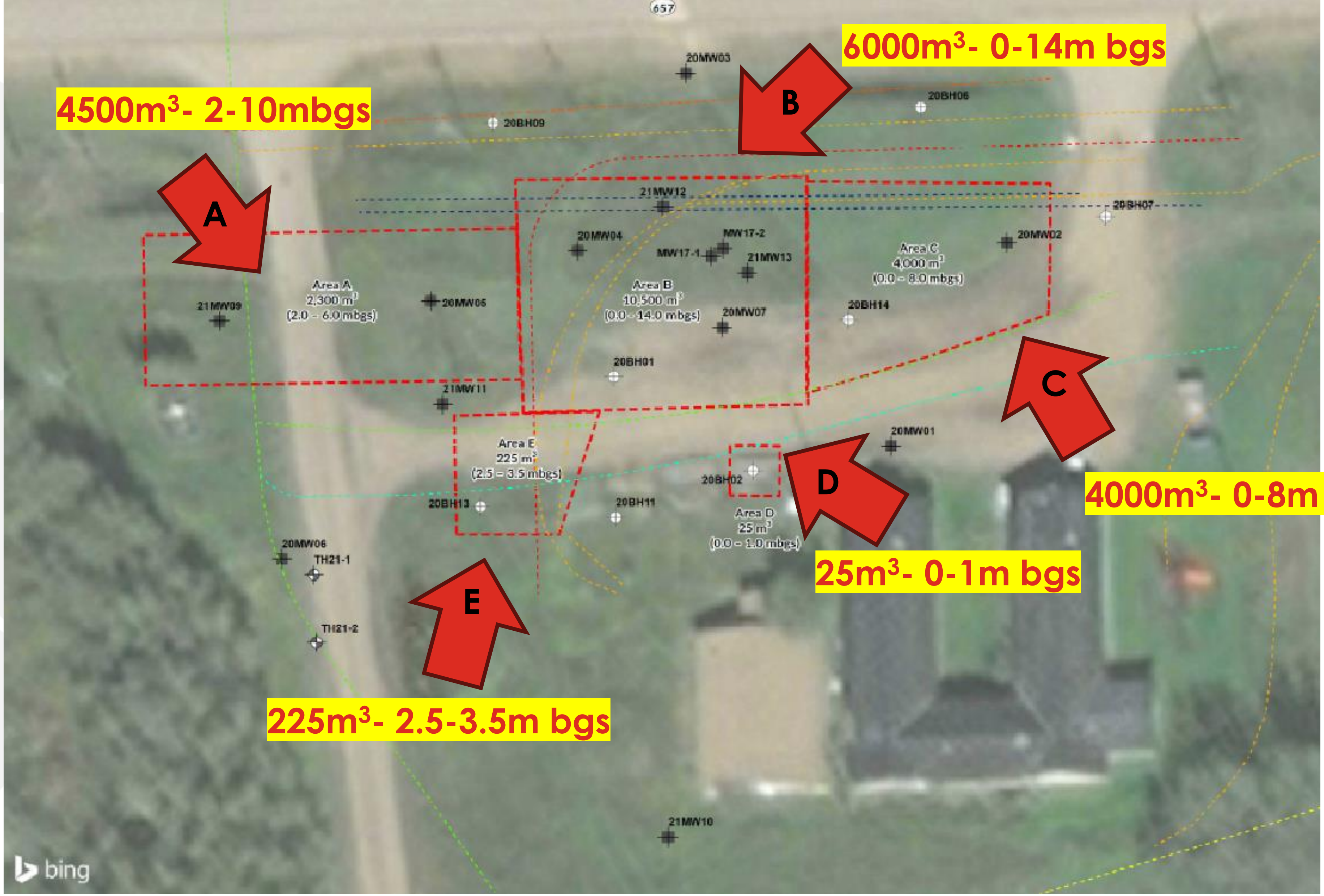
Site Plan (2,070m²)



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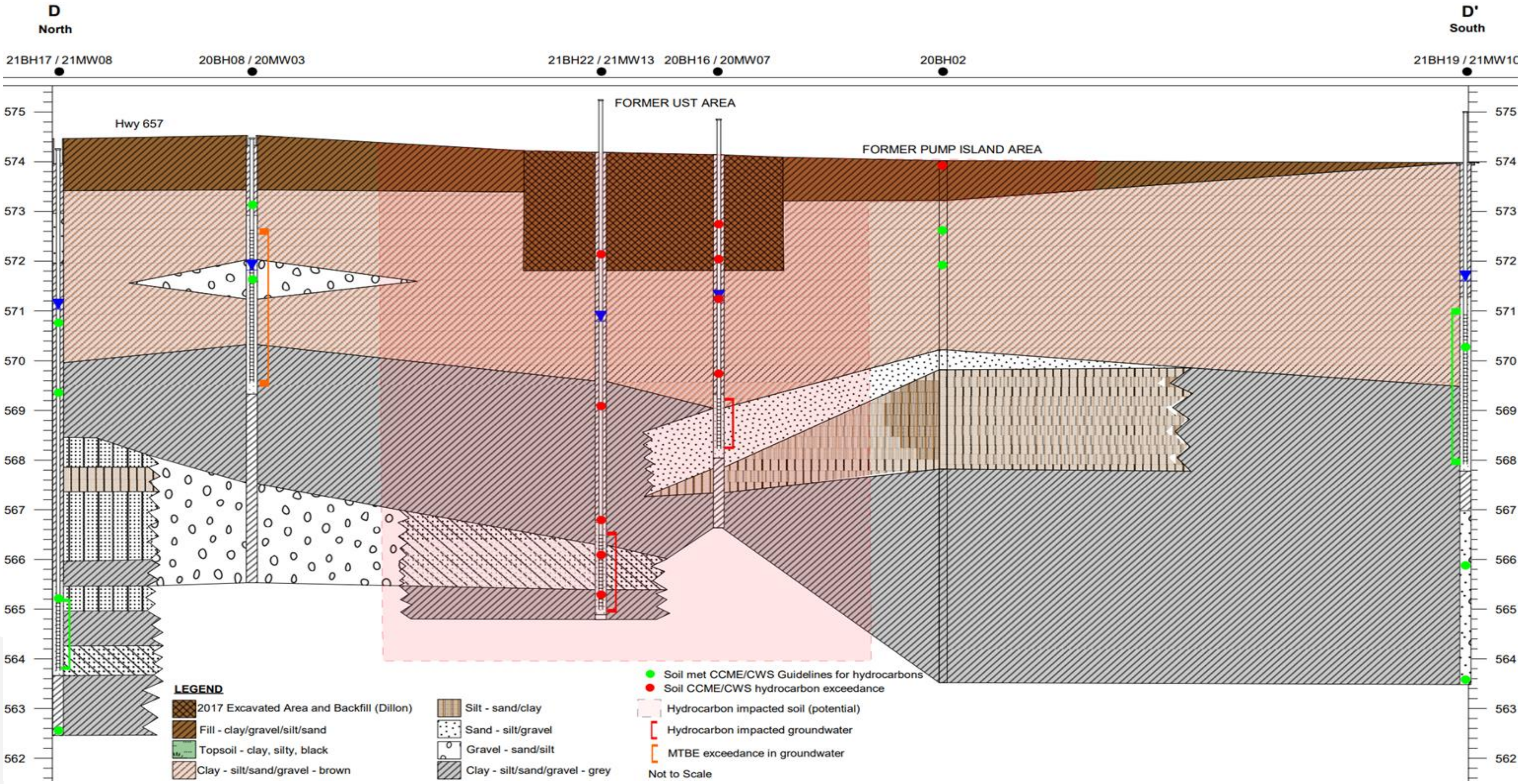
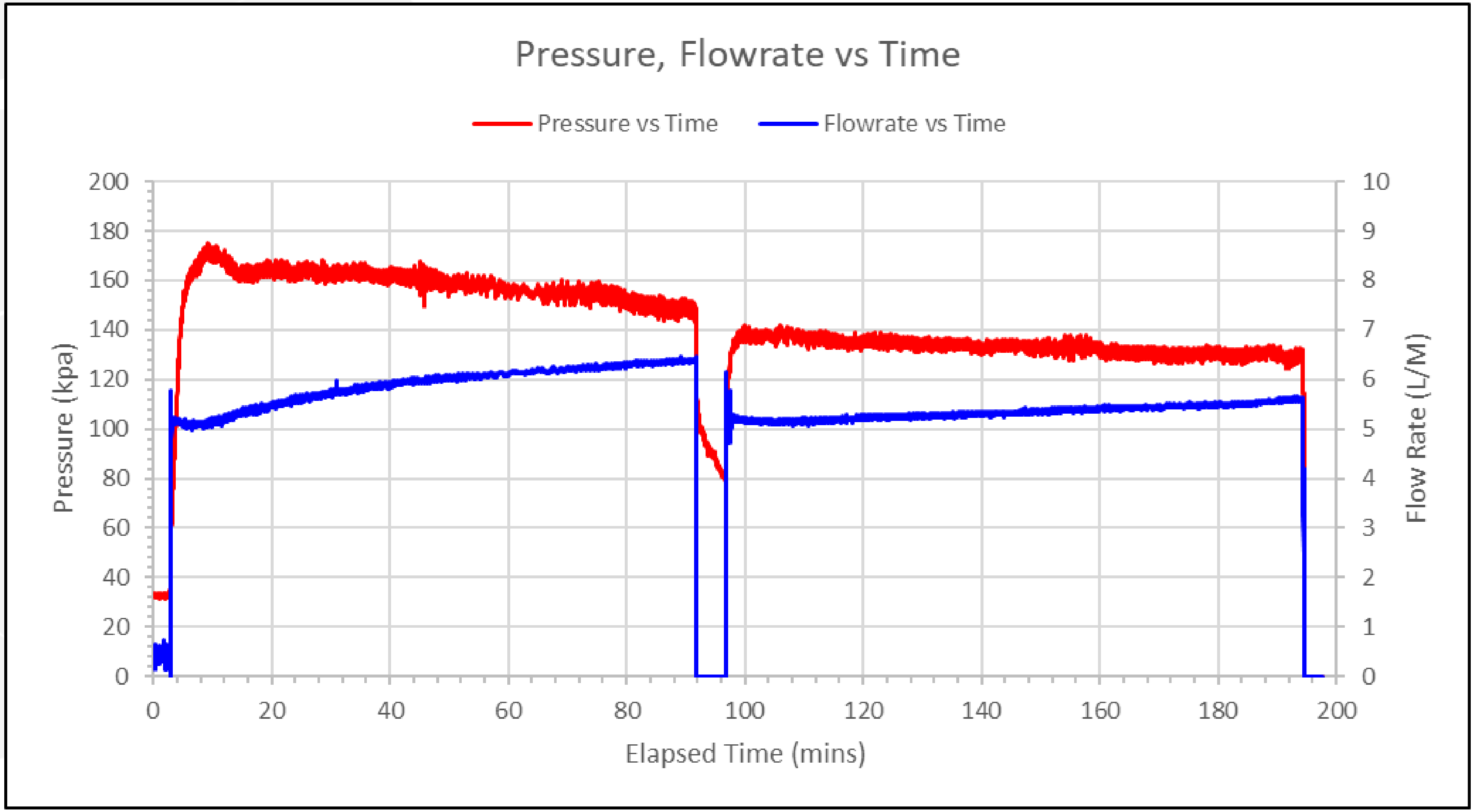
20BH06
20BH09
20BH07
A1S
A1D
A2S
A2D
A3S
A3D
A4S
A4D
A5S
20MW05
A6S
21MW03
A7S
A8S
A9S
Area A
2,300 m³
A10S
A11S
A5D
A6D
A7D
A8D
A12S
A13S
A14S
A15S
Area A location referenced to 20MW05 revised location
IWB1-G
B1
21MW12
B2MA
B2
B2M
IWB2-G
B3
IWB3-G
B3M
20MW04
IWB5-G
B5M
B5
B6
MW17-2
MW17-1
21MW13
IWB7-G
B7
Area B
9,750 m³
B4
IWB4A-G
B4M
IWB8-G
B8
B9
B9M
IWB9A-G
20MW07
B10
IWB10-G
20BH01
Area B location referenced MW17-1 location
C1S
C2S
C3S
C4S
C1D
C2D
C3D
20MW02
C8S
C5S
C6S
Area C
4,000 m³
C7S
C7D
C4D
20BH14
C9S
C6D
C13S
C12S
C5D
C10S
Area C location referenced 20MW02 location
20BH04
21MW11
E1
E2
Area E
E3
225 m³
E4
E5
20BH13
20BH11
Area E location referenced to 21MW11 location
20BH02
Area D
25 m³
20MW01
20MW06
Access Road
21MW10
Area A - Approximate shallow iPAC slurry Injection locations
Area A - Approximate deep iPAC slurry injection locations
Area B - General approximate locations of the sand slury injection, step-offs, and deep injection well locations associated with [B]# location
Area B - Approximate shallow injection well locations
Area B - Approximate iPAC make-up boreholes
Area C - Approximate shallow iPAC slurry injection locations
Area C - Approximate deep iPAC slurry injection locations
Area E - Approximate iPAC slurry injection locations
20 MW05 Revised location based on measuments taken in field
0
10
20
30
40
Meters

2020-8714.000

Figure B5



Permeation Injection into Sand Propped Fractures



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Injection Summary

Injection Event, Area, Completion Date	Number of Injection Locations	Number of Injection Intervals	Number of Wells Injected	Total Injection Volume (m^3)	Total PTS Injected (kg)	Total PTBac Injected (kg)	Total iPAC Injected (kg)	Total Sand Injected (kg)
1 (All Areas), March 2022	72	352	20	229	11,170	128	10,995	59,575
2 (B &C) October 2022	22	111	2	51	5,125	27	1,020	NA
3 (B&C) August 2023	43	264	NA	108	2,335	66	4,710	NA
Total All Injections	**137**	**727**	**22**	**388**	**16,295**	**155**	**16,725**	**59,575**

Results

Table 8-2 Maximum Concentrations in Groundwater

Area	Parameters	Maximum Concentration (mg/L)	
		Pre- and During Remediation	Post-remediation (December 2023)
A	Benzene Ethylbenzene Naphthalene MTBE	0.00620 0.463 0.0381 0.0226	<0.00050 <0.00050 0.0000580 <0.00050
B	Benzene Toluene Ethylbenzene Xylenes PHC F1	19.4 3.87 2.57 5.63 29.0	1.88 0.0202 0.07 0.15 2.24
	Naphthalene Chloroform Methylene chloride MTBE 1,1,2,2-Tetrachloroethane	0.458 0.0108 0.151 6.83 0.0224	0.0218 <0.0010[1] 0.0262[1] 0.694 <0.0010[1]
C	Benzene Toluene Ethylbenzene Xylenes PHC F1 Naphthalene MTBE	6.5 0.163 0.910 0.790 <3.38 0.0587 1.38	<0.00050 <0.00050 <0.00050 <0.00050 <0.100 <0.000030 0.00343

Red indicates a guideline exceedance. [1] Well was decommissioned before December 2023.

Anaerobic Biodegradation Parameters

Well		20MW05					MW17-1			20MW02		
Date Sampled		08-Nov-20	26-May-22	26-Oct-22	18-May-23	13-Dec-23	09-Nov-20	27-May-22	27-Oct-22	08-Nov-20	26-May-22	27-Oct-22
Parameter	**Units**	**Area A**					**Area B**			**Area C**		
Alkalinity, Total (as CaCO3)	mg/L	1,010	814	868	558	760	1,477	1200	1150	752	803	713
Nitrate and Nitrite (as N)	mg/L	0.24	<0.112	0.627	250	33.3	0	<0.224	<0.447	<0.11	0.671	<0.224
pH (field)	pH	7.12	7.34	7.19	8.72	7.37	4	7.37	7.34	6.7	7.03	7.08
Sulfate (SO4)	mg/L	2270	4320	3750	2200	3040	326	5200	12400	2250	4120	6980
Iron-Dissolved	mg/L	2.94	<0.050	<0.050	0.016	<0.050	6	0.723	1.55	<0.050	<0.050	<0.050
Manganese-Dissolved	mg/L	3.21	1.94	2.78	1.27	1.59	1	1.58	3.86	1.25	0.766	4.53
Dissolved Oxygen (Field; In-Situ)	mg/L	-	-	0.75	-	-	-	-	0.52	-	-	-
Oxidation-Reduction Potential (ORP) (Field; In-Situ)	mV	-	-	53.7	-	-	-	-	-101.5	-	-	-

Dissolved Chemistries

(blue)	Good for Anaerobic biodegradation
(green)	Terminal Electron Acceptors for Anaerobic reduction

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Challenges Encountered

Challenge	Action
Coinciding projects- Lift station build occurring at the same time	Clear communication between all contractors and stakeholders to move forward with minimal delays
Surfacing in some parts of Area B and C.	Additional injection locations were used.
Sand propped fracture network less effective for permeation injection than expected due some surfacing and a high degree of interconnection.	Amendment injected with fracture injection was increased, particularly for Injection 2.
Unmarked, difficult to locate utilities resulted in stopping Injection 2 before the planned injections were completed.	Injection 3 adjusted to accommodate amendment mass not used in Injection 2 and remaining mass of PTS used to treat open excavation.

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Conclusion

- Collaboration is "KEY" for projects with multiple stakeholders
  - Clear and consistent communication important when project adjustments need to be made

- Injection services benefited from local engagement

- Multi-discipline approach to reach remediation and risk management goals

Thank you to all partners!!

Indigenous Services Canada / Services aux Autochtones Canada

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Questions??

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