Management of Multiple Data Streams for *In Situ* Remediation

2022 International Conference on Environmental Data Management

September 21-22, 2022 – Troutdale, Oregon

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Overview

- Project
- In Situ Chemical Oxidation (ISCO)
- Site
- Data Streams
- Visualization Demo
- Outcomes

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Project

Develop a workflow that enables the project team to provide adaptive site management practices to dynamically assess system performance and tune the injection system to meet clean-up objectives.

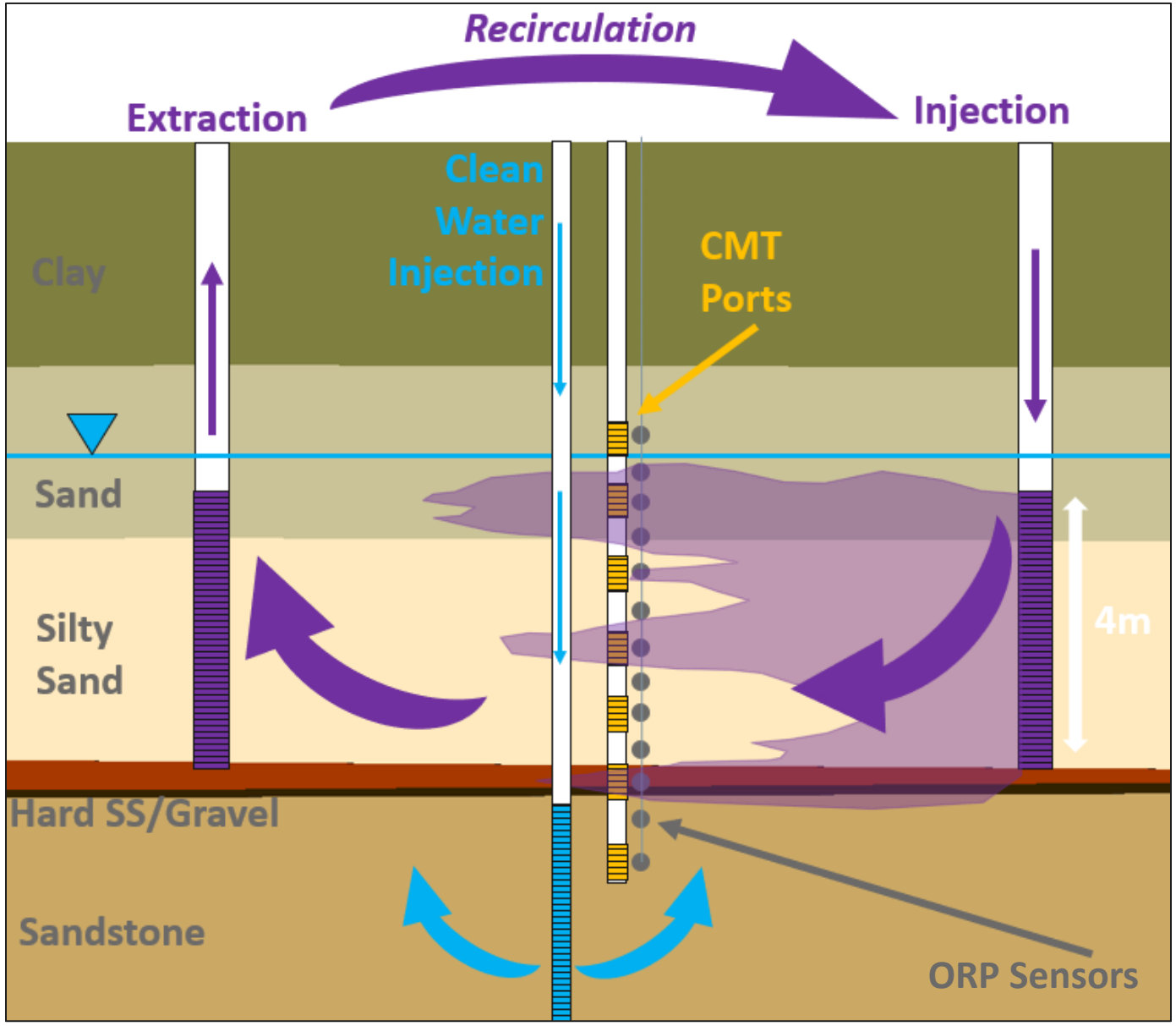
Forward thinking client and regulators were ready for this approach!

- Needed a coherent, data-centric system to scrub and manage the data
- System needed to accommodate, manage (via code where possible), and integrate multiple data streams
- Careful consideration of what data to include

What is ISCO?

In Situ Chemical Oxidation

- Injection of an oxidant (sodium permanganate)
- Chemical reaction occurs destroying the contamination (TCE)
- Extraction of groundwater to help draw the permanganate through the subsurface
- Reinjection of permanganate to the subsurface
- Strings of ORP sensors to monitor the progress of the permanganate



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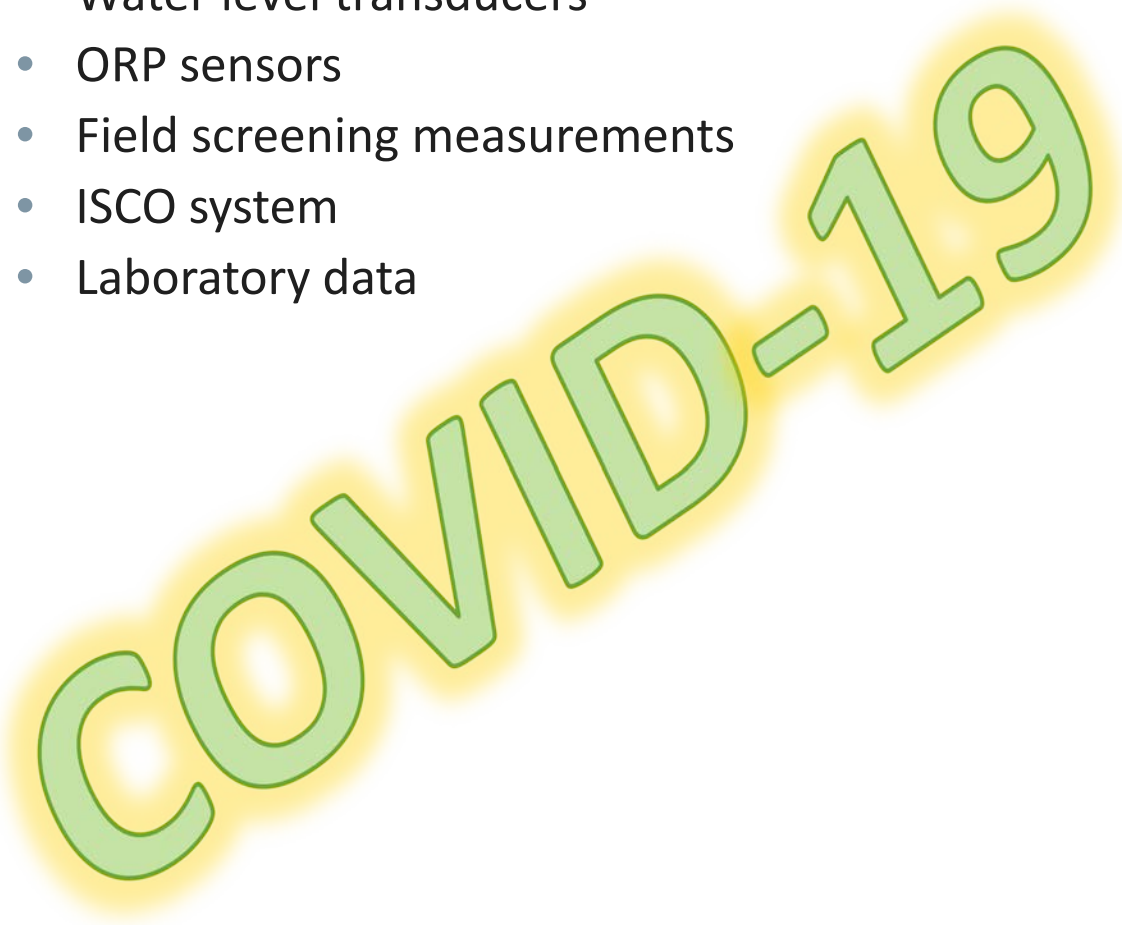
Project

- Multi-National Effort
  - Site in France
  - Sanborn Head in New England
    - 6-hour time difference
    - Project Team and DM&V Team
  - Local French contractor
    - Language and culture differences
  - Drillers from UK
  - ISCO system from Netherlands
  - ORP sensors/monitoring from USA
  - Laboratory services from French lab
  - Consulted with University of Guelph in Canada
- Multiple Data Collection Methods
  - Verbal over Teams call
  - Excel field forms
  - Water level transducers
  - ORP sensors
  - Field screening measurements
  - ISCO system
  - Laboratory data



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Data Technologies in Use

- EQuIS
- Microsoft SQL Server
- Excel
- SharePoint
- Python
- R
- ArcGIS
- EVS
- Power BI

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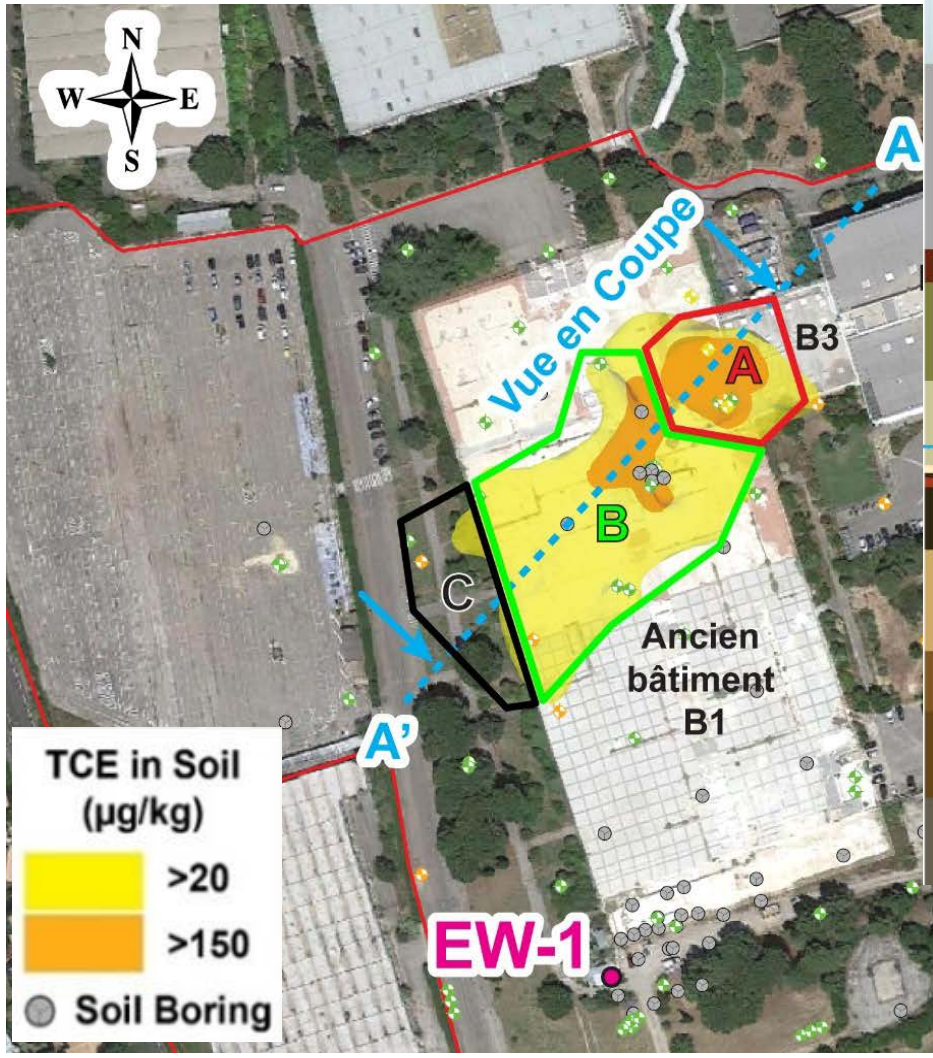
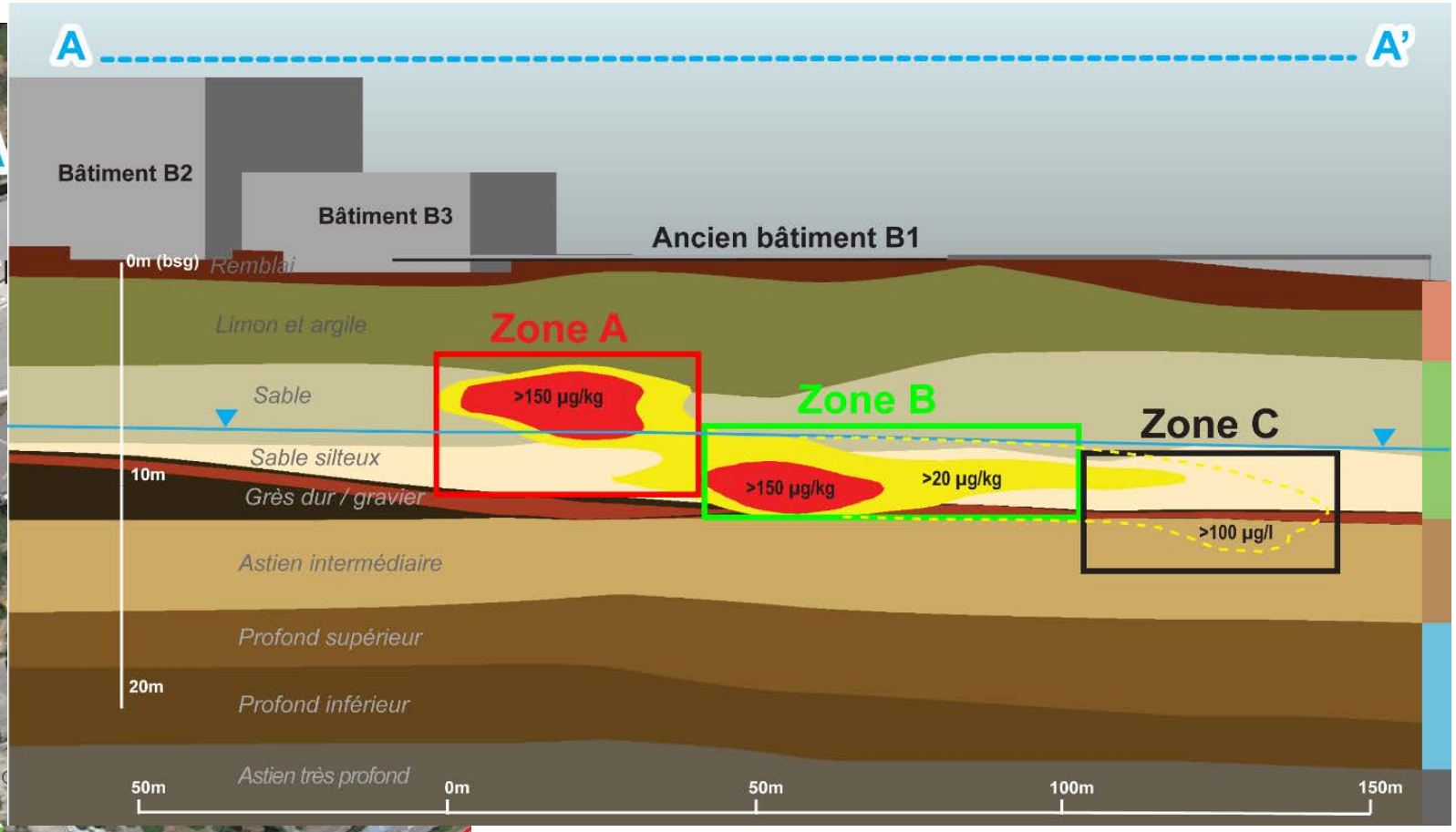
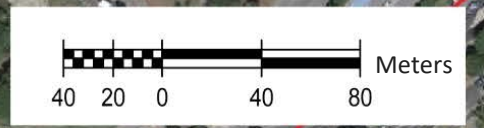
Site







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Site

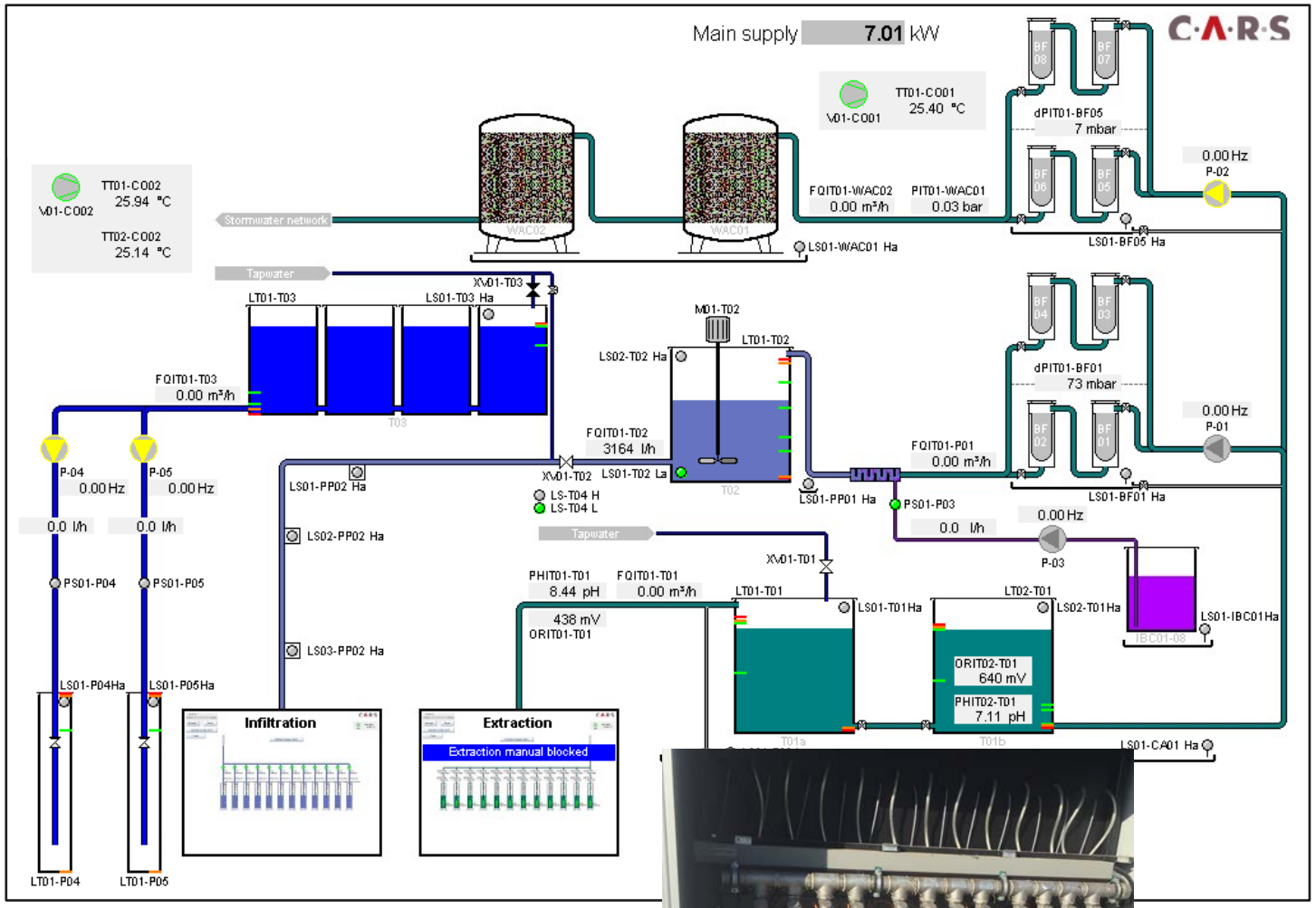
Subsurface Network

- 193 injection/extraction wells
  - 17 rows (A through Q)
- 62 MWs, including 12 CMTs
- 44 *in situ* remote ORP sensor strings
  - 548 individual sensors

Site

ISCO Surface System

- Closed, recirculatory permanganate injection/extraction system
- Remotely monitored and operated; periodically operated without personnel on-site
- Set up on trolleys to move from one row to the next as clean-up objectives are met

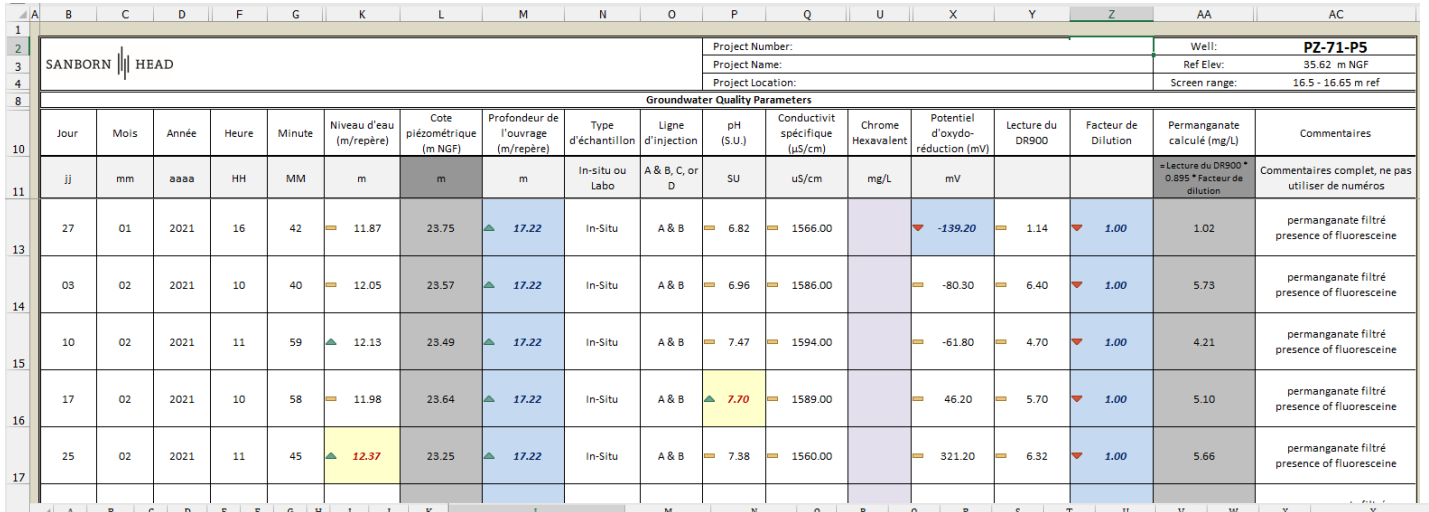


Data Streams

- ISCO System
  - 5-minute recording frequency
  - No API available
  - ISCO system sends csv files to SharePoint every 6 hours
  - Python transforms and pushes the data into on-premise SQL database
- ORP Sensors
  - Hourly measurements
  - API via cell
  - Automatic daily API call via R script. API provides data in JSON format, R script converts to csv and appends to master file which is then consumed by additional R scripts, ArcGIS, EVS, and Power BI
- Water Level Transducers
  - 15-minute recording frequency
  - Manually csv files downloaded at wellhead, uploaded to SharePoint
  - Processed in R and master csv file is then consumed by additional R scripts, ArcGIS, EVS, and Power BI

Data Streams

- Daily / Weekly Groundwater Field Measurements
  - Water levels
  - Colorimetric Permanganate screening
  - pH, ORP, Specific Conductivity, Temp
  - Excel field forms with cell validation
  - Delivered via SharePoint
  - Processed via Python uploaded to SQL
- Quarterly Groundwater and Annual Soil Sampling
  - French lab – EDDs in German format
  - Processed manually due to persistent inconsistencies in the EDDs and uploaded to EQuIS
- Lithology
  - From coring/well installation
  - Logged Excel field forms
  - Data consumed in EVS and Power BI



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Project Number:
Project Name:
Project Location:

Well: PZ-71-P5
Ref Elev: 35.62 m NGF
Screen range: 16.5 - 16.65 m ref

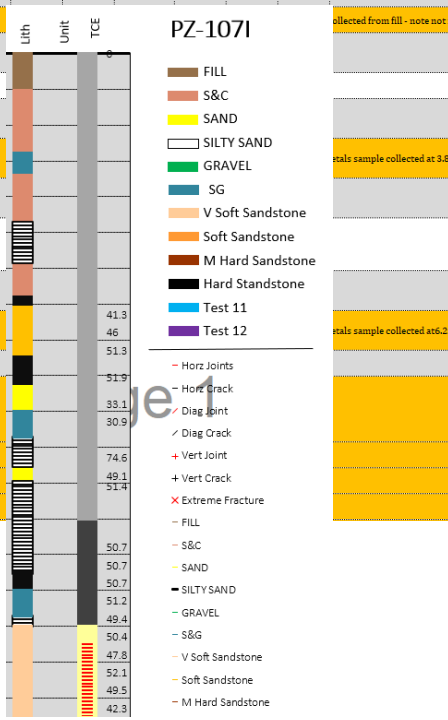
Groundwater Quality Parameters

Jour	Mois	Année	Heure	Minute	Niveau d'eau (m/repère)	Cote piézométrique (m NGF)	Profondeur de l'ouvrage (m/repère)	Type d'échantillon	Ligne d'injection	pH (S.U.)	Conductivit spécifique (µS/cm)	Chrome Hexavalent	Potentiel d'oxydo-réduction (mV)	Lecture du DR900	Facteur de Dilution	Permanganate calculé (mg/L)	Commentaires
jj	mm	aaaa	HH	MM	m	m	m	In-situ ou Labo	A & B, C, or D	SU	uS/cm	mg/L	mV			= Lecture du DR900 * 0.895 * Facteur de dilution	Commentaires complet, ne pas utiliser de numéros
27	01	2021	16	42	11.87	23.75	17.22	In-Situ	A & B	6.82	1566.00		-139.20	1.14	1.00	1.02	permanganate filtré presence of fluoresceine
03	02	2021	10	40	12.05	23.57	17.22	In-Situ	A & B	6.96	1586.00		-80.30	6.40	1.00	5.73	permanganate filtré presence of fluoresceine
10	02	2021	11	59	12.13	23.49	17.22	In-Situ	A & B	7.47	1594.00		-61.80	4.70	1.00	4.21	permanganate filtré presence of fluoresceine
17	02	2021	10	58	11.98	23.64	17.22	In-Situ	A & B	7.70	1589.00		46.20	5.70	1.00	5.10	permanganate filtré presence of fluoresceine
25	02	2021	11	45	12.37	23.25	17.22	In-Situ	A & B	7.38	1560.00		321.20	6.32	1.00	5.66	permanganate filtré presence of fluoresceine

CP-Name	Sampler	Prop CP	X	Y	Z
PZ-107I	PJP	PZ-107I			35.05

Sample Run Top (m)	Bottom (m)	SMP #	Date	Time	Pen (m)	Rec (m)	SUB Sample Top (m)	Bot (m)	SUB SMP	Comments	General Lithology	Geo Unit	PID	Analyze/ Hold	Mobile Vial ID	DUP Vial ID	MAE Vial ID	SMP Depth	Extraction	Fix Lab SMP	Phy Para Testing	QA/QC	SMP Comment
0	0.15	1	2/10	8:00	0	0.15	0	0.15	A	Concrete slab w/ brick	FILL	Fill		NO SMP									
0.15	1	2	2/10	8:10	0.85	0.85	0.15	1	A	Vacuum cleared fill	FILL	Fill		NO SMP									
1	2.5	3	2/10	8:35	1.5	1.5	1	1.05	A	Frequent thin plastic fragments	FILL	Fill		ANALYZE									collected from fill - note not
1	2.5	3	2/10	8:35	1.5	1.5	1.05	2.5	B	Black mineralization. Orange-gray mottling significant below 1.75m Dry/dessicated 1.95-2.20m.	S&C	Silt&Clay		NO SMP									
2.5	4	4	2/10	9:30	1.5	1.4	2.5	2.8	A	Slight orange oxidation. White chalk nodules.	S&C	Silt&Clay		NO SMP									
2.5	4	4	2/10	9:30	1.5	1.4	2.8	3.35	B	Slight orange oxidation. Frequent shell fragments. Grades finer with depth.	S&G	Silt&Clay		NO SMP									
							3.35	4	C	Prominent orange-gray mottling. Black mineralization. Breaks along vertical planes.	S&C	Silt&Clay		ANALYZE									etals sample collected at 3.8
							4	4.75	A	Orange-gray mottling to 4.3m. dk. Gray to lt. gray 4.3-4.75m. Black mineralization. Whitechalk nodules.	S&C	Silt&Clay		NO SMP									
							4.75	5.5	B	Grades sandier, looser with depth. Orange oxidation increases with depth. Gravel layer 5.1m. White chalk noduels	SILTY SAND	Silt&Clay		NO SMP									
							5.5	5.89	A	Slight orange oxidation, increase withdepth.Blackmineralization ("web" like filaments)	SILTY SAND	Silt&Clay		NO SMP									
							5.89	6.8	B	Orange oxidized. Black mineralization. Orange clay laminations spaced~1cm apart.	S&C	Silt&Clay		ANALYZE									etals sample collected at6.2
							6.8	7	C	Orange oxidized, mod. Weathered. Shells	Hard Sandstone	Shallow Unsat		NO SMP									
							7	7.5	A	Varying hardness throughout.VOC collected in unconsolidatedzones with red-orange staining. Vugs present. Moderately weathered. Unconsolidated 7.5-7.8m.	Soft Sandstone	Shallow Unsat		ANALYZE	100								
							7.5	8	B	Same as above, broken for additional sampling	Soft Sandstone	Shallow Unsat		ANALYZE	101								
							8	8.5	C	Same as above, broken for additional sampling	Soft Sandstone	Shallow Unsat		ANALYZE	102								
							8.5	9.25	A	Sl. Orange oxidation. Unconsolidated 9.02-9.12m. Sl. Weathered.	Hard Sandstone	Shallow Unsat		ANALYZE	103								

EXPLORATION NAME:		PZ-107I	
S&C	5.89	6.8	6.2
Hard Sandstone	6.8	7	0
Soft Sandstone	7	7.5	7.3
Soft Sandstone	7.5	8	7.8
Soft Sandstone	8	8.5	8.3
Hard Sandstone	8.5	9.25	9.05
SAND	9.25	9.6	9.3
SAND	9.6	10	9.8
S&G	10	10.75	10.3
SILTY SAND	10.75	11	10.8
SILTY SAND	11	11.5	11.3
SAND	11.5	12	11.8
SILTY SAND	12	12.15	12.1
SILTY SAND	12.15	13	12.8
SILTY SAND	13	13.5	13.3
SILTY SAND	13.5	14	13.8
SILTY SAND	14	14.5	14.3
Hard Sandstone	14.5	14.9	14.8
S&G	14.9	15.75	15.3
SILTY SAND	15.75	16	15.8
V Soft Sandstone	16	16.5	16.3
V Soft Sandstone	16.5	17	16.8
V Soft Sandstone	17	17.5	17.3
V Soft Sandstone	17.5	18	17.8
V Soft Sandstone	18	18.5	18.3
V Soft Sandstone	18.5	19	18.8
Soft Sandstone	19	19.5	19.3
Soft Sandstone	19.5	20	19.8



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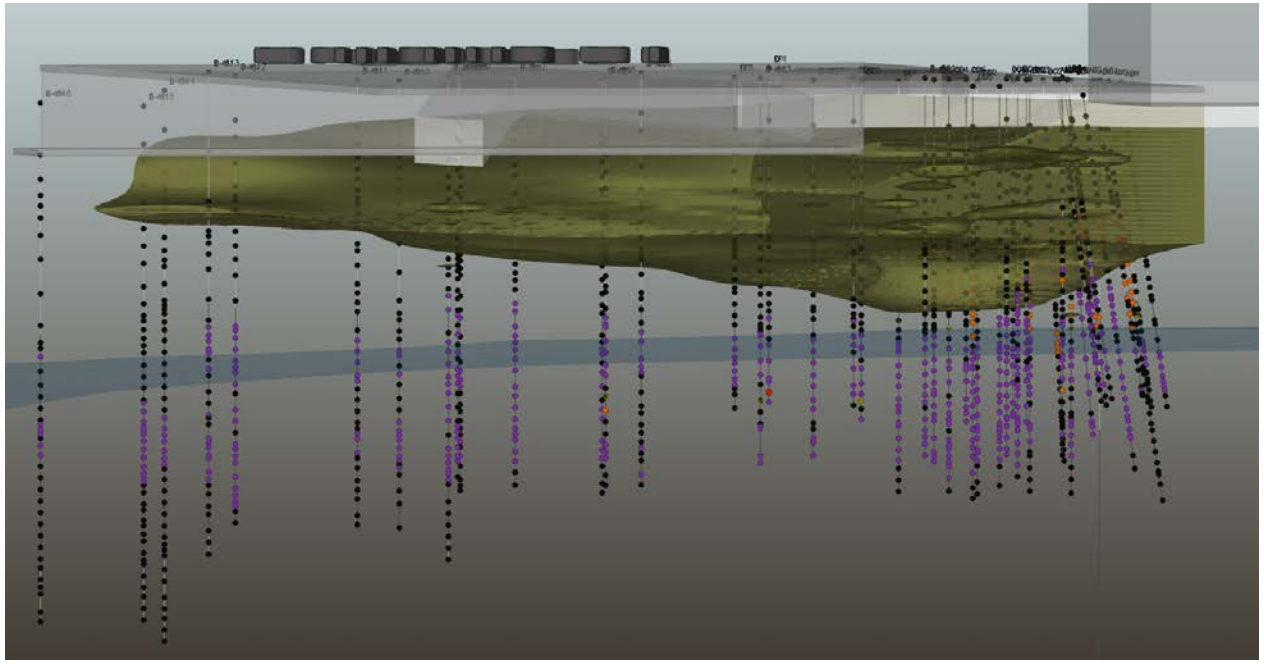
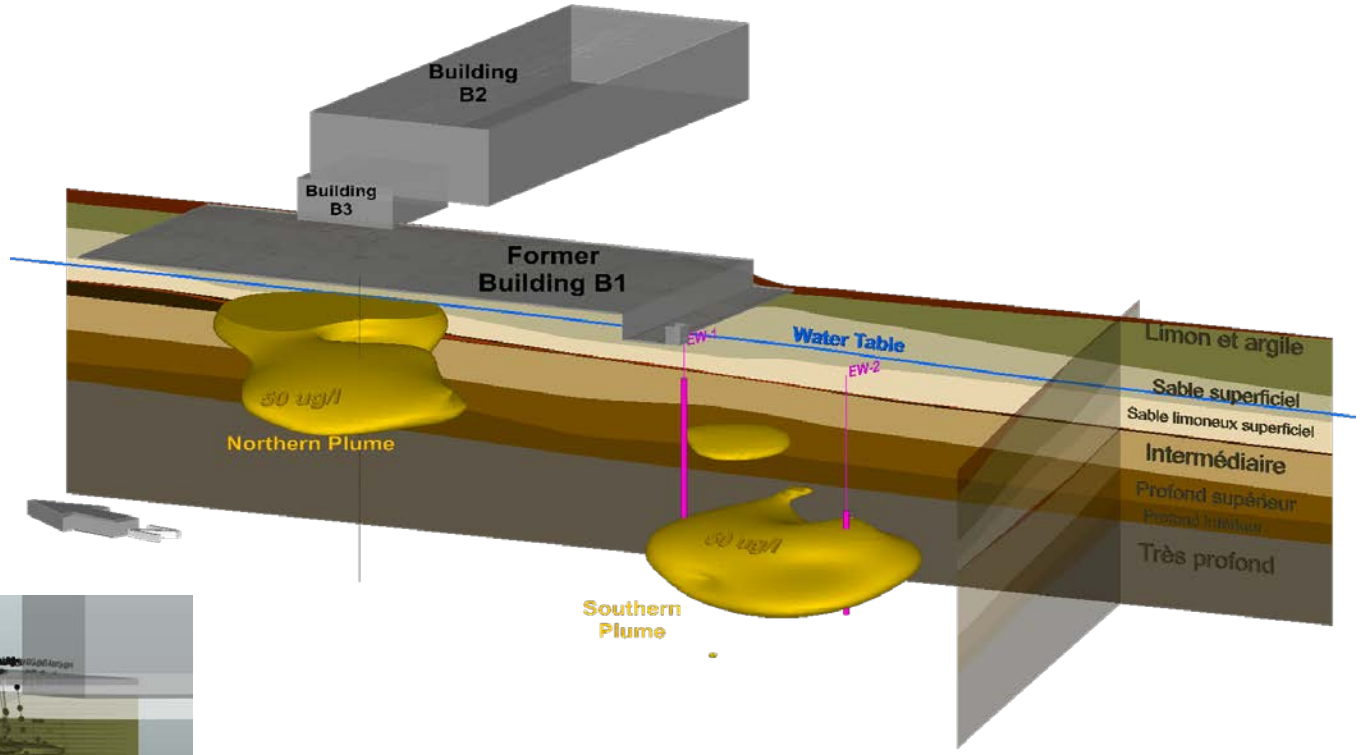
Visualizations

- R output example
- EVS 3D model
- Power BI dashboard

EVS Soil Permanganate and TCE Results





EVS Groundwater TCE Plume

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Takeaways

- A multi-faceted approach to data management and visualizations has allowed us to use adaptive site management, dynamically assess system performance, and tune the injection system to meet clean-up objectives.
- Careful consideration in the early stages of the project of which data to NOT include in the data processing was critical. By including more data, rather than less, we were able to have the data required to troubleshoot unanticipated problems when they occurred later in the project.
- An enterprise approach to data management system design has allowed us to more easily repurpose various components for other projects.
- Sensor technology continues to become more accessible to our industry, allowing us to use real-time monitoring of surrogates to have more complete “digital twins” of the subsurface and thereby achieve better outcomes for our remediation programs.

Questions

Please contact us!

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