

**2024 Battelle Chlorinated Conference**

June 2-6, 2024 | Denver, Colorado

# Optimizing Injection Dosage of Enhanced In Situ Bioremediation Substrate and Incorporating Interactive Data Visualization Software for System Management



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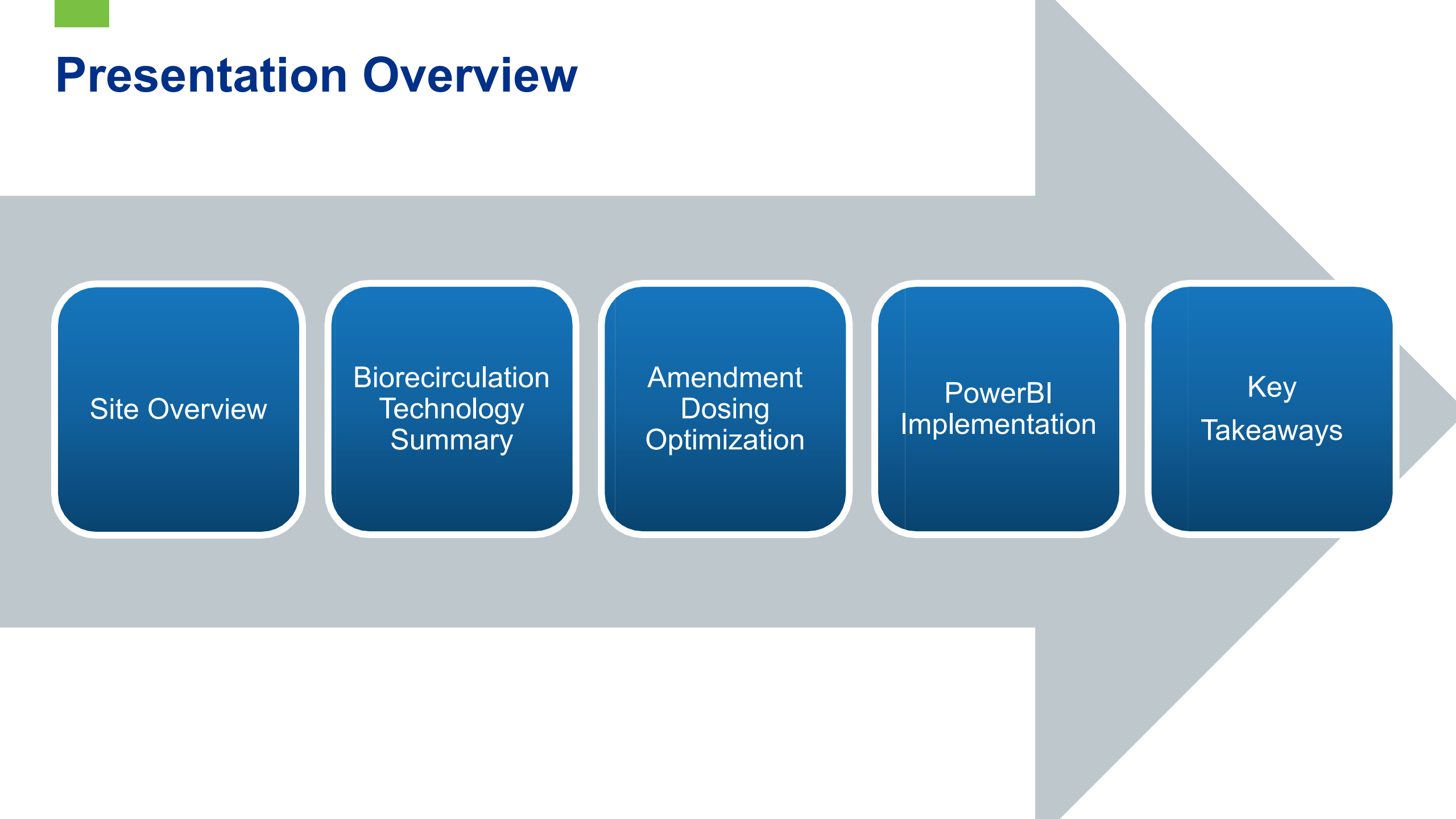
**Michael Nigro**

June 3, 2024





# Presentation Overview



Site Overview

Biorecirculation  
Technology  
Summary

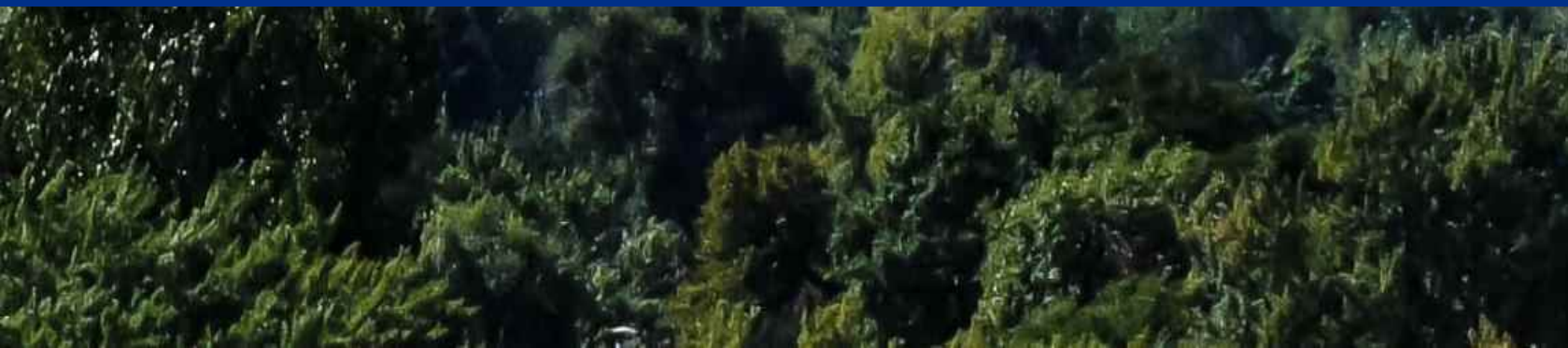
Amendment  
Dosing  
Optimization

PowerBI  
Implementation

Key  
Takeaways



# Project Overview



# Site Overview

- Active industrial facility
- Three interbedded hydro stratigraphic zones with perched groundwater
- CVOC source areas
  - PCE, TCE, 1,1-DCE

## HORIZON 1

~50 to 60 feet below  
ground surface (ft  
bgs)

- Sands with varying silt
- Downward vertical gradient
- Existing SVE and TPE  
→ low groundwater concentrations

## CONFINING LAYER 1

~60 to 70 ft bgs

- Silt and clay with  
varying sand
- Varying CVOC  
residual mass

## HORIZON 2

~70 to 85 ft bgs

- Sand and silt
- High CVOC  
concentrations→  
interim remedial action

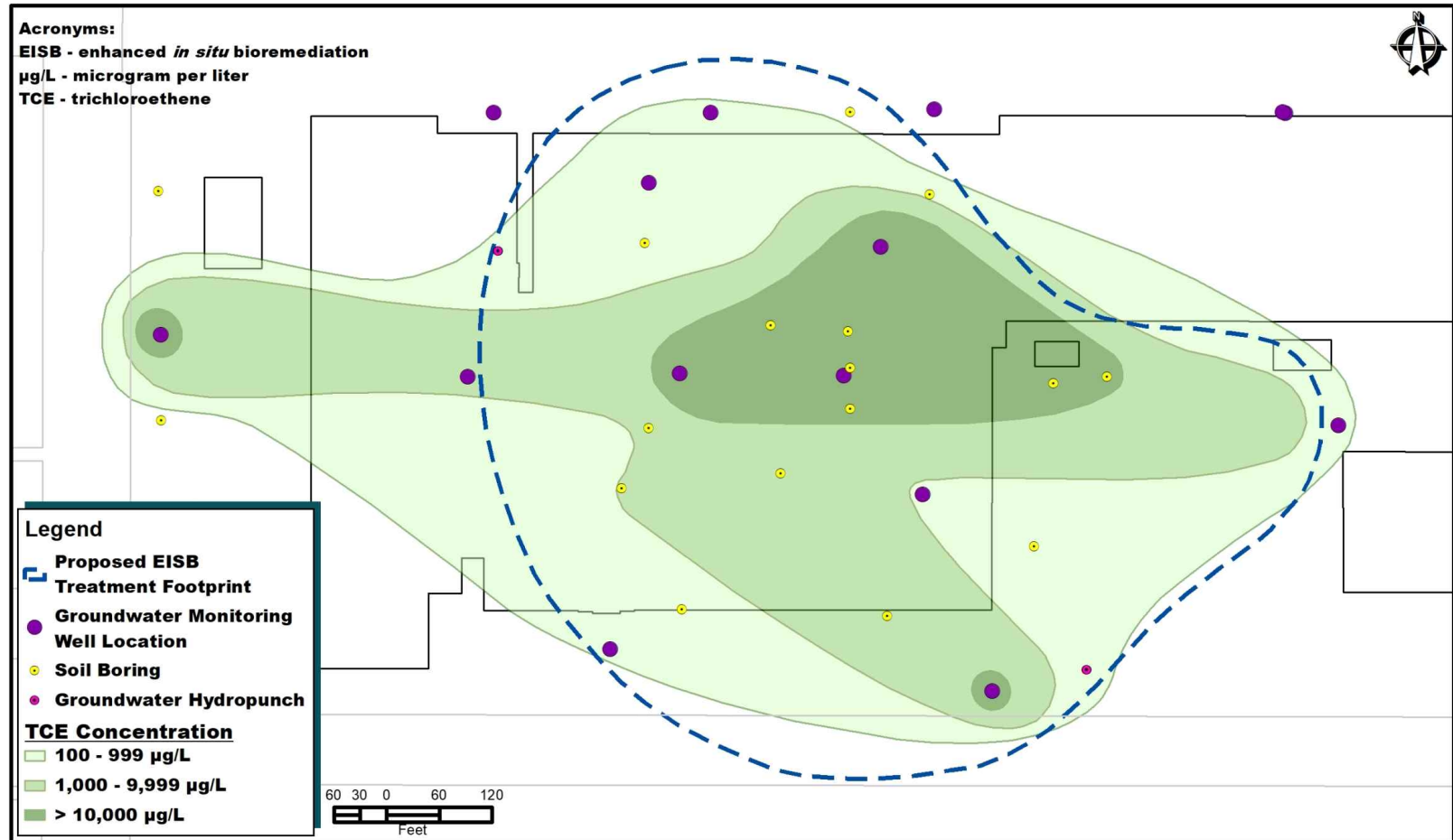
## CONFINING LAYER 2

~85 to 95 ft bgs

- Silt and clay

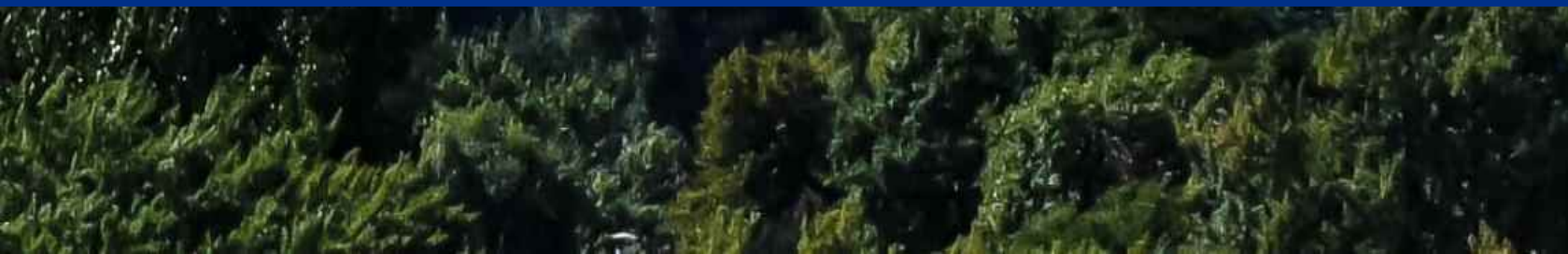
# Site Contamination

- TCE mass in Confining Layer 1
  - 1 to 7 mg/kg
- CVOC mass in Horizon 2
  - TCE: 280,000 µg/L max
  - PCE: 35,000 µg/L max
- Flat gradient
- Clays lenses within Horizon 2
- Past remedial action
  - SVE, TPE in Horizon 1
  - EISB pilot test in Horizon 2





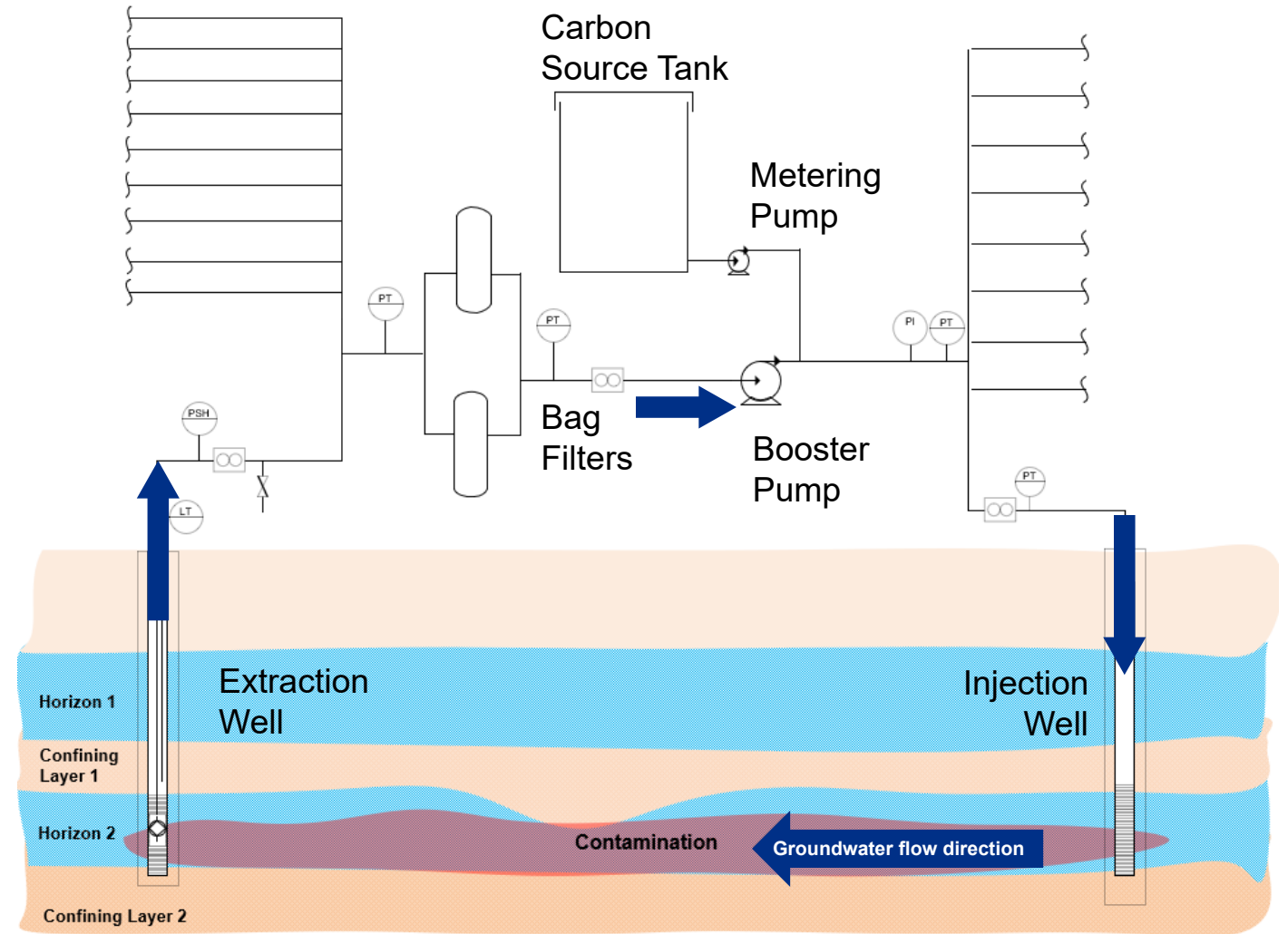
# Remediation Technology: Biorecirculation



# System Design

- Amendment distribution
- Hydraulic capture
- No net removal or discharge
- Closed system
- Automatic controls (especially for injection balancing)

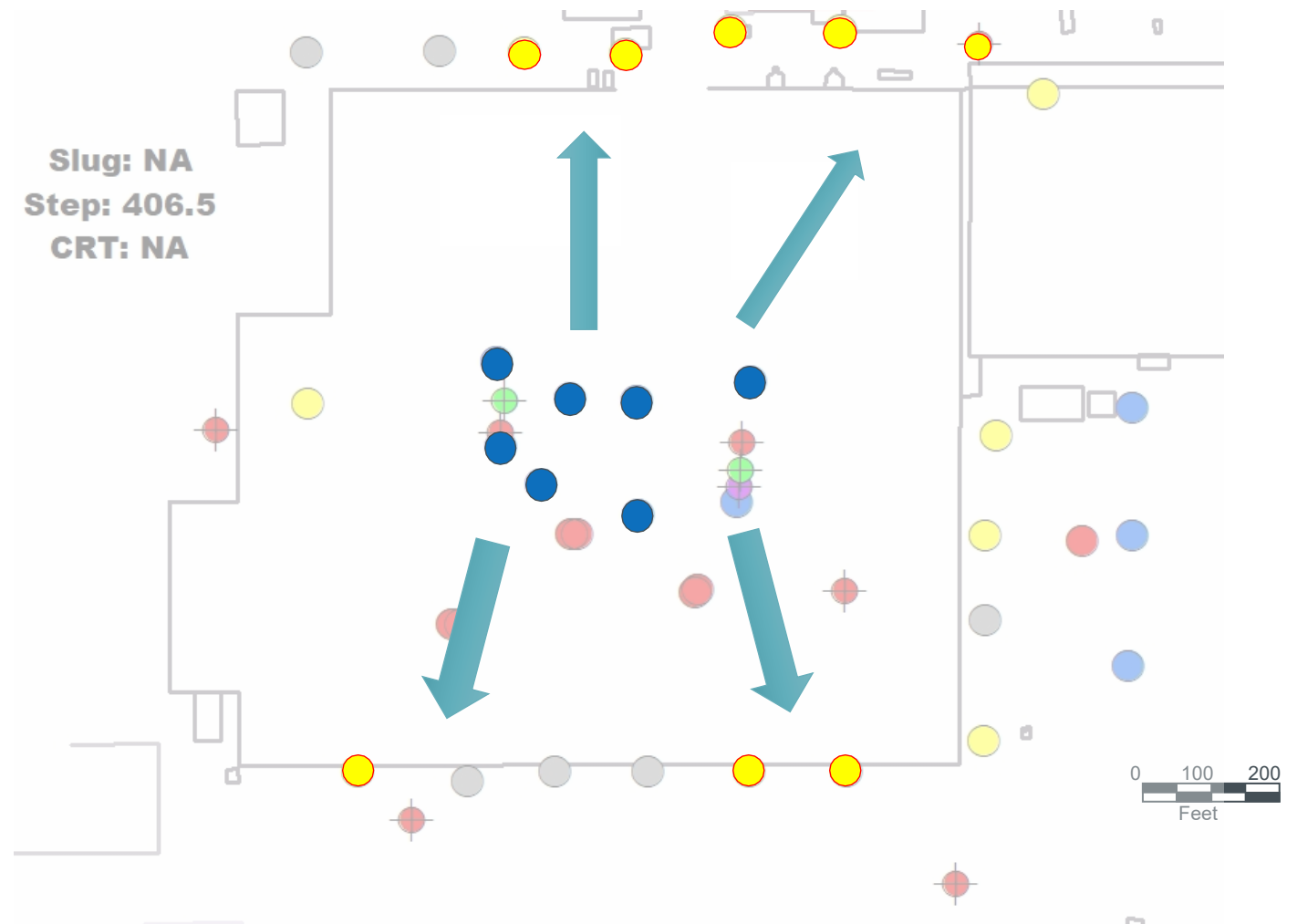
## Enhanced in situ bioremediation (EISB) recirculation system



# Current Biorecirculation System Layout

■ 8 EWs, 7 IWs

■ ~200 – 275 feet  
from IWs to EWs

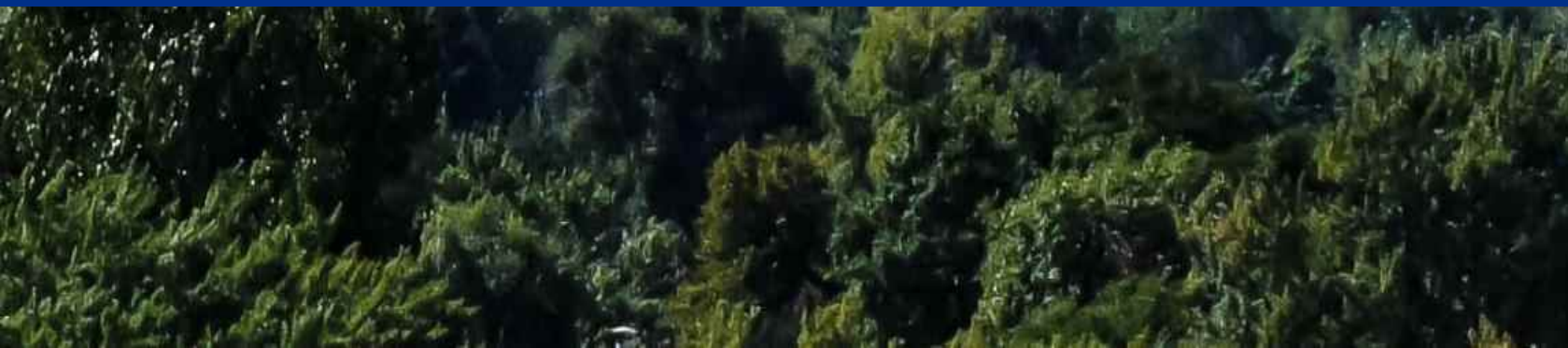


● Extraction Well (EW)

● Injection Well (IW)



# Amendment Dosing Optimization



# Dosing Timeframe

- Pilot study demonstrated amendment delivery effectiveness and complete dechlorination of the parent compound (TCE) of all wells influenced by and located within the pilot test area
- Amendment added in short-term pulses

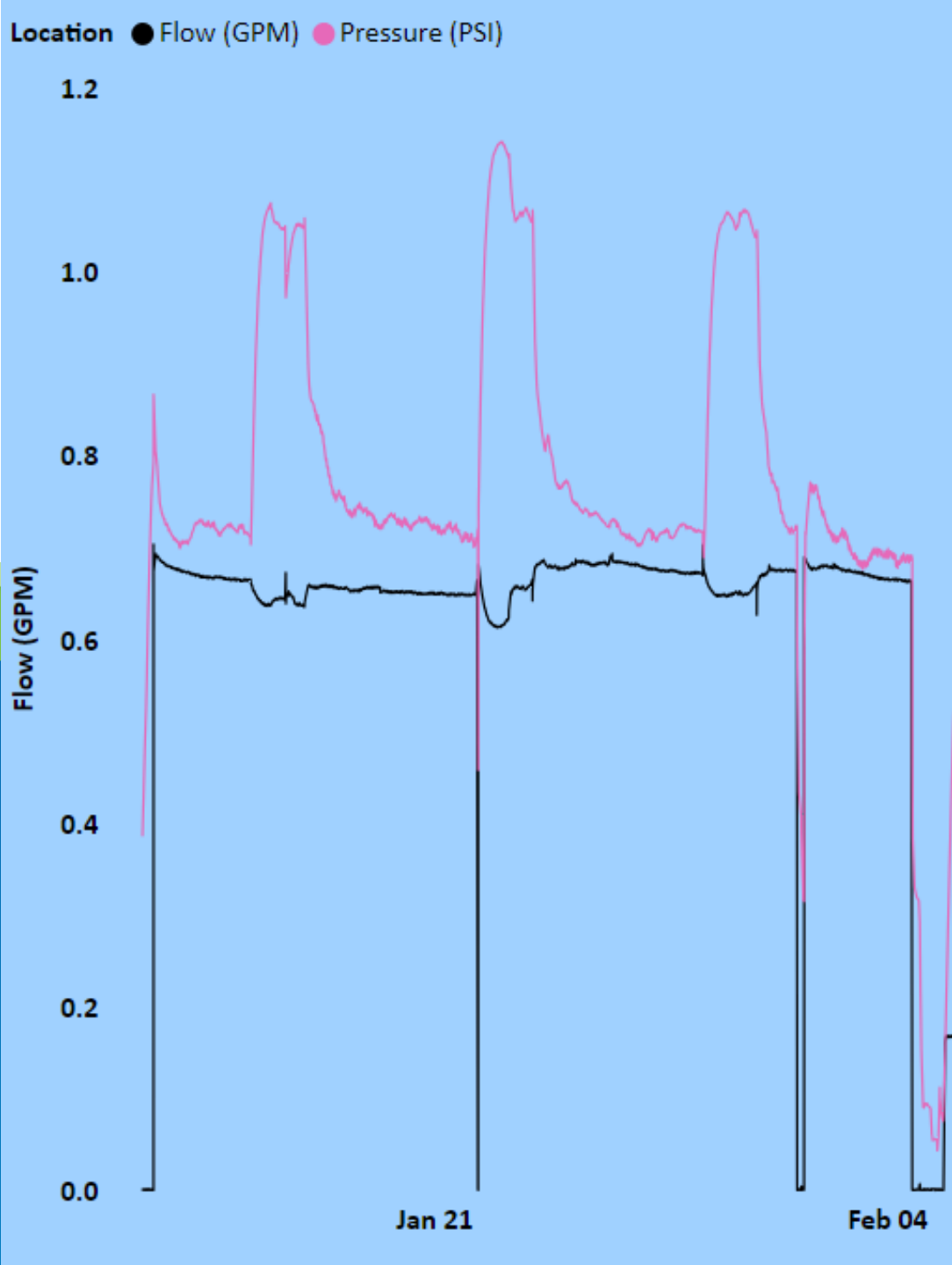
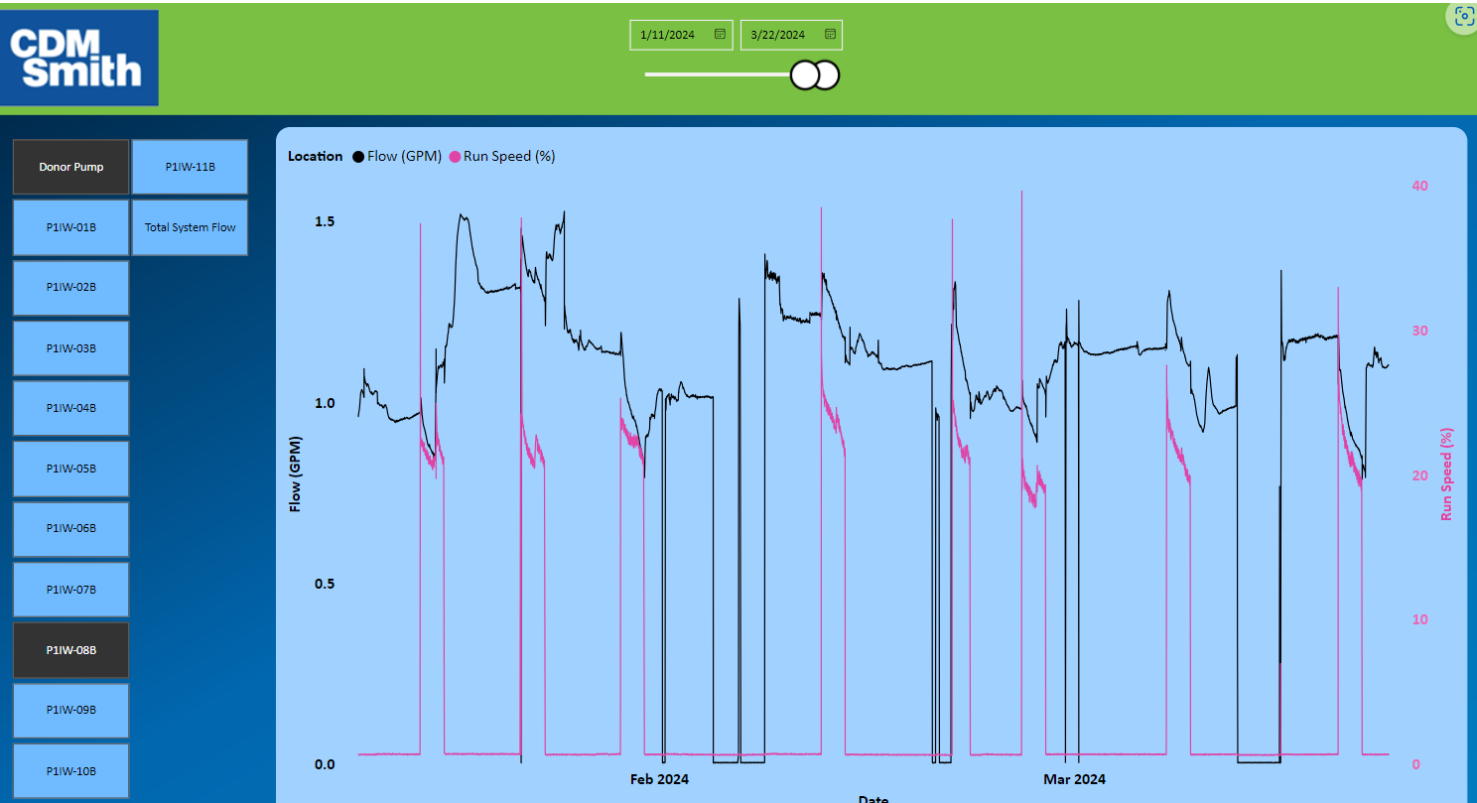
|                                            |     |      |
|--------------------------------------------|-----|------|
| Hand                                       | Off | Auto |
| Water SP (Hrs)                             | 48  |      |
| Donor SP (Hrs)                             | 30  |      |
| Flush SP (Hrs)                             | 90  |      |
| <input checked="" type="checkbox"/> Repeat |     |      |

|                                            |     |      |
|--------------------------------------------|-----|------|
| Hand                                       | Off | Auto |
| Water SP (Hrs)                             | 48  |      |
| Donor SP (Hrs)                             | 40  |      |
| Flush SP (Hrs)                             | 80  |      |
| <input checked="" type="checkbox"/> Repeat |     |      |

|                                            |     |      |
|--------------------------------------------|-----|------|
| Hand                                       | Off | Auto |
| Water SP (Hrs)                             | 0   |      |
| Donor SP (Hrs)                             | 30  |      |
| Flush SP (Hrs)                             | 0   |      |
| <input checked="" type="checkbox"/> Repeat |     |      |

# Jumping Ahead

- Amendment Activity
- PowerBI Interactive Visualizations

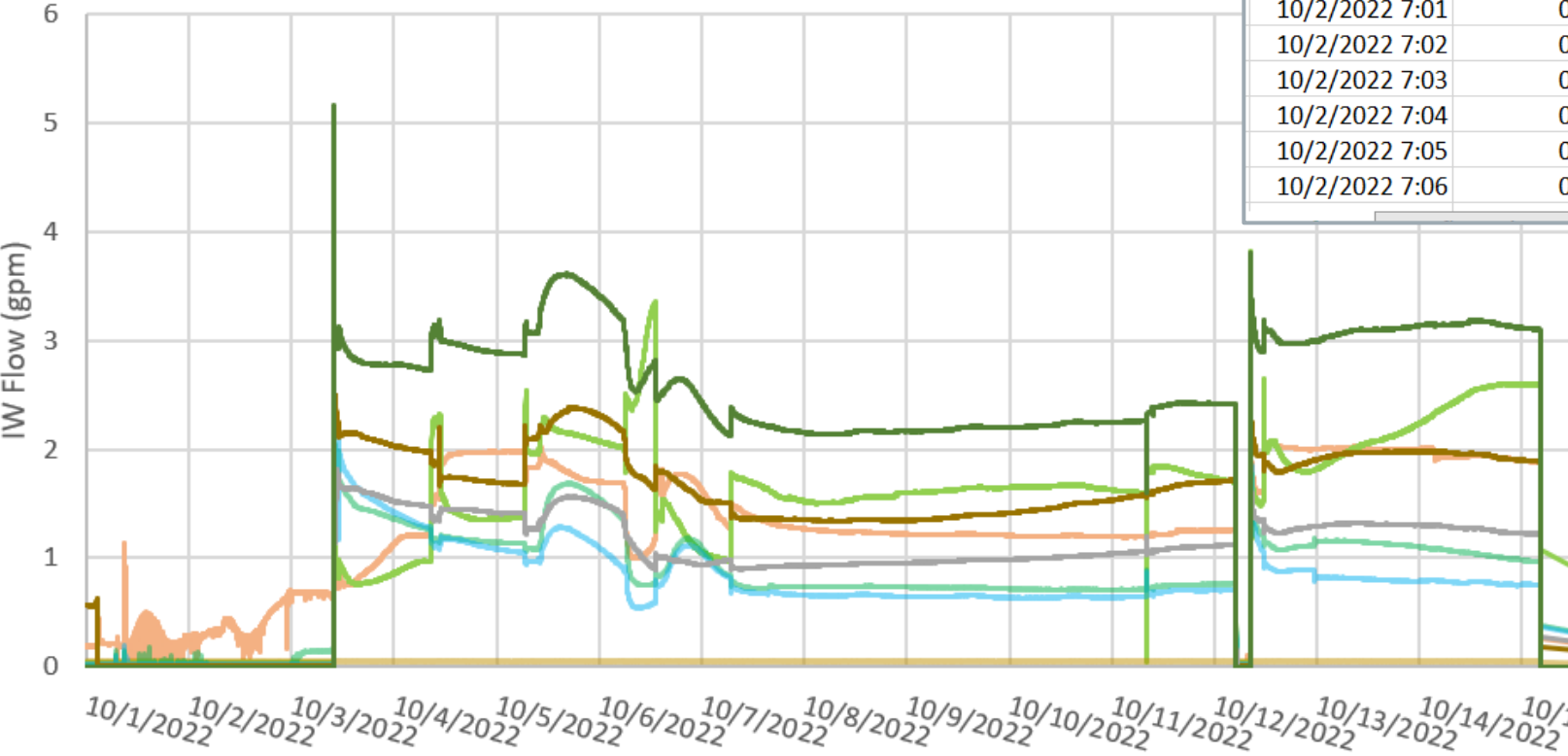




# Interactive Data Visualization: EQUIS™ & PowerBI™

# Microsoft Excel™

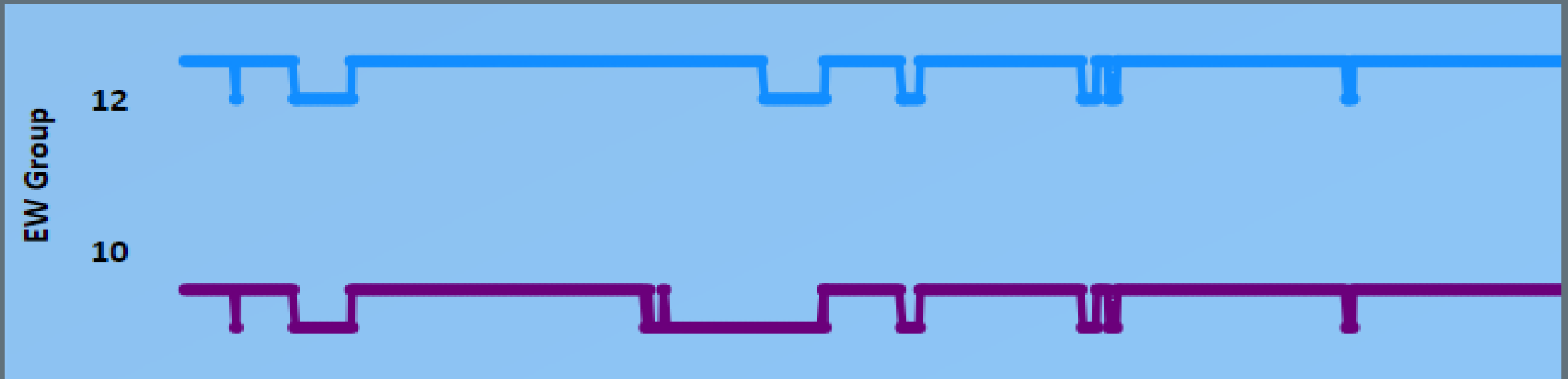
- Frequent crashes of application
- More susceptible to errors with large datasets



| B              | C     | D        | E        | F        | G        | H        | I        |
|----------------|-------|----------|----------|----------|----------|----------|----------|
| Timestamp_adj  | FT510 | FT520    | FT530    | FT540    | FT550    | FT560    | FT570    |
| 10/2/2022 6:48 | 0     | 0.010937 | 0.02375  | 0.013438 | 0.2925   | 0.038438 | 0.12625  |
| 10/2/2022 6:49 | 0     | 0.007188 | 0.024062 | 0.012187 | 0.290312 | 0.04     | 0.126563 |
| 10/2/2022 6:50 | 0     | 0.009688 | 0.023125 | 0.013438 | 0.2925   | 0.039687 | 0.125625 |
| 10/2/2022 6:51 | 0     | 0.009062 | 0.02375  | 0.015625 | 0.294062 | 0.036562 | 0.126875 |
| 10/2/2022 6:52 | 0     | 0.010625 | 0.023438 | 0.010937 | 0.295625 | 0.04125  | 0.126563 |
| 10/2/2022 6:53 | 0     | 0.008125 | 0.022813 | 0.01125  | 0.2425   | 0.035    | 0.125938 |
| 10/2/2022 6:54 | 0     | 0.010937 | 0.020312 | 0.015625 | 0.27875  | 0.03625  | 0.121875 |
| 10/2/2022 6:55 | 0     | 0.00625  | 0.02     | 0.010625 | 0.29     | 0.035937 | 0.124375 |
| 10/2/2022 6:56 | 0     | 0.0075   | 0.019063 | 0.014062 | 0.29     | 0.035625 | 0.124688 |
| 10/2/2022 6:57 | 0     | 0.005937 | 0.0175   | 0.012812 | 0.289063 | 0.032812 | 0.12375  |
| 10/2/2022 6:58 | 0     | 0.01125  | 0.0175   | 0.010625 | 0.291875 | 0.038438 | 0.123438 |
| 10/2/2022 6:59 | 0     | 0.010313 | 0.021562 | 0.011875 | 0.291562 | 0.036562 | 0.125625 |
| 10/2/2022 7:00 | 0     | 0.006562 | 0.02375  | 0.014375 | 0.225625 | 0.035    | 0.124688 |
| 10/2/2022 7:01 | 0     | 0.011563 | 0.0225   | 0.010313 | 0.272812 | 0.036562 | 0.119687 |
| 10/2/2022 7:02 | 0     | 0.011563 | 0.020312 | 0.013125 | 0.290938 | 0.037813 | 0.127188 |
| 10/2/2022 7:03 | 0     | 0.00625  | 0.022813 | 0.015937 | 0.291562 | 0.036562 | 0.124063 |
| 10/2/2022 7:04 | 0     | 0.010625 | 0.023125 | 0.01125  | 0.286875 | 0.03875  | 0.126875 |
| 10/2/2022 7:05 | 0     | 0.005625 | 0.022813 | 0.012187 | 0.29125  | 0.033125 | 0.121563 |
| 10/2/2022 7:06 | 0     | 0.01125  | 0.023125 | 0.015625 | 0.290625 | 0.0375   | 0.124688 |

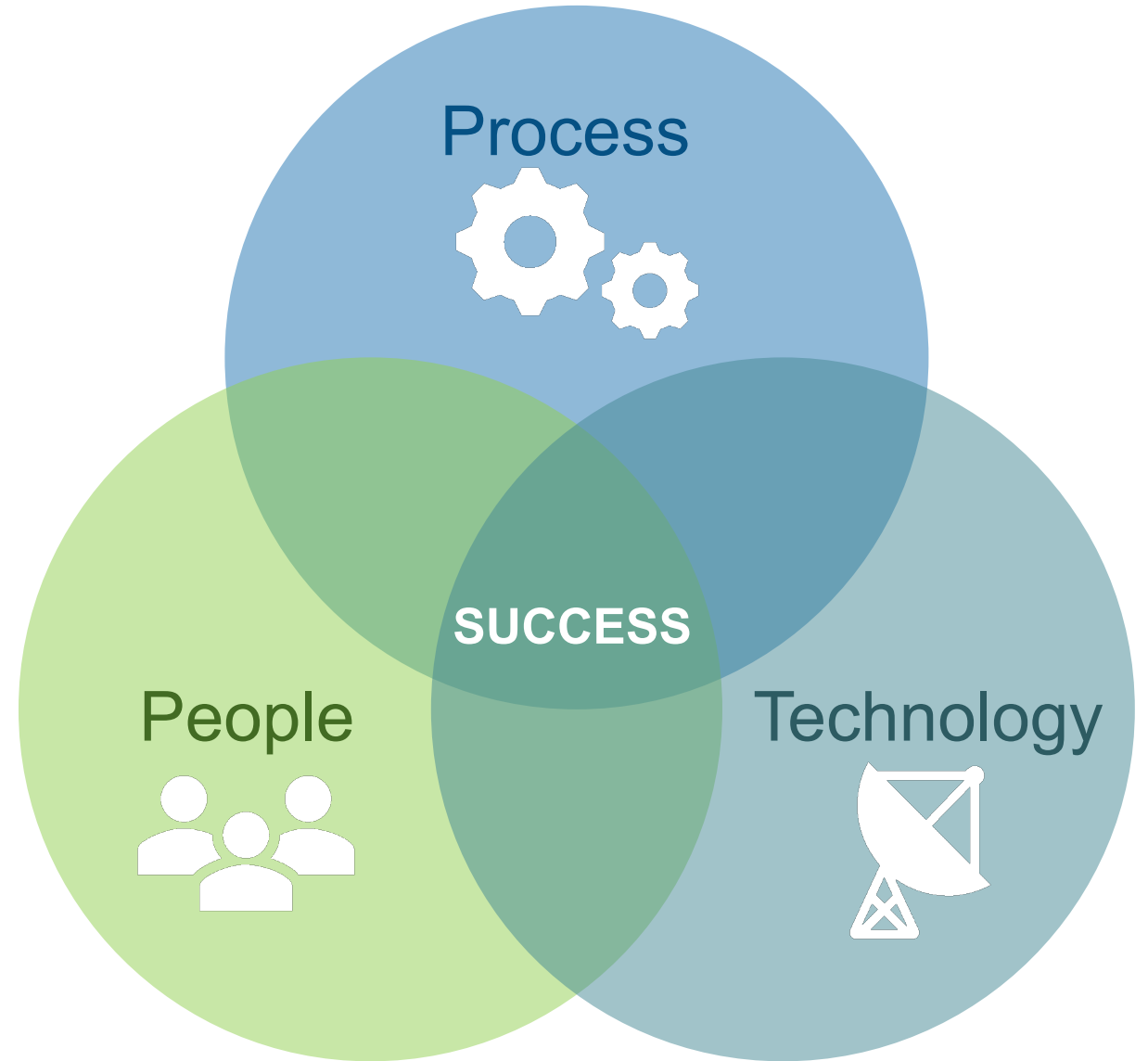
# Power BI™

- Data uploaded from operator via thumb drive onto SFT link
- Data moved to EQuIS™ database in SQL server database with quality checking built-in features
- PowerBI™ connects to EQuIS™



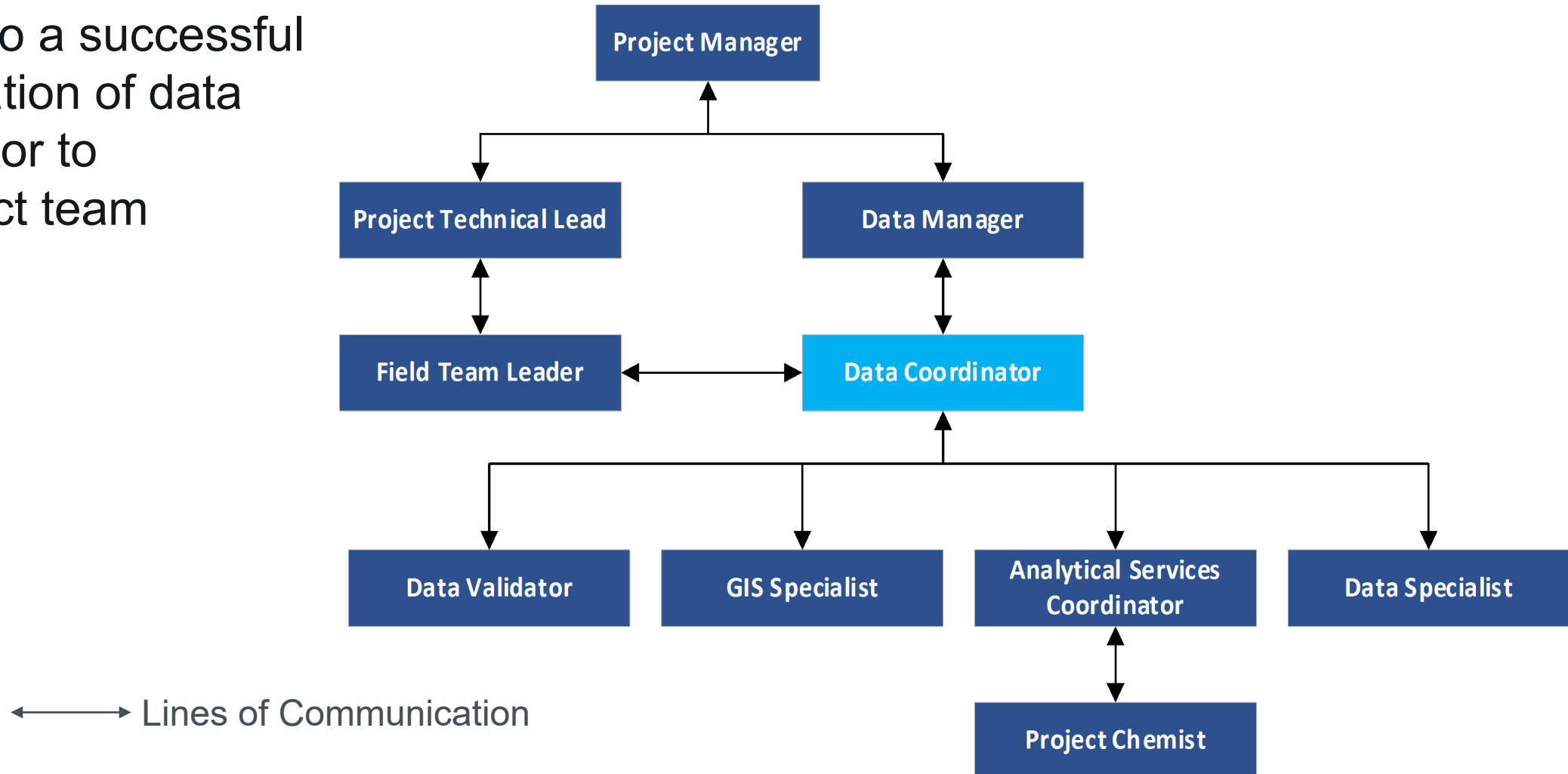
# Environmental Data Management

- Continuous Improvement within the environmental data management **processes**
- Leverage existing and emerging **technologies** aligned with business needs
- Foster inter/intra discipline **collaboration** to cultivate innovation and growth



# Data Management Coordination

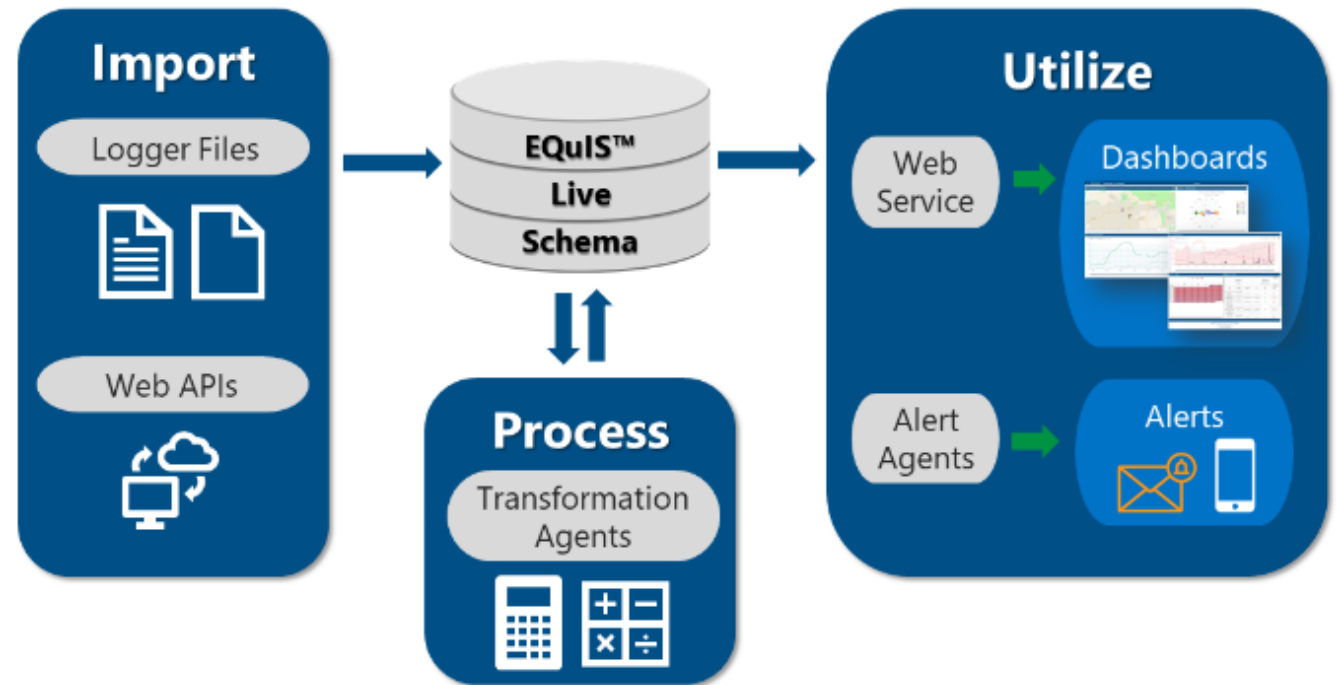
- Communication and teamwork are vital to a successful incorporation of data coordinator to the project team



# Data Coordinator: EQuIS Live

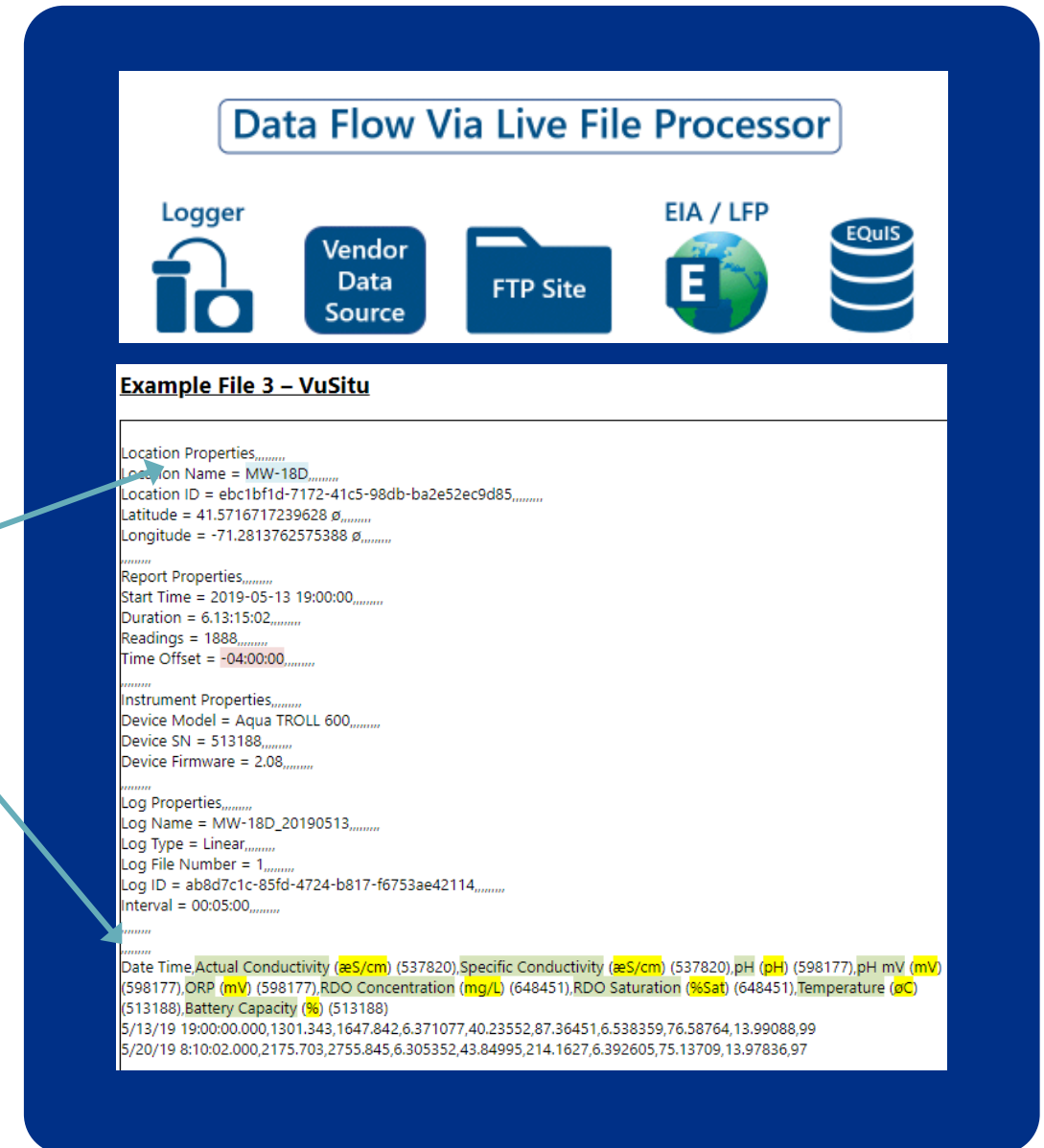
- A module in EQuIS for managing real-time sensor data.
- Optimized for high-frequency/high-volume data sources.
- Collaboration with multiple hardware vendors
  - AreaRAE
  - E-BAM
  - In-Situ
  - YSI
  - Horiba
  - and more... [Live File Processor Agent Examples](#)

## EQuIS Live Workflow



# EQuIS Live - File Processor Agent (FPA)

- Upload data into EQuIS Live database tables
- FPA reads files
- Uses RegEx (regular expressions) to select data
- Run the agent manually in EQuIS Professional (desktop app) or automatically as an EIA (EQuIS Information Agent)



# EQuIS Live – Transformation Agents

- Calculate water head
- Aggregate high frequency data
- Copy data to other EQuIS tables
- Data correction/calibration



# EQuIS Live - Reporting

- Reports can be run in EQuIS Professional or set up in EQuIS Enterprise
- PowerBI dashboards can connect to EQuIS Live data and provide a more robust visualization
- Custom queries can help identify data gaps or invalid data points

| EQuIS Live - Live Table |                  |                  |                             |                       |              |         |         |
|-------------------------|------------------|------------------|-----------------------------|-----------------------|--------------|---------|---------|
| Refresh Interval        |                  |                  |                             | Date/Time Format      |              |         |         |
| 1 min 0 sec             |                  |                  |                             | YYYY-MM-DD / HH:mm:ss |              |         |         |
| Series                  | User Defined Min | User Defined Max | Date - Logger               | Date (UTC)            | Age          | Value   | Change  |
| Water Level Elevation   |                  |                  | 2023-01-31 23:00:00 (UTC-6) | 2023-02-01 05:00:00   | 4 months ago | 4595.74 | ▼ -0.01 |
| Depth to Water (ft)     |                  |                  | 2023-01-31 23:00:00 (UTC-6) | 2023-02-01 05:00:00   | 4 months ago | 60.94   | ▲ 0.01  |



# Power BI™ – Data Sources

Excel

SQL  
Server

EQulS

Access

Oracle

Sharepoi  
nt

Salesforc  
e Reports

Web  
Sites

- From these sources, a data model between different data streams can be created to prepare data and visuals in Power BI.
- Data can be easily transformed and manipulated through use of Power Query, Power Pivot.
- In addition to source data, manipulated data sources can be reloaded and added to the data model to be used in visualizations.

# SQL Server/EQUIS Live

```
import pandas as pd
from sqlalchemy import create_engine, text
from xlswriter.utility import xl_rowcol_to_cell
import os
import pyodbc

eq_cnxn = pyodbc.connect(driver = '{SQL Server}', server = 'AW02PSLSR004', database = 'EQUIS_NSG_Other', Trusted_Connection= True)
eq_cursor = eq_cnxn.cursor()
# CONNECTION_STRING = "DRIVER={ODBC Driver 17 For SQL Server};SERVER=AW02PSLSR004;DATABASE=EQUIS_NSG_Other;Trusted_Connection=yes"
# CONNECTION_URL = URL.create("mssql+pyodbc", query={"odbc_connect": CONNECTION_STRING})
# ENGINE = create_engine(CONNECTION_URL, fast_executemany=True)

#Query for Flow/pressure
QRY_LOCS = """select sys_loc_code, ds.logger_series_id,
CASE WHEN location_param_code = 'FlowTransmitters' then 'Flow (gpm)' else 'Pressure (psi)' end as series_desc,
series_unit, convert(varchar(10),datum_utc_dt,111) injection_date,
max(datum_value) max_result, min(datum_value) min_result
from dt_logger_datum dr
inner join dt_logger_series ds on ds.logger_series_id = dr.logger_series_id
where sys_loc_code like 'P11W-X'
and datum_utc_dt >= '01/01/2024' and datum_utc_dt < '04/01/2024'
group by sys_loc_code, ds.logger_series_id, location_param_code, series_unit, convert(varchar(10),datum_utc_dt,111)
order by sys_loc_code, injection_date, location_param_code"""
# Query for total system flow
QRY_TOTFLOW = """select sys_loc_code, ds.logger_series_id, location_param_code, series_unit, datum_utc_dt, datum_value,
convert(varchar(10),datum_utc_dt,111) injection_date,
CASE WHEN (LEAD(datum_value) OVER (PARTITION BY series_unit ORDER BY datum_utc_dt) + datum_value)/2 < 0.2 then 0
else DATEDIFF(MINUTE, datum_utc_dt, LEAD(datum_utc_dt) OVER (PARTITION BY series_unit ORDER BY datum_utc_dt))*((LEAD(datum_value) OVER (PARTITION BY series_unit ORDER BY datum_utc_dt) + datum_value)/2)
end as volume
from dt_logger_datum dr
inner join dt_logger_series ds on ds.logger_series_id = dr.logger_series_id
where sys_loc_code = 'Total System Flow'
and datum_utc_dt >= '01/01/2024' and datum_utc_dt < '04/01/2024'
and datum_qualifier is null
order by sys_loc_code, datum_utc_dt"""
```

- EQuIS file processing
- Python code used to generate summative excel files

EQUIS Live: File Processor

st\_report st\_report\_use

Parameter Files for this report: (None Available) User Reports: (None Available)

File types: **SystemData, In-Situ-5**

No file info action: **config**

UPDATE existing values? **config**

Details to be included in report output: **info**

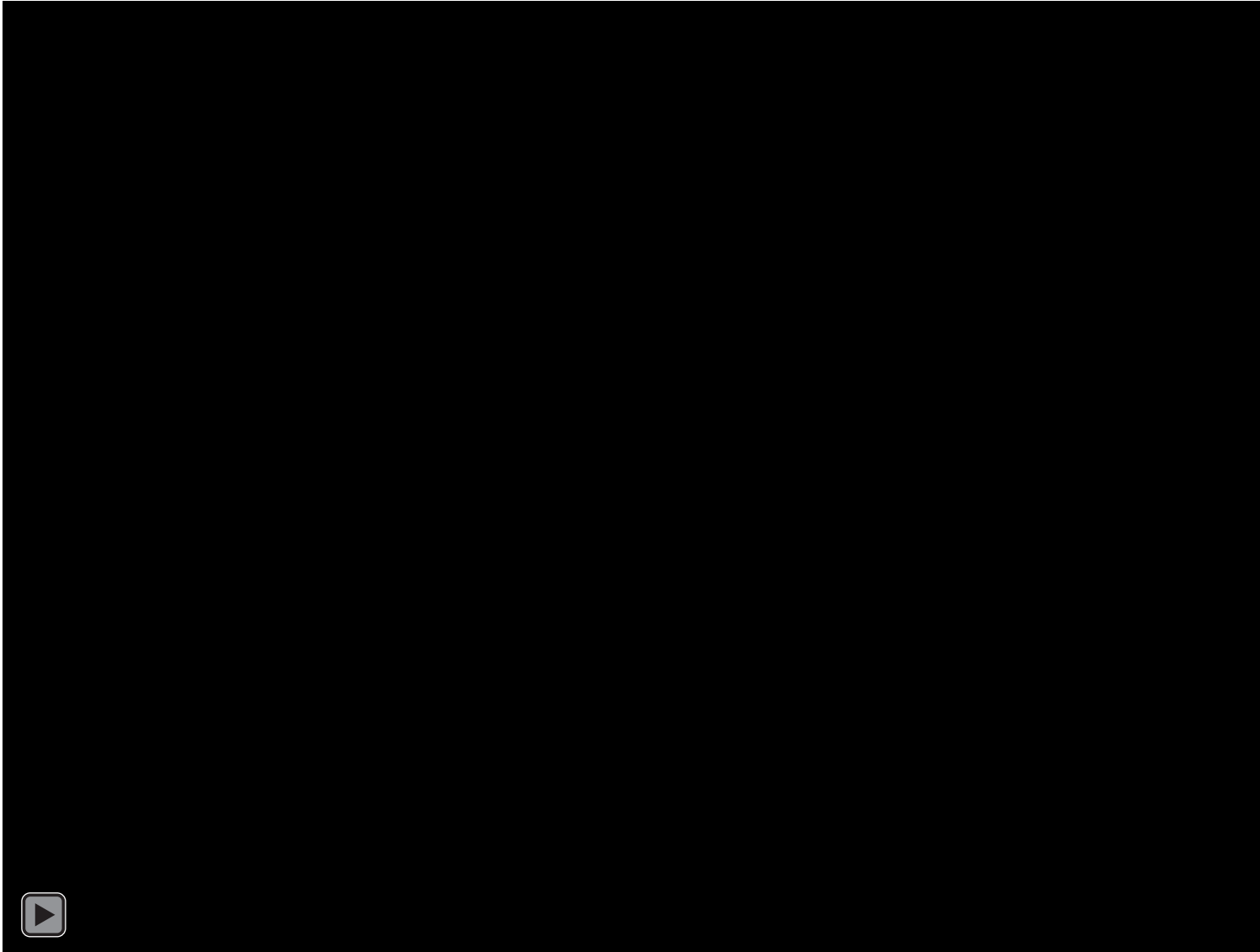
Select one or more st\_config.config\_keys and object\_types; config\_section = 'Live.FileProcessor'.

View Clear Selected

| config_key | object_type |
|------------|-------------|
| SystemData | In-Situ-5   |

| config_section     | config_key | object_type | object_value                            | string_value                                                              | euid |
|--------------------|------------|-------------|-----------------------------------------|---------------------------------------------------------------------------|------|
| Live.FileProcessor | SystemData | In-Situ-5   | locationParamCodeHeaderLinesRegexGroups | ^(# Data Collection)[ :]*(?a[^\,]*)                                       |      |
| Live.FileProcessor | SystemData | In-Situ-5   | dateTimeColumnHeaderRegex               | ^\s*(Timestamp)                                                           |      |
| Live.FileProcessor | SystemData | In-Situ-5   | folderWatcherPath                       | C:\Users\raurr\OneDrive - CDM Smith\Documents\Projects\LiveFileProcessor  |      |
| Live.FileProcessor | SystemData | In-Situ-5   | headerLinesRegex                        | ^\s*(Timestamp)                                                           |      |
| Live.FileProcessor | SystemData | In-Situ-5   | loggerCodeHeaderLinesRegexGroups        | ^(# HMI Device)[ :]*(?a[^\,]*)                                            |      |
| Live.FileProcessor | SystemData | In-Situ-5   | seriesNameColumnHeaderRegexGroups       | (?a.*)\s*(.*\s*[\[\]\[d:]+\[\]\\$](?b[^\[\]\\$])                          |      |
| Live.FileProcessor | SystemData | In-Situ-5   | archiveFilePath                         | C:\Users\raurr\OneDrive - CDM Smith\Documents\ProjectArchiveFileProcessor |      |
| Live.FileProcessor | SystemData | In-Situ-5   | archiveFileName                         | {fileNameWithoutExtension}-{Now:yyyyMMddHHmm}-LOADED.{fileExtension}      |      |

# Let's See it in Action



# Key Takeaways

Plenty of time and resources can be saved by implementing interactive data visualizations with data quality control features built-in

Increased dosing time of substrate aids in reducing CVOCs though caution should be taken so that fouling of the system pipelines/wells do not hinder system performance

Having two dimensional visuals readily available allows for implementation of technologies that can greatly improve system performance such as flow controlling devices

# Thank you!



**To learn more, contact:**

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