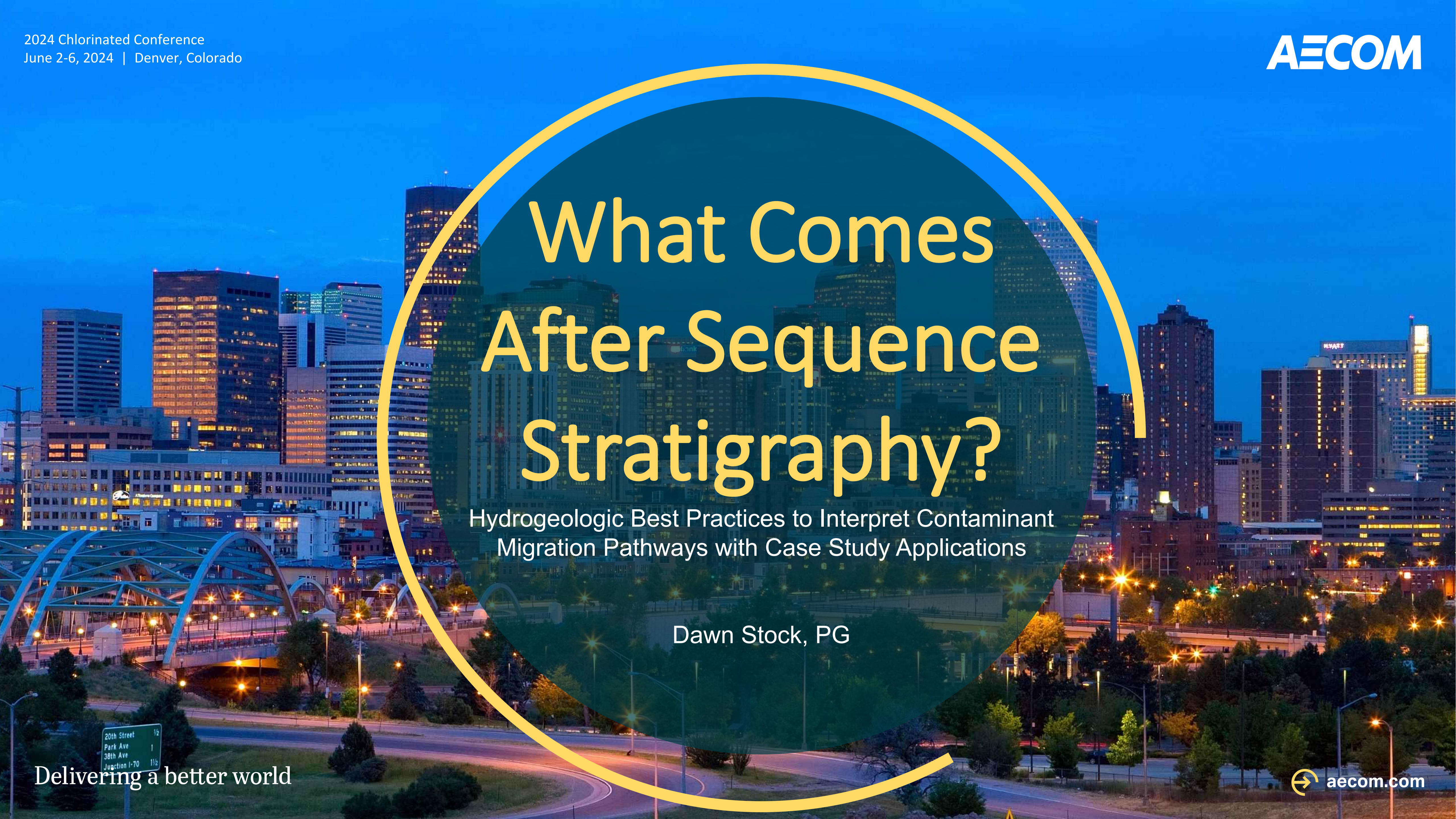
2024 Chlorinated Conference
June 2-6, 2024 | Denver, Colorado

AECOM

What Comes After Sequence Stratigraphy?

Hydrogeologic Best Practices to Interpret Contaminant Migration Pathways with Case Study Applications

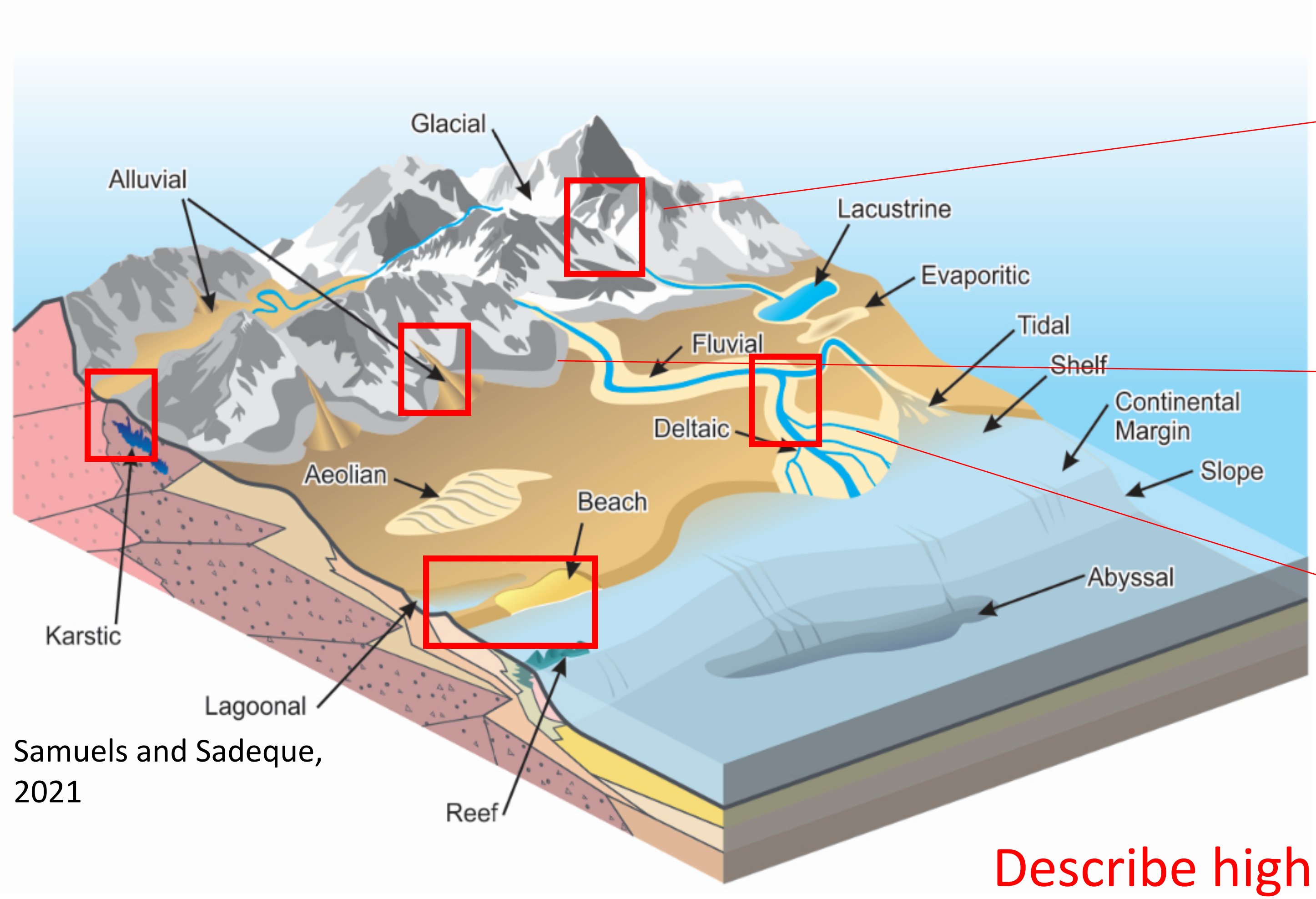
Dawn Stock, PG



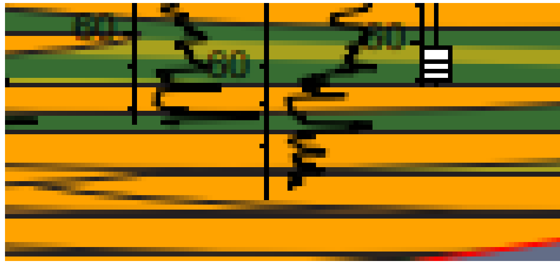
Delivering a better world

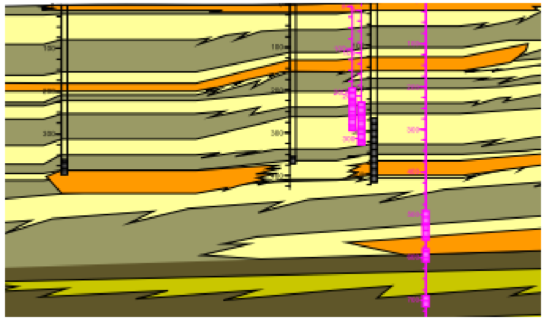
aecom.com

Best Practice: Describe Primary Transport and Storage Units within Site Deposits



Samuels and Sadeque, 2021



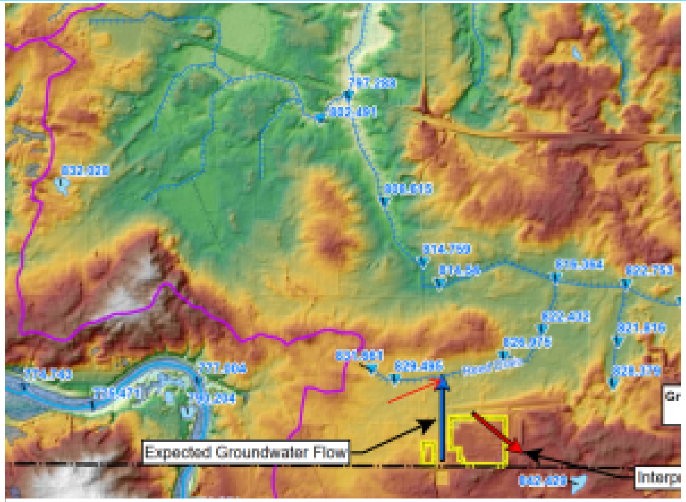


Describe high transmissivity preferential pathways in each depositional environment

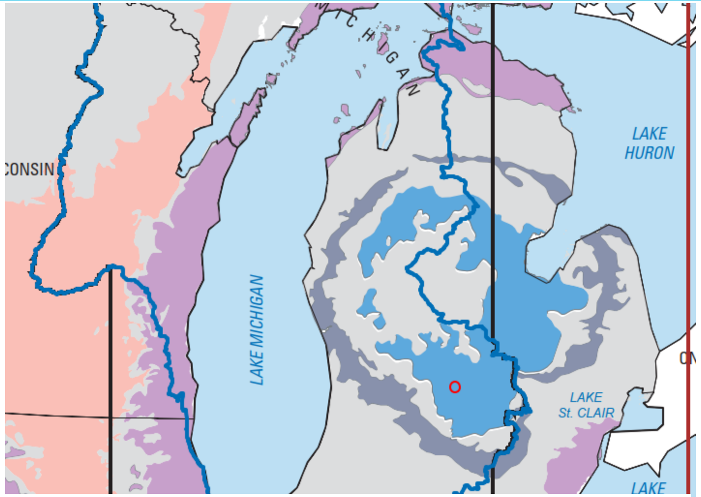
High Transmissivity

- Braided Channel Bar Sands: Well Graded Sands, Sand w/ Clay Clasts
- Meandering Channel Bar Sand and Silt: Well Graded with Silt & Clay Clasts

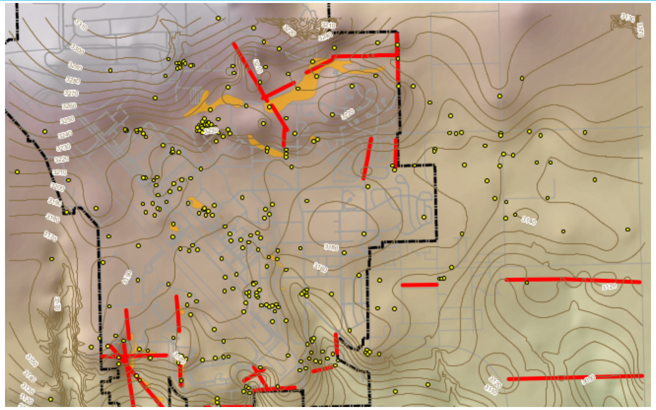
Best Practice: Use Publicly Available Literature and GIS



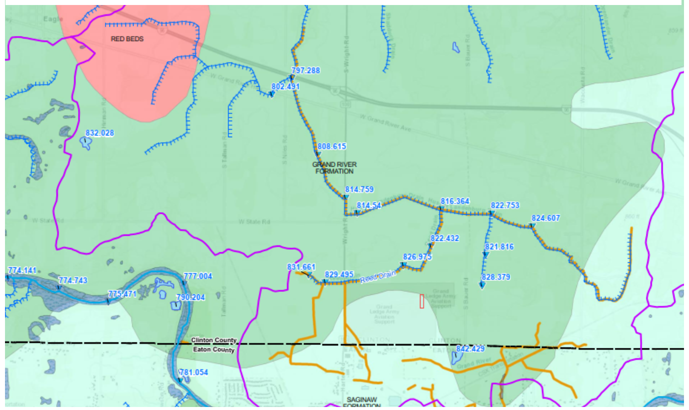
Topographic DEM



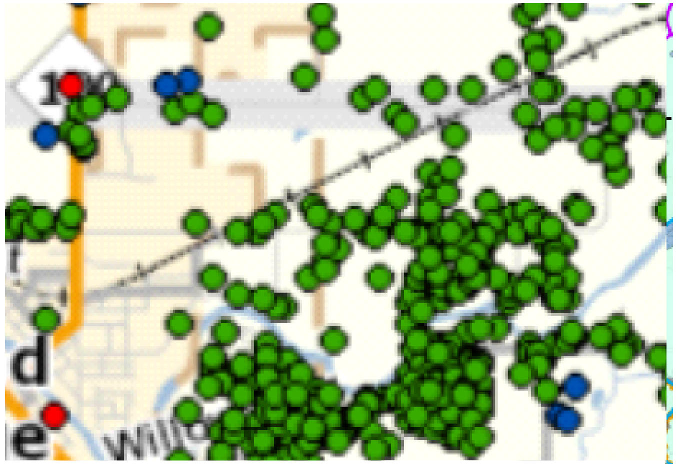
Aquifer Presence



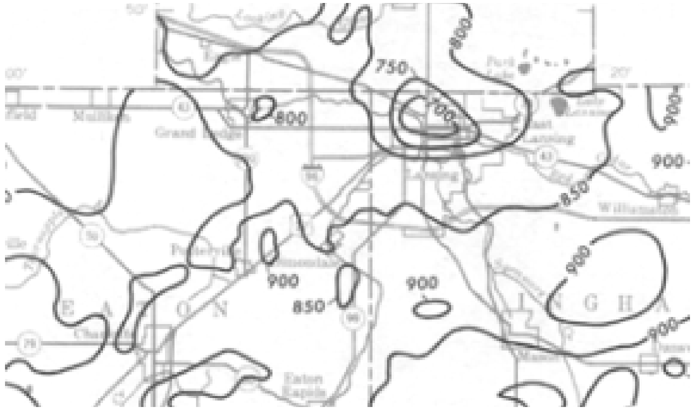
Top of Bedrock, Geophysical Data



Bedrock Geology and Confining Units



Pumping Wells



Regional Groundwater Maps

Gives Regional Context, Demonstrates Understanding, and Gains Stakeholder Trust

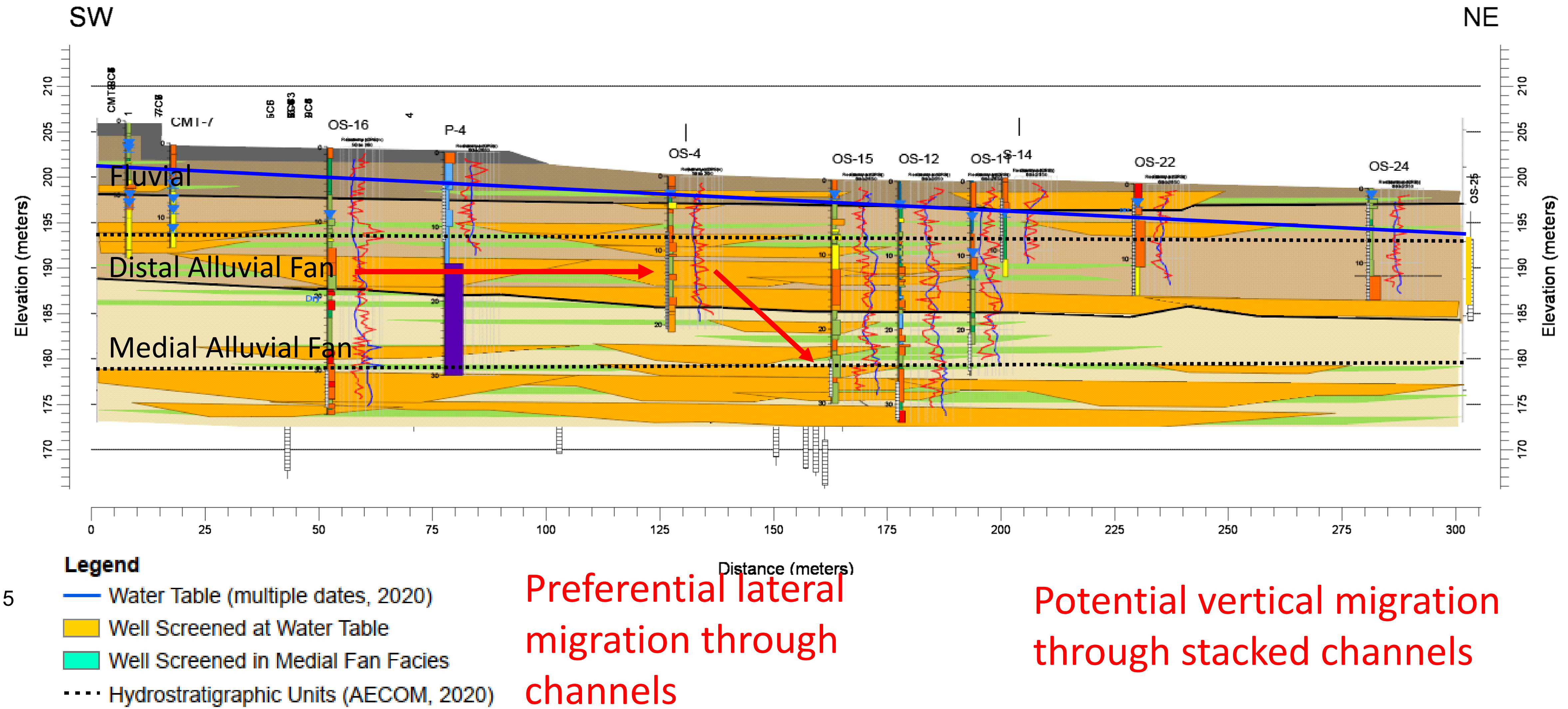
Best Practice: Develop/Maintain Comprehensive Well Inventory

Well Identification	Cross Section	Easting	Northing	Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Depth (ft bgs)	Top of Screen (ft bgs)	Top of Screen (ft amsl)	Bottom of Screen (ft bgs)	Bottom of Screen (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Notes
4533-MW1		2307263.55	580879.88	75.3203964	75.09	14	4	71.09	13.7	61.39	NM	NM	Abandoned
4533-MW2		2307302.04	580873.46	76.4674988	75.5	14	4	71.5	13.7	61.8	NM	NM	not found
4533-MW3		2307293.28	580900.92	76.4674988	76.12	14	4	72.12	13.7	62.42	NM	NM	Abandoned
64MW-1S		2311996.11	583855.6	99.0450974	97.49	15	10	87.49	15	82.49	NM	NM	not found
64MW-3		2312051.07	583887.86	98.1456985	98.78	15	10	88.78	15	83.78	NM	NM	not found
64MW-4		2311930.47	583843.89	97.8289032	98.22	15	10	88.22	15	83.22	NM	NM	Abandoned
64MW-5		2311945.22	583944.41	95.4756012	95.13	15	10	85.13	15	80.13	NM	NM	not found
64MW-6		2311898.2	583920.45	96.2555008	97.97	15	10	87.97	15	82.97	NM	NM	Abandoned
86IW-1		2308402.06	587204.27	103.3649979	104.75	25	20	84.75	24.75	80	20.03	84.72	
86IW-2		2308407.62	587194.29	103.3649979	104.87	25	20	84.87	24.75	80.12	19.45	85.42	
86IW-3		2308419.94	587193.81	103.0930023	104.75	25	20	84.75	24.75	80	19.5	85.25	
86MW-4S		2308389.66	587308.29	102.8769989	102.57	25	20	82.57	25	77.57	NM	NM	not found
86MW-5S		2308343.19	587242.92	103.8570023	103.85	25	20	83.85	25	78.85	19.48	84.37	
86MW-6		2308378.61	587134.76	104.1149979	103.87	25	20	83.87	25	78.87	18.75	85.12	
86MW-7		2308480.68	587242.54	104.1429977	104.02	25	20	84.02	25	79.02	NM	NM	not found
86MW-8		2308412.15	587201.35	103.3649979	105.09	25	20	85.09	25	80.09	19.98	85.11	
86TW-1		2308444.33	587251.03	102.5149994	102.75	25	20	82.75	24.75	78	NM	NM	not found
86TW-2		2308404.11	587258.52	101.3669968	102.75	25	20	82.75	24.75	78	NM	NM	not found
AOC32-TW1		2303566.54	580876.04	70.7018967	72.57	15	5	67.57	14.45	58.12	NM	NM	not found
AOC32-TW2		2303576.25	580778.99	71.5675964	73.86	19	9	64.86	18.45	55.41	NM	NM	not found
AOC32-TW3		2303433.79	580706.4	72.240097	74.24	20	10	64.24	19.45	54.79	NM	NM	not found
AOC32-TW4	A-A'	2303443.2	580598.63	75.8843002	79.8	25	15	64.8	24.45	55.35	NM	NM	not found
AOC33-DPTW-11		2305019	582215.6	74.1705017	77	15	NA	#VALUE!	NA	#VALUE!	NM	NM	not found

Easily integrates into GIS to develop maps

(e.g., bedrock elevation, contamination by elevation interval, pump rates)

Use Sequence Stratigraphy to Classify Well Network by Hydrostratigraphic Unit (HSU), not depth



Preferential lateral migration through channels

Potential vertical migration through stacked channels

Use Sequence Stratigraphy to Classify Well Network by Hydrostratigraphic Unit (HSU), not depth

Suggested Hydro-stratigraphic Units

Water Table

Distal Fan/ Crossover

Medial Fan

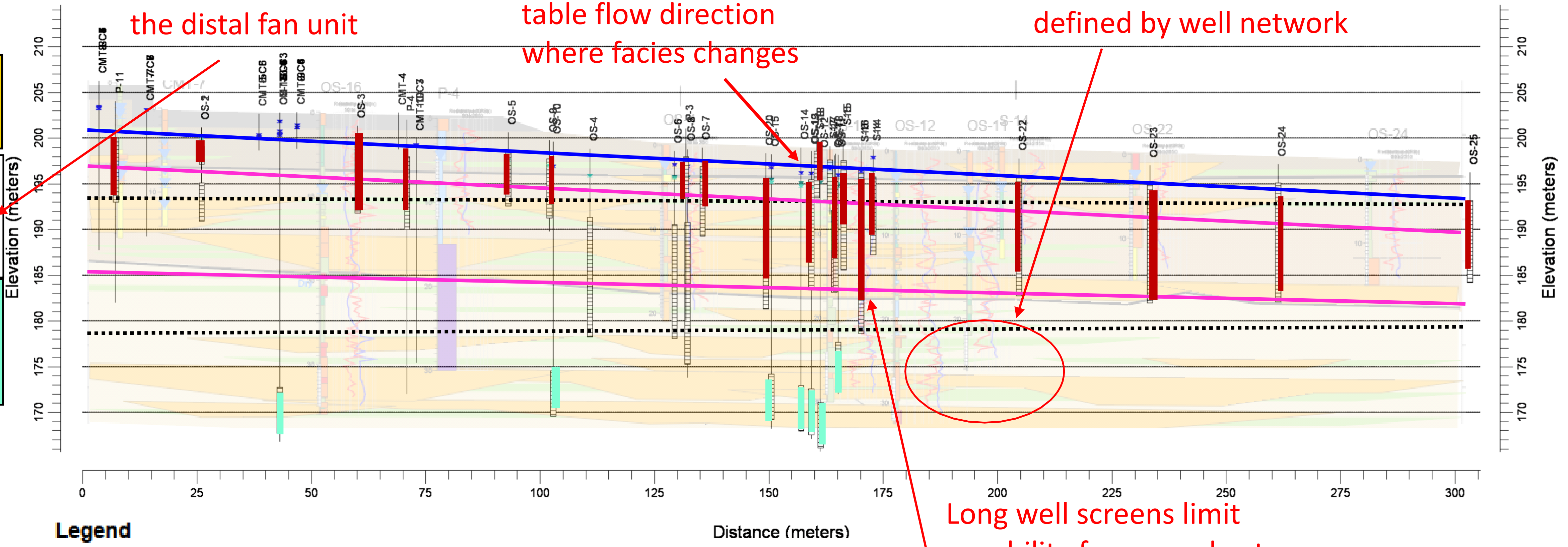
Water Table in Terrace Facies

Water Table in Distal Fan Facies

None of the well screens characterize the distal fan unit

Slight change in water table flow direction where facies changes

Deep contamination is not defined by well network



Long well screens limit useability for groundwater flow and plumes and can be conduits

Legend

- Water Table (multiple dates, 2020)
- Well Screened at Water Table
- Well Screened in Medial Fan Facies
- Hydrostratigraphic Units (AECOM, 2020)

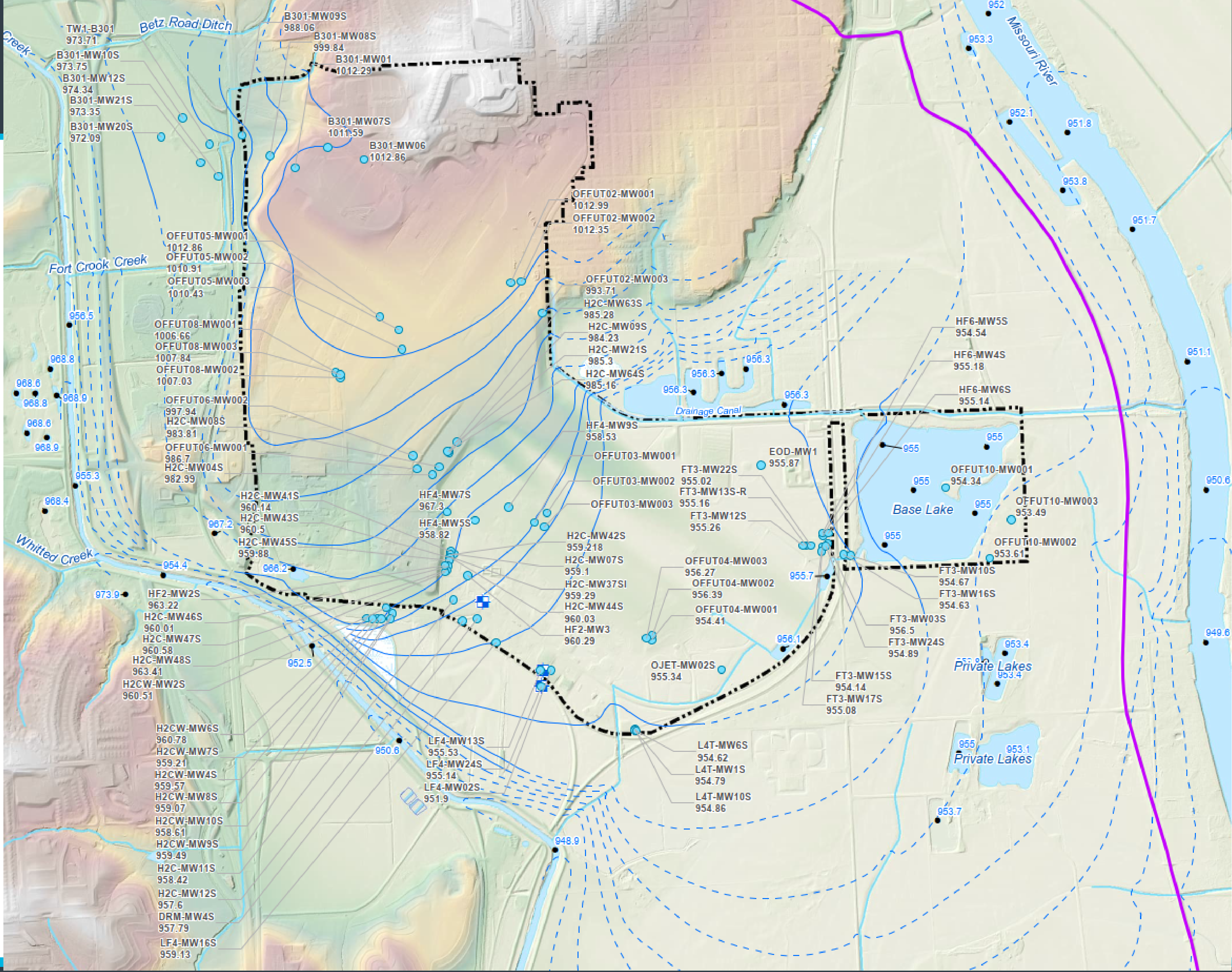
Best Practice: Use Maps to Interpret Flow

1. Use classified well network. Map wells in same HSU.

2. Use relevant, publicly available base maps!

- Incorporate surface water/ Watersheds
- Topographic DEM - extract SW elevations
- Consider gaining/losing stream relationship to GW

3. Develop concept outside data



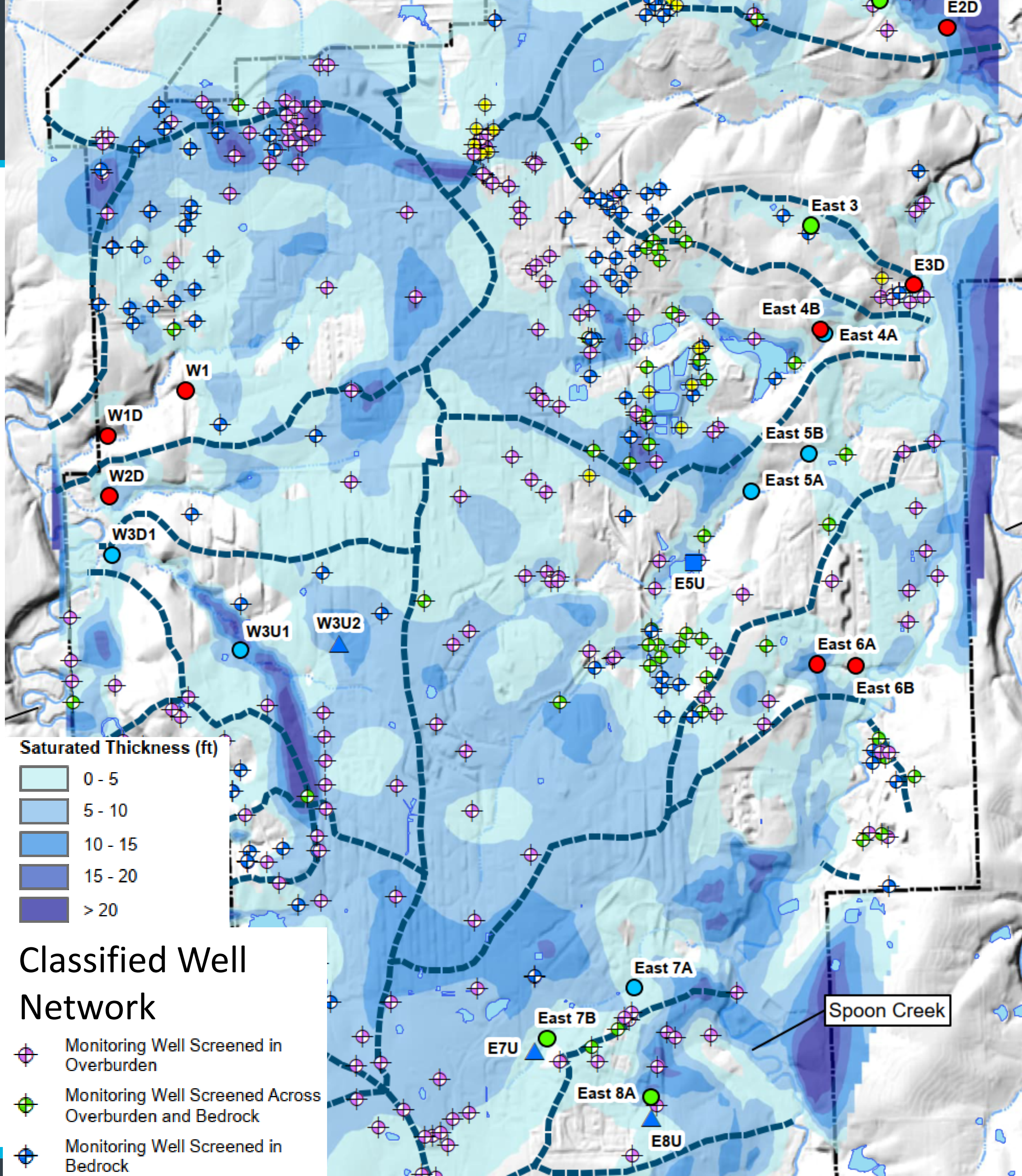
Best Practice: Develop Robust CSM Prior to Investigation

Develop CSM Maps during planning to support scoping:

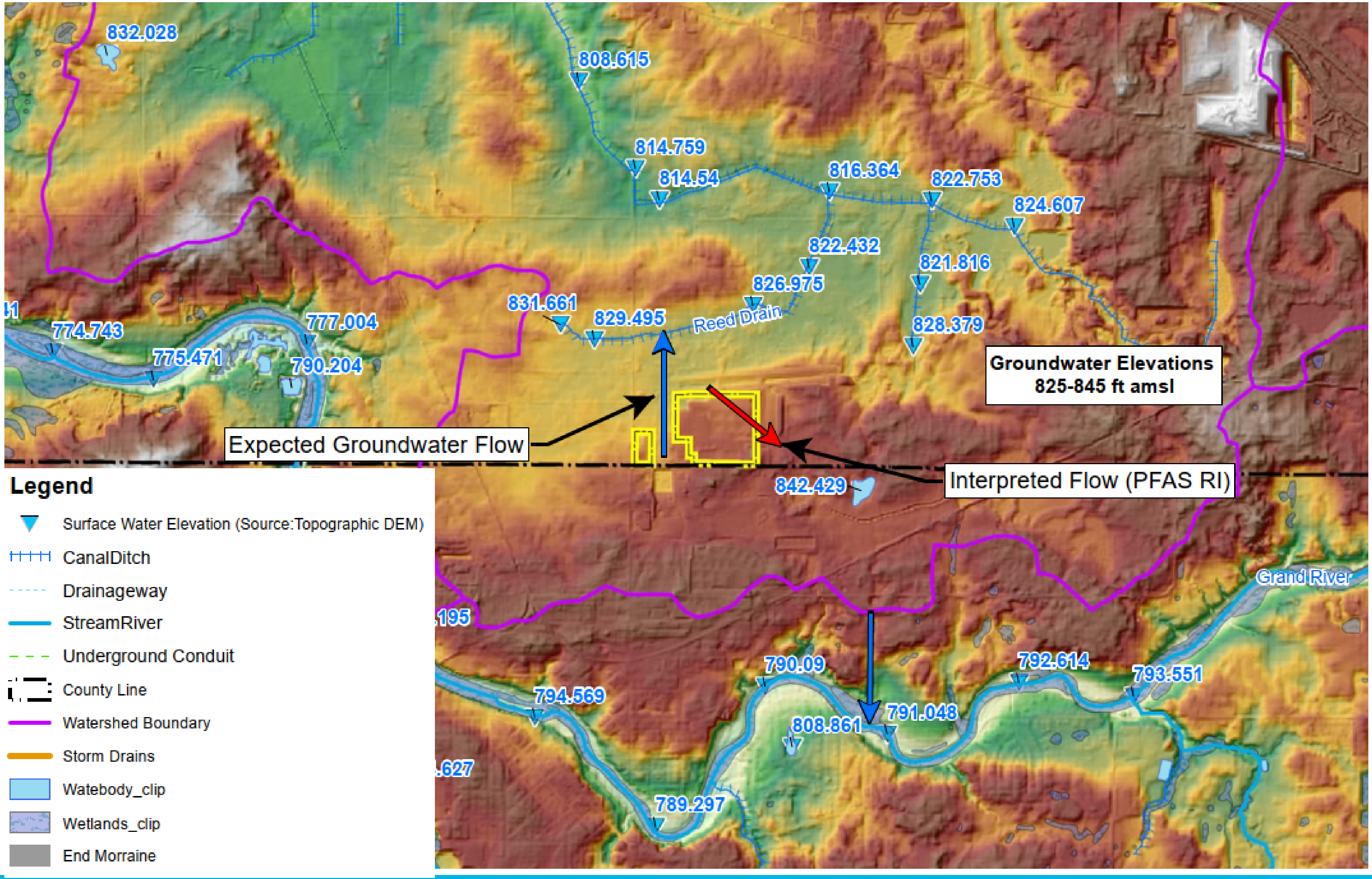
- Where water will be encountered
- Drilling conditions (e.g., bedrock)
- Planned well depths
- Expected pump rates
- Where GW may be discharging to surface water
- Potential bedrock recharge areas

Maximize Field Visits (e.g., outcrops, surface water, document pump data)

Review CSM and rationale for data gap targets with field staff



Case Study 1: Use Publicly Available GIS to Develop Concept

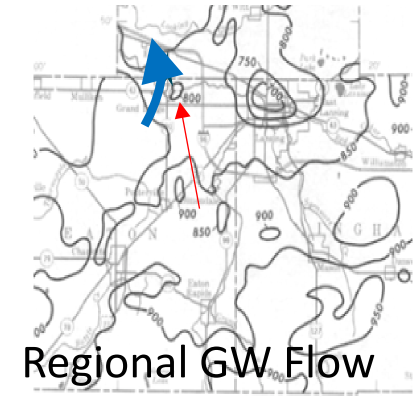


Problems:

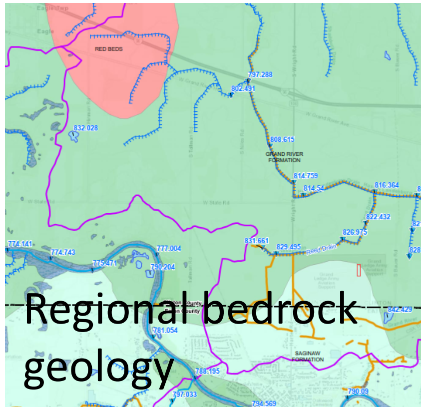
1) Measured groundwater flow at the site is to SE, 90+ degrees different than would be expected based on topography and literature.

2) Step outs could be misplaced

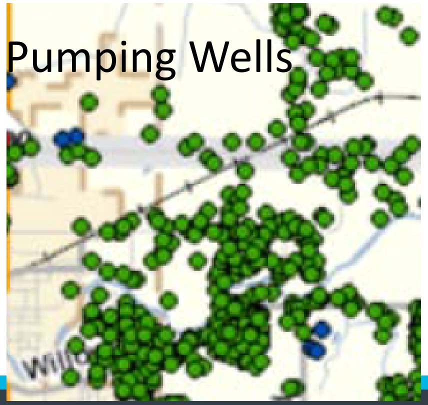
Case Study 1: Use Publicly Available GIS to Develop Concept



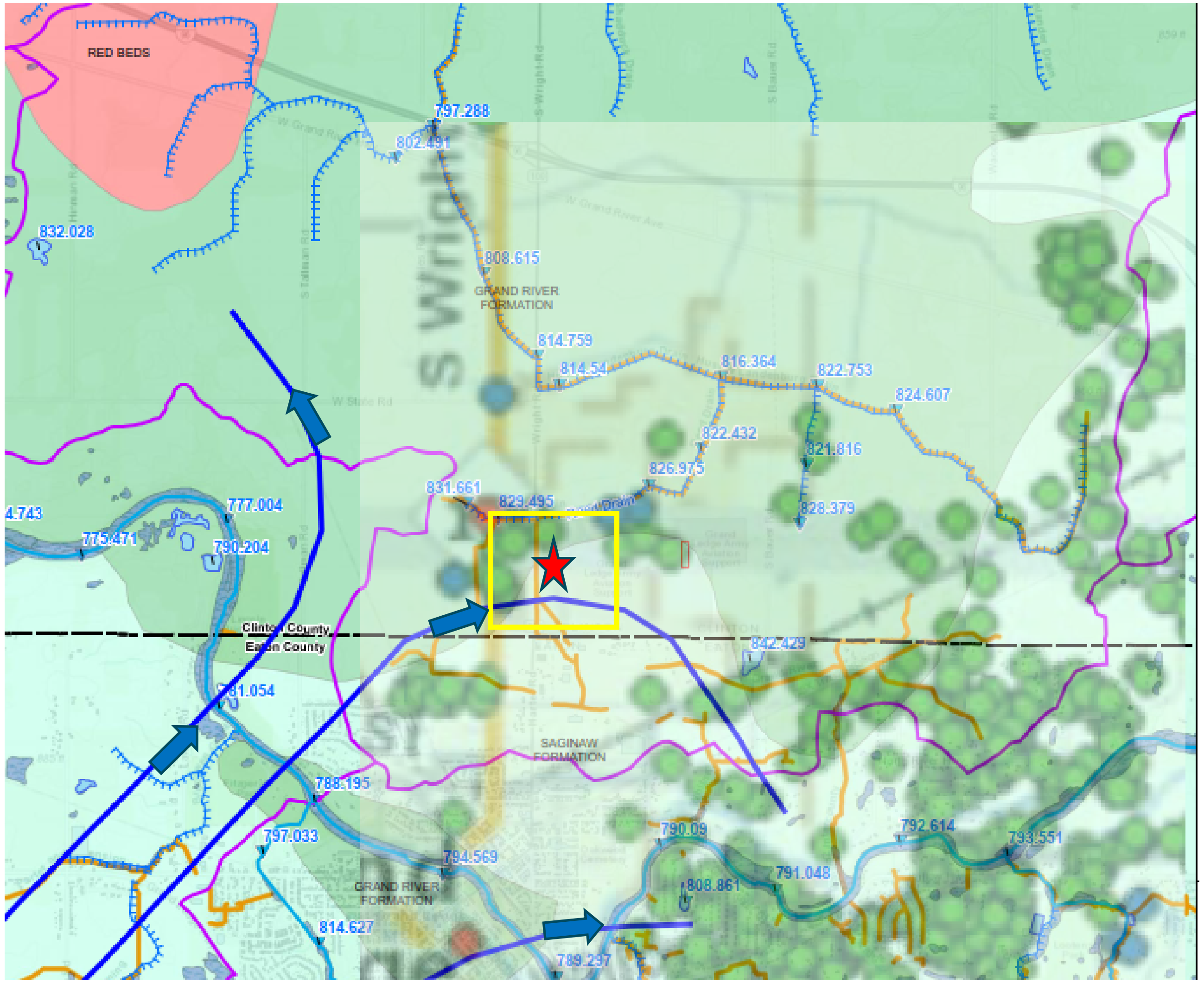
Regional GW Flow



Regional bedrock geology



Pumping Wells



Findings:

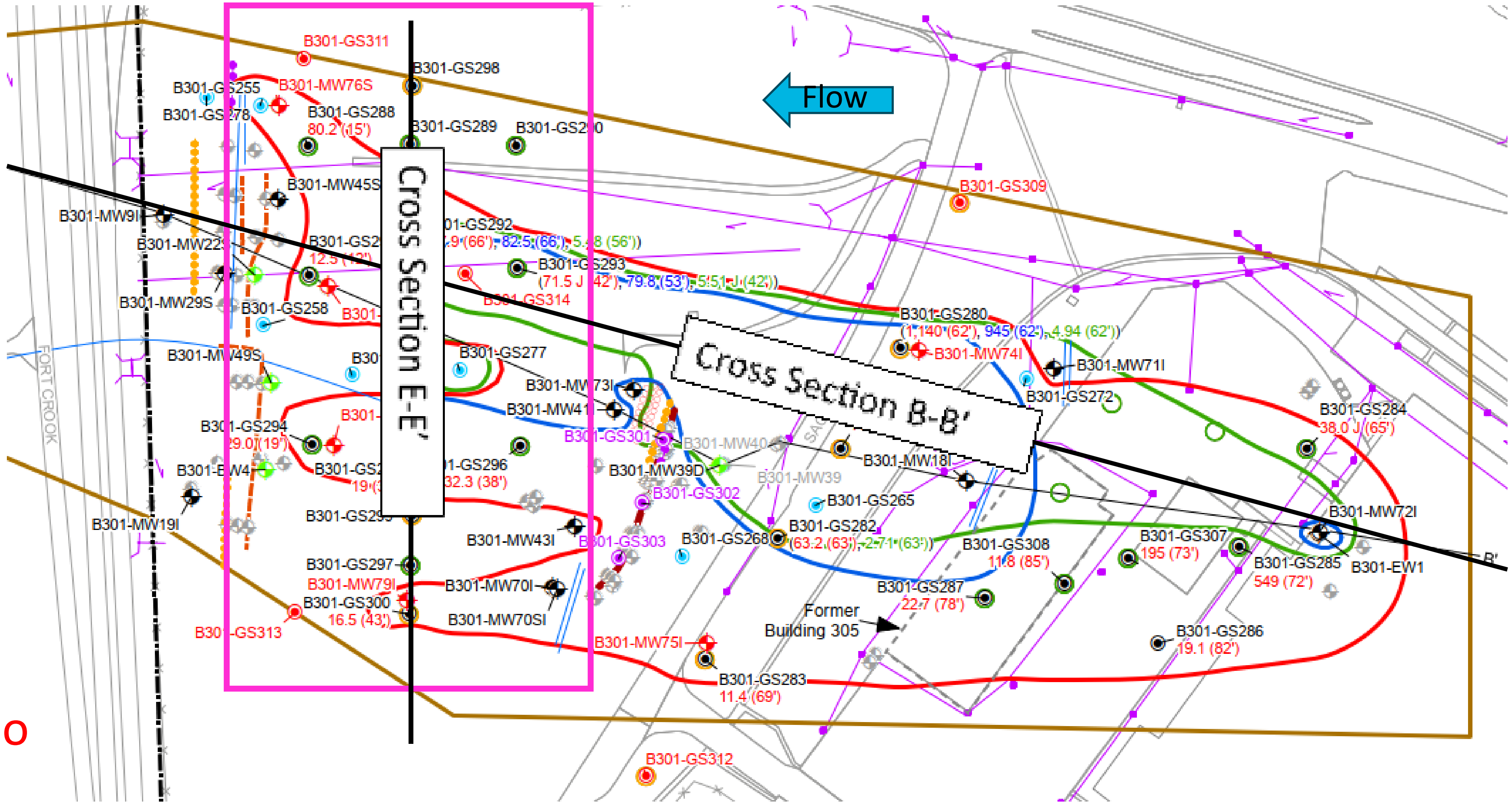
1. Confining Unit not present at the site - Surficial Aquifer connected to drinking water aquifer
2. Extensive pumping southeast of site could impact flow
3. Potential groundwater divide between two AOCs

Case Study 2: Interpret the data to define pathways and data gaps

Creek Alluvium | Area of Interest | Glacial Deposits

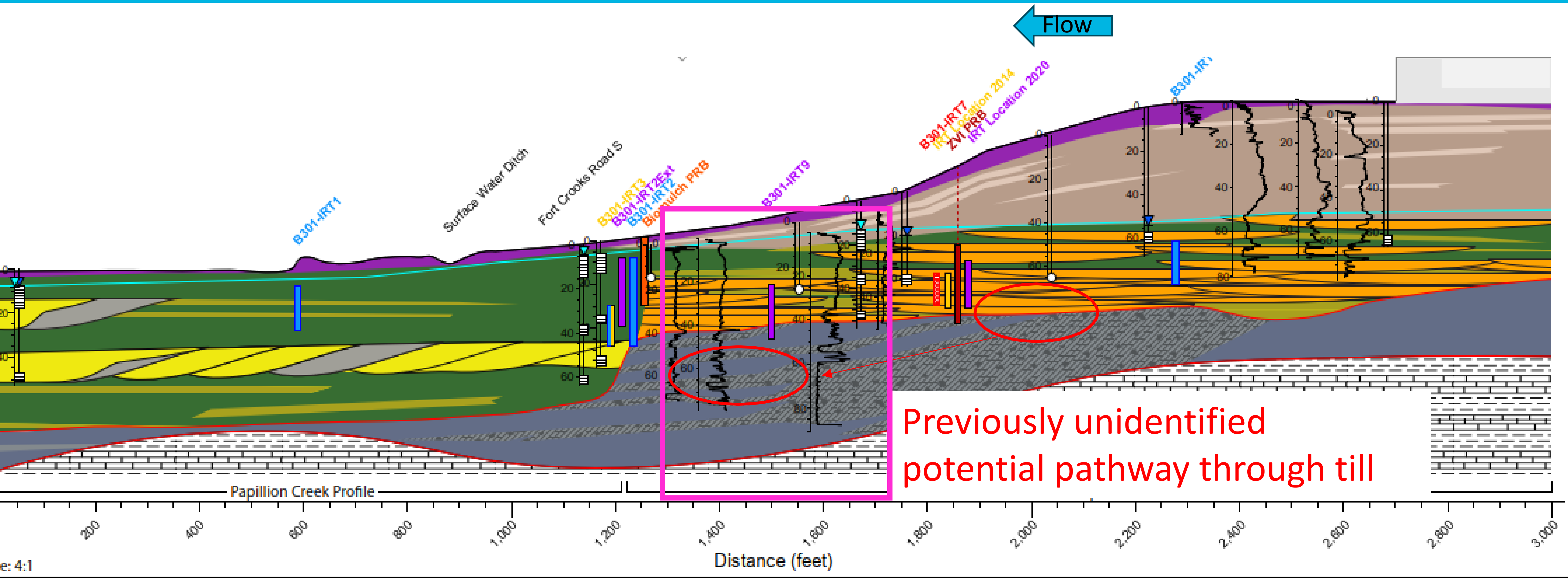
Goals:

1. Determine where depositional environment changes
2. Define preferential migration pathway
3. Define source of downgradient detections



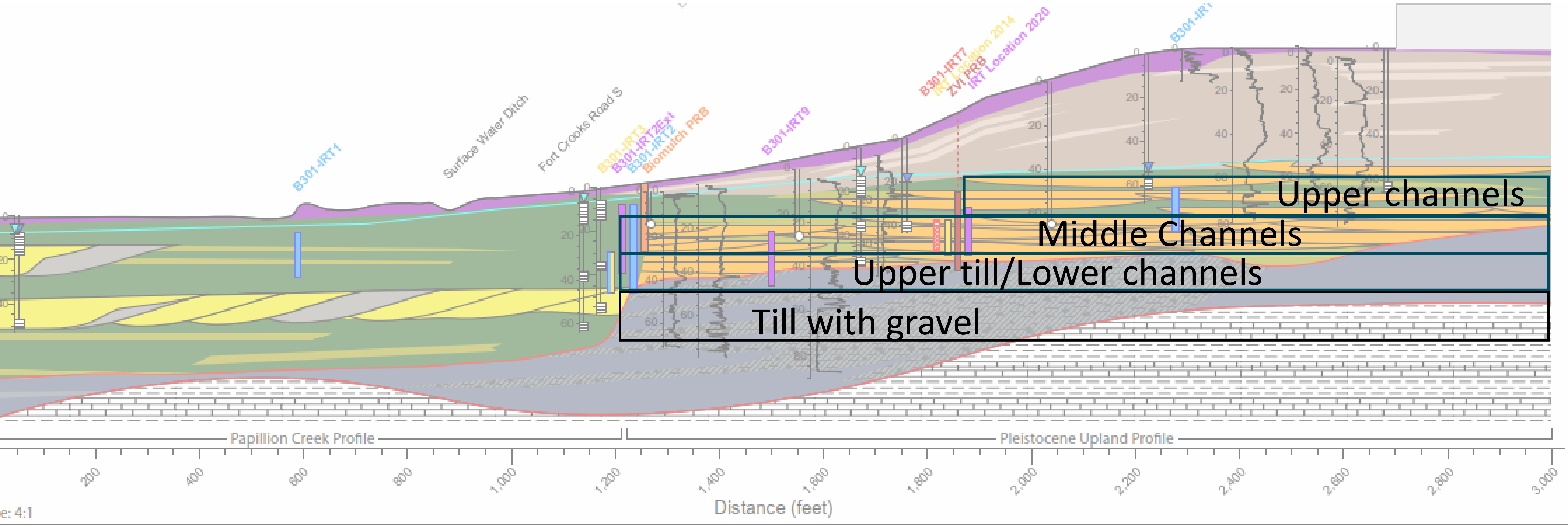
Hard to interpret so much data!

Case Study 2: Interpret the data to define pathways and data gaps



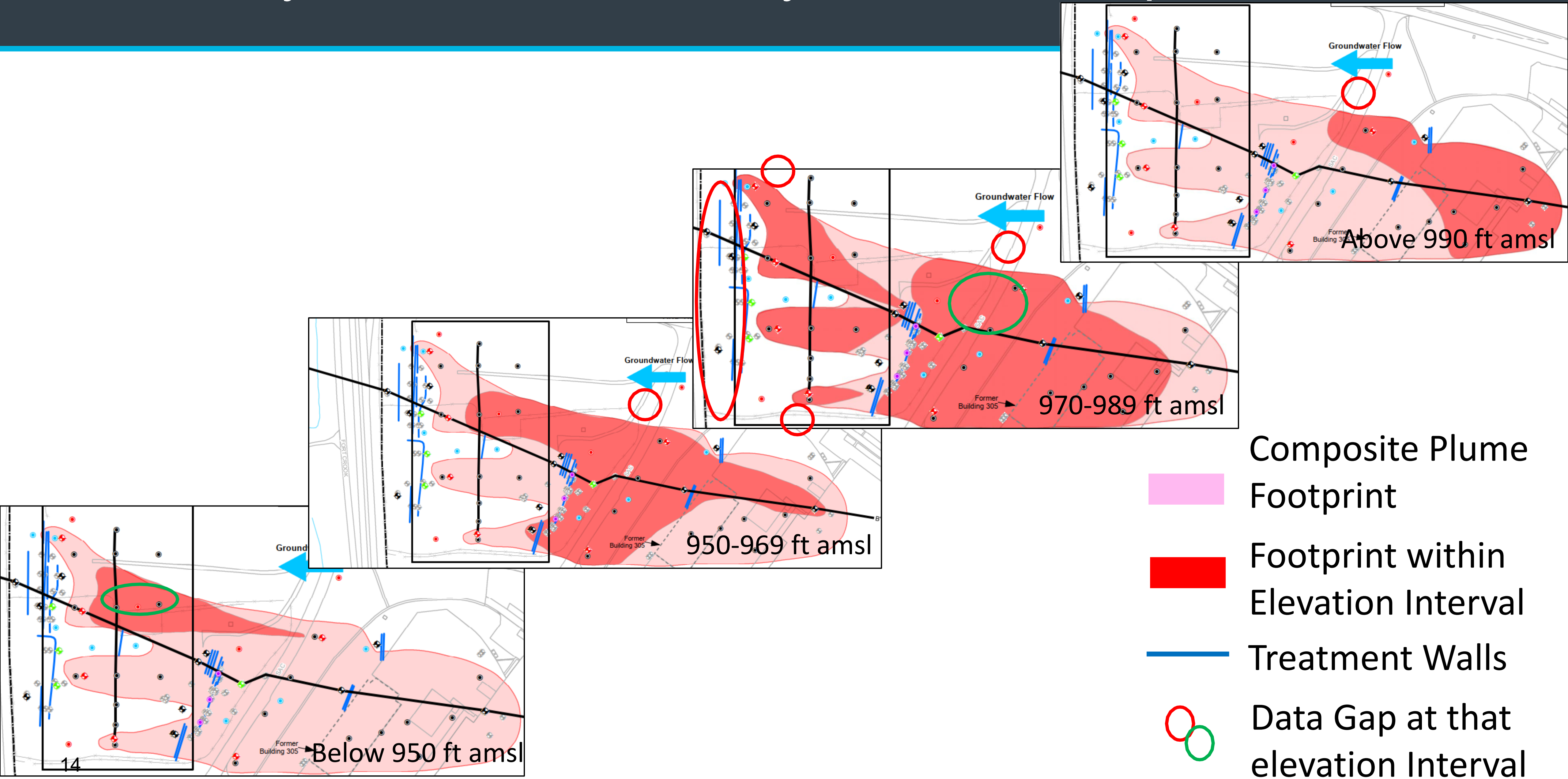
Papillion Creek Alluvial Deposits	Area of Interest	Loess, Glacial Outwash and Till Deposits

Case Study 2: Interpret the data to define pathways and data gaps

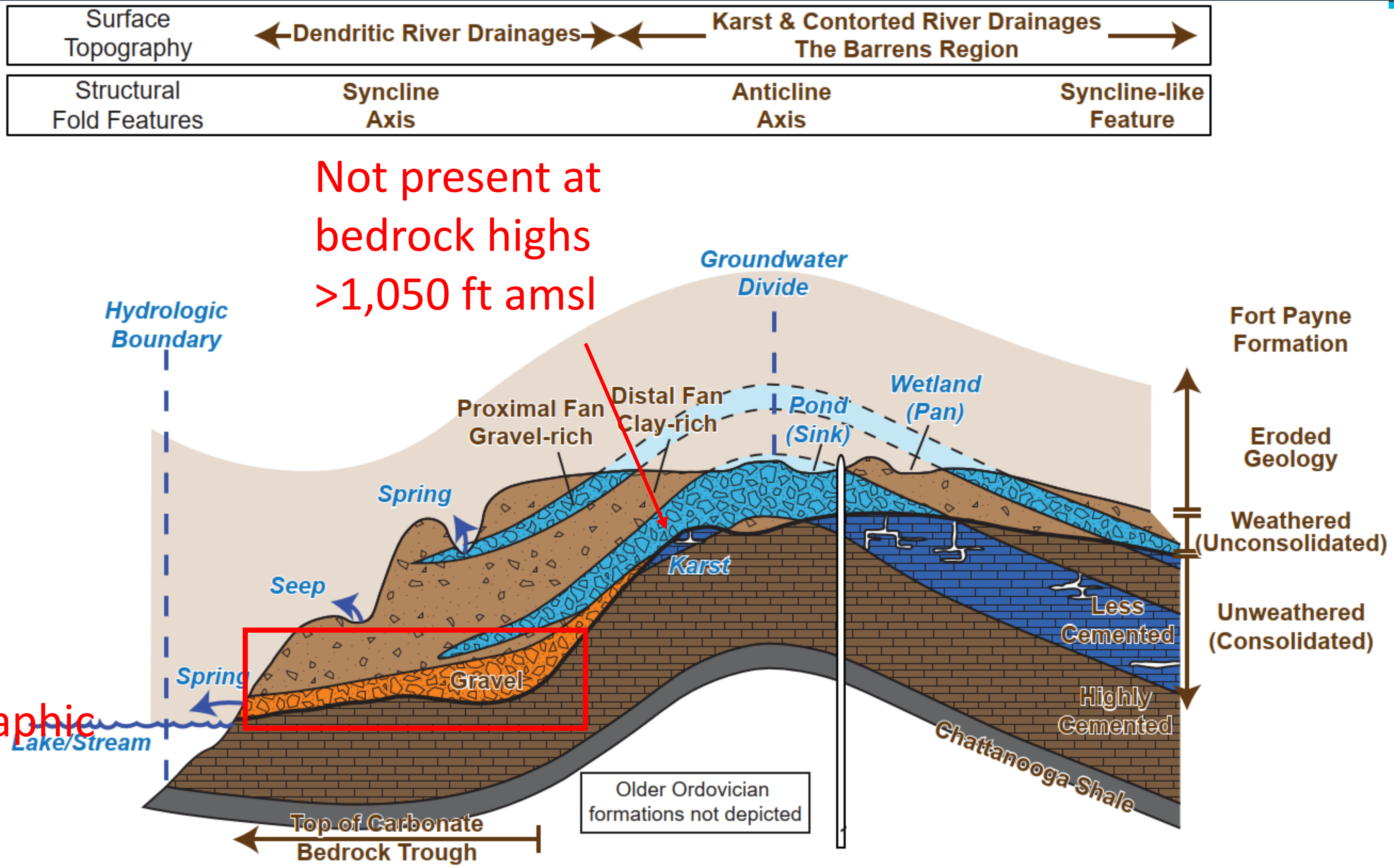


Papillion Creek Alluvial Deposits	Area of Interest	Loess, Glacial Outwash and Till Deposits

Case Study 2: Success! Pathways and Data Gaps Defined

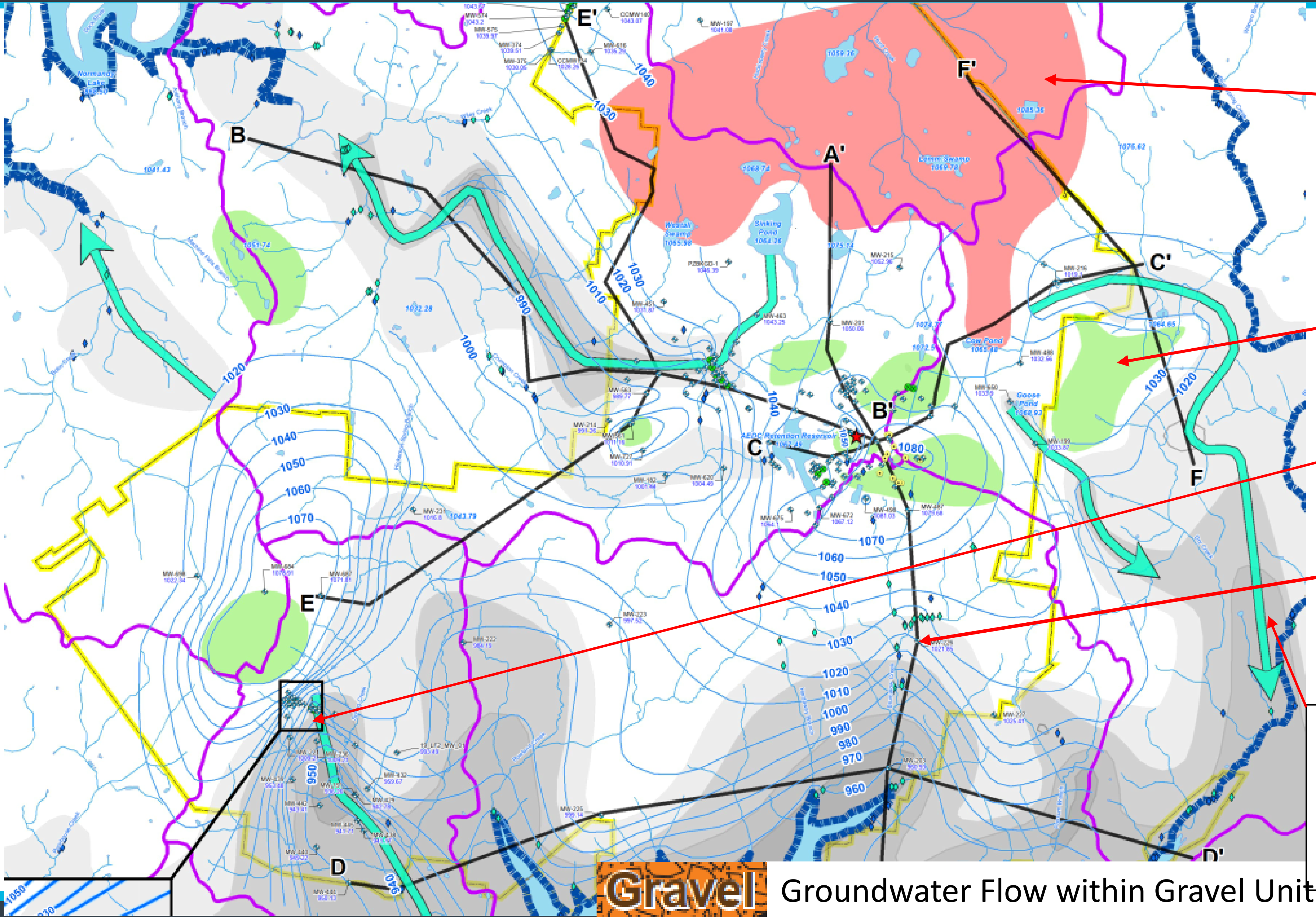


Case Study 3: Map Features Dictating Flow with Classified Well Network



Gravel hydrostratigraphic unit

Case Study 3: Map Features Dictating Flow with Classified Well Network



Flow boundary at bedrock high >1050 ft amsl

GW flows away from/around bedrock highs >1000 ft amsl

GW flows into surface water where gravel unit intersects surface

GW flows toward troughs in consolidated bedrock surface

Summary

- Develop a hydrogeologic CSM concept with a solid foundation
  - Sequence stratigraphy to define migration pathways in observed facies
  - Regional literature for completeness and credibility
  - Publicly available GIS Data to support interpretation
- Use sequence stratigraphic framework to inform classification of well network into hydrostratigraphic units (HSUs) referencing screen elevations (not depths)
- Define features controlling flow in each HSU and use for mapping
- Visualize contamination by elevation and HSU
- Develop CSM in planning stage, scope investigation to answer data gaps, communicate CSM to field staff

AECOM

Questions?

Dawn Stock, PG
Dawn.stock@aecom.com