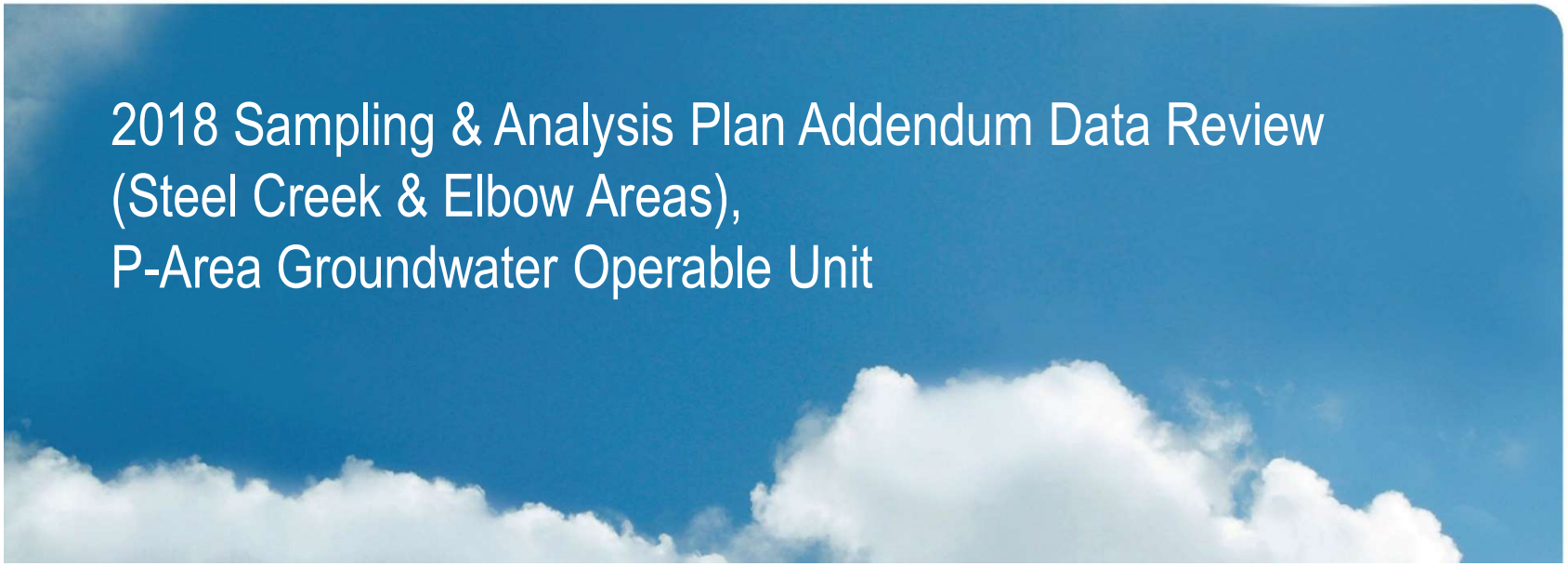
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2018 Sampling & Analysis Plan Addendum Data Review (Steel Creek & Elbow Areas), P-Area Groundwater Operable Unit

Core Team Information Meeting
July 15, 2020

Background – SAP Core Team Decisions

- **Jan 2017 Scoping Meeting - 2013 SAP review**
  - Core Team agreed on completeness of 2013 SAP field activities
  - Core Team recognized that tritium and volatile organic compounds (VOCs) are present over extensive areas in two aquifer zones that are not collocated
  - Core Team agreed that an opportunity exist to address portions of the overall groundwater plumes since Steel Creek is impacted by discharges of contaminated groundwater
  - Core Team agreed that a better understanding to the extent of VOC groundwater contamination and impact to Steel Creek in the Elbow/Distal areas was needed

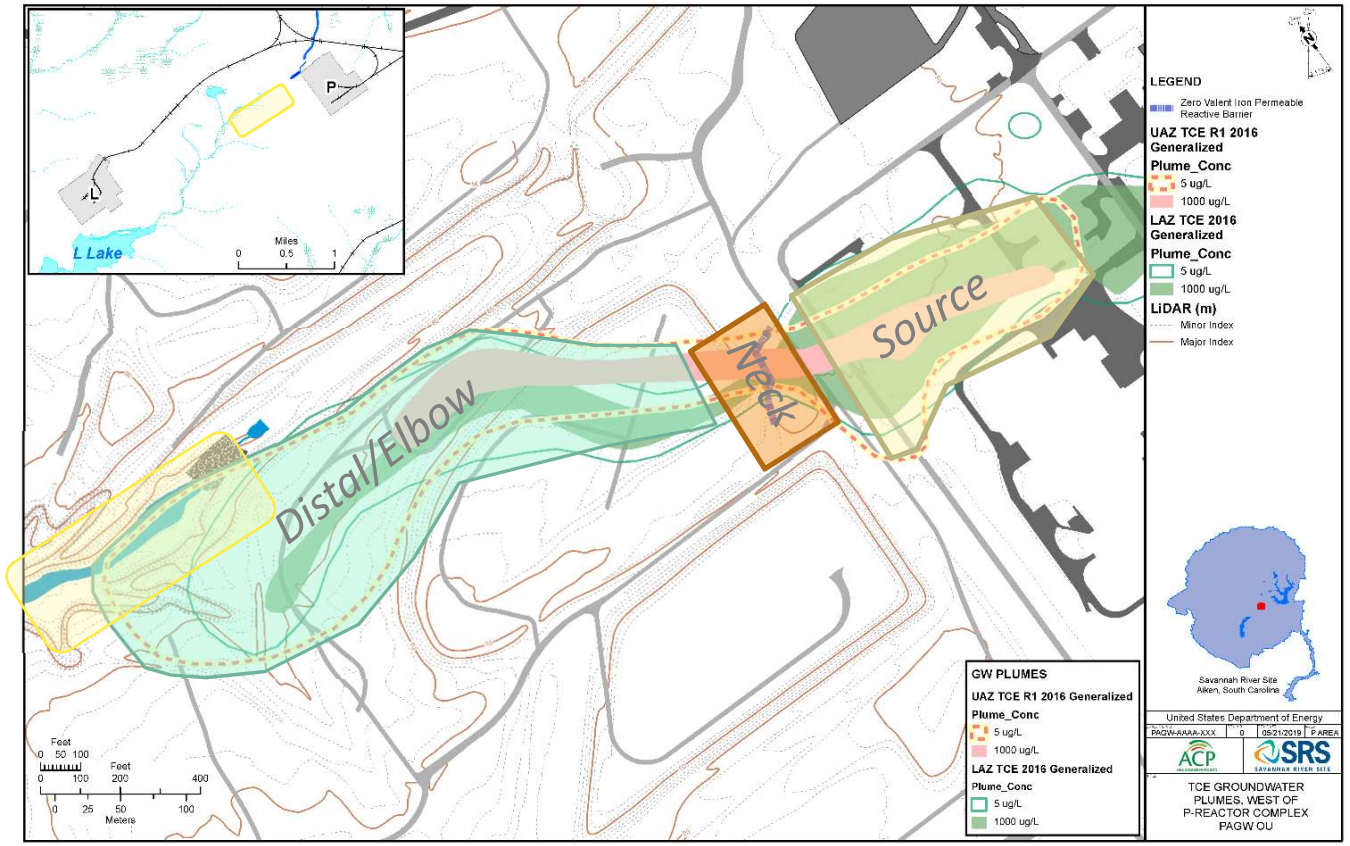
Background – SAP Core Team Decisions (continued)

- **May 2017 Scoping Meeting - Discuss Removal Actions for Neck/Elbow Areas**
  - Core Team agreed to evaluate removal actions (e.g., No Action, PRB, In Situ Chemical Oxidation) at both Neck and Elbow/Distal areas and document in RSER/EE/CA
  - Core Team agreed to a SAP Addendum to define VOC impact to Steel Creek, determine VOC extent in Distal area, and establish long-term surface water and groundwater monitoring

- **Sampling and Analysis Plan (SAP) Addendum submitted and approved Aug 2018**
  - Fieldwork began Feb 2018

Purpose of SAP Addendum

- **Characterize Steel Creek surface water and shallow groundwater in areas potentially impacting Steel Creek**
- **Characterize Elbow/Distal portion of the groundwater plumes to determine extent of VOC contamination**



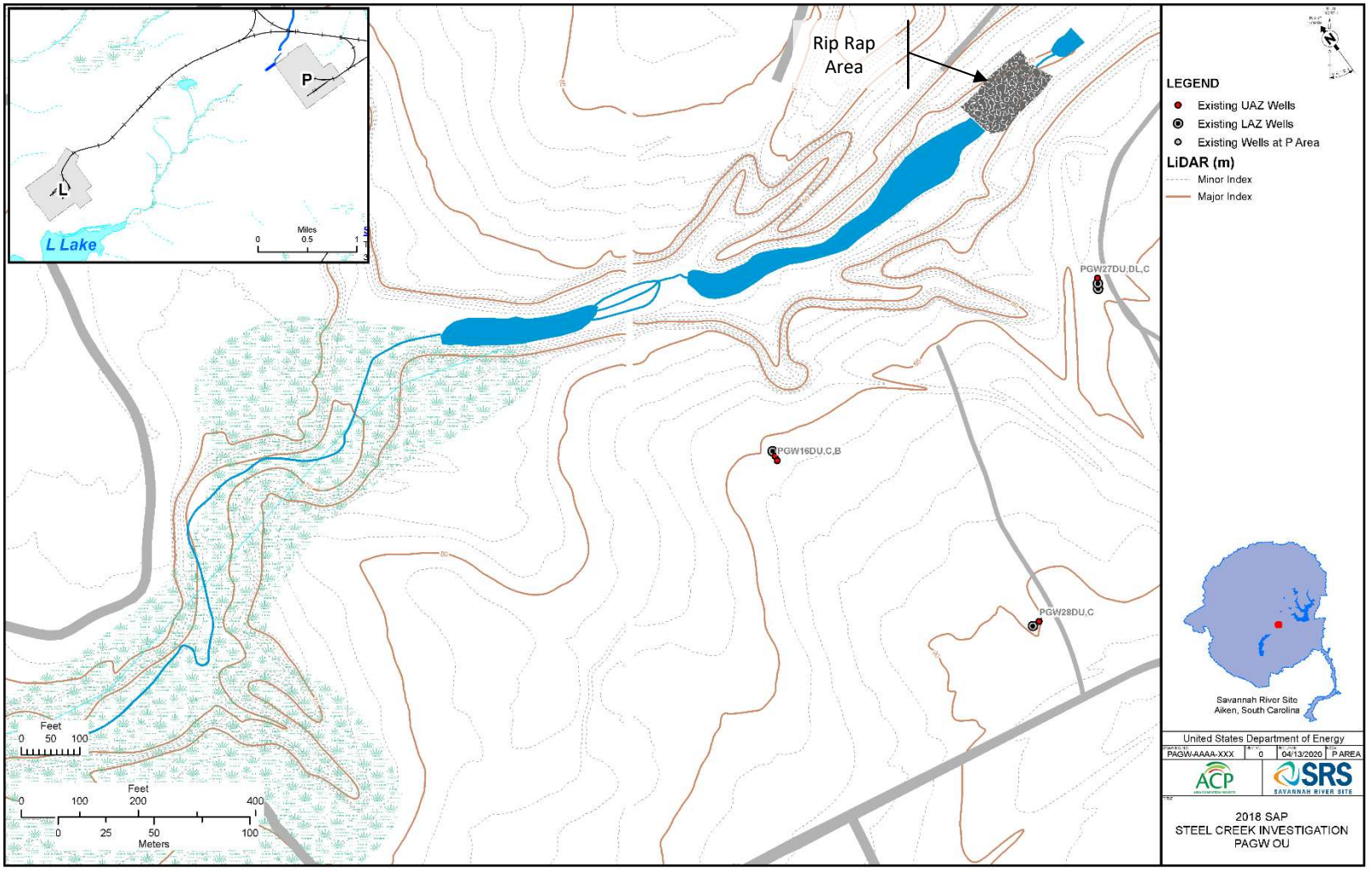
Steel Creek Characterization

Purpose: To determine area(s) of impact from shallow groundwater into Steel Creek and to determine extent of surface water contaminant concentrations from SC-02 to SC-04

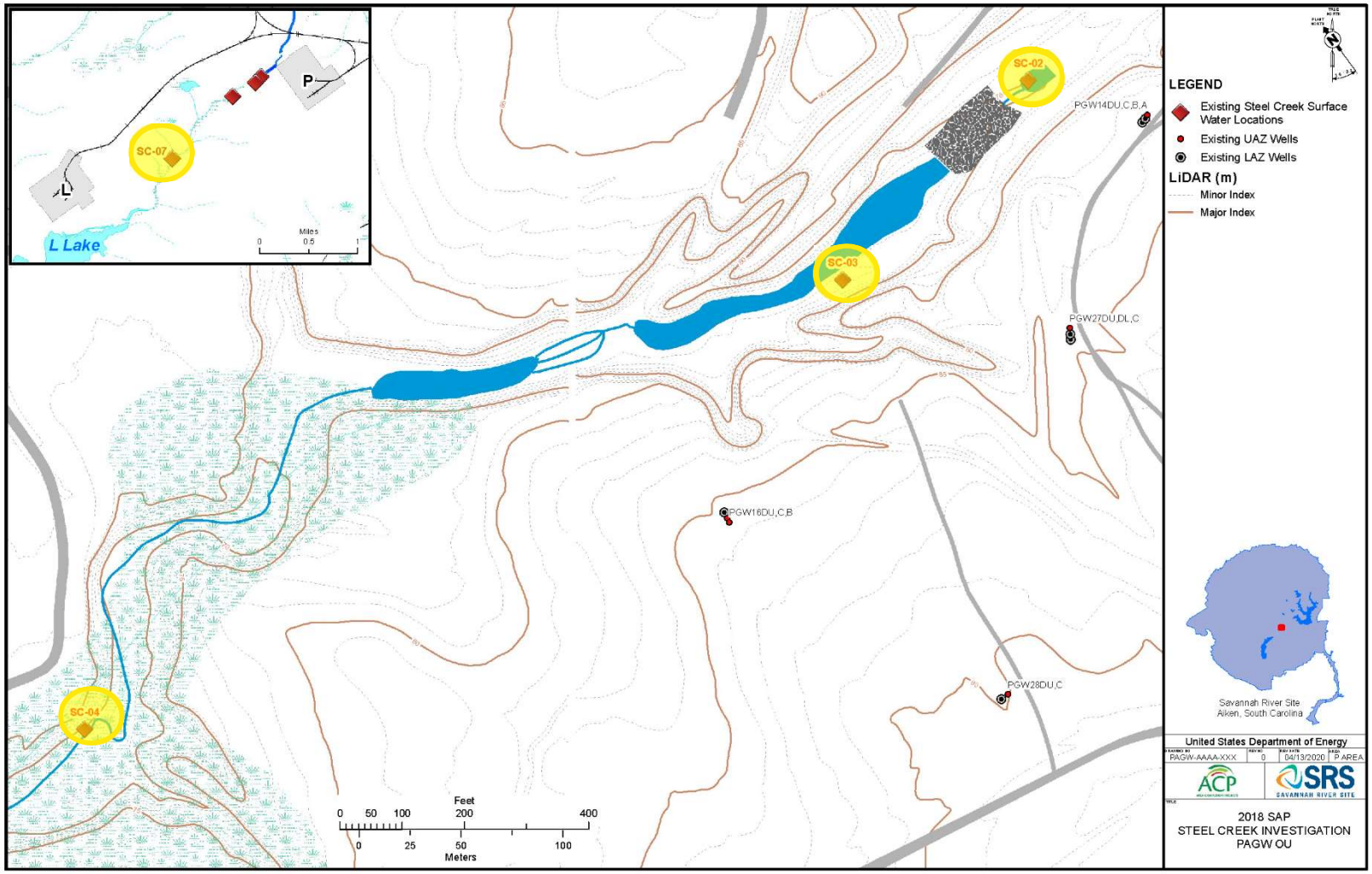
Proposed activities included:

- **Sample 6 new Steel Creek surface water locations between SC-02 and SC-04**
  - Determine locations to be retained for long-term monitoring
- **Establish and sample a new Steel Creek surface water location upstream of the high water stage of L Lake**
- **Sample 3 new surface water locations associated with Carolina Bay discharges into Steel Creek**
- **Install 11 shallow well points**
  - 5 well clusters (2 wells per cluster)
    - *3-5 and 8-10 feet deep (2 foot screen lengths)*
  - 1 single well from 8-10 feet (near surface water location SC-02)

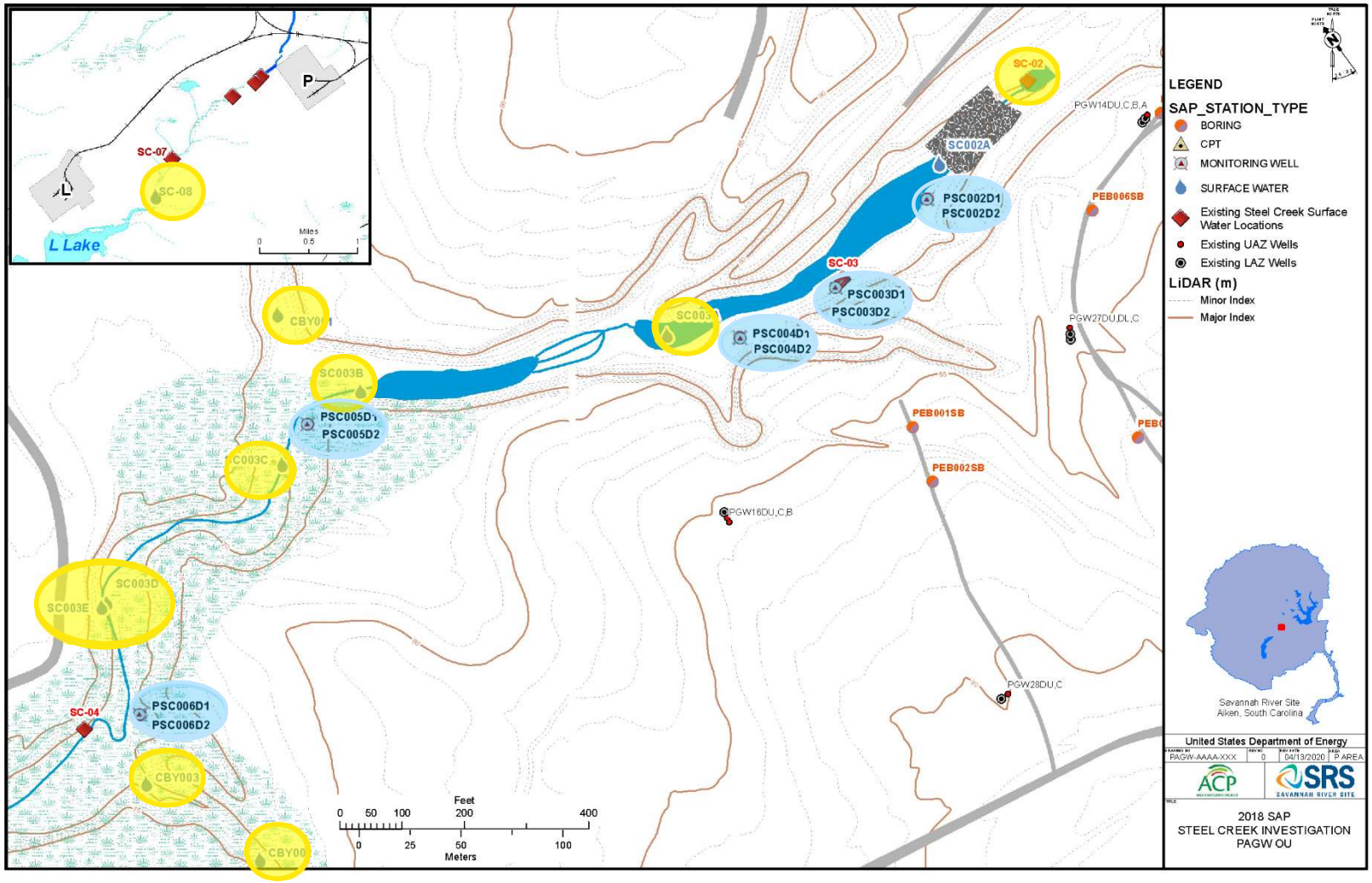
Steel Creek Characterization



Steel Creek Characterization



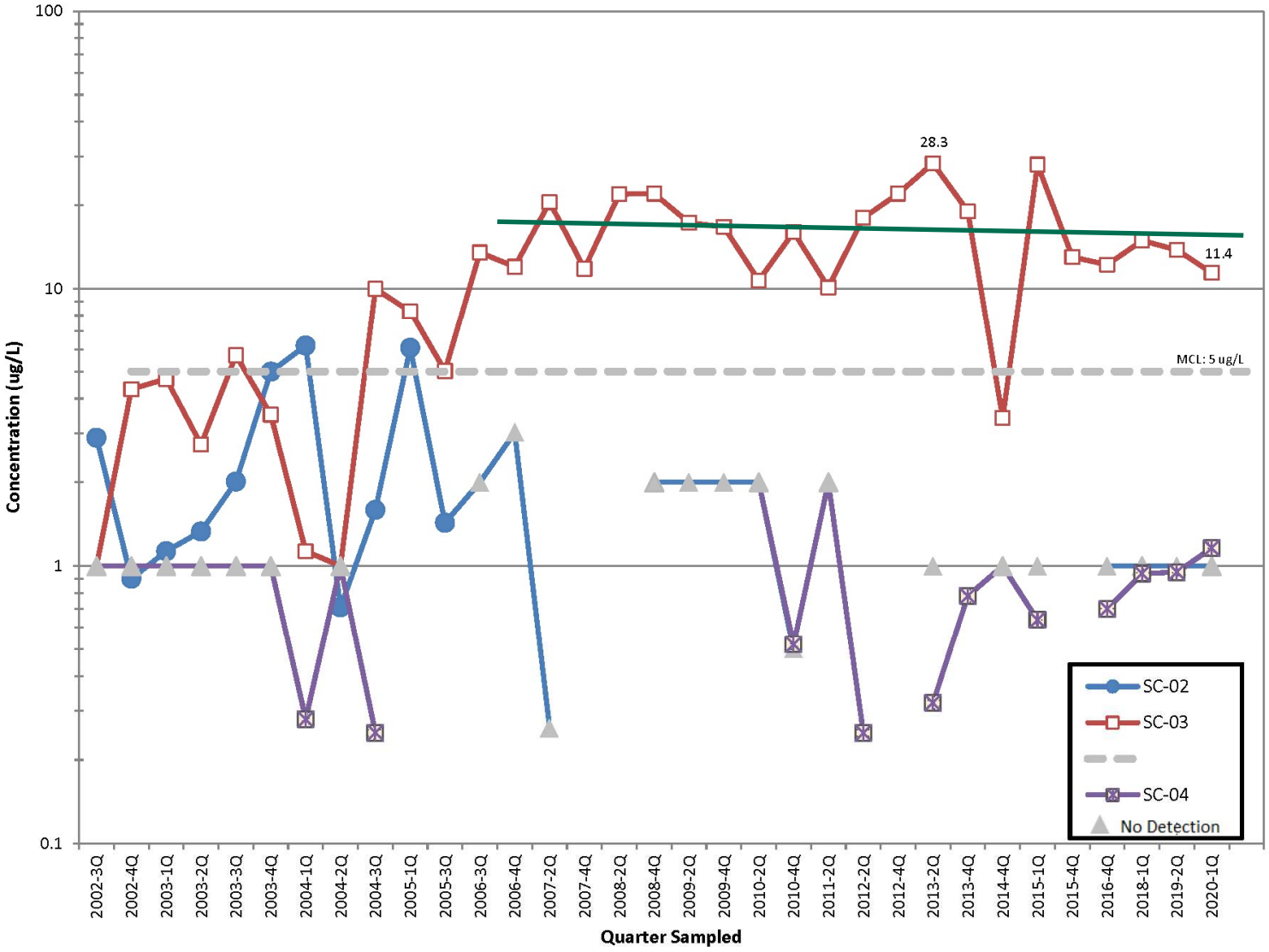
Steel Creek Characterization



Steel Creek Characterization - Planned vs Completed

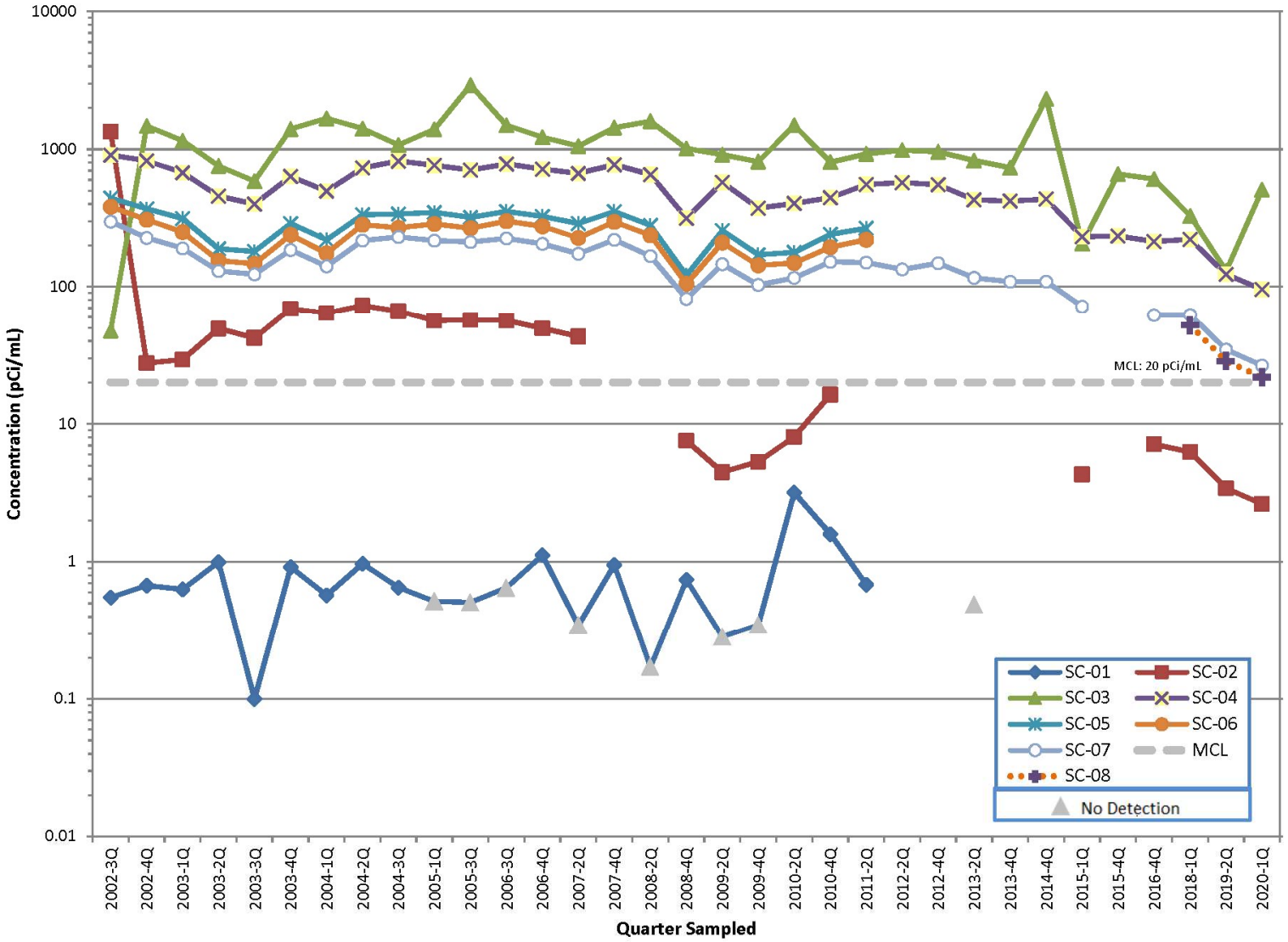
Planned Activities	Completed Activities
• **Sample existing surface water stations SC-02, SC-03, SC-04, and SC-07**	• **Existing 4 surface water stations sampled**
• **Sample 6 new Steel Creek surface water locations between SC-02 and SC-04** – Determine locations to be retained for long-term monitoring	• **6 new stations (SC002A, SC003A-3E) sampled** – None were selected for long-term monitoring
• **Establish and sample a new Steel Creek surface water location upstream of the high water stage of L Lake**	• **New location SC-08 selected and sampled**
• **Sample 3 new surface water locations associated with Carolina Bay discharges into Steel Creek**	• **Sampled 2 of 3 surface water locations**
• **Install 11 shallow well points**	• **10 of 11 shallow well points installed** – All 5 wells clusters (2 wells/cluster) installed – Single well near SC-02 not installed

Surface Water TCE Time-Trend Concentrations (Existing Locations)



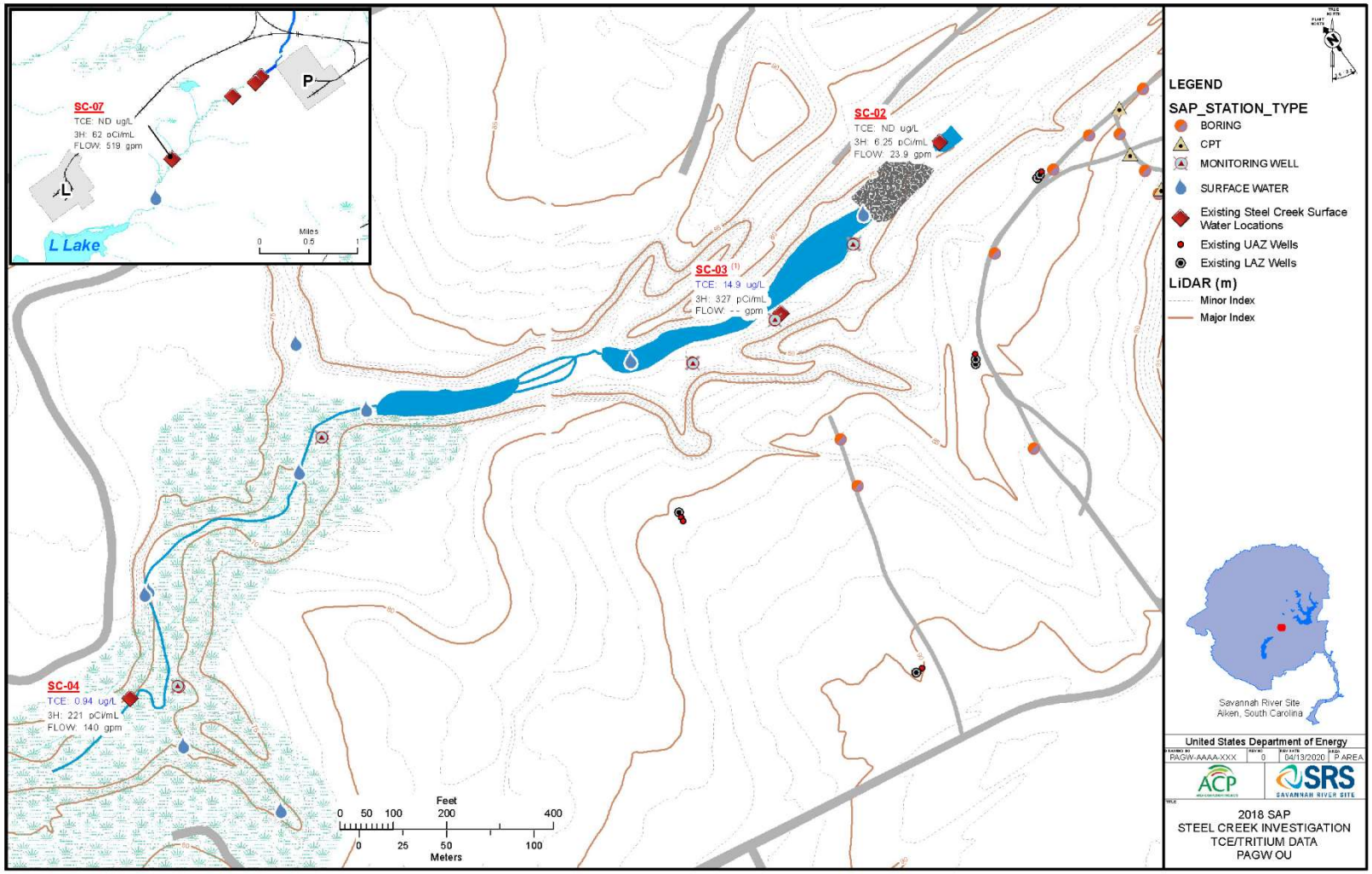
- Over last 14 yrs, no TCE detects at SC-02
- No increase in TCE at SC-03 since all time high of 28.3 ug/L in 2013 and again in 2015
- Overall trend of TCE concentrations at SC-03 have remained relatively flat over last 12 yrs
- TCE concentrations detected at SC-04, but near the detection limit
- SC-07 has no detections of TCE

Surface Water Tritium Time-Trend Concentrations (Existing Locations)

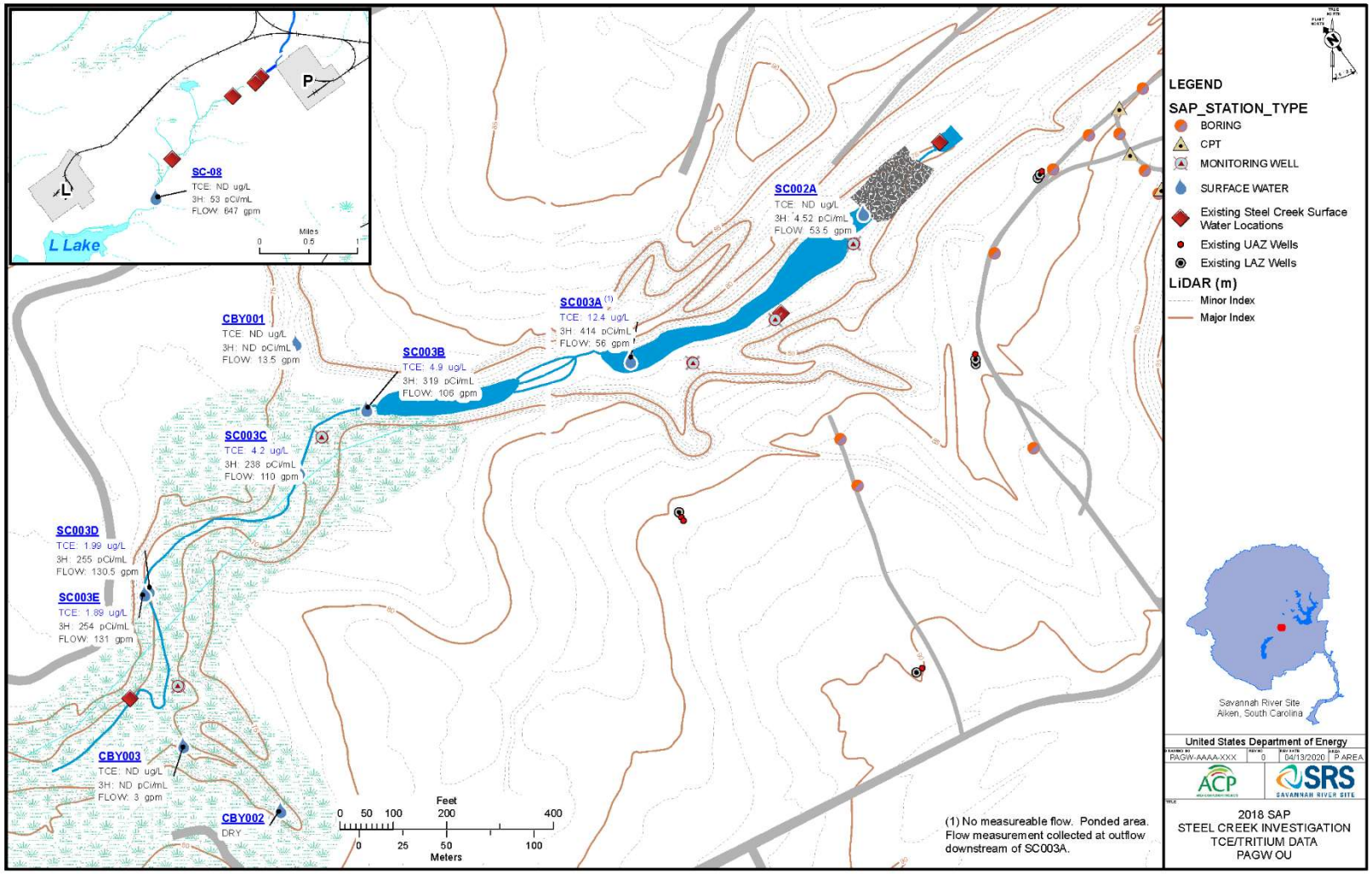


- **Since 2012, overall trend is decreasing at all locations**
- **Further supported by decreasing tritium trends in monitoring wells**

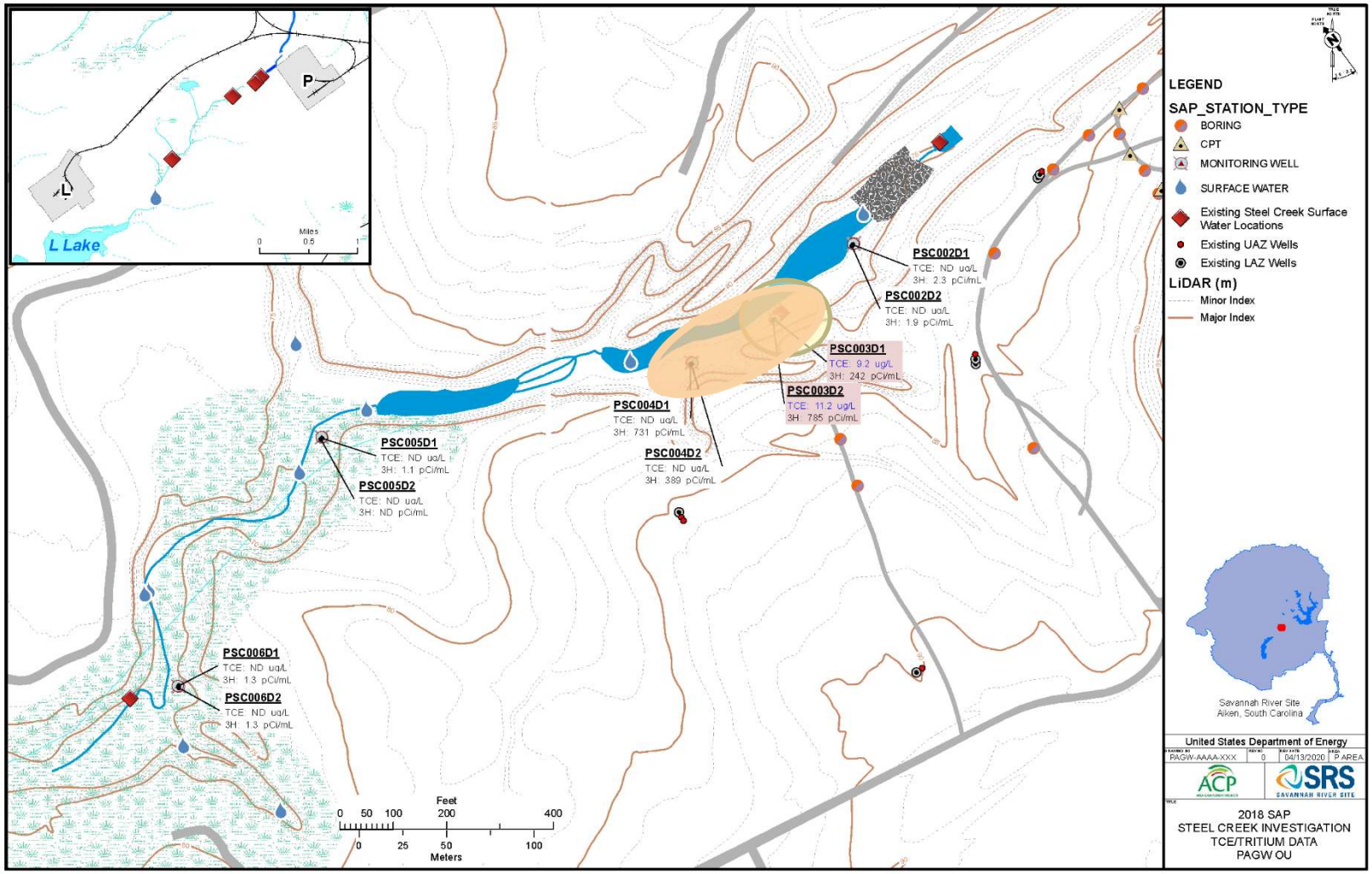
Steel Creek Characterization – Existing Surface Water Locations



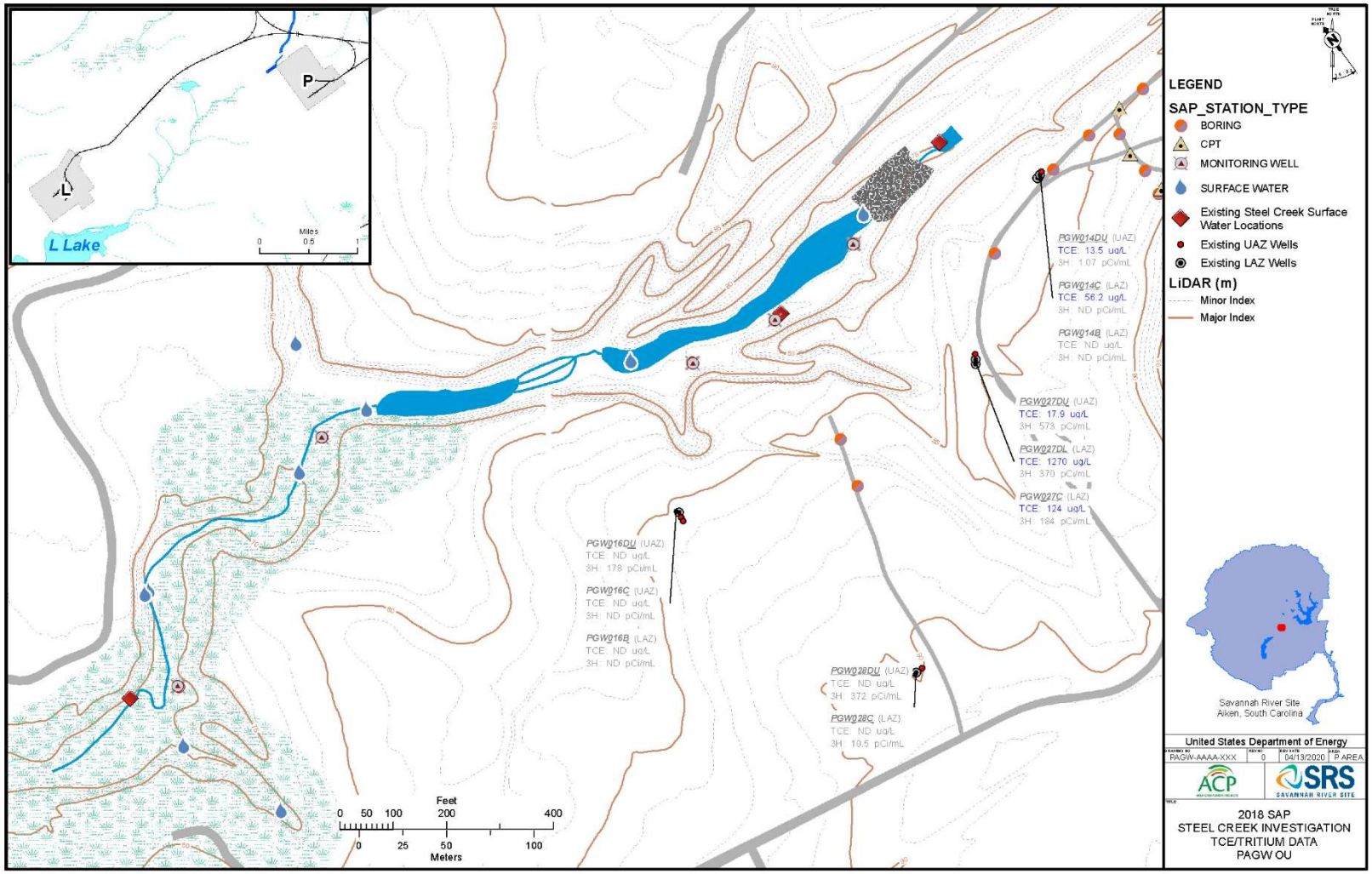
Steel Creek Characterization – SAP Surface Water Locations



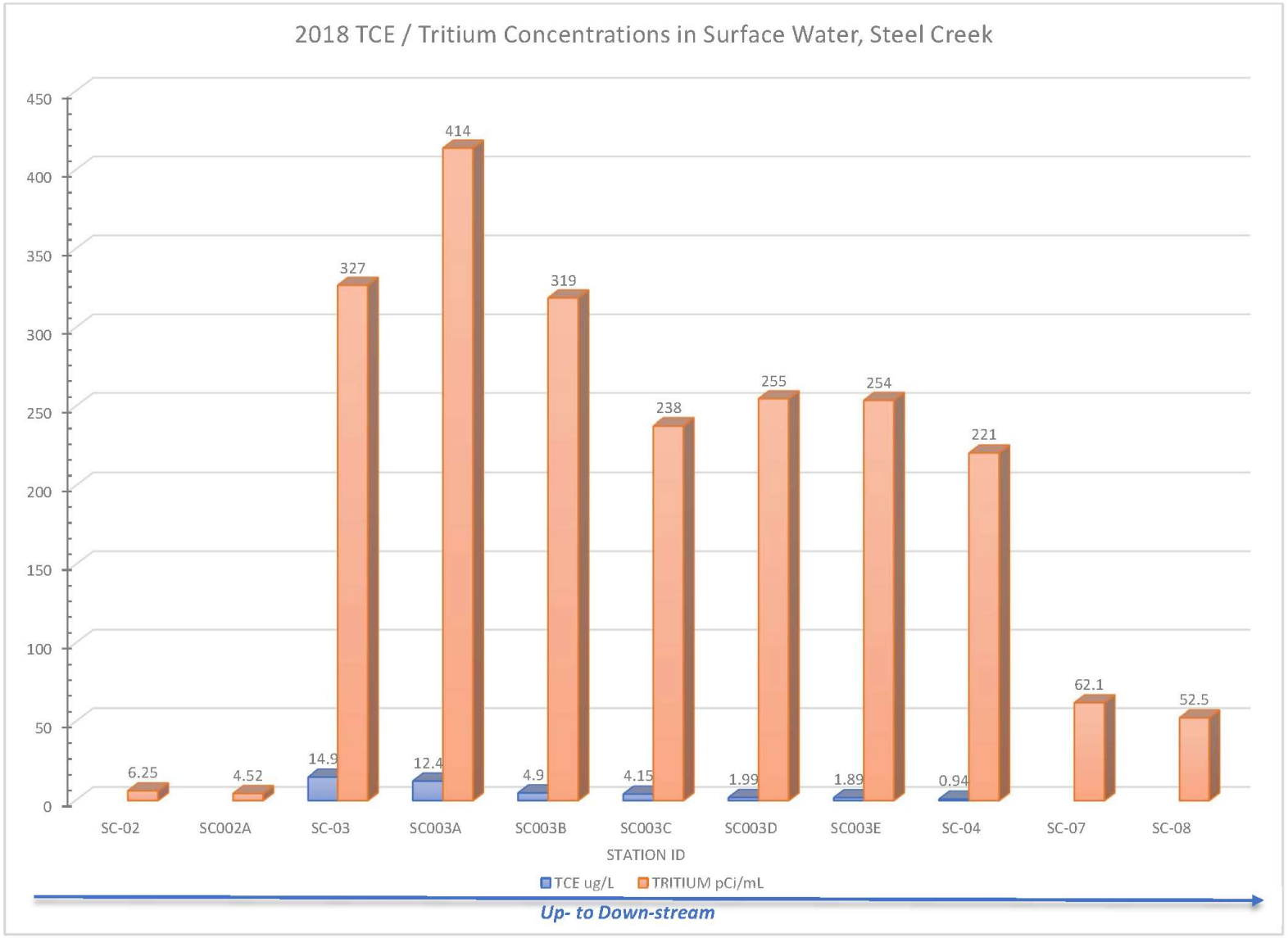
Steel Creek Characterization – New Shallow Monitoring Well Locations



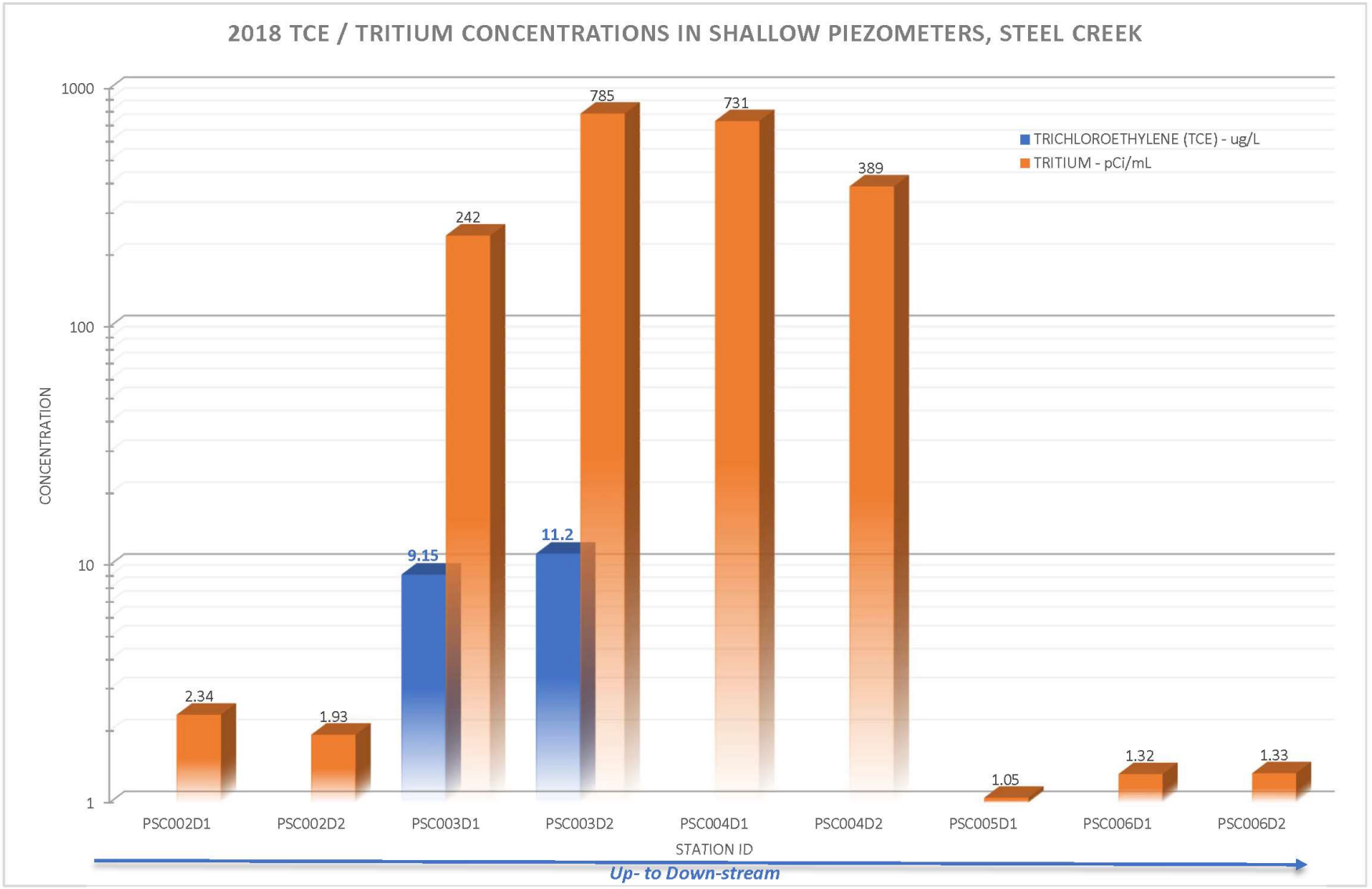
Steel Creek Characterization – Existing Groundwater Monitoring Well Locations



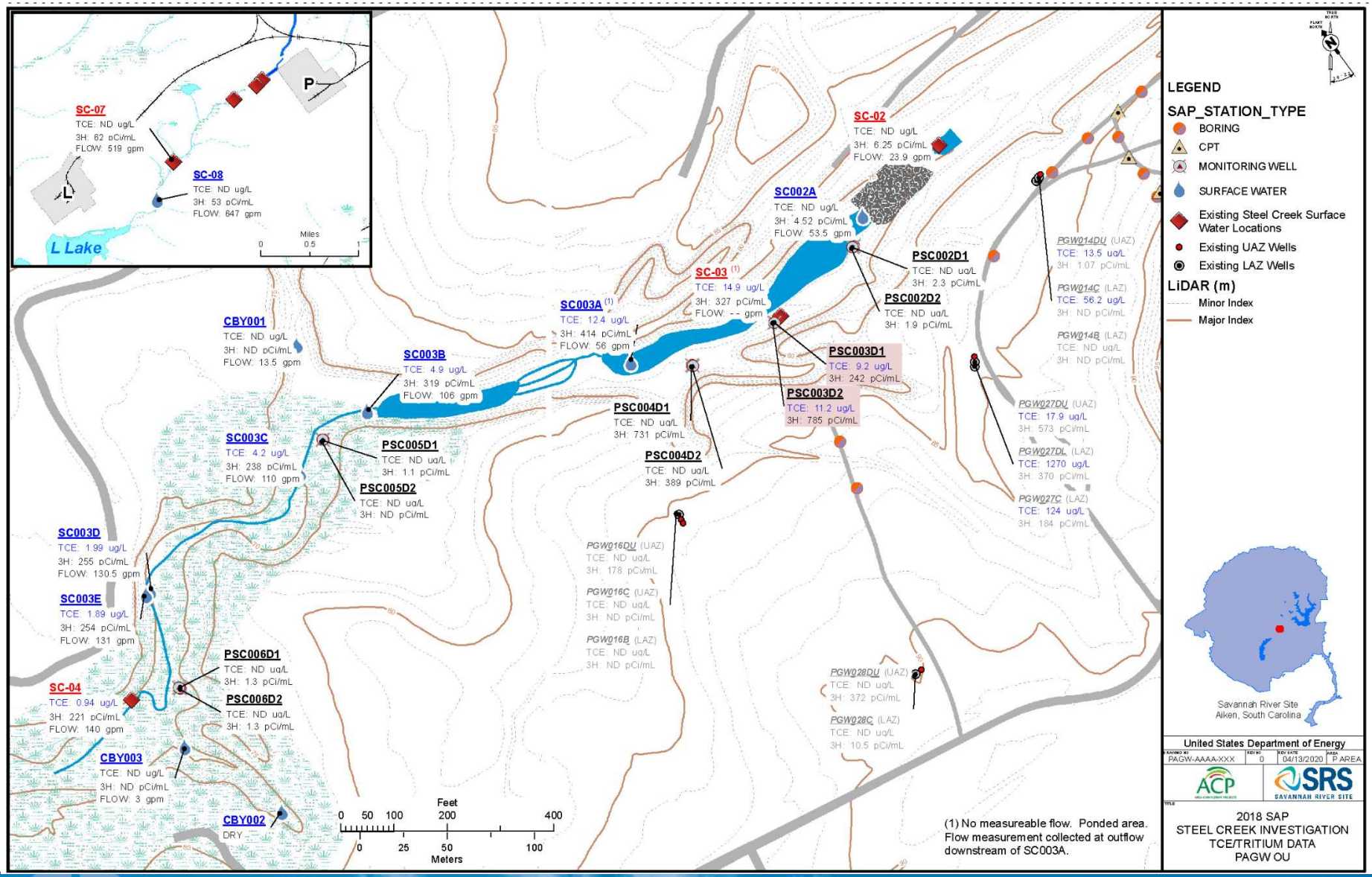
Steel Creek Characterization – Surface Water TCE/Tritium Graph



Steel Creek Characterization – Shallow Piezometers TCE/Tritium Graph



Steel Creek Characterization



Steel Creek Characterization – SC-02



Steel Creek Characterization – Proposed PSC001D2 @ Rip Rap



Steel Creek Characterization – SC002A @ Rip Rap



Steel Creek Characterization – SC-03 (looking downstream)



Steel Creek Characterization – SC-03 (looking upstream)



Steel Creek Characterization - Challenges



Steel Creek Characterization – SC-07 (looking downstream)



Steel Creek Characterization – L Lake, North SRS Rd B



Steel Creek Characterization – New SC-08



Steel Creek Characterization – CBY002/003





Steel Creek Characterization – Outcrop @ CBY002



Steel Creek Characterization – Well Installation (PSC004)



Steel Creek Characterization – Well Installation





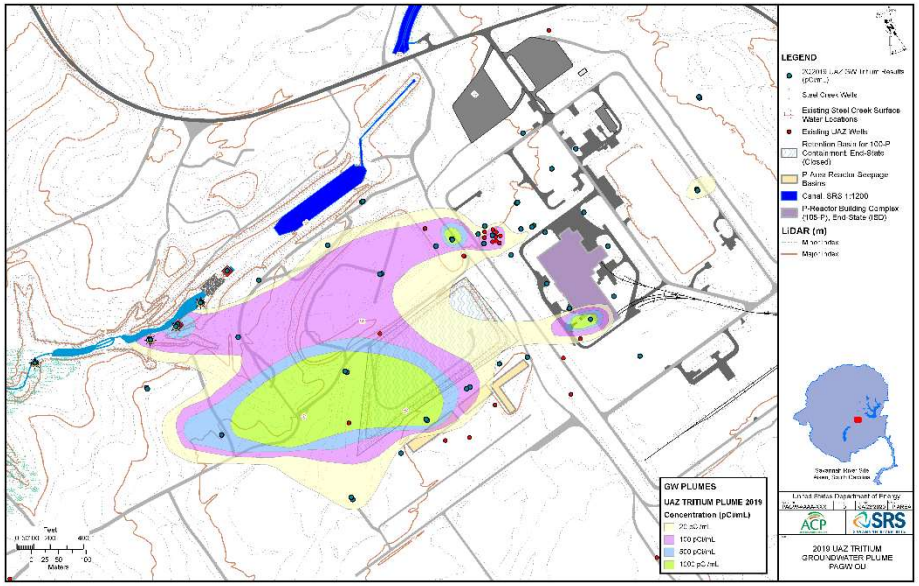
Steel Creek Characterization – Summary of Findings

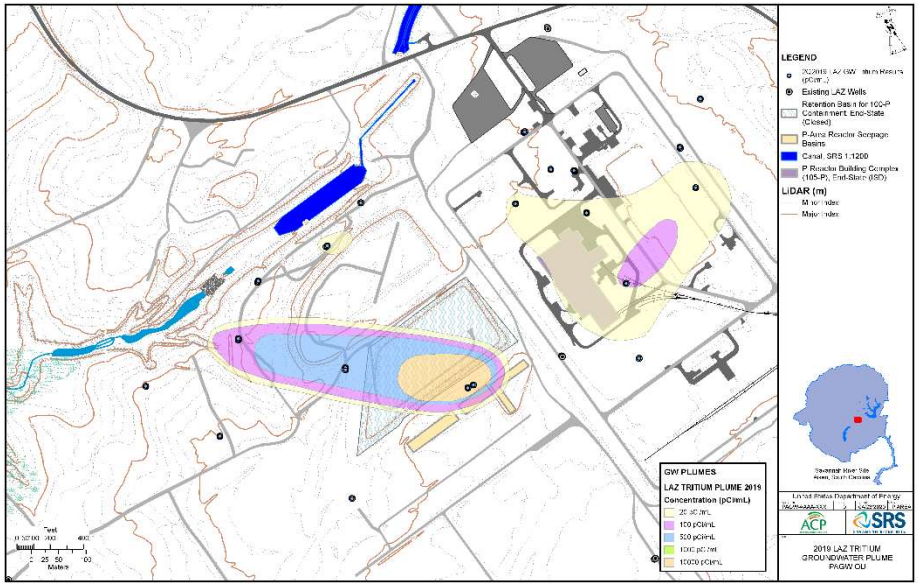
- **Tritium concentrations > MCL (20 pCi/mL) from P Area to L Lake**
  - Concentrations have been declining for a number of years
- **TCE detected from SC-03 to SC-04**
  - SC-03 routinely exhibits elevated TCE > MCL (5 ug/L)
  - No increase in concentrations since 2013/2015 at SC-03
    - *Highest concentration measured was 28.3 ug/L in 2013 and again in 2015*
  - Trend relatively flat last 14 yrs
  - SC-04 has shown concentrations near the detection limit with no detections downstream
- **Surface water flow rates increase ~3x from SC002A to SC-04**
  - Range from 53.5 to 140 gpm over a distance of 1,900 ft
  - Flow rate increase to ~650 gpm at SC-08



Steel Creek Characterization – Summary of Findings (continued…)

- **Shallow well sampling**
  - TCE detected >MCL at one well cluster (PSC003)
  - Tritium detected >MCL at well clusters PSC003 and -004
- **Contaminated groundwater impact to Steel Creek located within small area at well clusters PSC003 and -004 and surface water location SC-03**
  - Current and future data obtained from existing locations SC-03 and SC-04 adequate for monitoring impact to Steel Creek
  - No new surface water locations retained, except SC-08





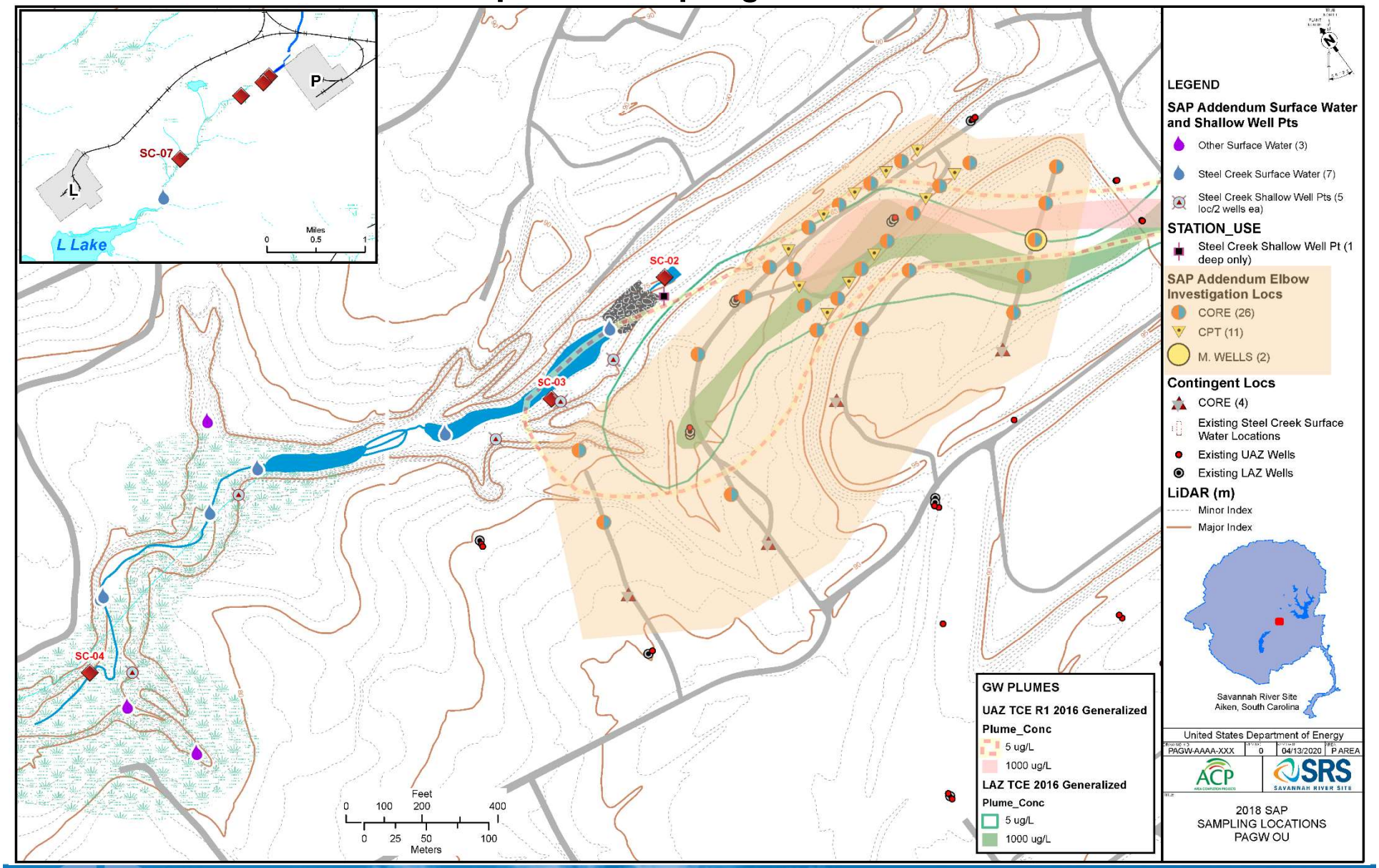
Elbow Characterization

Purpose: To determine areal extent of cVOC groundwater contamination between the neck and elbow area near Steel Creek and obtain lithologic and geotechnical data to aid in placement and design of future removal action

Proposed activities included:

- **11 CPT pushes with piezocone to collect geotechnical soil property data**
- **30 soil borings**
  - All borings to be cored and described in field
  - Headspace samples collected from all locations to determine cVOC concentrations
    - *Samples collected from UAZ to "Green Clay"*
  - Geophysically log 7 of the 30 boring locations
  - Terminate at "Green Clay" for confirmation of unit
  - Collect 7 undisturbed Shelby tube samples for geotechnical analysis from 6 of the 30 boring locations
- **Install a 2 well cluster**

Elbow Characterization - Proposed Sampling Locations



Elbow Characterization - Planned vs Completed

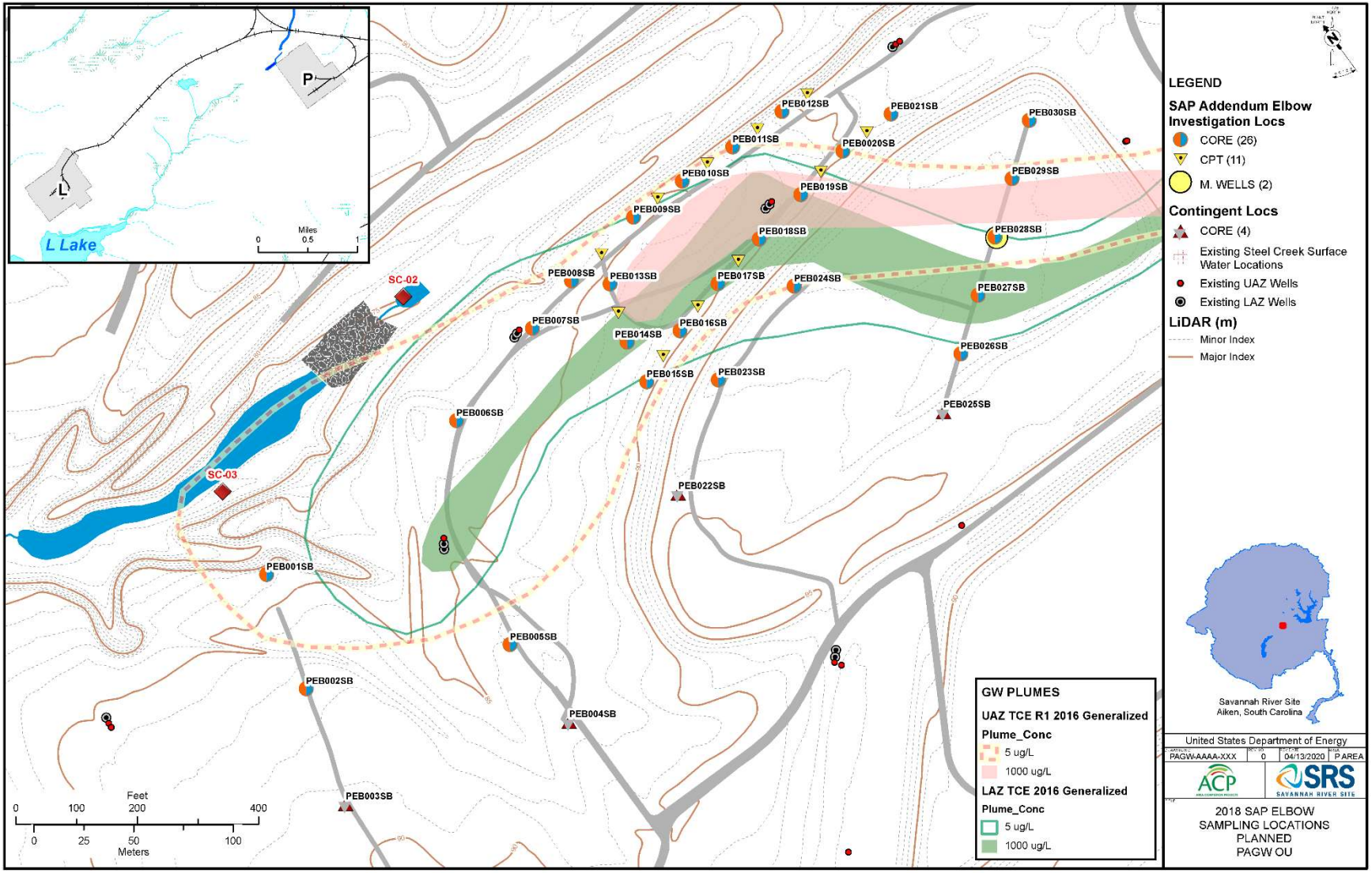
Planned Activities

- **Complete 11 CPTs for geotechnical characterization**
- **30 Continuous Boring Locations**
  - 26 planned locations
  - 4 contingency locations
  - Continuously core each location
    - *Terminate at "Green Clay" for confirmation of unit*
  - Geophysically log 7 of the 30 boring locations
  - Collect 7 undisturbed Shelby tube samples for geotechnical analysis from 6 of the 30 boring locations
  - Collect soil samples for VOC analysis
- **Install a 2-well cluster**

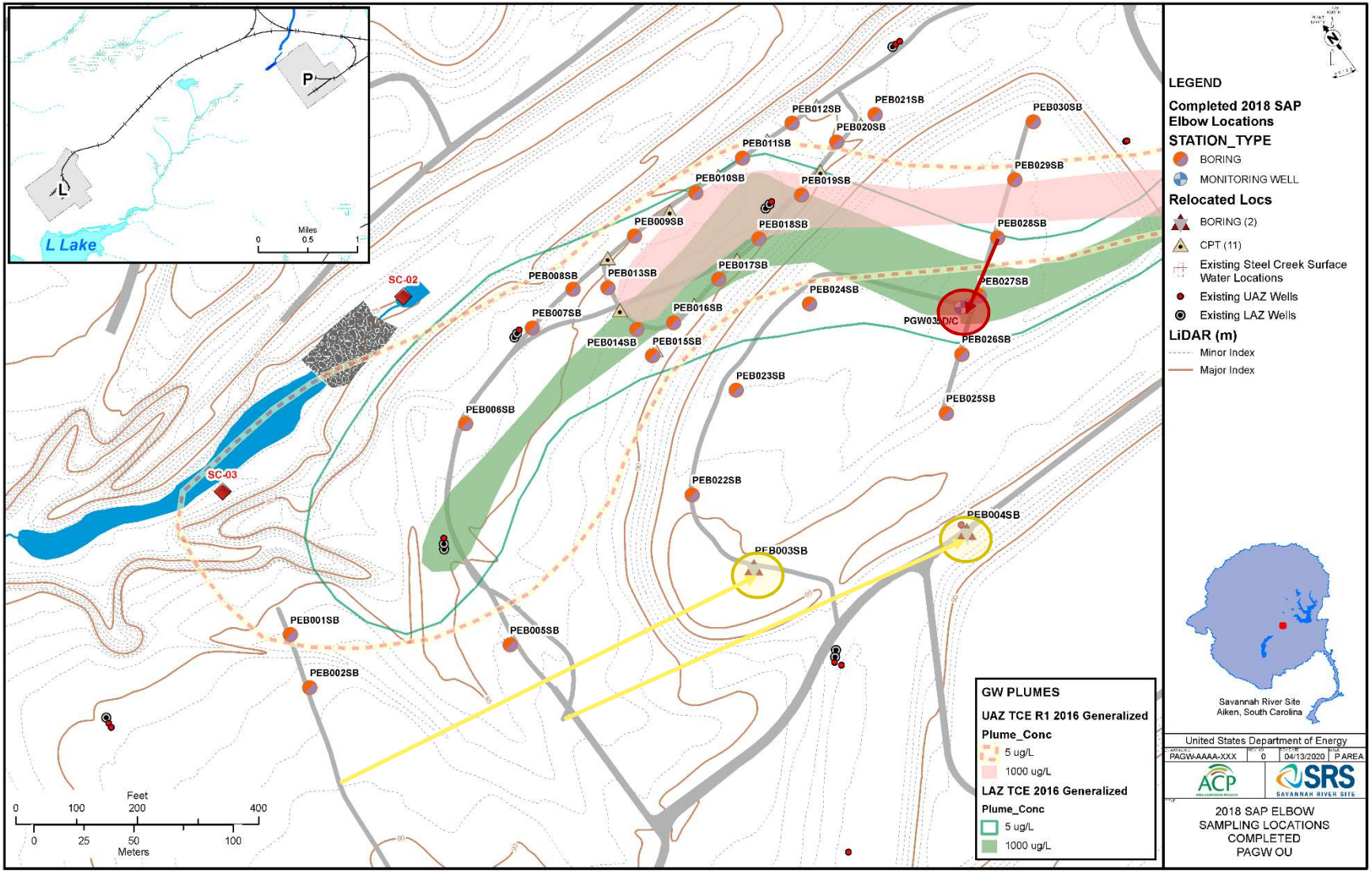
Completed Activities

- **All 11 CPTs were completed**
  - 10 of 11 terminated at 171 ft bls; one at 142 ft
  - All 26 boring locations cored and sampled
  - All 4 contingency borings cored and sampled
    - *Two of the four relocated based on field data*
  - All borings continuously cored and described
  - 7 locations were geophysically logged
  - Collected 41 samples
    - *18-UAZ, 8-TCCZ-14-LAZ, 1-GCU*
  - Approximately 2600 soil samples collected
- **2-Well cluster installed**
  - Relocated based on field data

Elbow Characterization – Planned Locations



Elbow Characterization – Completed Locations

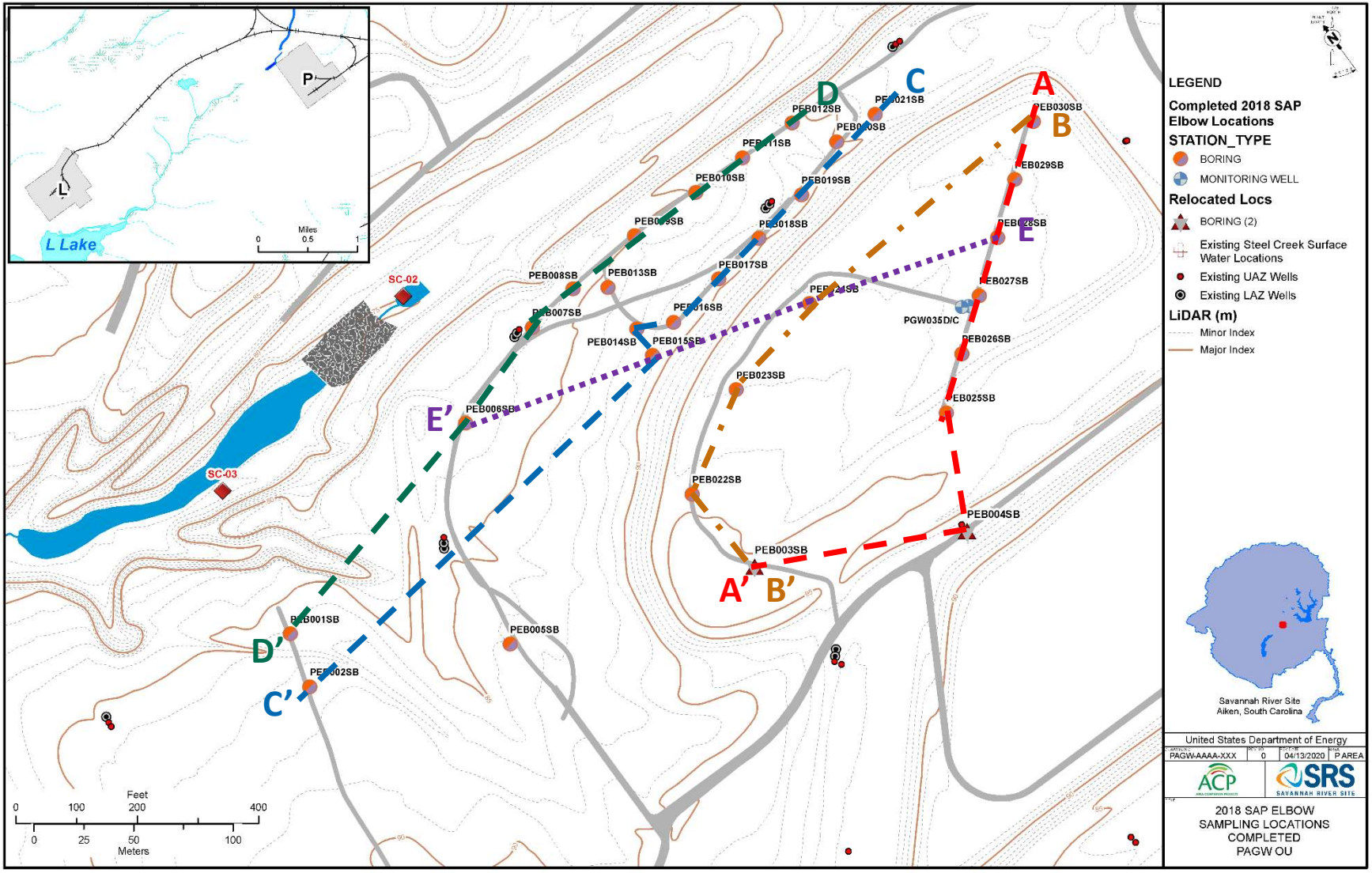


Elbow Characterization – TCE Soils Data (Summary)

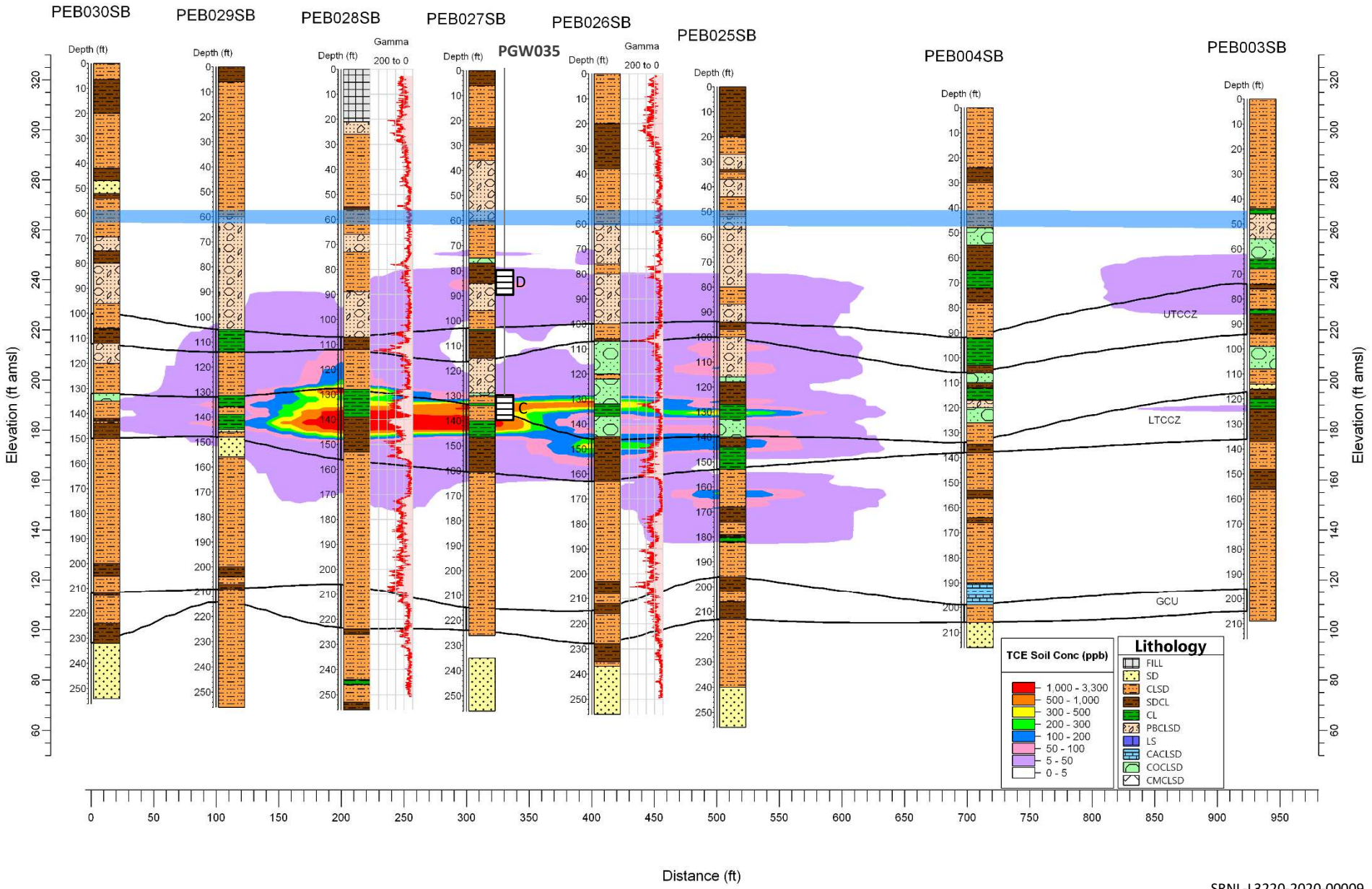
30 Borings
2,597 Samples Collected

Total # Samples Collected	HydroStrat Unit	# of Samples with Detected TCE Results	% of Samples Detected	Max Soil Result (ug/kg)	Boring ID
1,259	UAZ	814	65%	1640.55	PEB013SB
278	TCCZ	201	72%	3274.50	PEB028SB
844	LAZ	499	59%	1456.32	PEB019SB
76	GCU	42	55%	188.89	PEB014SB
140	GAU	112	80%	59.73	PEB013SB

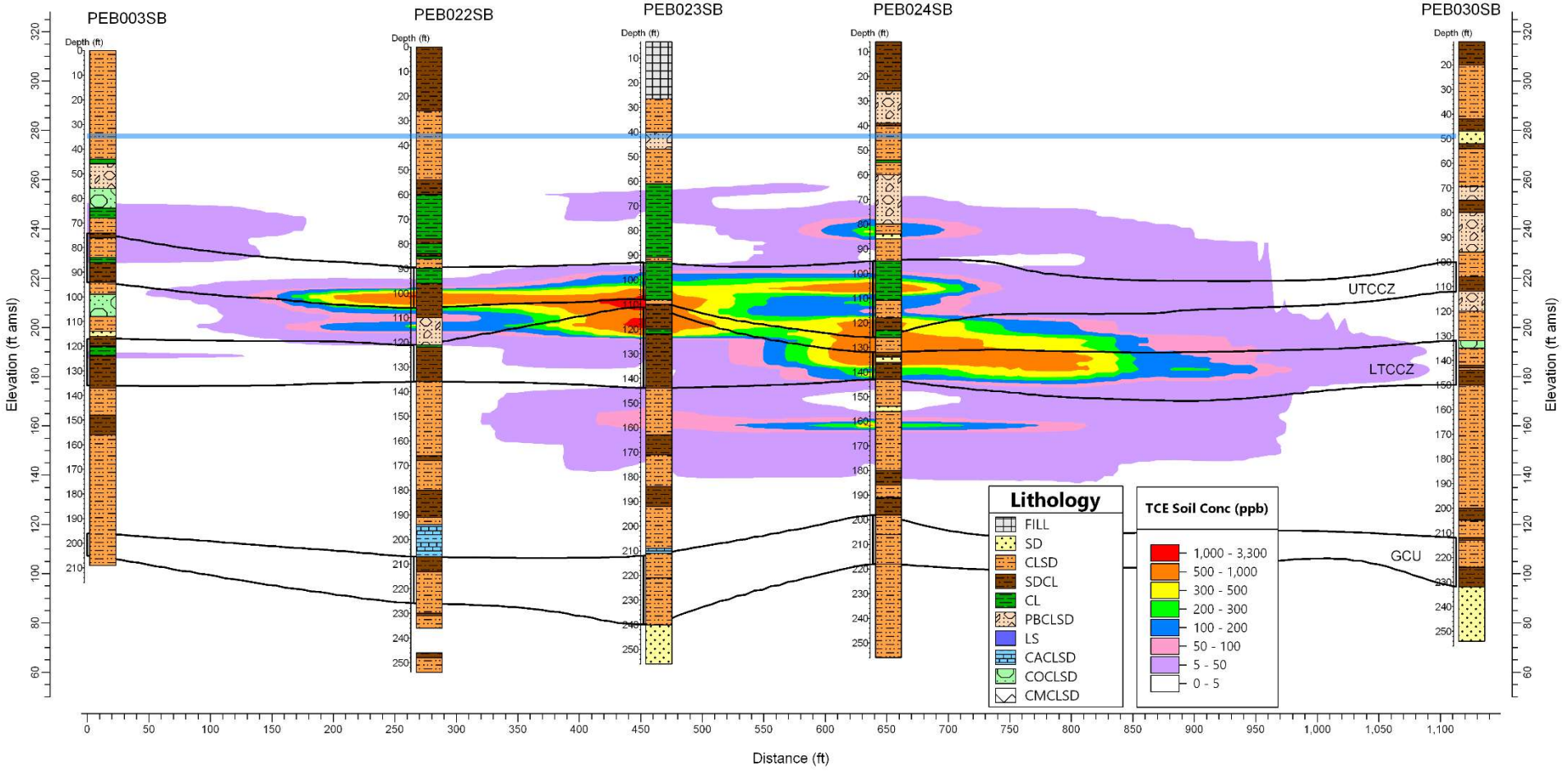
Elbow Characterization – Location of Cross Sections



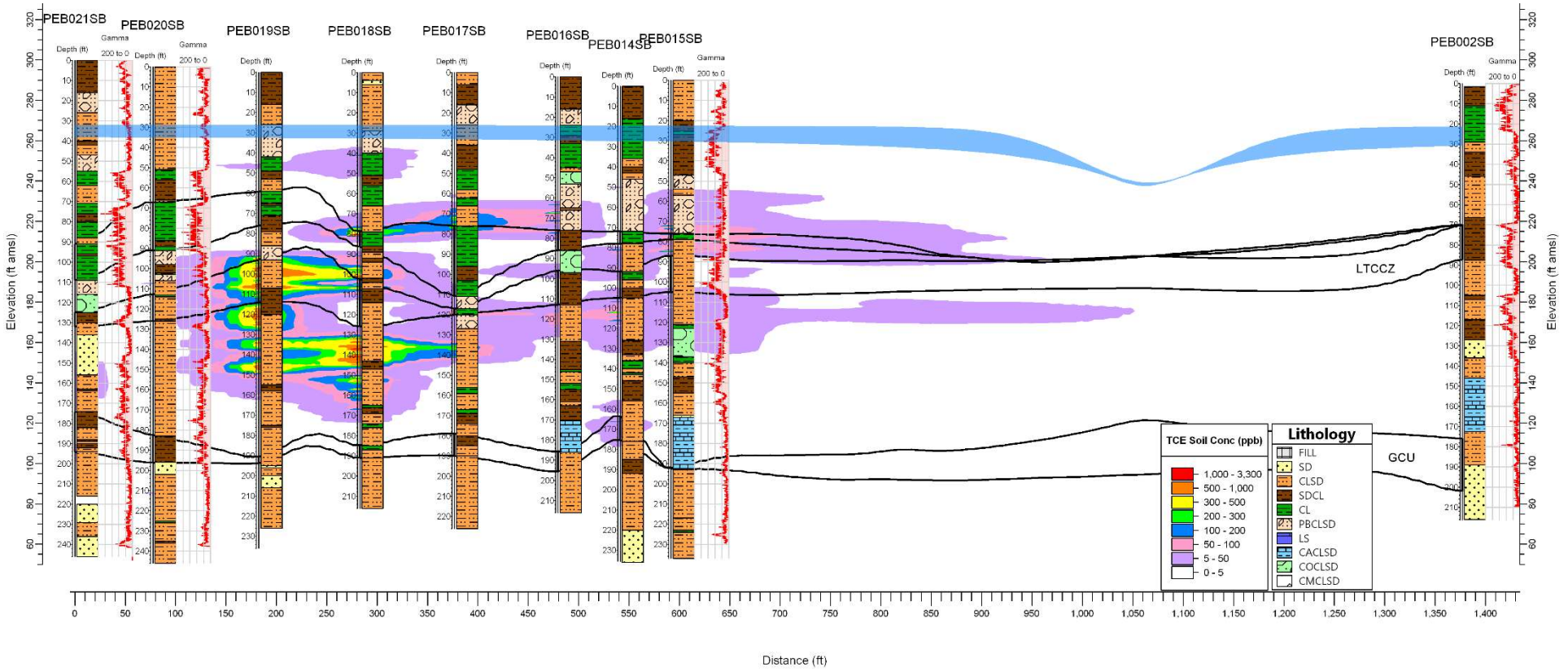
Elbow Characterization – Cross Section A – A’



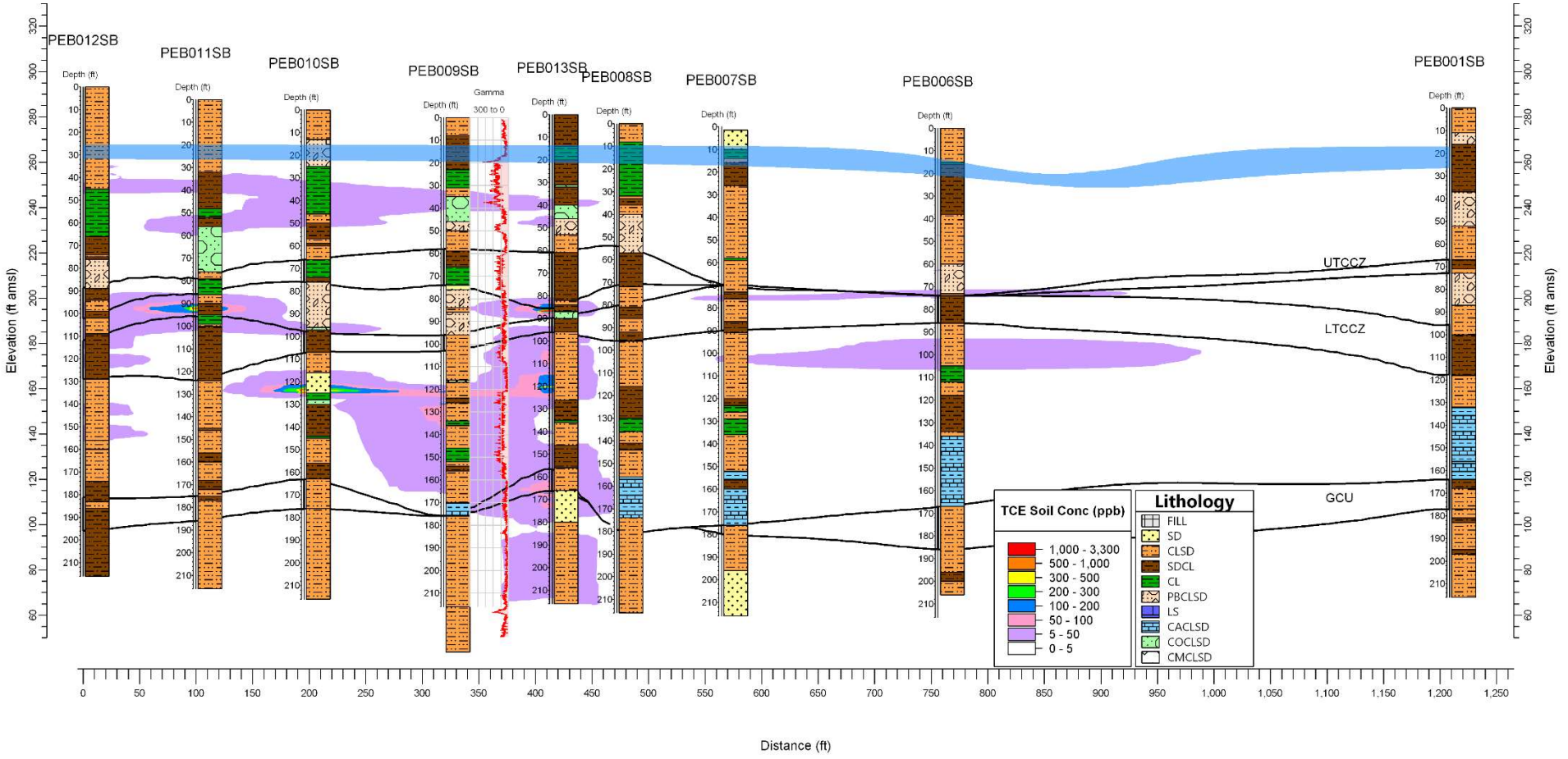
Elbow Characterization – Cross Section B - B’



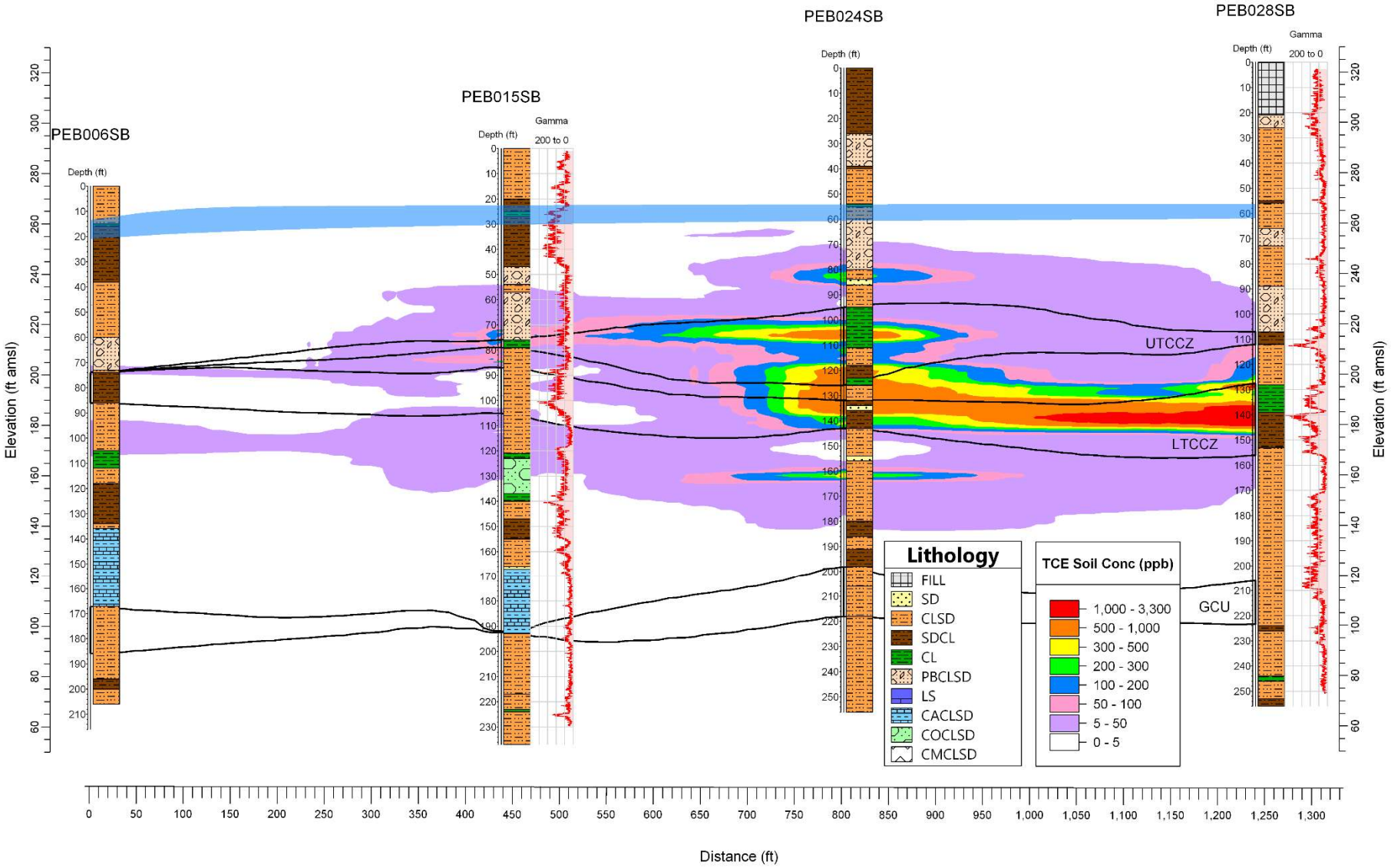
Elbow Characterization – Cross Section C - C’



Elbow Characterization – Cross Section D - D’

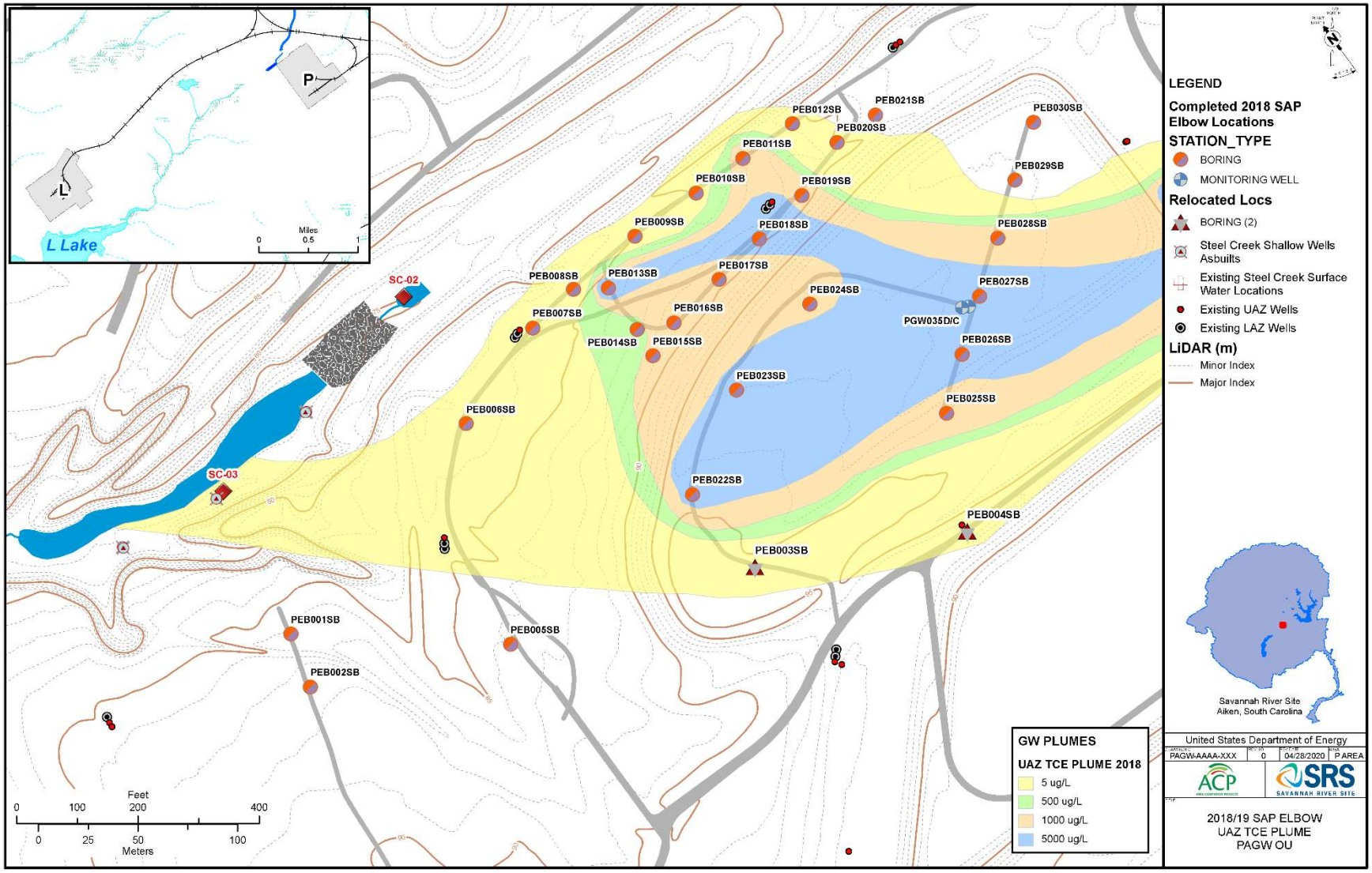


Elbow Characterization – Cross Section E - E'



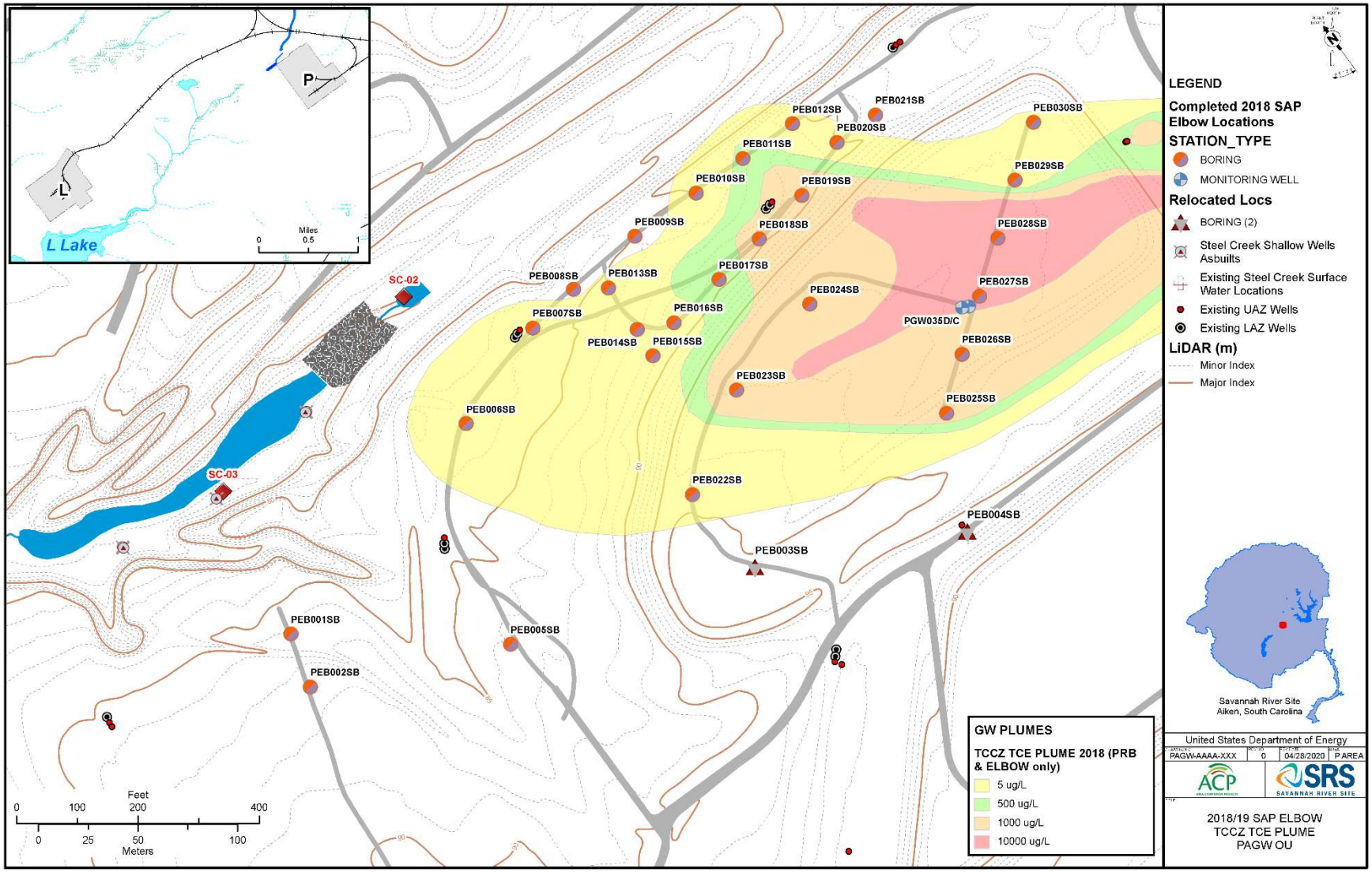
Elbow Characterization – TCE Plume (UAZ)

(Based on max TCE result)



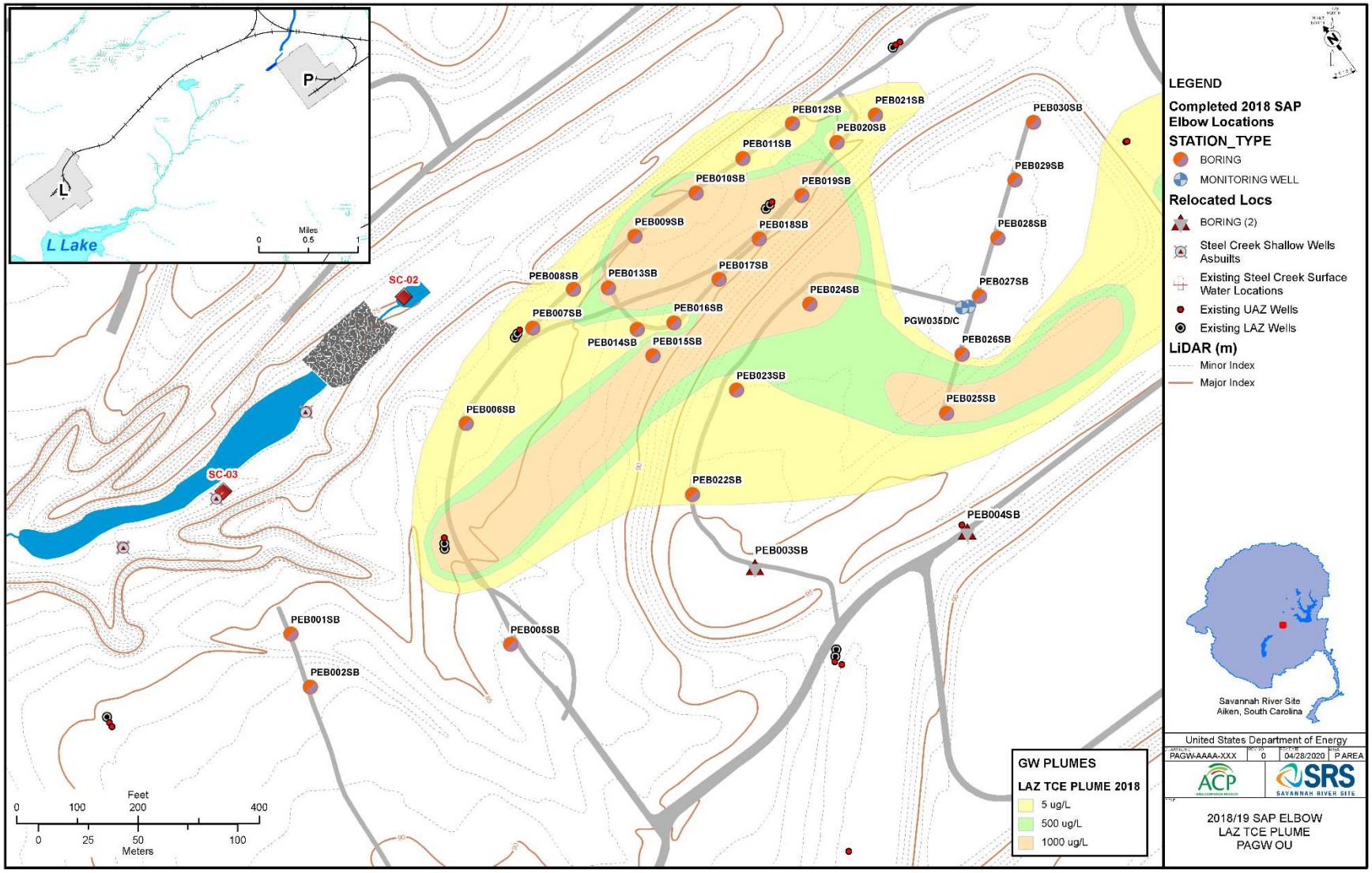
Elbow Characterization – TCE Plume (Tan Clay Confining Zone)

(Based on max TCE result)



Elbow Characterization – TCE Plume (LAZ)

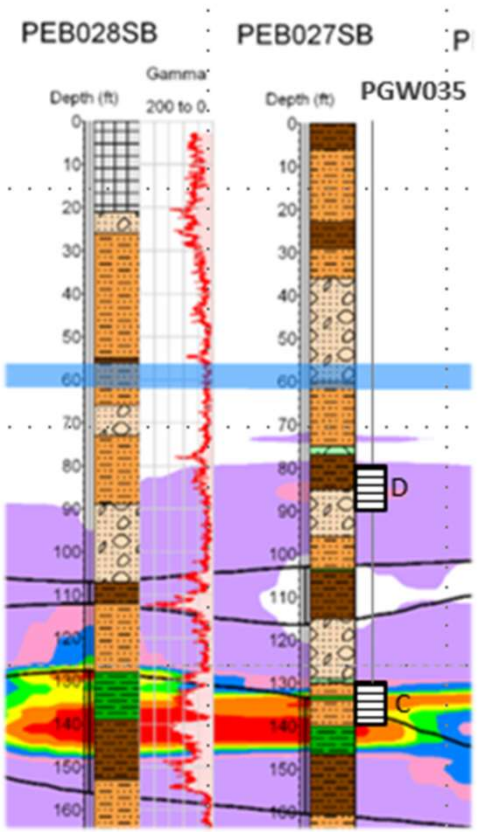
(Based on max TCE result)



Elbow Characterization – PGW035 Well Cluster

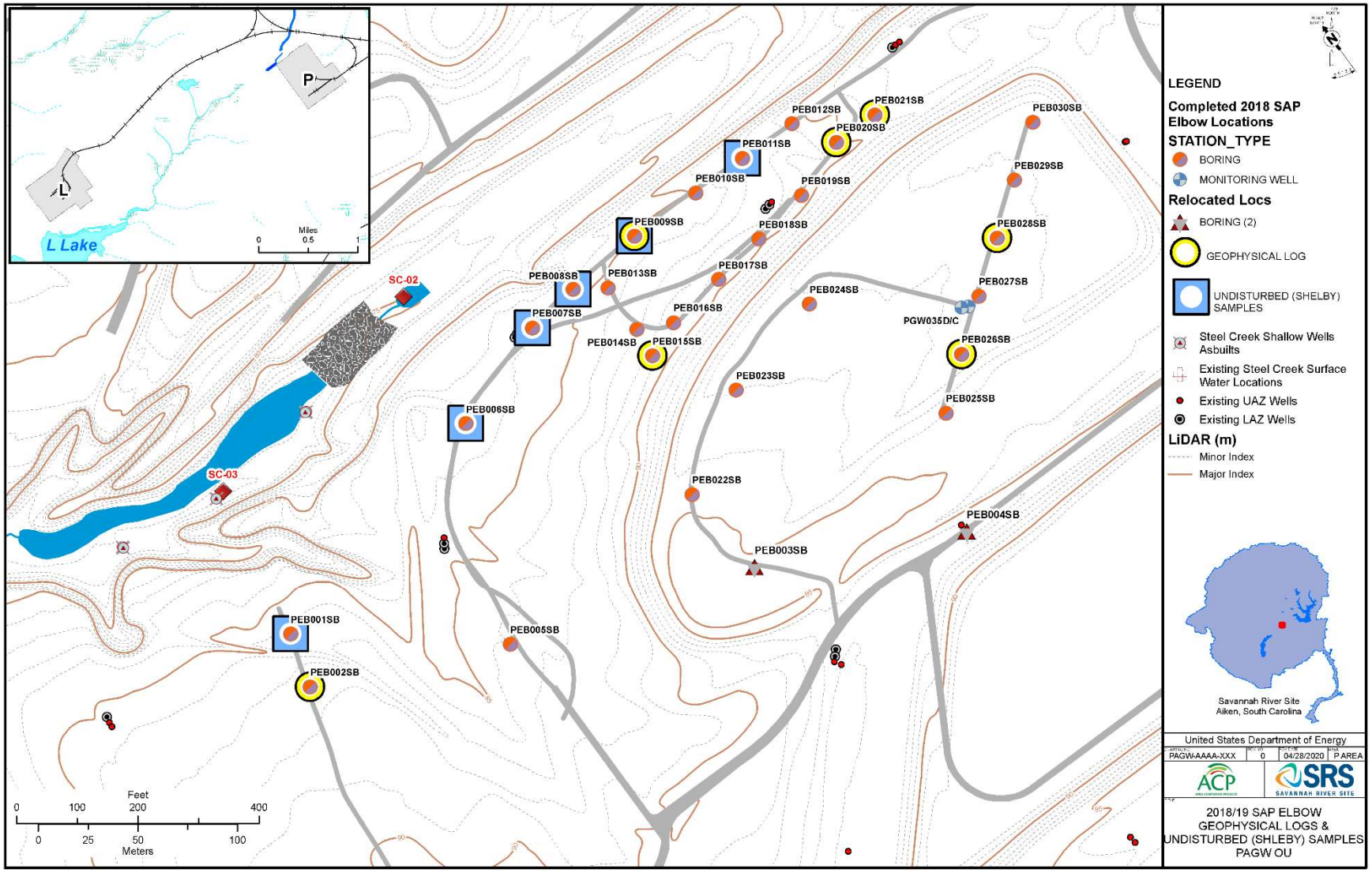
AQUIFER	ANALYTE NAME	QTR	UNITS	PGW035C	PGW035D
UAZ	TETRACHLOROETHYLENE (PCE)	2018-3Q	ug/L	200	3.93
		2018-4Q	ug/L	15.6	1.29
		2019-1Q	ug/L	17	1.32
		2019-2Q	ug/L	250	1.14
		2020-1Q	ug/L	100	1.34
	TRICHLOROETHYLENE (TCE)	2018-3Q	ug/L	5590	53.7
		2018-4Q	ug/L	6410	39.5
		2019-1Q	ug/L	5560	34.2
		2019-2Q	ug/L	5380	33
		2020-1Q	ug/L	6390	32.4
	TRITIUM	2018-3Q	pCi/mL	241	9.24
		2018-4Q	pCi/mL	193	8.61
		2019-2Q	pCi/mL	174	6.64
		2020-1Q	pCi/mL	151	5.93

>MCL

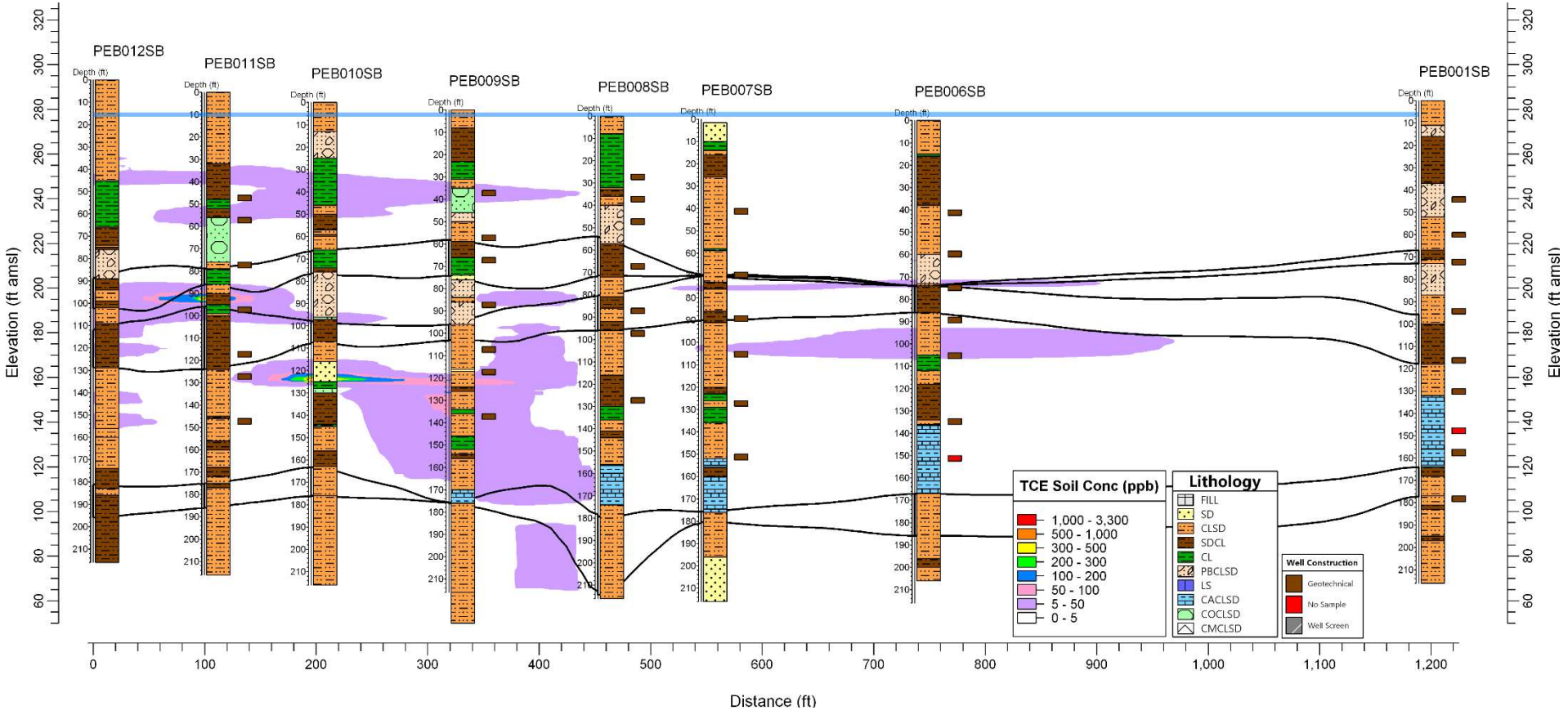


- **Highest concentrations observed in PGW035C (UAZ)**
  - Correlates to elevated TCE concentrations observed in boring PEB027SB (TCCZ)
  - Monitoring well partially installed in TCCZ

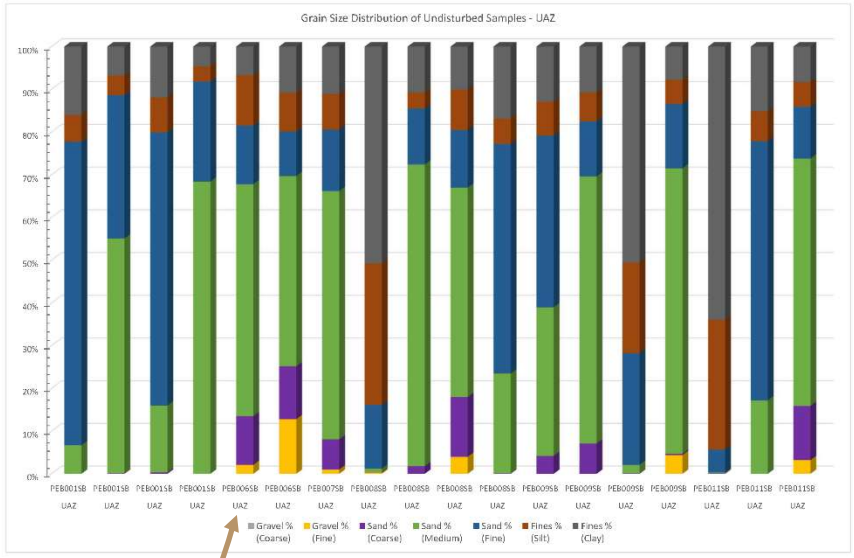
Elbow Characterization – Geotech Locations

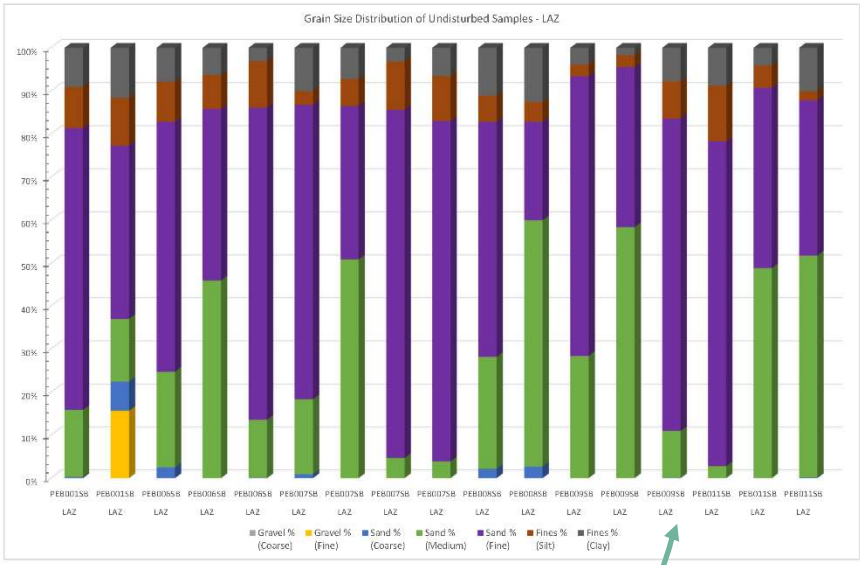


Elbow Characterization – Geotech Samples



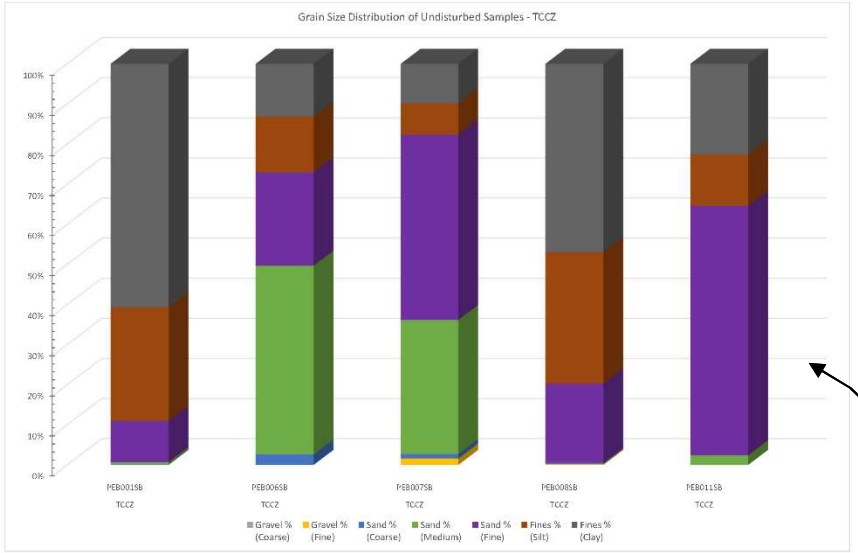
Elbow Characterization – Grain-Size Distribution





UAZ

- Mostly med-fine grained sand
- Some coarse sand with gravel
- Small percentage (~20%) of fine-grained material



LAZ

- Mostly fine-grained, w/ some med-grained, sand

TCCZ

- Variable lithological makeup
- Higher silt-clay content
- Fine-med grained sand zones present

Elbow Characterization – Geotech Undisturbed Samples

Hydrostrat Unit	# of Samples	Minimum Kh (cm/sec)	Maximum Kh (cm/sec)	Average Kh (cm/sec)	Minimum Porosity	Maximum Porosity	Average Porosity
UAZ	18	6.30E-08	4.07E-04	8.05E-05	37%	49%	42.9%
TCCZ	8	1.50E-07	2.51E-04	5.31E-05	29%	66%	41.1%
LAZ	14	1.27E-07	1.80E-04	3.23E-05	35%	45%	39.9%
GCU	1	3.10E-04	3.10E-04	3.10E-04	41%	41%	41.0%

- **Porosity values on average approximately 2x more than what is typically assumed for SRS sediments**
- **Hydraulic conductivity (K_h) values on average are uniform throughout**
  - Samples with higher sand content have K_h values 10E-04 to 10E-06 (typical of UAZ and LAZ)
  - Samples with higher silt/clay content have K_h values 10E-07 to 10E-08 (typical of TCCZ)

Elbow Characterization – Summary of Findings

- **TCE contaminated groundwater discharge to Steel Creek in same locale as tritium**
  - TCE soils data support limited areal impact to Steel Creek
- **Highest levels of TCE found central to Elbow area**
  - Contained within low permeability sediments (e.g., TCCZ)
  - Plumes are larger than previously thought
    - *Due to limited areal extent of well data within the plume*
    - *Current well network bounds the extent of the TCE plumes*
  - Extent of contamination limited to within bounds of sampling locations
  - Primary impact to LAZ from vertical migration of TCE in overlying UAZ
    - *Smaller area of impact to LAZ possibly originating from PRB site, fully penetrating well*
- **Geology highly variable**
  - Large section of calcareous material found in area at western end in the LAZ
  - Abundance of clay, silt rich material

Investigation Summary

Steel Creek

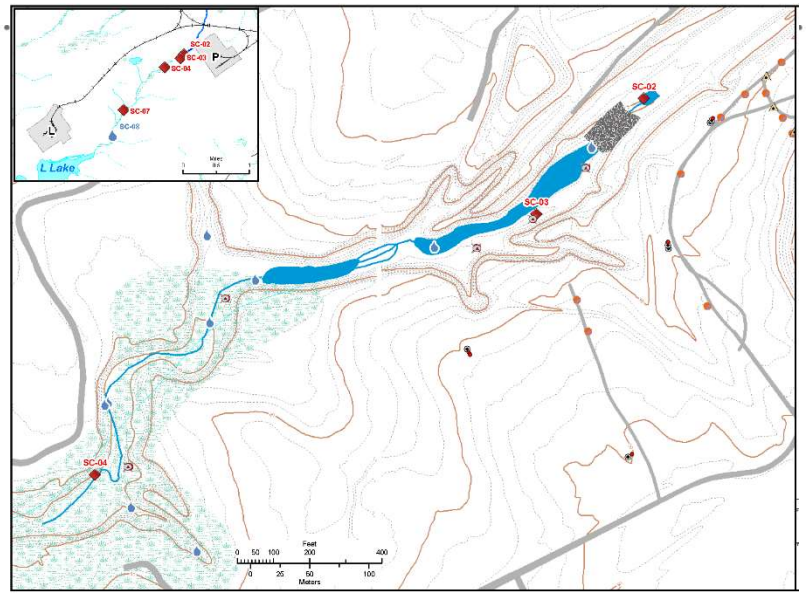
- Current impact to surface water in localized area
  - *Contaminated groundwater discharge in area between well clusters PSC003 and -004*
- TCE and tritium present in surface water > MCLs
- Tritium concentration trends are declining
  - *New surface water location, SC-08, indicates concentrations near MCL*
- TCE concentrations unchanged, no increase in trend

Elbow

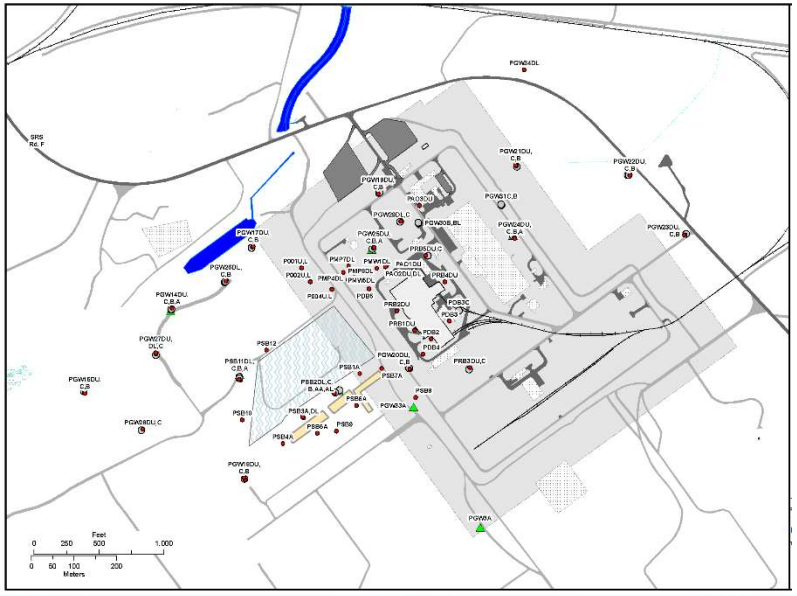
- TCE plumes are larger than expected
- Largest portion of the TCE mass centrally located within the Elbow area
- Majority of the TCE entrained in low permeable sediments
- Primary impact to LAZ from vertical migration of TCE from overlying UAZ

Long-Term Monitoring Summary

- **Steel Creek (4Q2018)**
  - Annual sample collection
    - *Surface Water*
      - **Sampled 4 existing locations**
      - **Included one new station near L-Lake (SC-08)**
    - *Shallow monitoring wells*
      - **Sampled 5 clusters (2 wells/cluster) along Steel Creek**



- **Groundwater Monitoring (2Q2019)**
  - Annual sample collection
  - Semi-annual synchronous water levels



Path Forward

- **Permeable Reactive Barrier (PRB) Removal Action Report, July 2020**
- **PAGW Effectiveness Monitoring Report (EMR), Sept 2020**
- **PRB Removal Action EMR, July 2021**

- **RSER/EE/CA**
  - Evaluate possible 2nd removal action in the Distal/Elbow area
  - Evaluate applicability of proposed Distal/Elbow action(s) after 3-5 yrs of PRB monitoring
    - *Allow for data to be collected in the near-term to evaluate overall effectiveness TCE removal from groundwater*
    - *Battelle study showed that it can take up to 5 yrs for changes to occur in groundwater where a PRB is constructed mid-plume*

Questions

