Air Force Civil Engineer Center

FORMER
WILLIAMS AIR FORCE BASE

Site ST012

Former Liquid Fuel Storage Area

BCT Conference Call

23 August 2018

Battle Ready…Built Right!

ED_005025_00011719-00001

Site ST012 Outline

- Summary of activities since Jul BCT call
- Update on SVE system
- LNAPL monitoring/removal update
- EBR pilot test re-baseline results update
- Path forward

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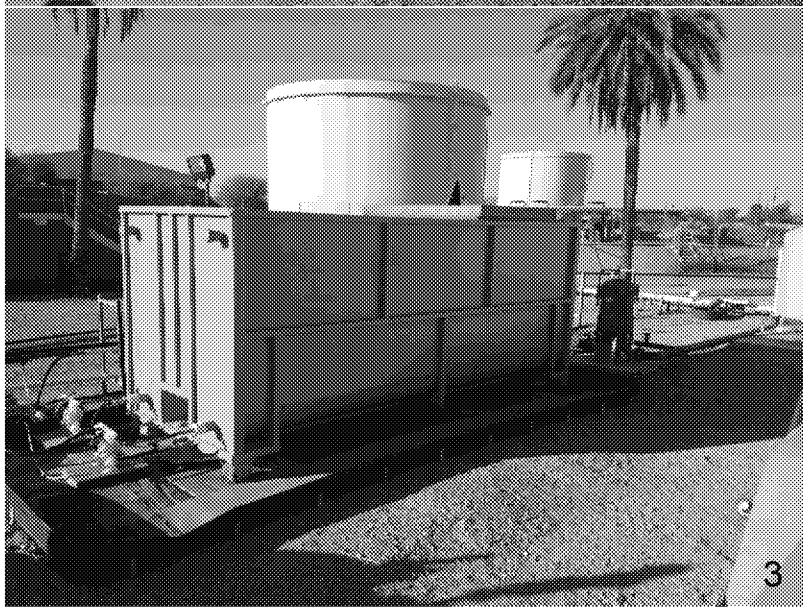
Site ST012 Activities Since July

- Continued SVE operation
- Continued LNAPL screening in accessible wells
- Operation of Extraction and Treatment
  - Troubleshooting Pumps in several wells
- Sampled additional perimeter wells (results pending)
- Monthly sampling of CZ23 (preliminary result of 13 µg/L benzene) indicates continuing reduction of benzene concentrations



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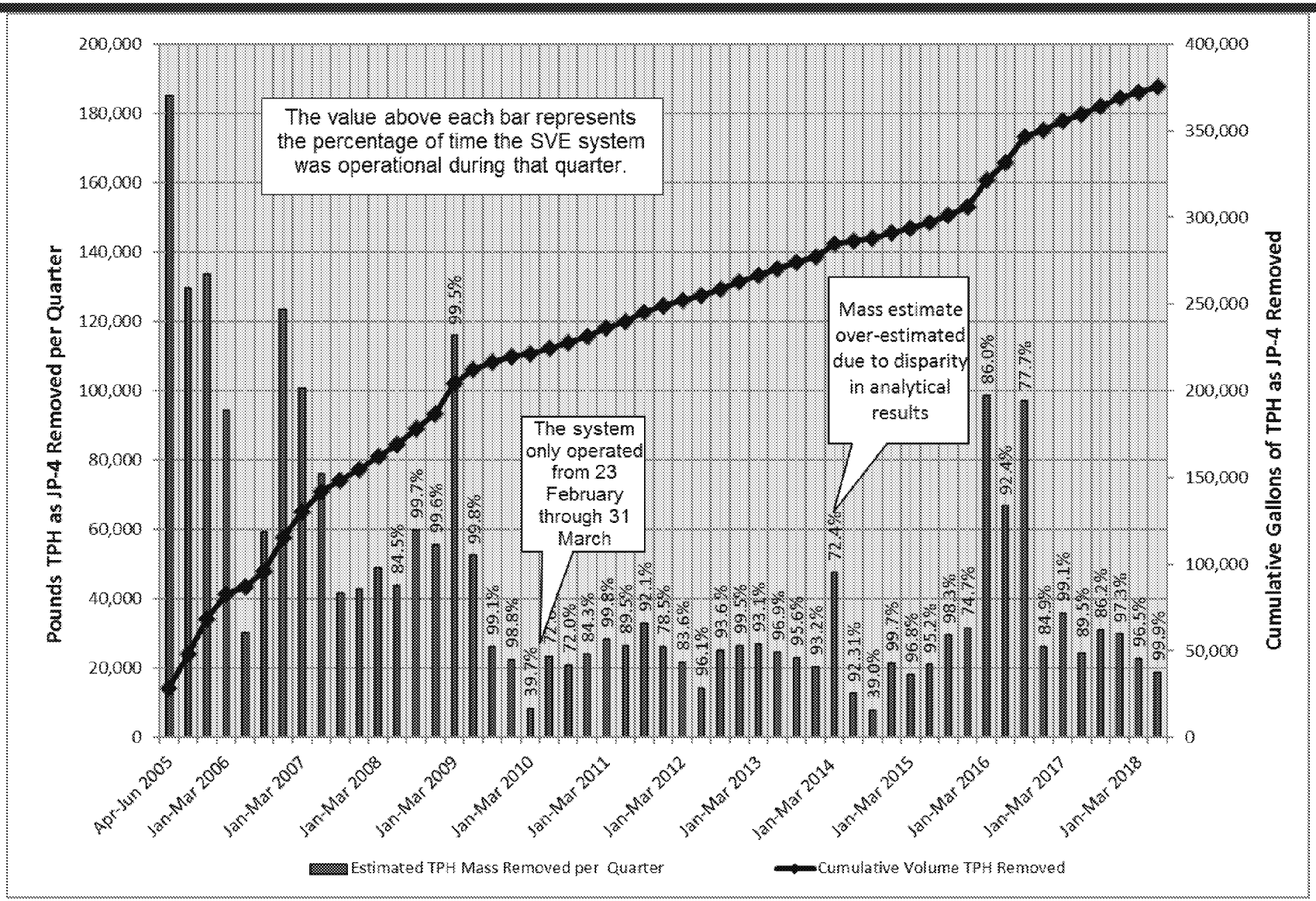
Soil Vapor Extraction System Update

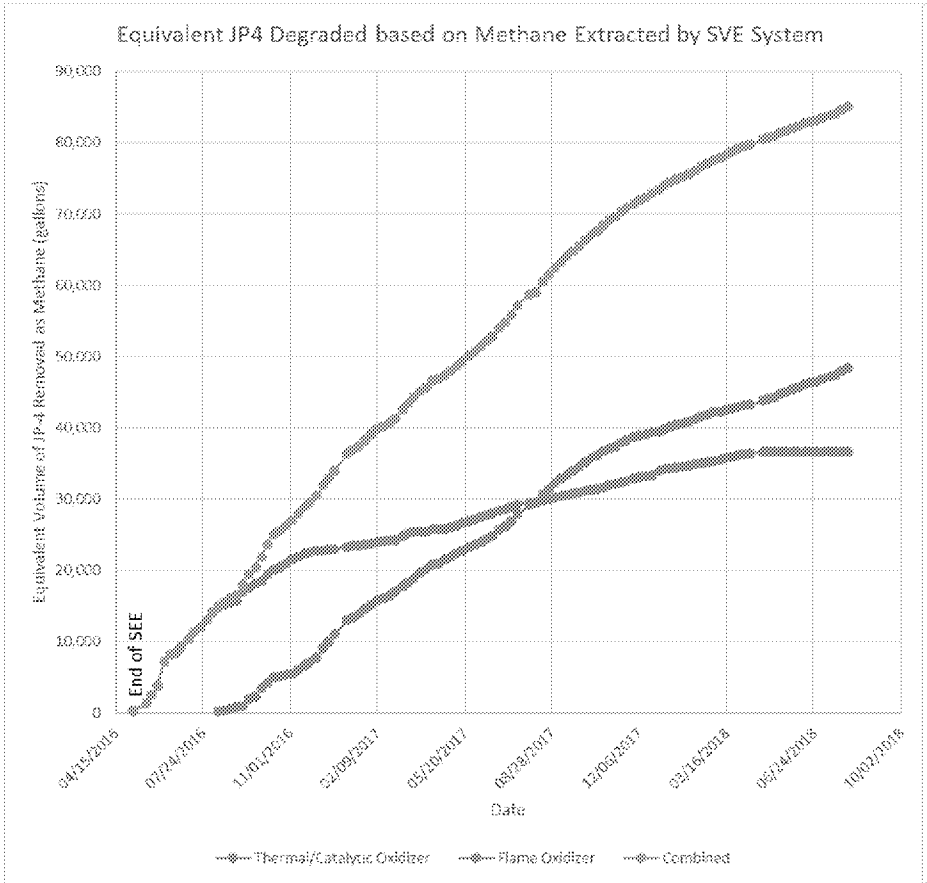
ST012 SVE System Update

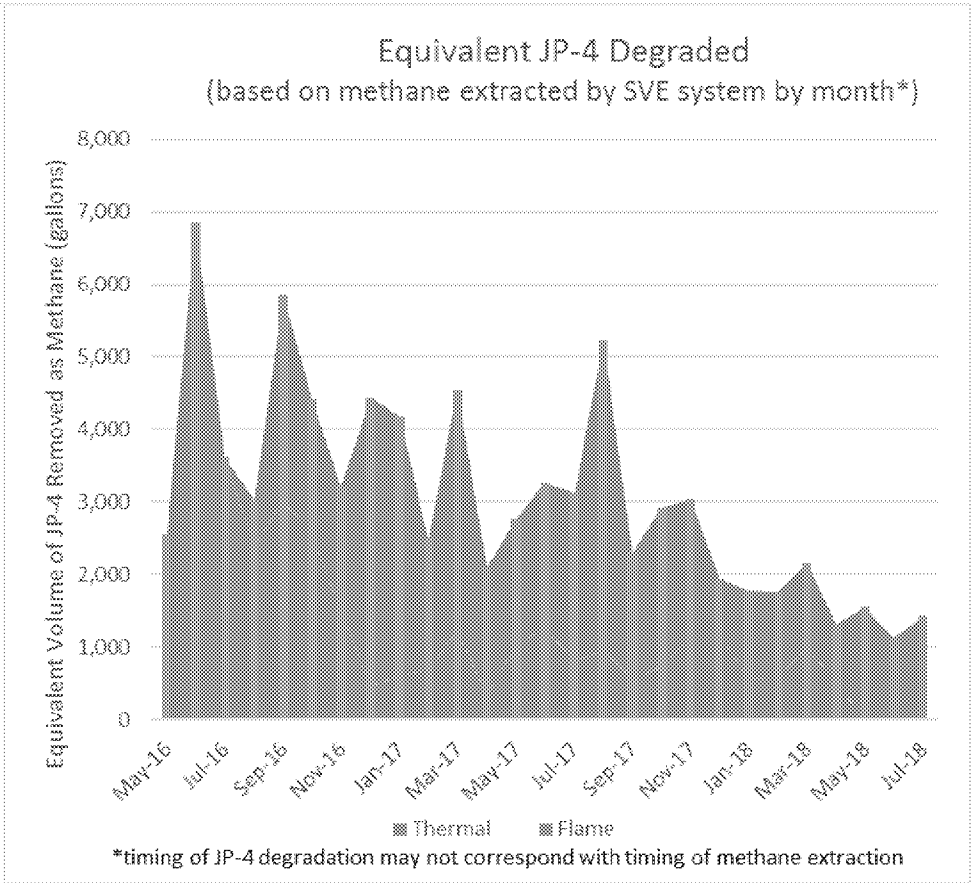
- **Apr – Jun 2018**
  - Thermox switched to air stripper off-gas end of April. SVE continued on Flameox only thereafter
  - 99.9% operational uptime Thermox; 99.9% operational uptime Flameox
  - Total petroleum hydrocarbon (TPH) removed – 19,011 pounds or 2,894 gallons

Site ST012 SVE System Performance



Site ST012 SVE System Equivalent JP-4 Degradation Based on Methane Removed

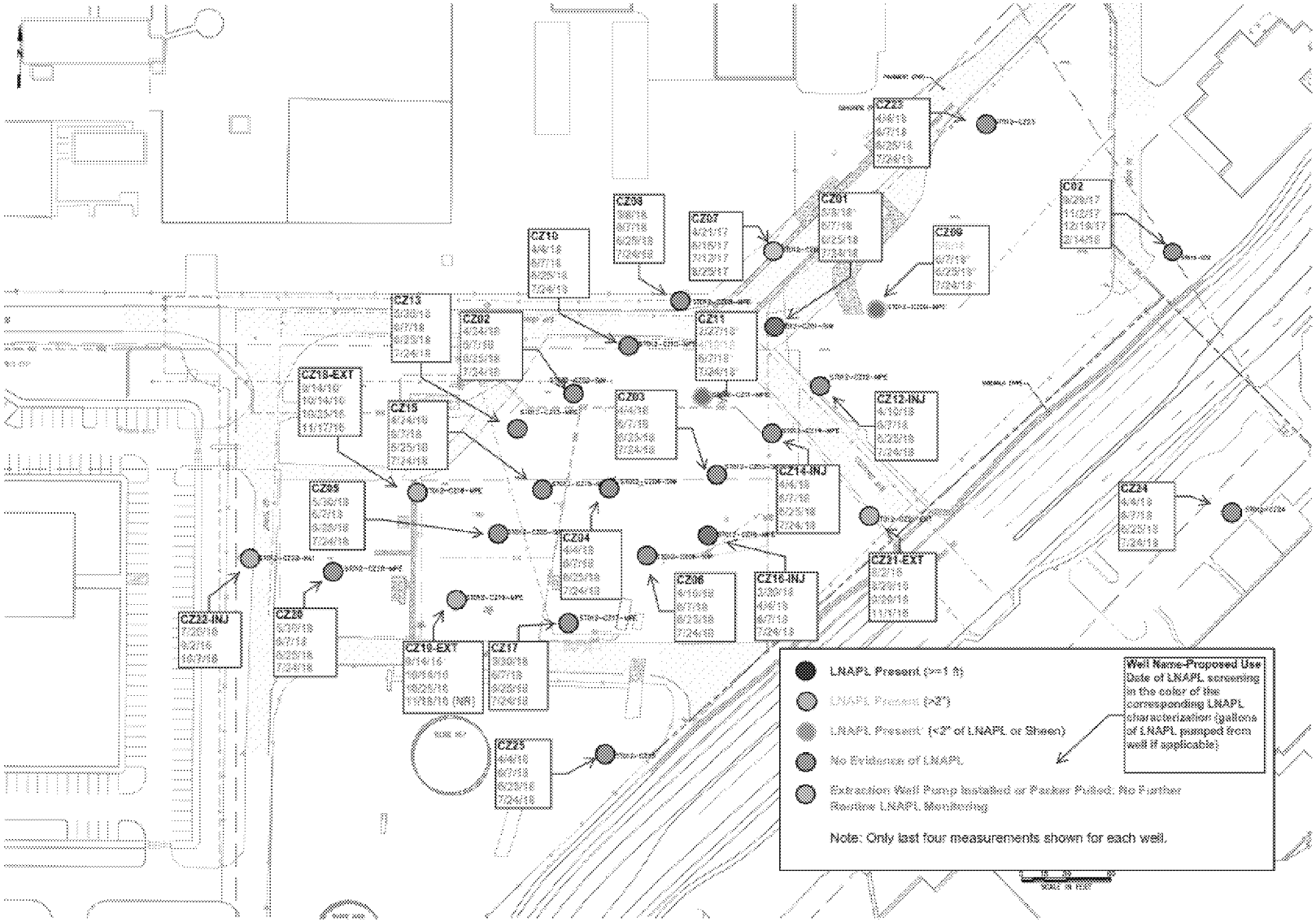




- Estimates through 2 Aug 2018.
- Estimated JP-4 degradation as methane is in addition to JP-4 removal reported for SVE
- Thermal oxidizer changed from SVE to groundwater treatment end of Apr

LNAPL Monitoring Update (through 24 Jul)

LNAPL Monitoring/Removal Status
Cobble Zone



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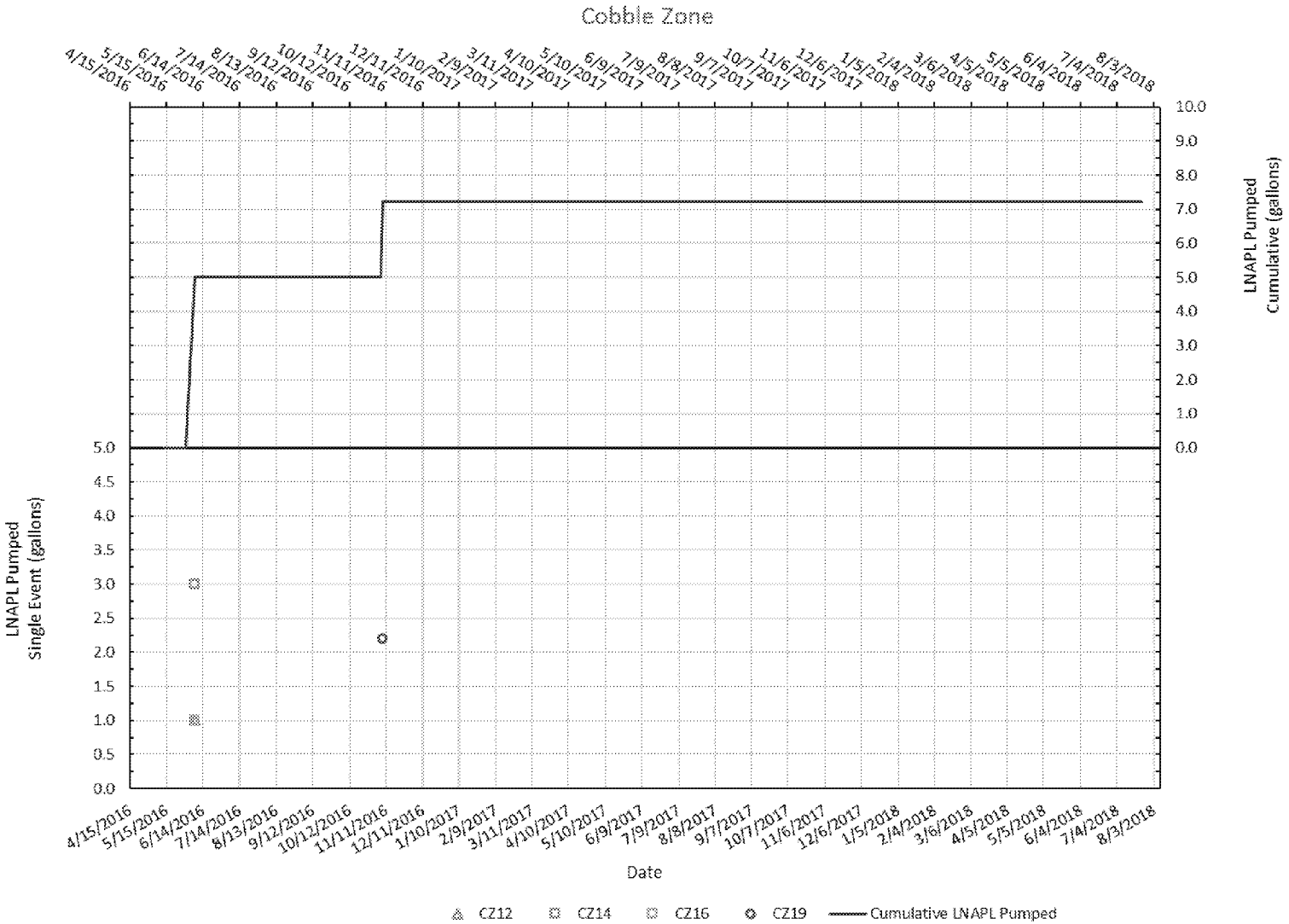
LNAPL Monitoring/Removal Status
Cobble Zone



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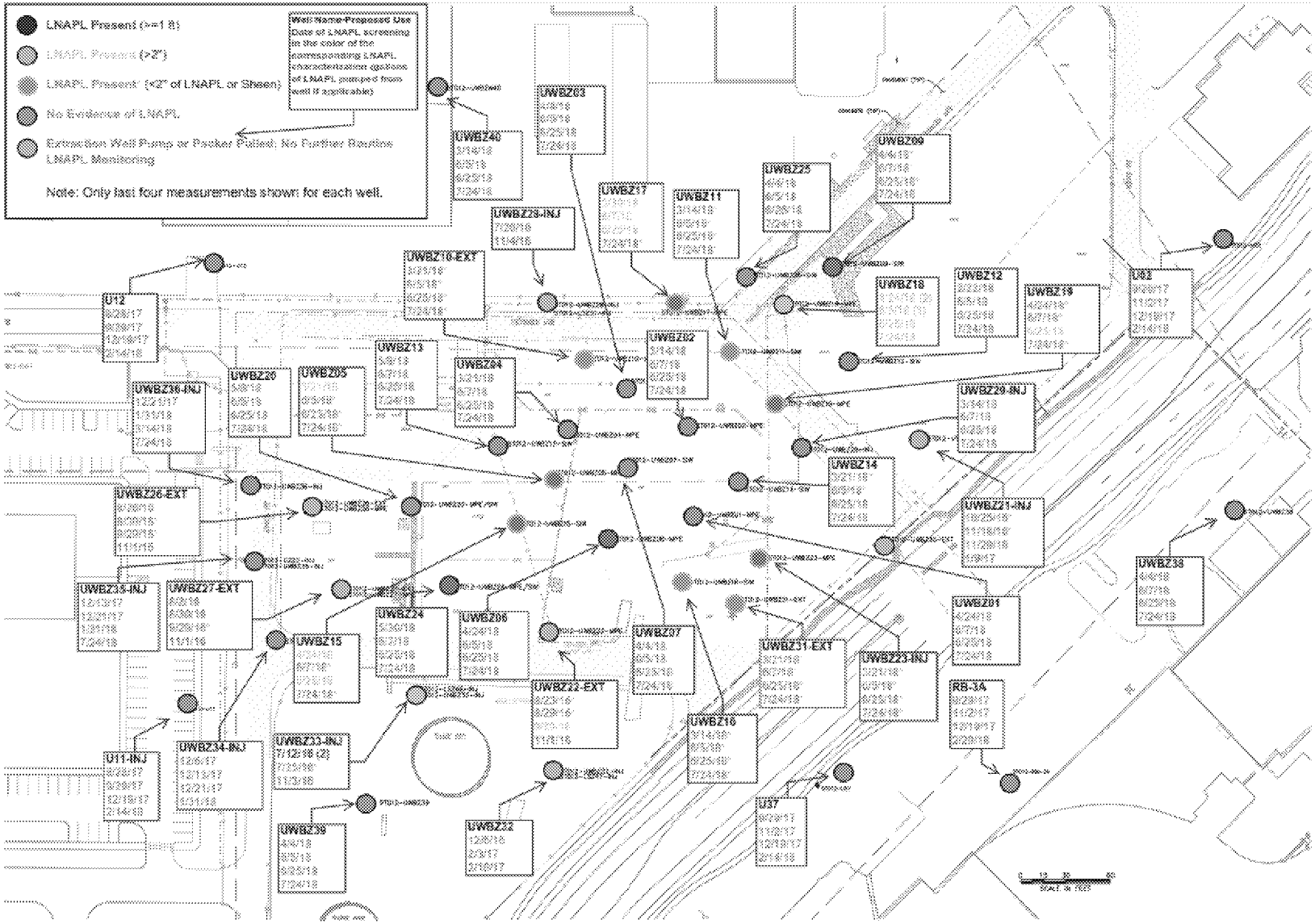
LNAPL Monitoring/Removal Status
Upper Water Bearing Zone



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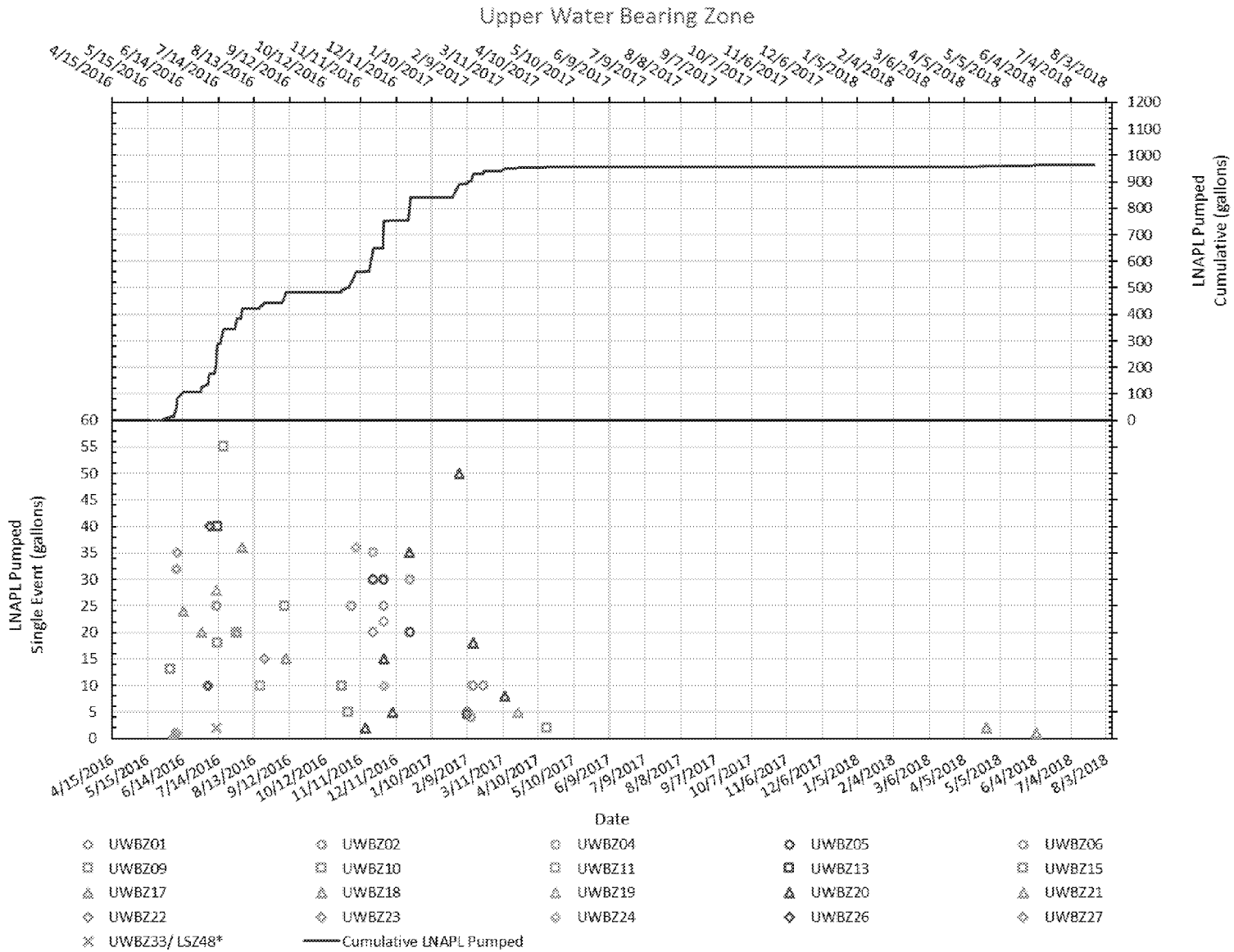
LNAPL Monitoring/Removal Status
Upper Water Bearing Zone



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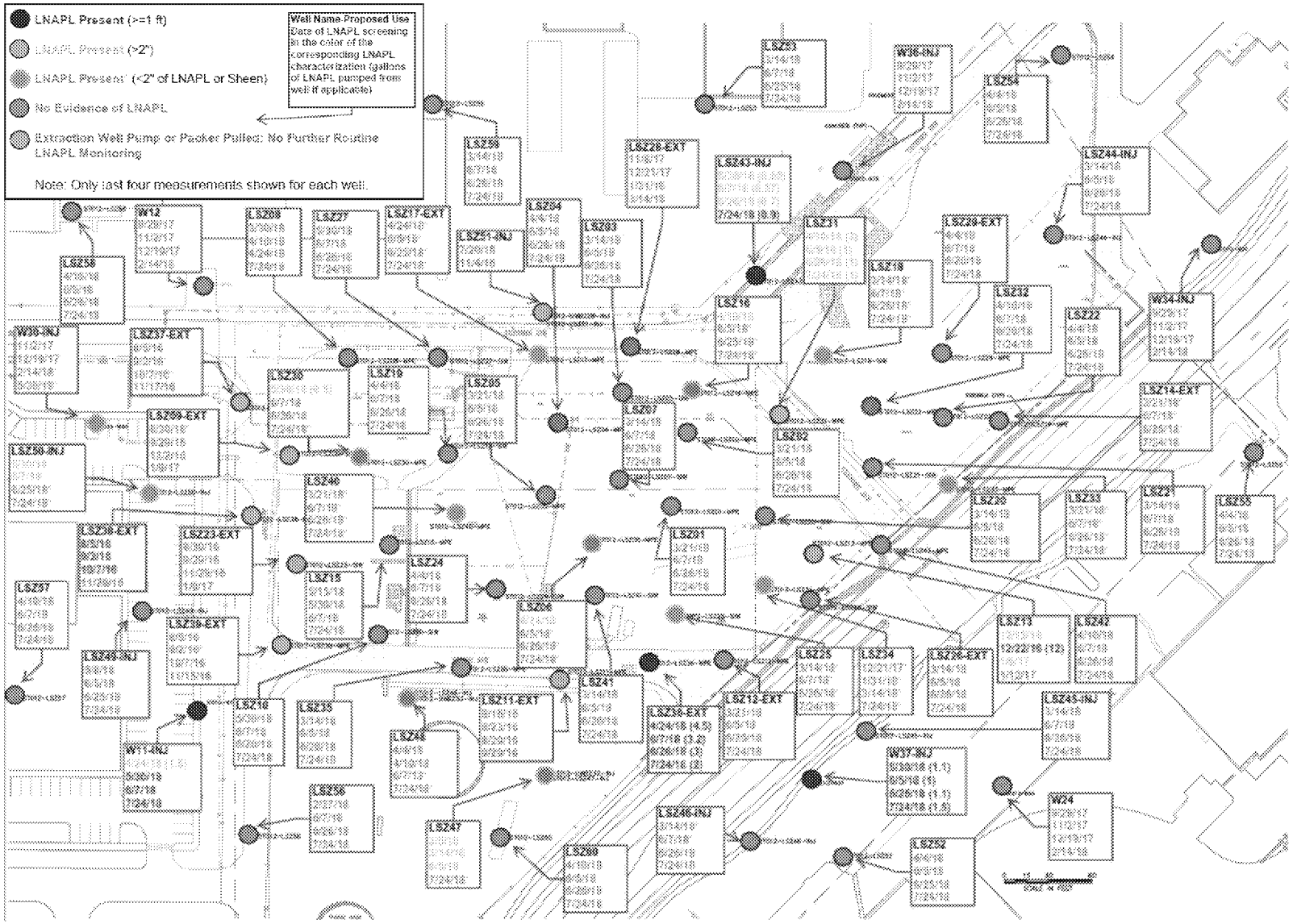
LNAPL Monitoring/Removal Status
Lower Saturated Zone



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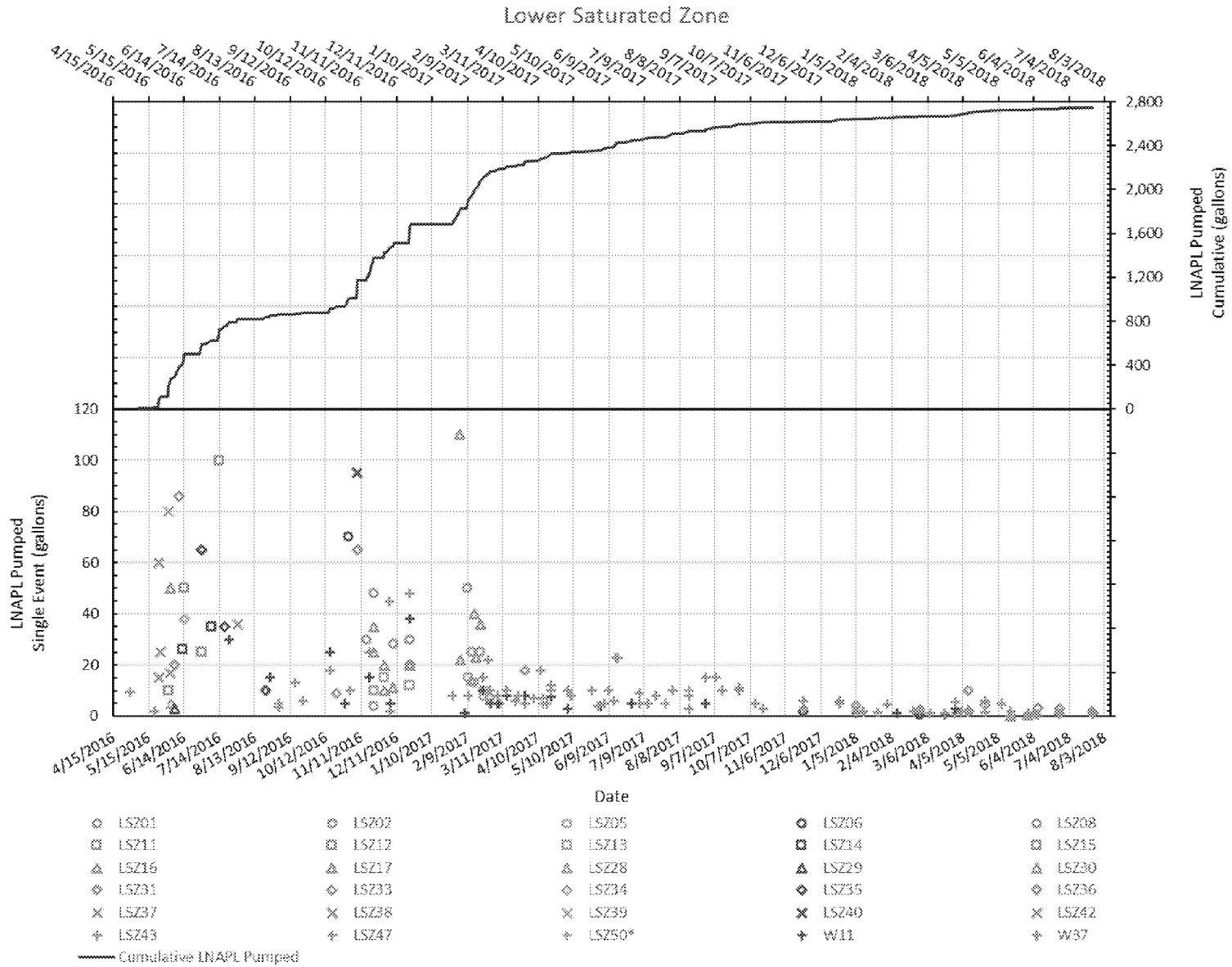
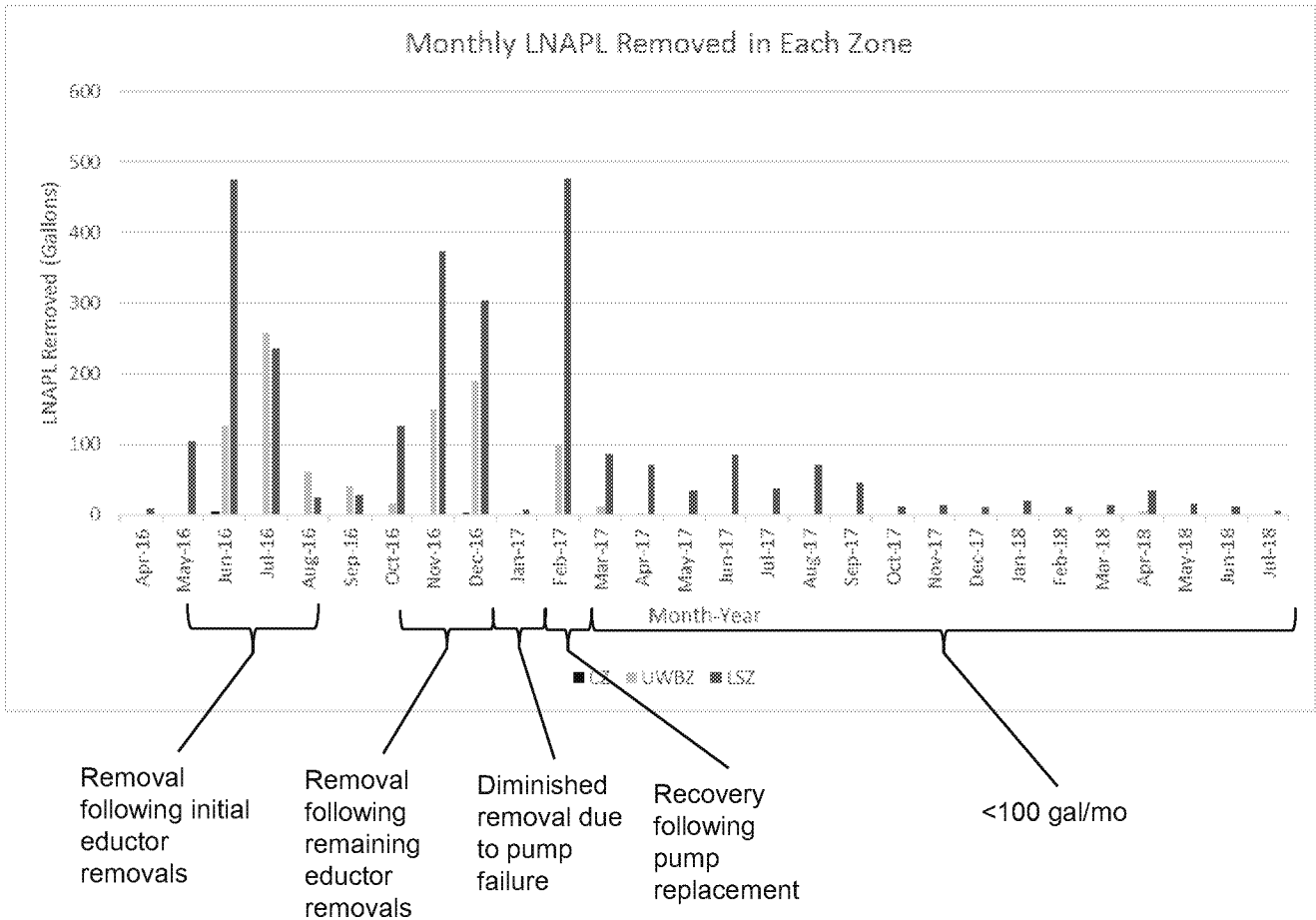
LNAPL Monitoring/Removal Status
Lower Saturated Zone



ST012 LNAPL Monitoring/Removal Summary

- CZ – 7 gallons of LNAPL removed. None since Nov 2016
- UWBZ - 961 gallons of LNAPL removed. None removed since Jun update
- LSZ - 2,745 gallons of LNAPL removed. 5 gallons removed since Jul update (W37, LSZ30, LSZ31, LSZ36, LSZ43).



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LNAPL Results (PIANO Analysis)

ST012 LNAPL Analysis

- LNAPL collected from 11 wells for EBR Pilot Test re-baseline (locations adjusted from work plan based on availability of adequate volume of LNAPL)
- Analyzed to characterize content by PIANO fractions (paraffinic, isoparaffinic, aromatic, naphthenic, and olefinic)
- Re-baseline compared to LNAPL results during SEE (next slides)
- Re-baseline PIANO fractions will be compared to LNAPL collected during pilot test (assuming LNAPL samples can be obtained) to evaluate additional changes in composition

ST012 LNAPL Analysis Observations

- LNAPL collected before (2014) and during SEE (2015) had component fractions similar to typical raw JP-4
- LNAPL collected for pilot re-baseline (2018) shows greater deviation from typical raw JP-4 than samples collected before or during SEE
  - Indicates that LNAPL composition in SEE treatment area was degraded by SEE
- BETX+N content in pilot re-baseline LNAPL samples (2018) 1-2 orders of magnitude lower than in SEE LNAPL samples
  - One upgradient pilot re-baseline sample (LSZ50) similar in composition to SEE LNAPL samples.
  - Mass of BTEX+N inside the former SEE TTZ is 1-2 orders of magnitude less than estimated in the Pilot Study Implementation Work Plan which is good for EBR.

ST012 LNAPL PIANO Analysis

Event Type	Zone	Well ID	% Paraffinic	% Isoparaffinic	% Rest of Aromatics	% Benzene	%Toluene	% Ethylbenzene	% Total Xylenes	% Rest of Naphthenic	% Naphthalene	% Olefinic	% Aromatic	% Naphthenic
Re-Baseline	CZ	ST012-CZ01	59.2	40.8	0.0	0.0048	0.0048	0.00	0.01	0.0	0.0048	0.0	0.0	0.0
		ST012-CZ09	43.3	34.1	14.7	0.0069	0.17	0.37	1.36	3.3	0.0352	2.6	16.6	3.3
	UWBZ	ST012-UWBZ05	49.8	14.5	31.1	0.0086	0.22	0.60	1.56	0.4	0.0917	1.7	33.5	0.5
		ST012-UWBZ17	33.3	24.5	21.0	0.0053	0.11	0.25	0.93	17.5	0.0510	2.4	22.3	17.6
		ST012-UWBZ17 (DUP)	26.7	23.6	17.5	0.1732	1.98	1.17	2.98	24.3	0.0731	1.5	23.8	24.4
		ST012-UWBZ31**	44.4	35.4	8.7	0.0096	0.18	0.31	2.90	5.5	0.0345	2.6	12.1	5.5
	LSZ	ST012-LSZ16	50.8	15.4	29.5	0.0063	0.05	0.38	1.34	0.4	0.0951	2.0	31.3	0.5
		ST012-LSZ30	100.0	0.0	0.0	0.0054	0.01	0.01	0.02	0.0	0.0054	0.0	0.0	0.0
		ST012-LSZ30 (DUP)	47.8	21.8	22.4	0.0060	0.04	0.14	0.73	4.6	0.0463	2.5	23.3	4.6
		ST012-LSZ50*	31.6	28.2	13.2	0.1810	1.67	1.00	3.55	18.6	0.0620	1.9	19.6	18.7
		ST012-W37	33.4	24.8	25.3	0.0079	0.07	0.07	0.21	14.7	0.0068	1.4	25.7	14.7
	Average	Av. Inside SEE TTZ	51.36	21.84	17.02	0.03	0.32	0.36	1.12	6.31	0.05	1.59	18.85	6.36
		Av. Outside SEE TTZ	36.47	29.47	15.75	0.07	0.64	0.46	2.22	12.93	0.03	1.97	19.13	12.97
During SEE TTZ (whole site)***		1/8/2015 Data	22.71	29.00	11.4	0.28	1.87	1.94	4.02	28.5	0.18	0.16	19.50	28.63
		2/19/2015 Data	23.88	29.80	9.1	0.45	0.00	1.92	4.85	29.5	0.25	0.28	16.27	29.78
		3/11/2015 Data	23.13	29.50	10.0	0.42	2.37	2.05	4.19	27.8	0.25	0.22	19.07	28.08
		3/25/2015 Data	22.47	29.96	9.1	0.47	2.56	2.02	4.14	29.0	0.11	0.17	18.27	29.14
		4/1/2015 Data	22.17	29.89	8.9	0.46	2.62	2.02	5.02	28.7	0.10	0.17	18.97	28.81
		5/6/2015 Data	23.31	24.52	19.3	0.29	1.92	2.26	5.10	21.6	0.67	0.47	28.85	22.26
		6/10/2015 Data	24.10	24.73	19.2	0.18	2.09	2.52	6.36	20.0	0.46	0.42	30.32	20.43
		8/19/2015 Data	6.80	30.70	41.0	0.10	2.86	1.89	11.15	3.3	1.16	1.11	57.0	4.4
		9/16/2015 Data	23.94	22.65	24.8	0.17	1.90	2.18	5.61	17.9	0.45	0.41	34.6	18.4
Typical Raw Fuel Composition		Aviation Gasoline	3.33	74.22	-1.4	0.13	22.73	0.11	0.31	0.51	0.00	0.01	21.92	0.51
		JP-4 Jet Fuel	29.34	31.02	7.4	1.07	5.64	2.03	7.75	13.16	0.17	2.58	23.90	13.16

* Well located outside of the SEE TTZ
** ST012-UWBZ31 well is located outside of the SEE TTZ, however, some heating of the area may have occurred from the LSZ heating below
*** Analytical results received for SEE TTZ were quantified as relative percent area method by GC/MS

Change (improvement) in reported results between SEE and EBR re-baseline. During SEE results were semi-quantitative (% of chromatogram area). During EBR results were quantitative (mg/kg)

No aromatics in ST012-CZ01

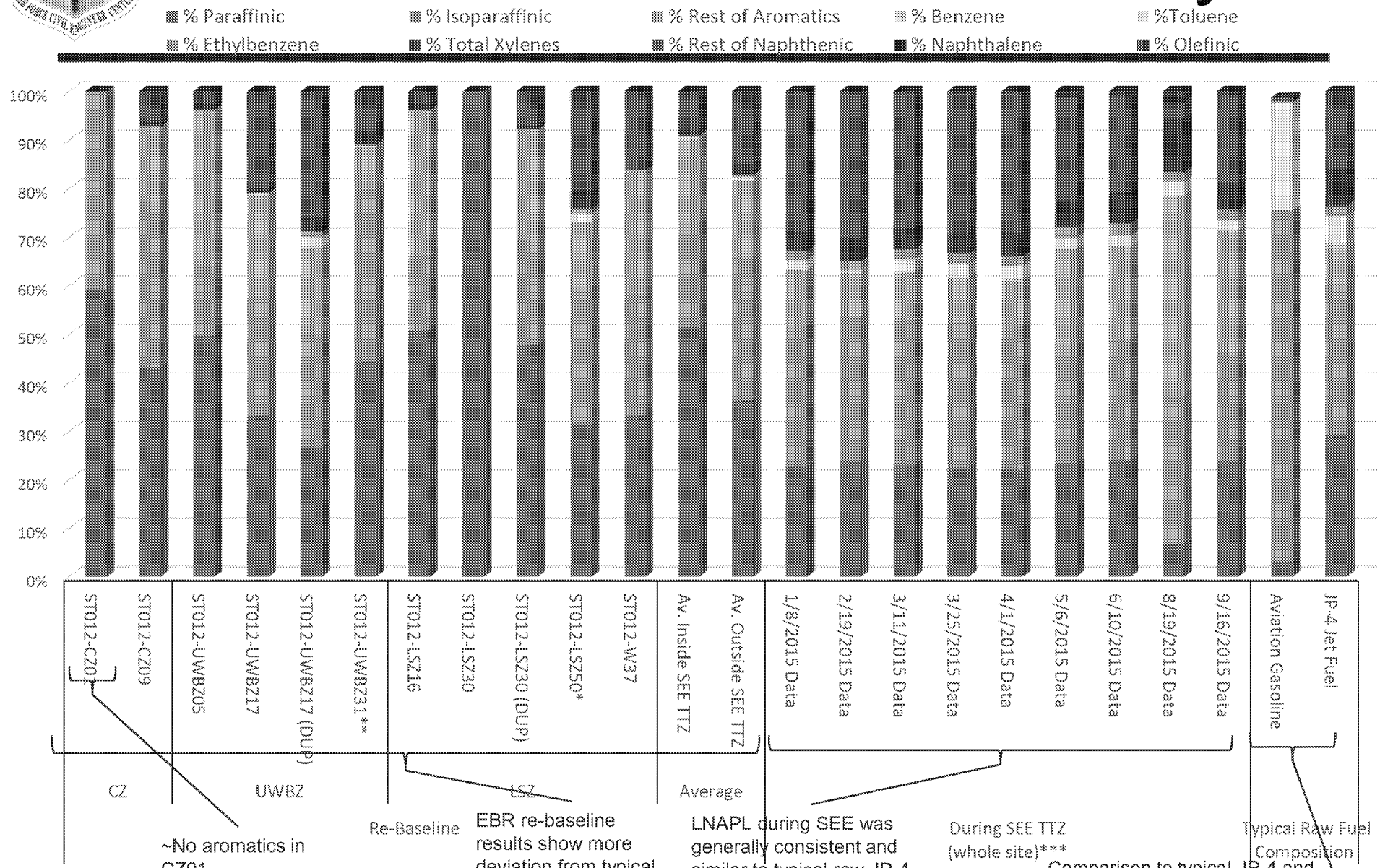
Extra bottles shipped and labeled ST012-LSZ17 but were not indicated on chain of custody. Analyzed but mislabeling is suspected.

ST012-LSZ30 composition results suspect, LSZ30 duplicate more consistent

BTEX+N in EBR re-baseline LNAPL samples generally significantly less than estimated from SEE data:

- Benzene, toluene, ethylbenzene, naphthalene – generally 1 to 2 orders of magnitude less, except LSZ50. LSZ50 located upgradient for former SEE footprint. Xylenes – generally 50% to 2 order of magnitude less

ST012 LNAPL PIANO Analysis



* Well located outside of the SEE TTZ.
** ST012-UWBZ31 well is located outside of the SEE TTZ, however, some heating of the area may have occurred from the LSZ heating below.
*** Analytical results received for SEE TTZ were quantified as relative percent area method by GC/MS.

Iron Speciation Results

ST012 Iron Speciation Summary

- Re-baseline samples analyzed for total iron per pilot study work plan.
- Ferrous iron is an indicator of activity by iron reducing bacteria
- Expectation is that high total iron concentrations will be due to mostly ferrous iron and low iron concentration may be a mix of ferrous and ferric
- Groundwater samples collected from two wells and tested by field kit for ferrous and total iron to evaluate if high total iron is a good indicator of high ferrous iron
- Picked two locations initially – 1 with high total iron (LSZ08) and 1 with low total iron (UWBZ36) in re-baseline results.

ST012 Iron Speciation Summary

- **LSZ08 (had 52 mg/L iron in lab re-baseline sample) – field kit result:**
  - Soluble/Ferrous Fe: 25 mg/L
  - Total Fe: 22.5 mg/L
  - Majority of iron is present as ferrous iron
  - LSZ08 results support expectation that high total iron represents high ferrous iron
  - Location had 2,500 µg/L benzene and <5 mg/L sulfate in re-baseline sample
- **UWBZ36 (had 1.2 mg/L total iron in lab re-baseline sample) – field kit result:**
  - Soluble/Ferrous Fe: 0.6 mg/L
  - Total Fe: 15 mg/L (higher than expected based on lab re-baseline)
  - Majority of iron is likely ferric iron
  - UWBZ36 results had low ferrous iron as expected but total iron from field test was much higher than indicated in the laboratory results
  - Location had <1 µg/L benzene and 150 mg/L sulfate in re-baseline sample
- **Field Tests will be conducted on another 4 to 8 wells week of 20 Aug 2018**

Analysis for Benzene Degraders

ST012 Bio Trap Analysis for Benzene Degraders

- **Requested Microbial Insights to run their QuantArray Petroleum analysis on samples from the same re-baseline six Bio Traps used for the qPCR sulfate reducing bacterial and total eubacteria**

- **QuantArray Petroleum analyses for genes associated with several different benzene degraders:**

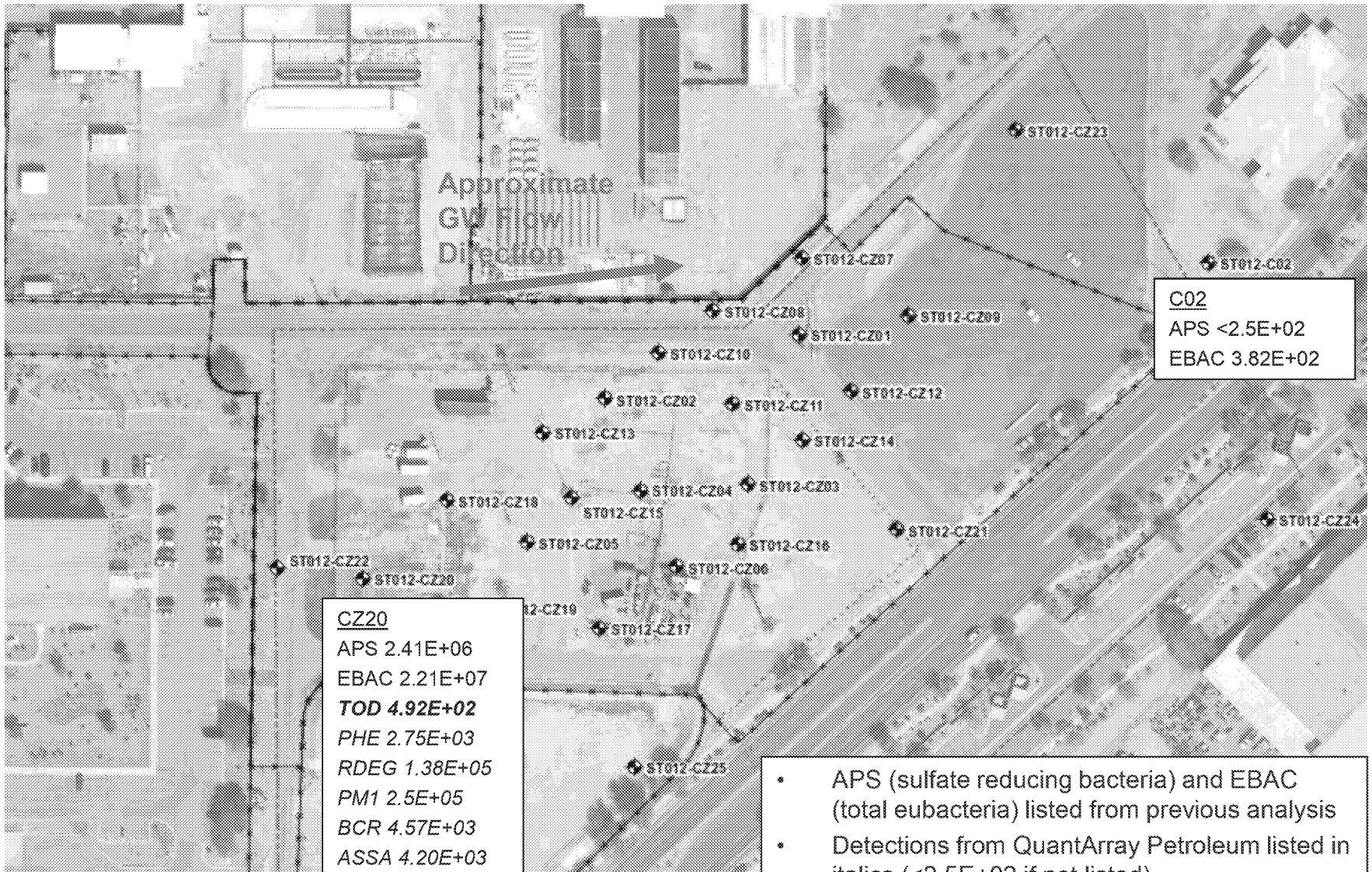
Aerobic BTEX and MTBE
Toluene/Benzene Dioxygenase (TOD)
Phenol Hydroxylase (PHE)
Toluene 2 Monooxygenase/Phenol Hydroxylase (RDEG)
Toluene Ring Hydroxylating Monooxygenases (RMO)
Xylene/Toluene Monooxygenase (TOL)
Ethylbenzene/Isopropylbenzene Dioxygenase (EDO)
Biphenyl/Isopropylbenzene Dioxygenase (BPH4)
Methylibium petroleiphilum PM1 (PM1)
TBA Monooxygenase (TBA)
Aerobic PAHs and Alkanes
Naphthalene Dioxygenase (NAH)
Naphthalene-inducible Dioxygenase (NidA)
Phenanthrene Dioxygenase (PHN)
Alkane Monooxygenase (ALK)
Alkane Monooxygenase (ALMA)
Anaerobic BTEX
Benzoyl Coenzyme A Reductase (BCR)
Benzylsuccinate Synthase (BSS)
Benzene Carboxylase (ABC)
Anaerobic PAHs and Alkanes
Naphthylmethylsuccinate Synthase (MNSSA)
Naphthalene Carboxylase (ANC)
Alkylsuccinate Synthase (ASSA)

- **Results reported in units of quantity of cells per bead**

ST012 BioTrap Analysis for Benzene Degraders

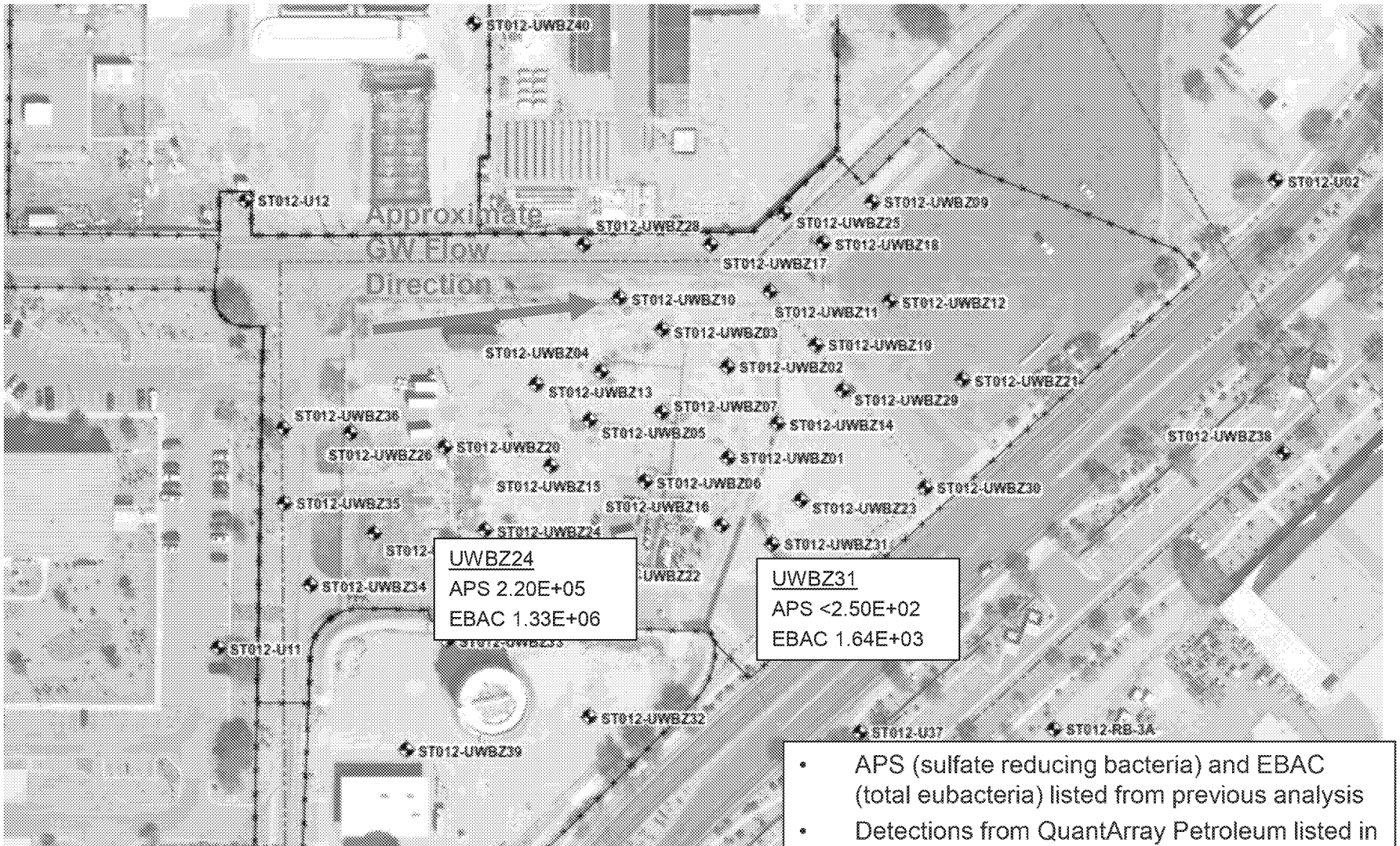
- Quantifiable populations of BTEX degraders observed in two samples (CZ20 and LSZ10)
- Aerobic and anaerobic BTEX degraders present in CZ20 sample
- Aerobic BTEX degraders present in LSZ10 sample
- Both samples with detections of degraders are on the upgradient side of the site where various terminal electron acceptors would typically be more available
- Samples with BTEX degraders had the highest total eubacteria out of the six sample locations
- Samples with lower total eubacteria populations contained sulfate reducing bacteria (i.e. UWBZ24 and LSZ42)
- BTEX degraders are present on site and could be enhanced to increase BTEX degradation

Site ST012 CZ qPCR/QuantArray Results (cells/bead)



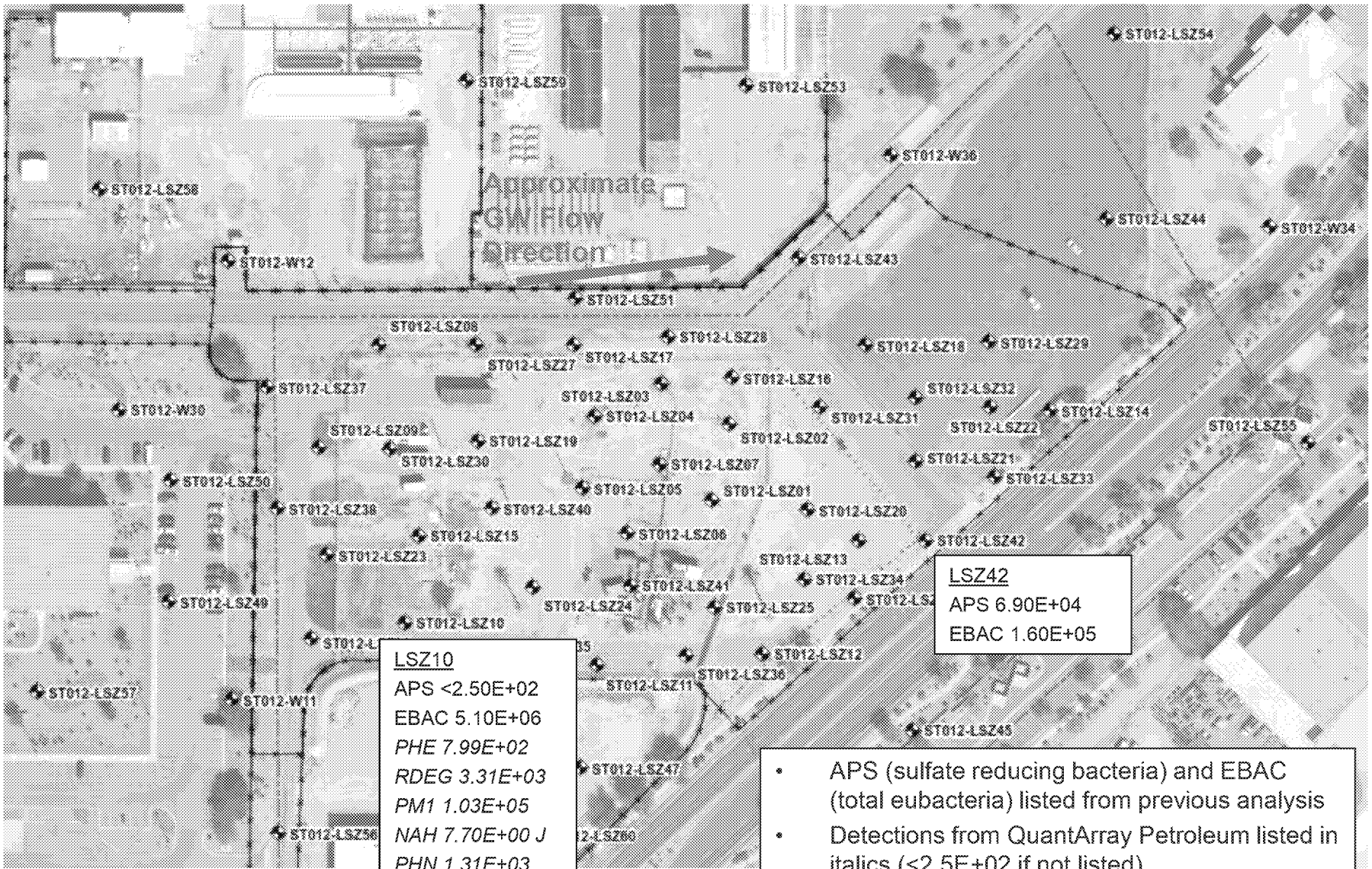
- APS (sulfate reducing bacteria) and EBAC (total eubacteria) listed from previous analysis
- Detections from QuantArray Petroleum listed in italics (<2.5E+02 if not listed)

Site ST012 UWBZ qPCR/QuantArray Results (cell/bead)



- APS (sulfate reducing bacteria) and EBAC (total eubacteria) listed from previous analysis
- Detections from QuantArray Petroleum listed in italics (<2.5E+02 if not listed)

Site ST012 LSZ qPCR/QuantArray Results (cells/bead)



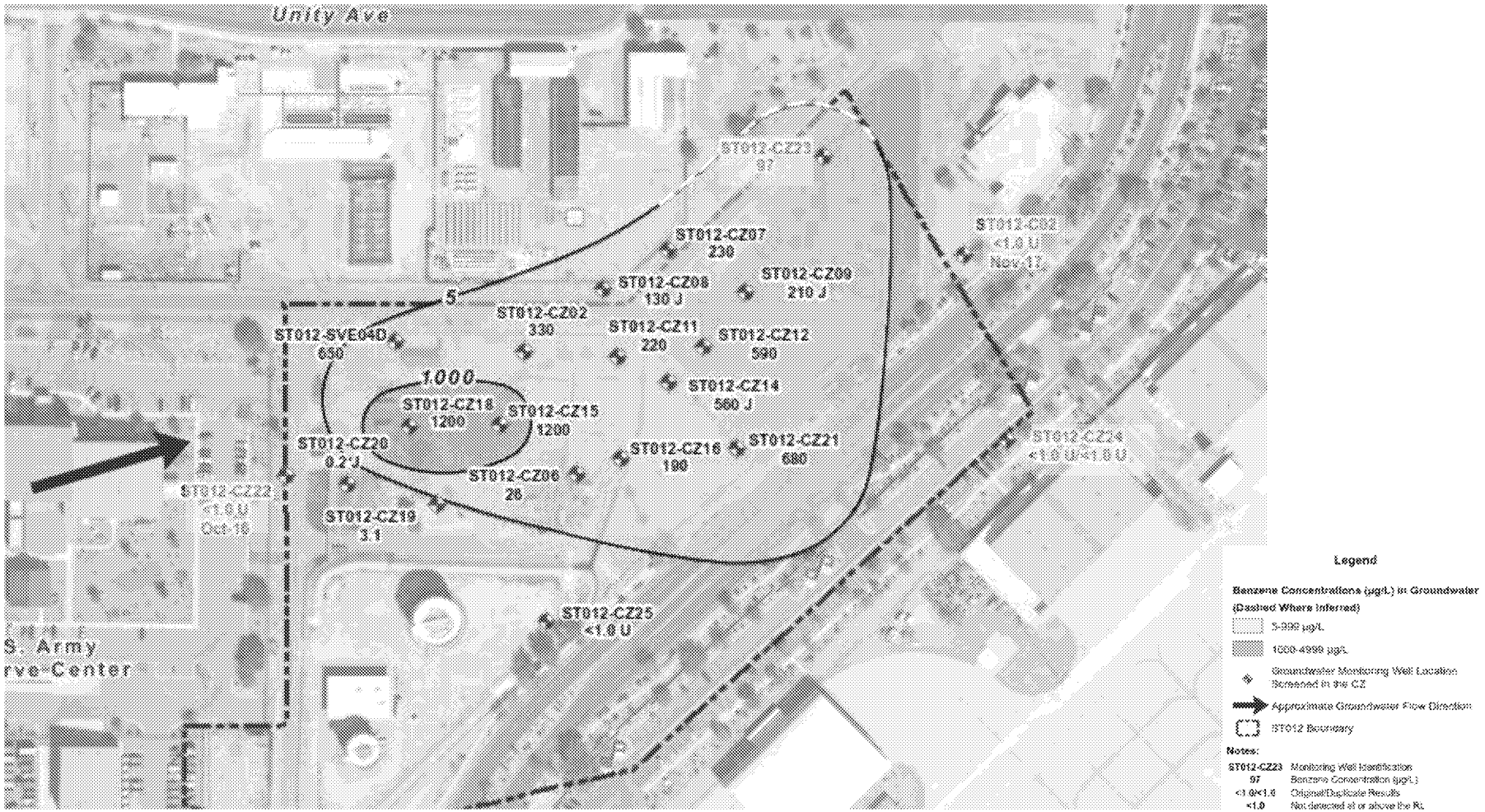
- APS (sulfate reducing bacteria) and EBAC (total eubacteria) listed from previous analysis
- Detections from QuantArray Petroleum listed in italics (<2.5E+02 if not listed)

Additional Perimeter Samples Collected

ST012 Late July/Early August Perimeter Sampling

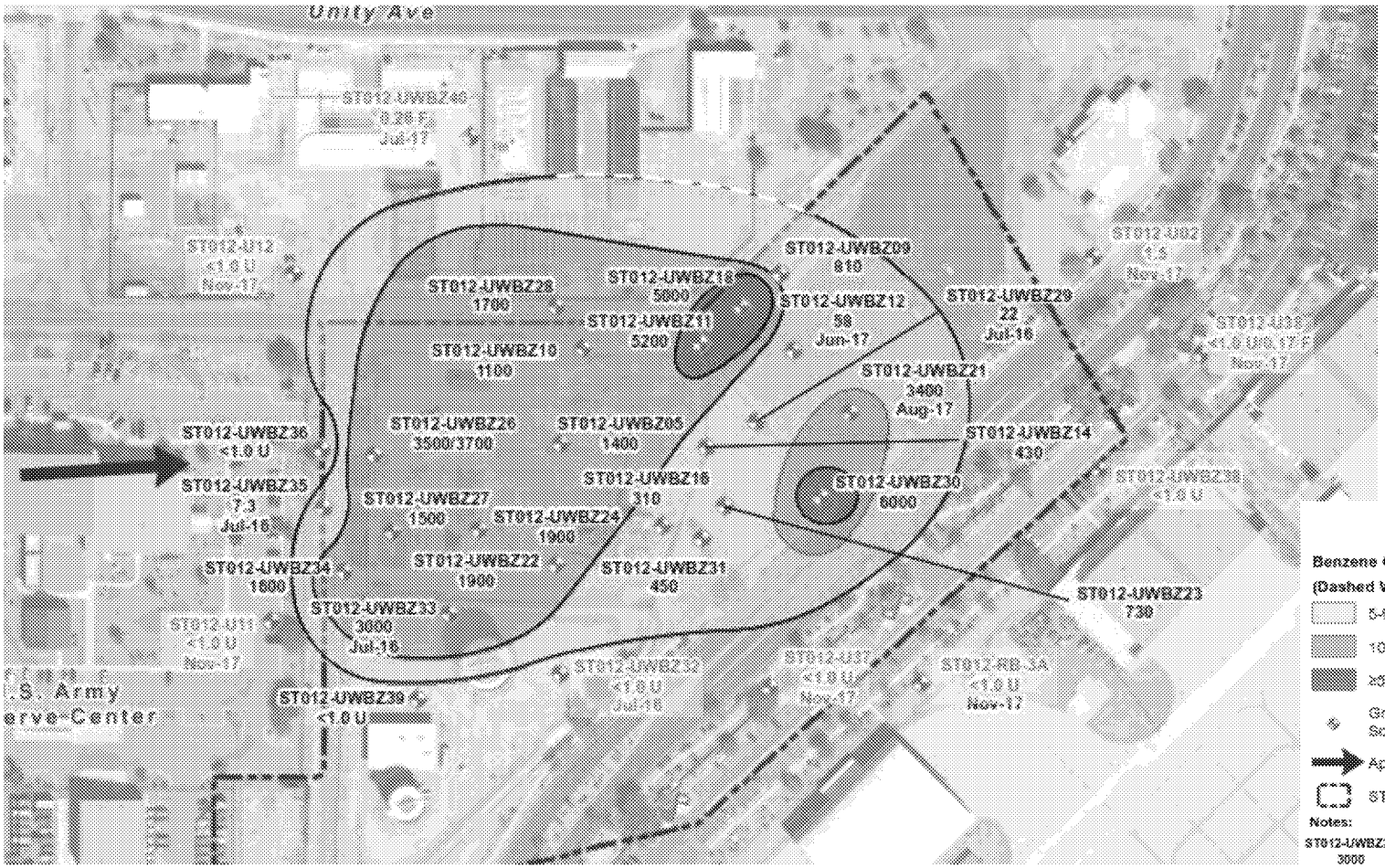
- Sampled several perimeter wells that were not part of the re-baseline event and had not been sampled since 2017
- Because injections are delayed and quarterly sampling for EBR pilot study monitoring is delayed, also re-sampled several downgradient perimeter wells that were part of re-baseline event
- Analytical results are pending

Site ST012 CZ Sampled Locations



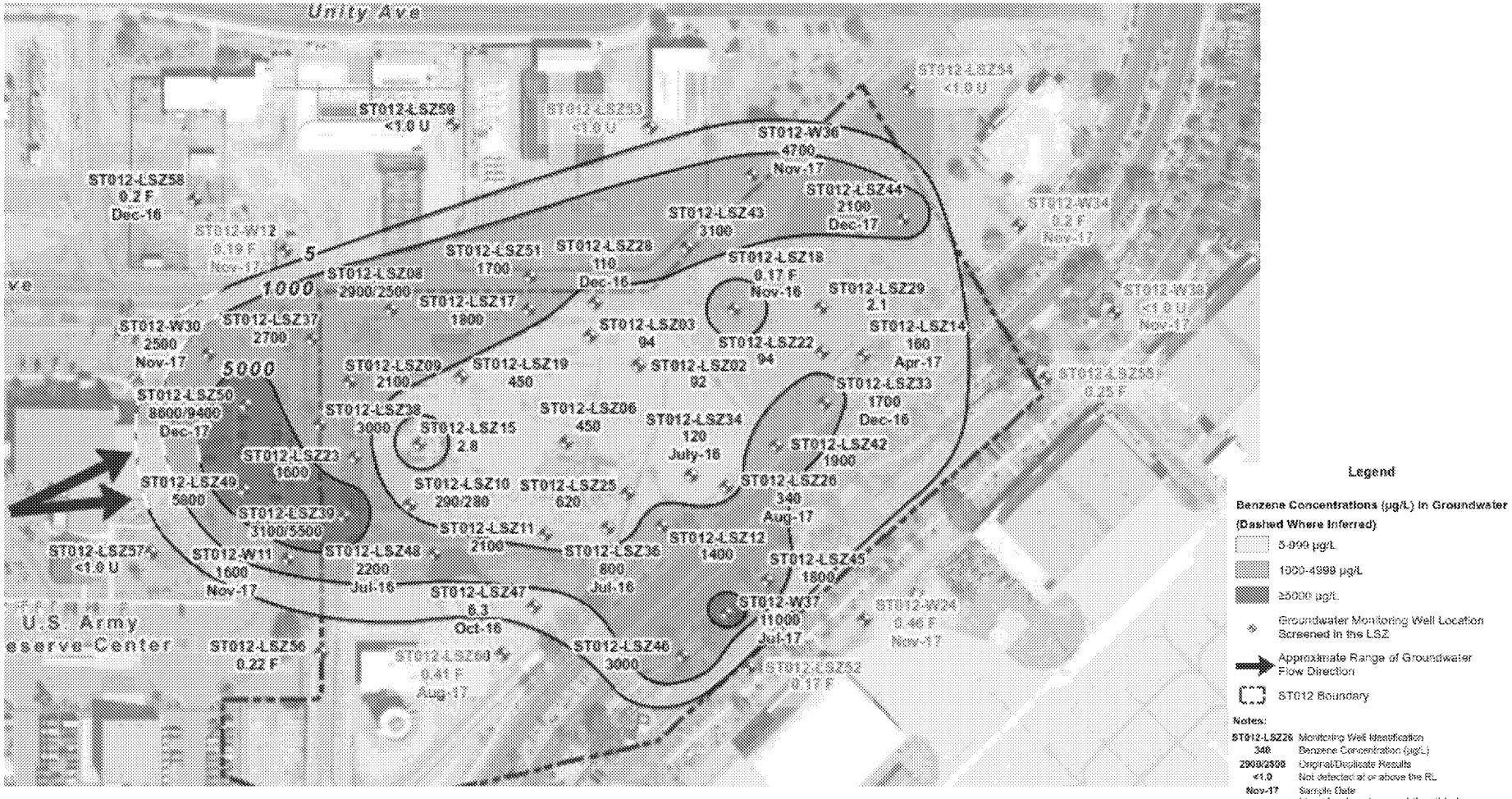
Perimeter well location sampled

Site ST012 UWBZ Sampled Locations



Perimeter well location sampled

Site ST012 LSZ Sampled Locations



Perimeter well location sampled

Site ST012 Activities Aug

- Continued SVE operation
- Continued monthly CZ23 sampling
- Pilot Study Implementation
  - Pending resolution of containment/characterization discussions

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