Air Force Civil Engineer Center

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Former Williams Air Force Base

BRAC Cleanup Team Meeting
15 March 2016

Air Force Civil Engineer Center

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FORMER
WILLIAMS AIR FORCE BASE

Site ST012
Former Liquid Fuels Storage Area Remedial Action

BRAC Cleanup Team Call
15 March 2016

Site ST012 Agenda

- SEE Operations Update
- SVE Operation Update
- Review of Transition Criteria

SEE Operations Update

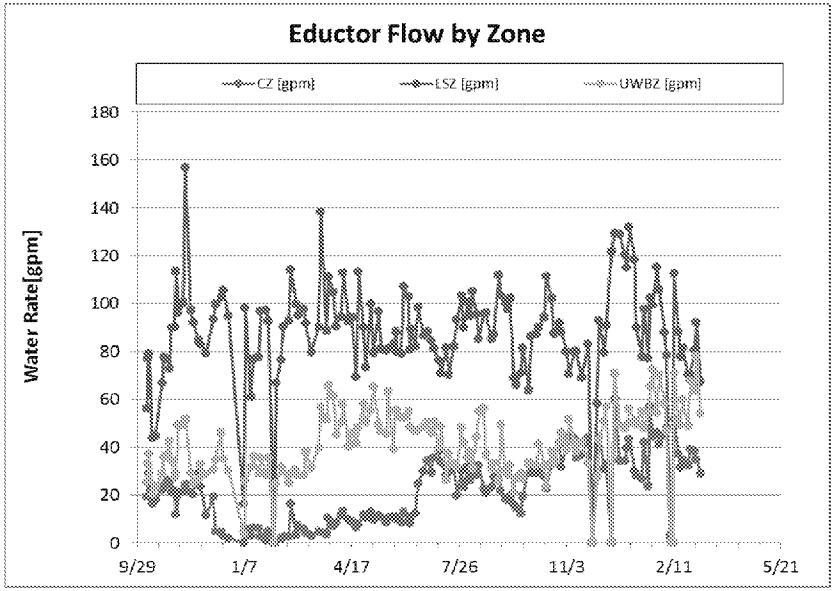
Site ST012 SEE System Status Summary (through 7 March)

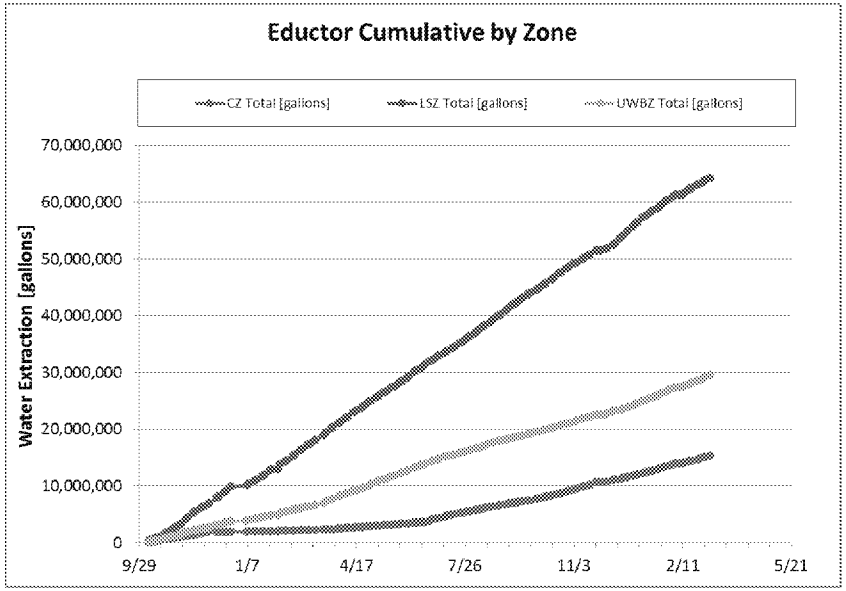
	Value	Unit
Target Treatment Zone (TTZ) Soil Volume	410,000	cubic yards (cy)
Area	199,000	square feet (ft^2)
Upper Depth of Treatment	145	feet (ft) below ground surface (bgs)
Lower Depth of Treatment	245	ft bgs
Vapor Liquid Treatment Started	09/29/14	
Thermal Operations Started	09/29/14	
Last Process Data Update	03/07/16	
Last Temperature Data Update	03/07/16	
Estimated Total Days of Operation	422	days
Days of Operation	525	days
Days of Operation vs. Estimate	124	percent (%)
Estimated Total Energy Usage	11,343,000	kilowatt hours (kWh)
Total Energy Used	5,421,853	kWh
Used Electrical Energy vs. Estimate	48	%
Total Steam Injected	302.4	million pounds (lbs)
Projected Total Steam Injection	320	million lbs
Steam Injected Vs Projected	94	%
Total Mass Removed in Vapor Based on Photoionization Detector (PID) Readings	1,096,456	lbs
Total Mass Removed as NAPL	1,342,107	lbs
Average Daily NAPL Mass Removal Last Week	0	lbs/day
Total Vapor and Liquid Mass Removal (based on PID readings)	2,438,563	lbs
Average Power Usage Rate Last Week	477	kilowatts (kW)
Average Wellfield Vapor Extraction Rate Last	538	standard cubic feet per minute (scfm)
Average Condensate Production Rate Last Week	1.1	gallons per minute (gpm)
Average Water Extraction Rate Last Week	157	gpm
Total Water Extracted	84,831,049	gallons
Total Recovered Light Non-Aqueous Phase Liquid	204,278	gallons
Average Water Discharge Rate Last Week	191	gpm
Total Treated Water Discharge	112,893,000	gallons

ST012 SEE Operational Progress

- **SEE System Operations 09 Feb – 07 Mar 2016**
  - **A site-wide pressurization began 18 Feb 2016. A site-wide depressurization was initiated 04 Mar 2016.**
  - **Average liquid extraction rate of 144 gpm**
  - **Typically all six eductor skids were online at a time**
  - **Average steam injection rates of 5,200 lbs per hour in the LSZ, 8,400 lbs per hour in the UWBZ, and 4,900 lbs per hour in the CZ**
  - **Twenty-eight steam wells online – injection rates at wells have varied due to pressure cycling conducted in the CZ, LSZ and UWBZ**

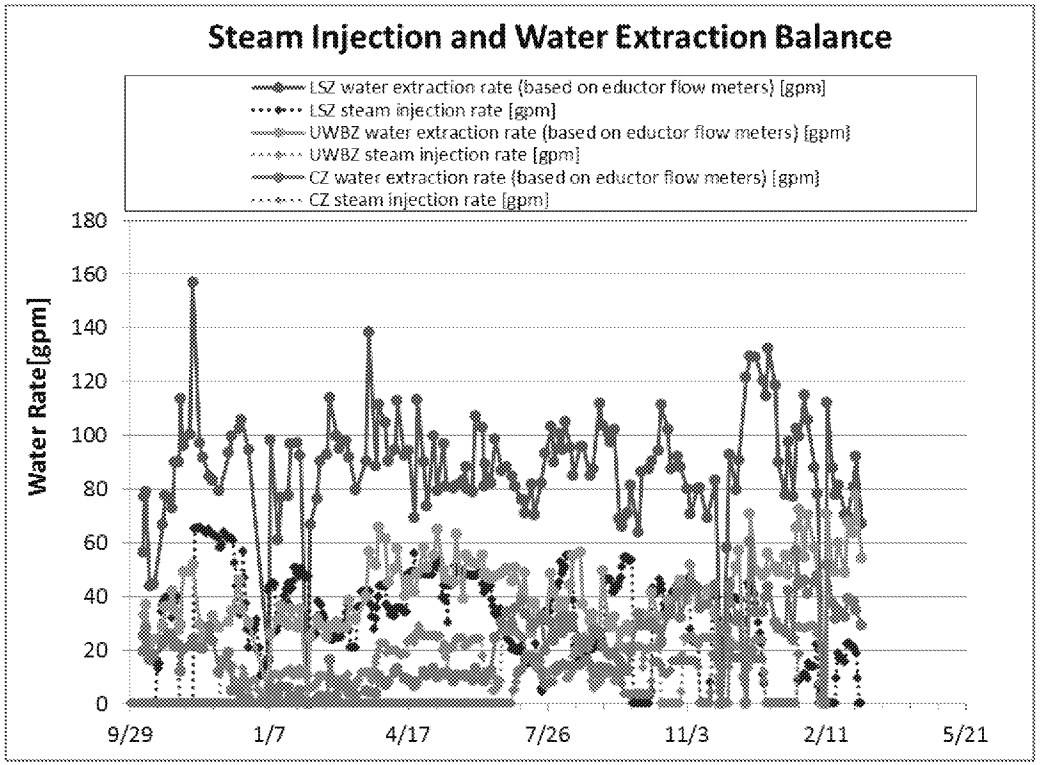
Site ST012 SEE System Water Extraction by Zone





- **Eductor extraction rates per zone are based on individual eductor feed and return meters**
- **Extraction: injection ratio for the period 09 Feb to 07 Mar based on average flows**
  - **CZ: 09 Feb – 07 Mar 2016 period: 3.0:1**
  - **UWBZ: 09 Feb – 07 Mar 2016 period: 2.9:1**
  - **LSZ: 09 Feb – 07 Mar 2016 period: 6.3:1**

Site ST012 SEE System Injection/Extraction Balance



	CZ [gallons]	UWBZ [gallons]	LSZ [gallons]
Water extracted to date	15,303,000	29,544,000	64,322,000
Water injected to date	3,885,000	9,890,000	22,542,000
Net extraction	11,418,000	19,654,000	41,780,000

Note: water extracted to date per zone is based on individual eductor meters

ST012 Perimeter Groundwater Monitoring

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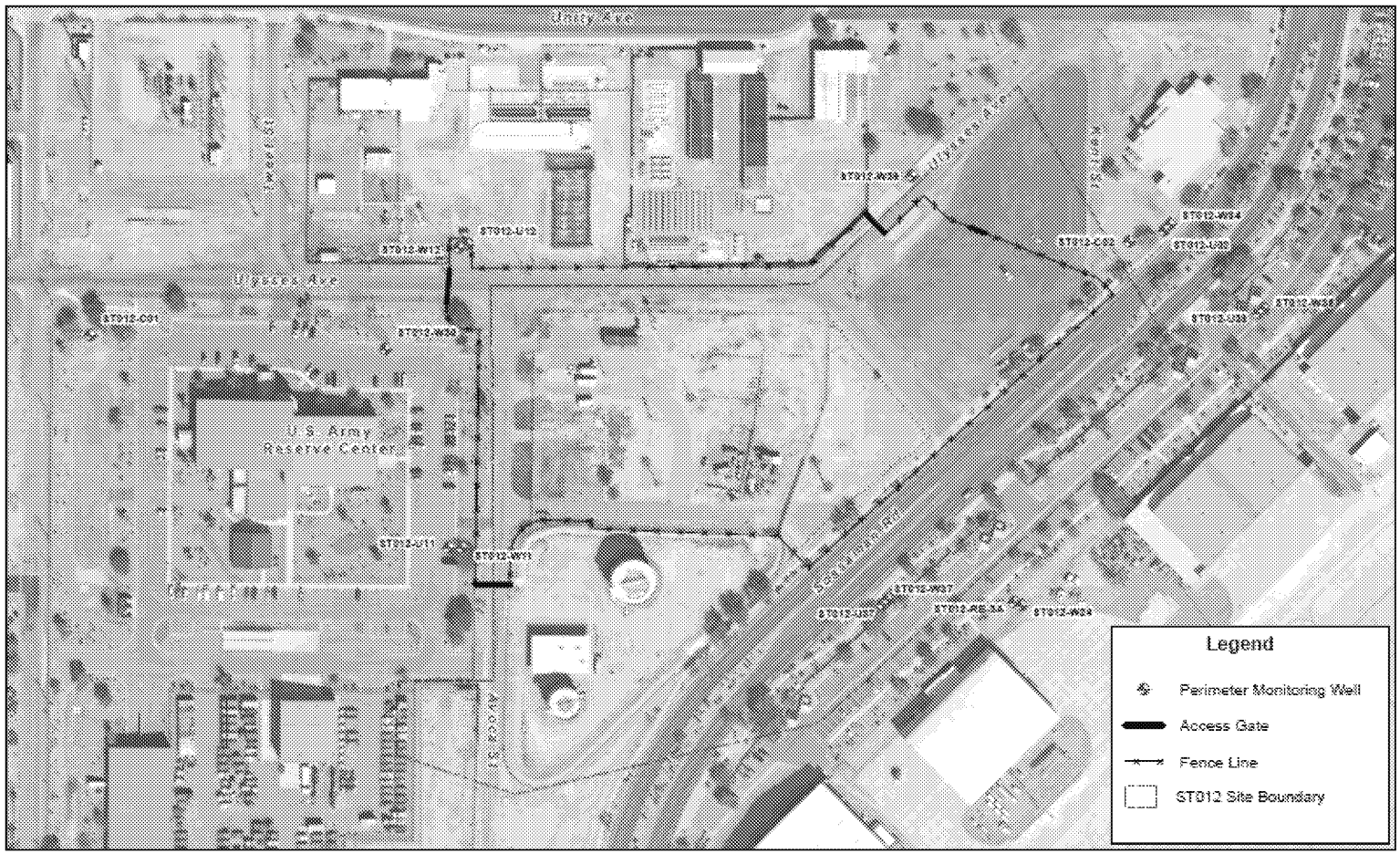
Site ST012 SEE Perimeter Groundwater Monitoring Wells



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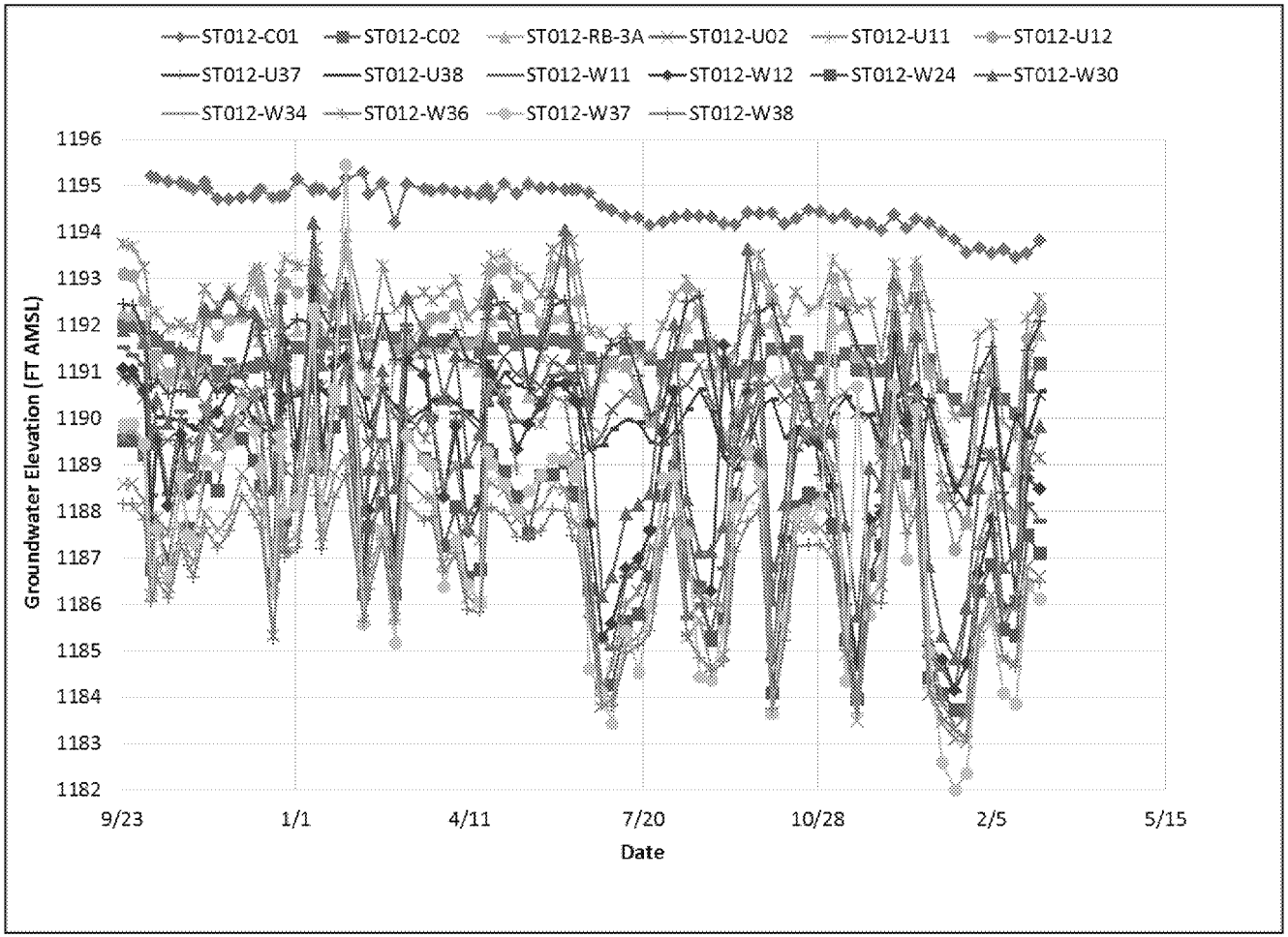
Site ST012 SEE Perimeter Groundwater Elevations



Water level increases are temporary

Site ST012 SEE Perimeter LNAPL Thicknesses (ft)

Monitoring Well	2/5/2016			2/12/2016			2/19/2016			2/26/2016			3/4/2016		
CZ/UWBZ Wells	Before bailing/ pumping	After Bailing/ pumping	Weekly Gallons Removed[1]	Before bailing/ pumping	After Bailing/ pumping	Weekly Gallons Removed[1]	Before bailing/ pumping	After Bailing/ pumping	Weekly Gallons Removed[1]	Before bailing/ pumping	After Bailing/ pumping	Weekly Gallons Removed[1]	Before bailing/ pumping	After Bailing/ pumping	Weekly Gallons Removed[2]
ST012-C01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-C02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UWBZ Wells															
ST012-U02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-RB-3A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSZ Wells															
ST012-W11	5.49	5.49	0.00	6.01	6.01	0.00	6.06	6.06	0.00	6.87	3.66	2.00	5.28	5.28	0.00
ST012-W12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W30	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
ST012-W34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W37	30.87	5.62	16.48	8.99	8.99	3.58[2]	23.04	5.88	15.48[2]	28.40	1.50	17.56	8.42	8.42	0.00
ST012-W38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes:

[1]Estimated gallons removed based on 4-inch casing and difference in product level in well before and after removal. Does not account for volume of hose or other equipment in the column of product. Includess all dates bailed/pumped in the week.

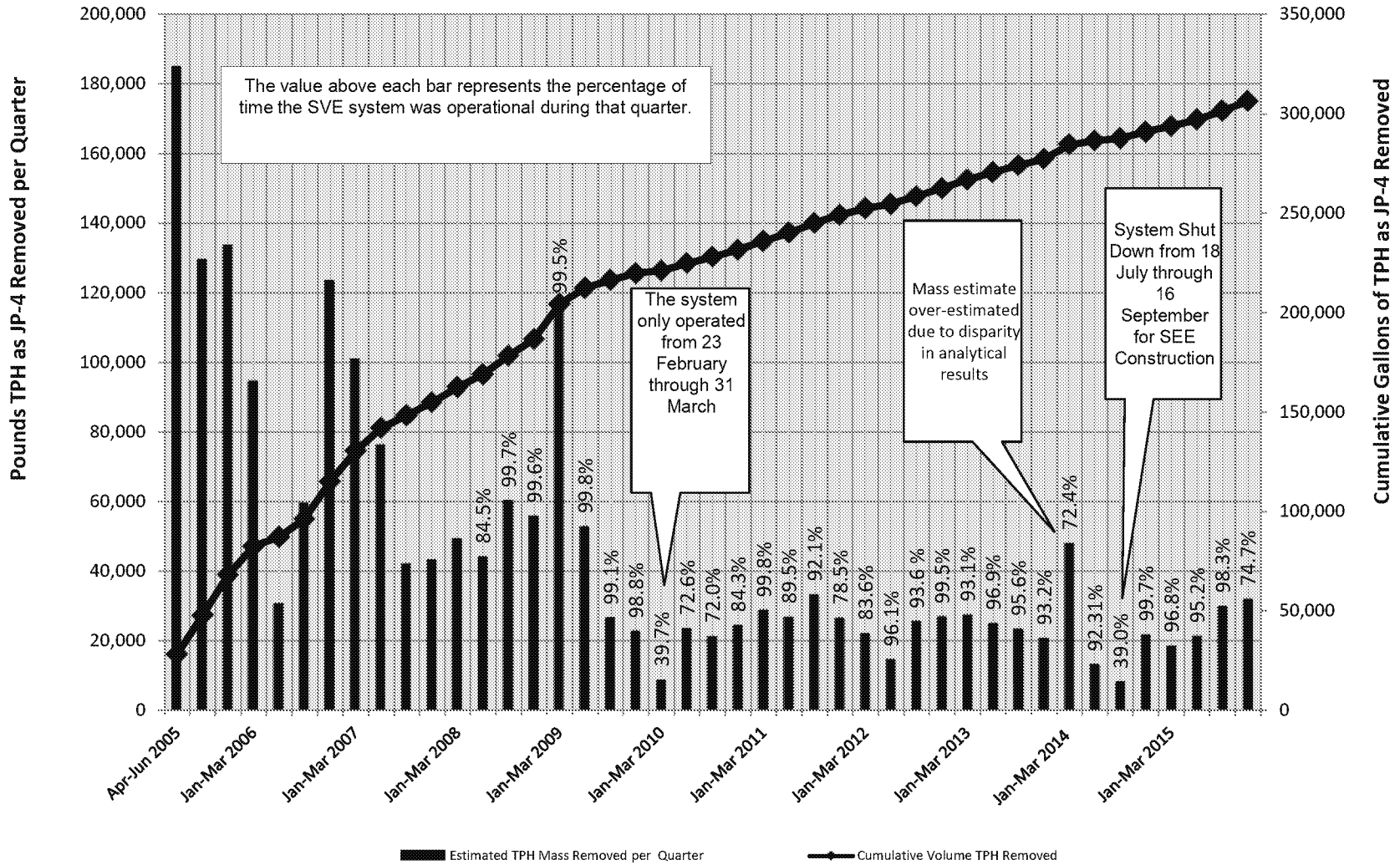
[2]In addition to the weekly measurements, ST012-W37 LNAPL levels were measured and LNAPL was pumped on 2/10/16 and 2/15/16

Soil Vapor Extraction System Update

ST012 SVE System Update

- **Jun – Sep 2015**
  - 98% operational uptime
  - Total petroleum hydrocarbon (TPH) removed – 29,800 pounds or 4,500 gallons
  - 7 of 25 SVE wells operating
- **Oct – Dec 2015**
  - 75% operational uptime (increased downtime due to high LEL conditions)
  - TPH removed – 31,900 pounds or 4,900 gallons
  - 9 of 25 SVE wells operating (SVE-4M and SVE-13 opened for dilution air). SVE-10 and SVE-14 connected to SEE due to steam breakthrough.

Site ST012 SVE System Performance



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Site ST012 SVE System Summary

- TPH removed through Dec 2015 – 306,400 gallons
- Mass removal has increased since SEE treatment of CZ started
- Two wells (SVE-10 and SVE-14) were transferred from SVE system to SEE system for extraction due to high temperatures or concentrations
- High LEL conditions at catalytic oxidizer addressed by opening lower concentration SVE wells (SVE-4M and SVE-13) to extraction for dilution air

Site ST012
Transition Criteria

Site ST012 Remedy

- **RODA2, Section 1.4**

  When the effectiveness of contaminant mass removal by SEE has diminished, the remedial action will transition to enhanced bioremediation. The criteria that will be evaluated for this transition will be developed jointly by the AF, EPA, and ADEQ as part of the Remedial Design/Remedial Action Work Plan. Enhanced bioremediation is the process of modifying existing conditions to promote biological activity among bacteria that feed off of contamination present at the site. The residual increase in temperature at the site after the cessation of SEE is anticipated to enhance biological activity. Further modifications to enhance biological activity may include introducing food sources to promote activity, or modifying physical or chemical characteristics (e.g., pH, temperature) to create an environment that is more hospitable to bacterial growth. The specific methods for enhanced bioremediation will be established in consultation with EPA and ADEQ based on biological and contaminant conditions after SEE implementation. After enhanced bioremediation, a period of monitored natural attenuation (MNA) may be necessary until cleanup levels have been achieved. The estimated timeframe to achieve cleanup levels is twenty (20) years (including Remedial Design/Remedial Action Work Plan, remedial system construction, remedial action operation and maintenance (O&M), and remedy completion).

- **RD/RAWP, Section 4.2.4**

  Data will be collected to support evaluation of these criteria as described in Section 5.6. These criteria will be tracked and presented as part of routine progress reports particulary as treatment approaches the transition point and some of the data (e.g., subsurface temperatures) will be available via a web page interface. These factors will also be considered in light of the final EBR design including predicted achievement of the cleanup levels within the 20 year remedial timeframe. The evaluation for completion of thermal operations will be made between AMEC and TerraTherm and discussed with the AF, EPA, and ADEQ prior to termination of steam injection.

Site ST012 Remedy

- **RD/RAWP, 4.2.4 Transition to Enhanced Bioremediation**

The overall strategy for the selected groundwater remedy is presented in Section 3.2.2. Multiple lines of evidence will be used to support the discussion to terminate steam injection and transition to EBR. The primary factors for making the determination to transition from SEE to EBR are achieving target subsurface temperatures and diminishing mass removal rates. Throughout steam injection, AMEC and TerraTherm will closely monitor the performance of the SEE system. Evaluations of thermal operation will be ongoing to determine when the transition to the next phase is warranted. The specific criteria that will be considered in the decision making process for transition are shown in Table 4-2. The criteria will be considered in total with the weight of evidence from these multiple lines being used for decisions. Monitoring associated with achieving the target criteria are presented in Section 5.6.3.

Site ST012 SEE System
SEE to EBR Transition Criteria

- Criteria established to evaluate when the effectiveness of contaminant mass removal by SEE has diminished:
  - Primary SEE to EBR Transition Criteria
    - Achieve target subsurface temperatures
    - Diminishing mass removal rates
  - Secondary SEE to EBR Transition Criteria
    - Completion of Pressure Cycling
    - Benzene Concentrations
    - Steam Injection
- Multiple lines of evidence will be used to support the discussion to terminate steam injection and transition to EBR
- Mobile LNAPL recovery from outside the TTZ is <u>not</u> an established transition criteria

Subsurface Temperatures and Steam Breakthrough

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Site ST012 SEE System
SEE to EBR Transition Criteria Progress

Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

Subsurface Temperature

Parameter	Target Criteria	Basis for Target Criteria	Description
Subsurface Temperature	Varies by Depth (higher boiling temperatures with depth – see Figure 5.3, in Appendix D of the RD/RAWP	Numerical thermal modeling of TTZs supported by depth-specific boiling points.	Efforts will be made during operations to inject steam throughout the TTZ to target achievement of boiling point temperatures for groundwater throughout the TTZ. A steam zone will be generated and maintained where possible with the goal of pushing steam across the TTZ to form a steam zone between injection and extraction wells, with breakthrough of steam demonstrated at extraction wells. It is anticipated that a steam zone will not be able to be created and maintained in the LPZ. Other areas of low permeability may also be discovered during operation that limit achievement of target temperatures. Operational adjustments will be made where possible to increase temperatures in such zones that are slower to reach target temperatures. The energy balance will be used to support evaluation of achieving the temperature goal. Shut-down of steam will only be considered after achieving boiling point temperatures throughout the TTZ with the exception of the LPZ and other potential areas of low permeability and provided that operational adjustments are made to attempt to achieve the temperature goal in areas that are resistant.

Site ST012 SEE TMP Maximum Depth-Averaged Temperature by Zone

Temperature Monitoring Point	Temperature Monitoring Point Maximum Depth-Averaged Temperature[1] (°C) During SEE Operations by Zone				
	CZ	UWBZ	LPZ	LSZ	LSZ (depths above 235 ft bgs)
TMP01	114.9	130.5	N/A	N/A	N/A
TMP03	N/A	N/A	137.5	114.2	120.7
TMP04	N/A	N/A	103.8	118.8	127.1
TMP05	110.3	N/A	N/A	N/A	N/A
TMP06	N/A	N/A	137.4	135.0	135.9
TMP07	N/A	N/A	134.6	137.2	140.2
TMP08	N/A	N/A	136.6	131.3	135.4
TMP09	N/A	N/A	132.5	134.1	139.3
TMP11	N/A	N/A	110.6	119.1	131.7
TMP12	78.1	93.4	121.8	121.4	131.3
TMP13	102.1	119.8	130.6	138.4	140.0
TMP14	N/A	N/A	133.6	124.3	136.3
TMP15	113.1	123.3	128.7	126.5	135.6
TMP16	N/A	N/A	126.7	120.5	131.0
TMP17	N/A	N/A	135.2	136.9	136.9
Maximum depth-averaged by zone[2]	**103.7**	**116.8**	**128.4**	**127.5**	**134.0**

If N/A, Temperature Monitoring Point has no sensors in that zone

[1] Temperature of the thermocouples across each depth zone are averaged for each TMP and each available time interval and then the maximum value of those averages throughout operations is listed in the table.

[2] Average of maximum depth-averages listed above for all TMPs in each zone.

- **Target treatment temperatures achieved in all zones (LSZ <235 ft bgs average is 134°C)**

CZ Target Treatment Temperature: ~100°C
UWBZ Target Treatment Temperature: ~114°C
LSZ Target Treatment Temperature: ~134°C

Site ST012 SEE
MPE Steam Breakthrough Achievement

Well	Well Location	Required to Reach Steam Temperature	Steam Breakthrough Achieved at MPE Temperature Calculated
CZ07	Perimeter	No	Yes
CZ08	Perimeter	No	Yes
CZ09	Perimeter	No	Yes
CZ10	Perimeter	No	Yes
CZ11	Interior	Yes	Yes
CZ12	Perimeter	No	Yes
CZ13	Perimeter	No	Yes
CZ14	Perimeter	No	Yes
CZ15	Interior	Yes	Yes
CZ16	Perimeter	No	Yes
CZ17	Perimeter	No	Yes
CZ18	Perimeter	No	Yes
CZ19	Perimeter	No	Yes
CZ20	Outside CZ	No	No

Well	Well Location	Required to Reach Steam Temperature	Steam Breakthrough Achieved at MPE Temperature Calculated
UWBZ01	Interior	Yes	Yes
UWBZ02	Interior	Yes	Yes
UWBZ04	Interior	Yes	Yes
UWBZ05	Interior	Yes	Yes
UWBZ06	Interior	Yes	Yes
UWBZ10	Perimeter	No	Yes
UWBZ17	Perimeter	No	Yes
UWBZ18	Interior	Yes	Yes
UWBZ19	Perimeter	No	Yes
UWBZ20	Dual Phase - Perimeter	No	No
UWBZ21	Outside UWBZ	No	Yes
UWBZ22	Perimeter	No	Yes
UWBZ23	Outside UWBZ	No	Yes
UWBZ24	Dual Phase - Perimeter	No	Yes
UWBZ26	Outside UWBZ	No	Yes
UWBZ27	Outside UWBZ	No	Yes

Well	Well Location	Required to Reach Steam Temperature	Steam Breakthrough Achieved at MPE Temperature Calculated
LSZ01	Interior	Yes	Yes
LSZ02	Interior	Yes	Yes
LZS04	Interior	Yes	Yes
LSZ05	Interior	Yes	Yes
LSZ06	Interior	Yes	Yes
LSZ08	Perimeter	No	Yes
LSZ11	Perimeter	No	Yes
LSZ12	Perimeter	No	Yes
LSZ13	Interior	Yes	Yes
LSZ14	Perimeter	No	Yes
LSZ15	Interior	Yes	Yes
LSZ16	Interior	Yes	Yes
LSZ17	Perimeter	No	Yes
LSZ28	Perimeter	No	Yes
LSZ29	Perimeter	No	Yes
LSZ30	Interior	Yes	Yes
LSZ31	Interior	Yes	Yes
LSZ32	Interior	Yes	Yes
LSZ33	Perimeter	No	Yes
LSZ34	Interior	Yes	Yes
LSZ35	Perimeter	No	Yes
LSZ36	Perimeter	No	Yes
LSZ37	Perimeter	No	Yes
LSZ38	Perimeter	No	Yes
LSZ39	Perimeter	No	No
LSZ40	Interior	Yes	Yes
LSZ42	Perimeter	No	Yes

- **Steam breakthrough has been achieved at all interior MPE wells**

Mass Removal

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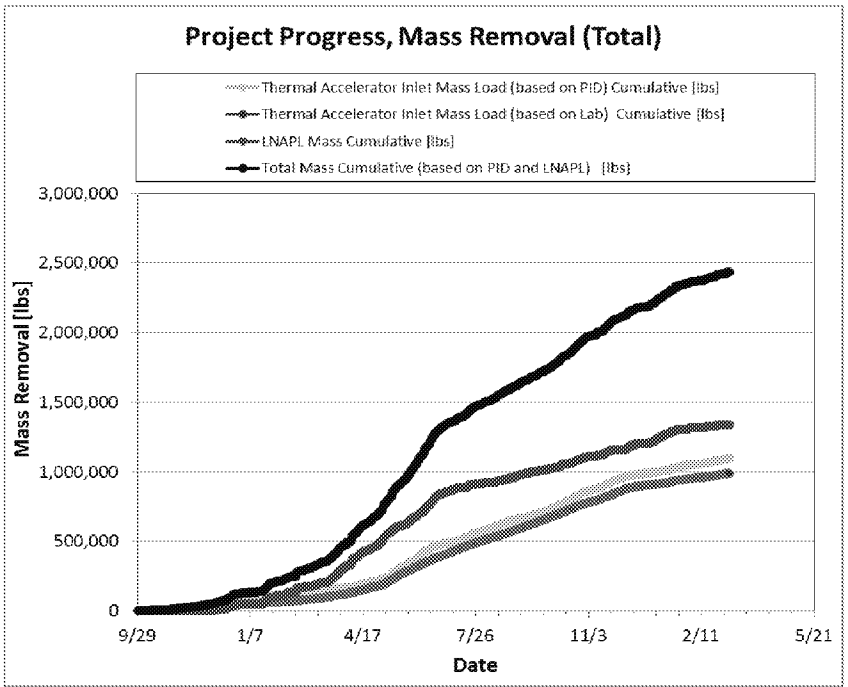
Site ST012 SEE System
SEE to EBR Transition Criteria Progress

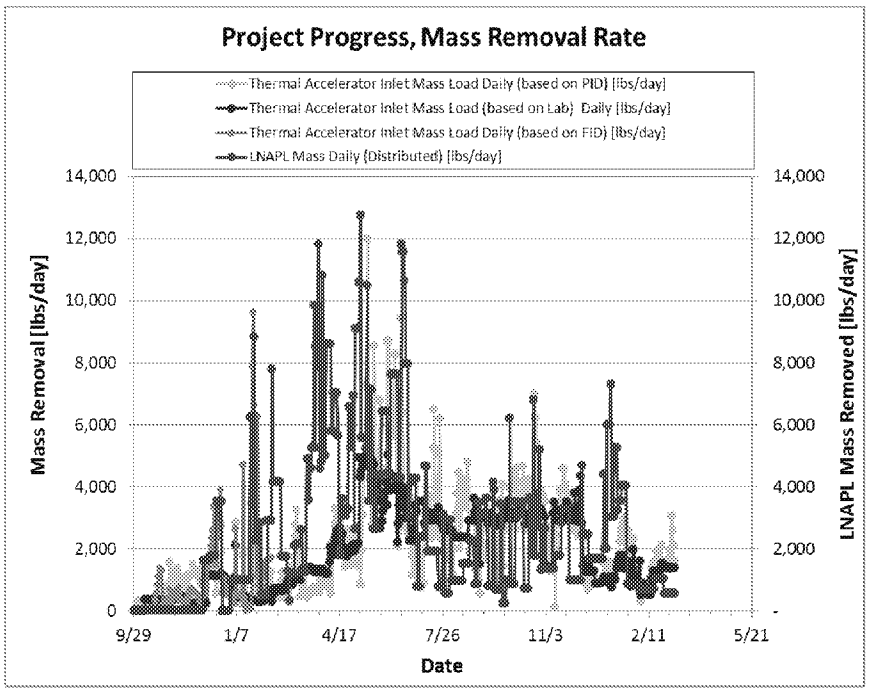
Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

Mass Removal

Parameter	Target Criteria	Basis for Target Criteria	Description
Mass removal	Less than 10 percent of peak removal rate	10 percent selected as an indication of significant decline in mass removal by SEE. This target is consistent with removal rate trends observed at other sites and provides some accommodation for the uncertain mass present and the uncertain peak extraction rate. The actual site-specific removal rate curve will be evaluated to confirm or adjust the appropriateness of this value to represent a condition of diminishing returns.	The rate of contaminant mass removal from the subsurface will play a major factor in determining when SEE is complete or sufficient. The mass removal rate will be closely monitored and will be optimized by using pressure cycling events. Toward the end of the operational period, the mass removal rates will be modest when compared to the peak removal rates (typically less than 10 percent of the rate observed at peak operations). Contaminant mass located around the perimeter of the TTZ may contribute a continuing source of mass for removal by the SEE system, which could mask the progress of mass removal within the TTZs, so the contribution of perimeter/interior extraction wells may be evaluated for mass removal towards the end of operations to identify any perimeter influx. Continued operation below the 10 percent of peak removal rate may be implemented depending on the significance of continued mass removal, the status of COC concentrations (e.g., benzene) in extracted fluids, and the need/ability for EBR to achieve further degradation based on data collected during the EBR field test.

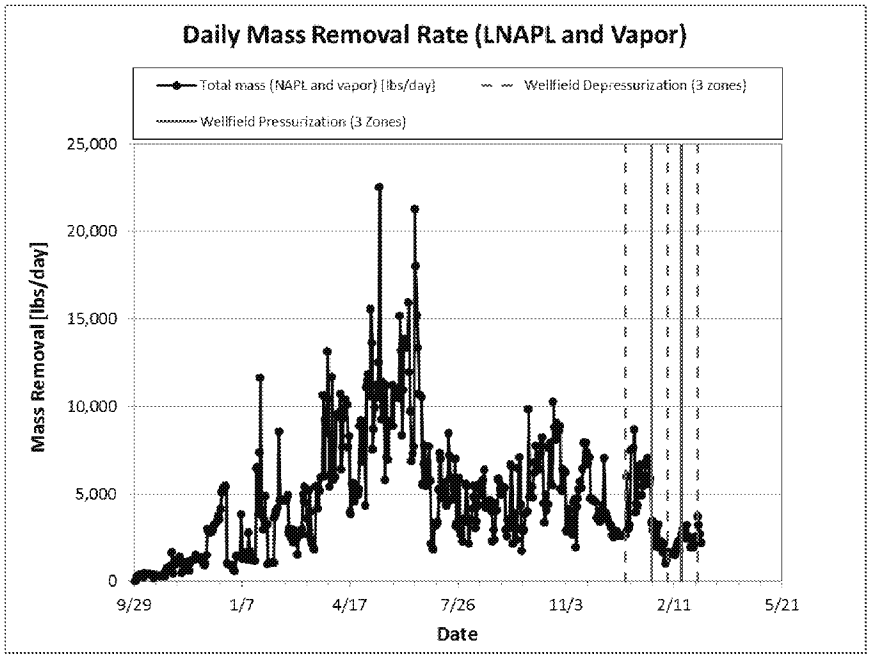
Site ST012 SEE System Mass Removal

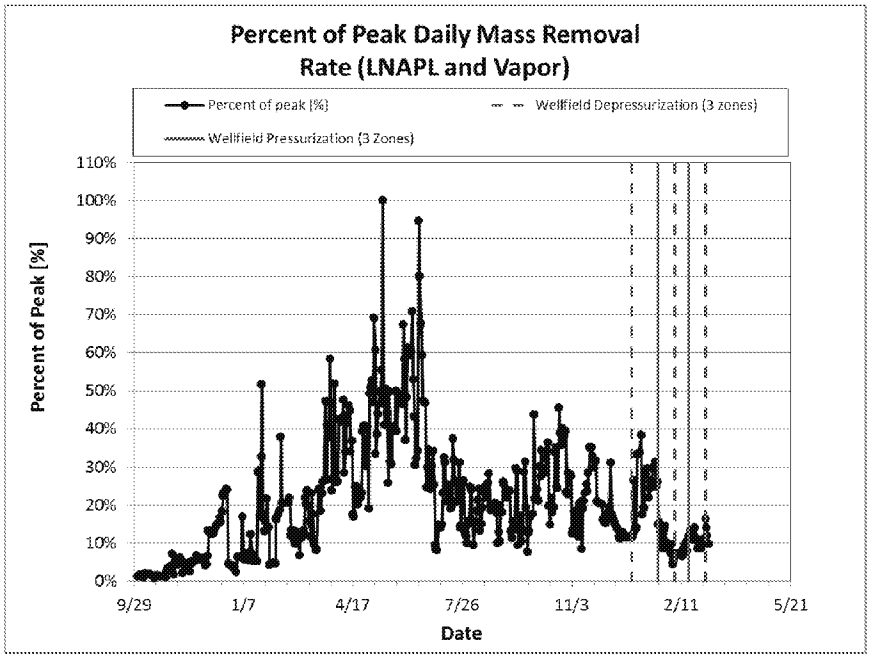




- **Total Contaminant Mass Removal: 2,438,563 lbs recovered**
- **An estimated 1,342,107 lbs (204,278 gallons) as non-aqueous phase liquid (NAPL)**
- **An estimated 1,096,456 lbs of mass (PID) removed in the vapor phase**

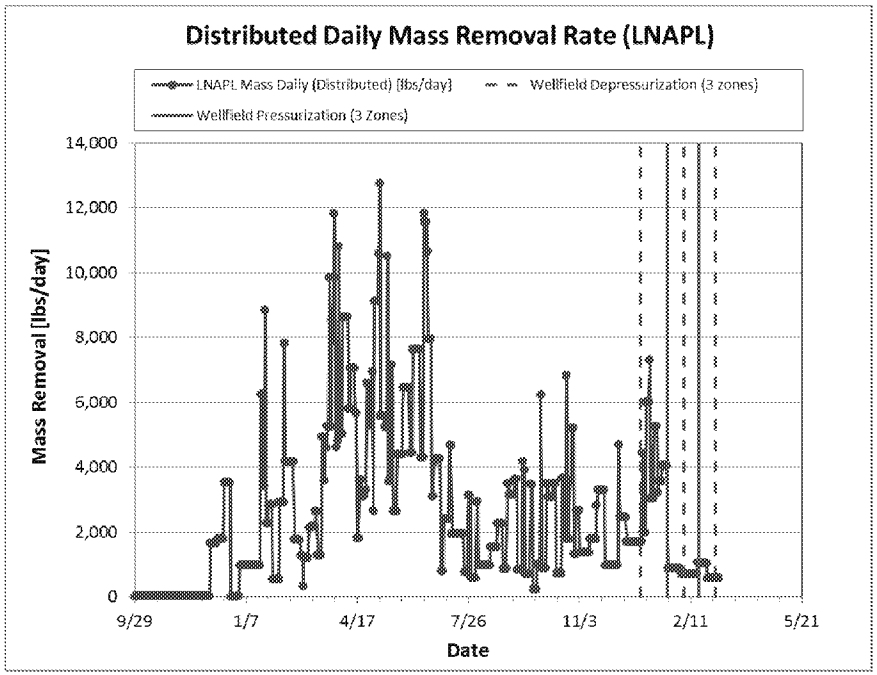
Site ST012 SEE System
Daily Mass Removal - Total

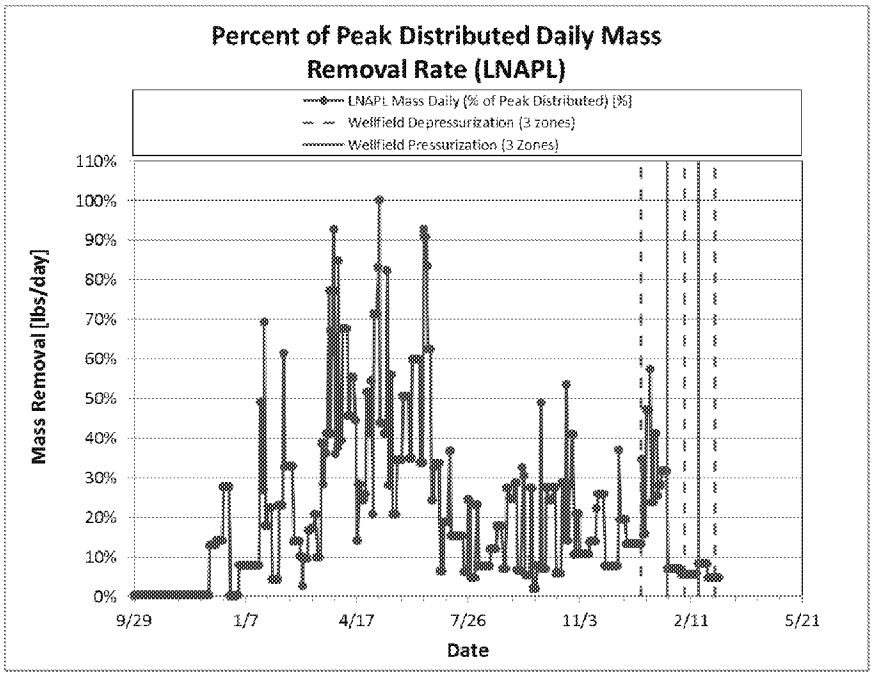




- **Mass removal peaked on 14 May 2015 at 22,506 lbs/day**
- **Mass recovery is 10.3% of peak on average from 09 Feb to 07 Mar 2016 (2,316 lbs/day)**

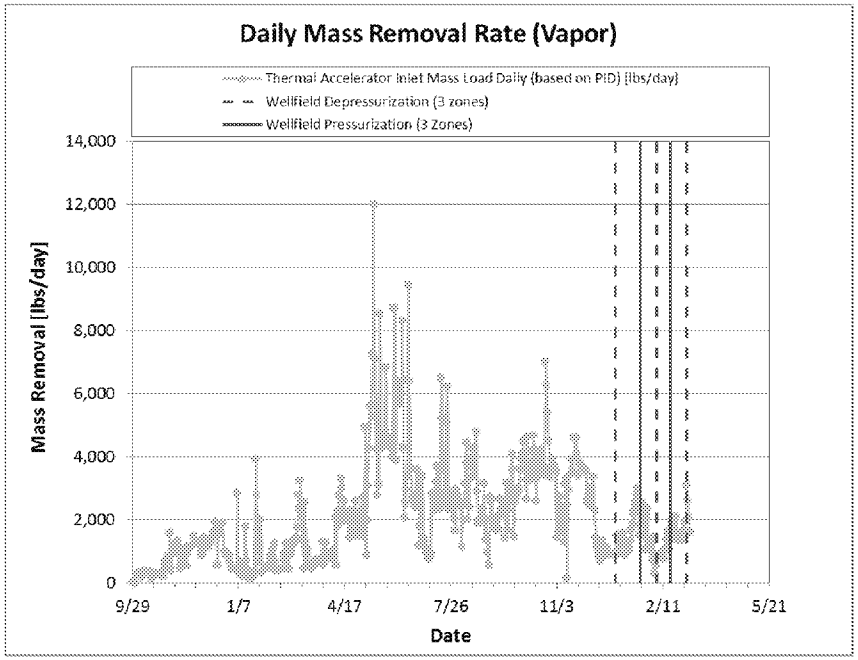
Site ST012 SEE System
Daily Mass Removal - LNAPL

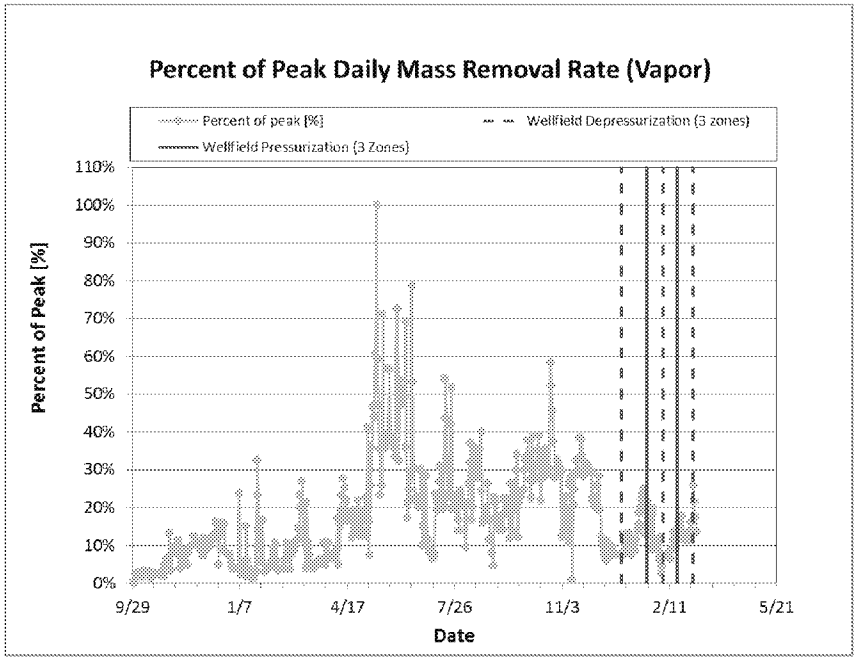




- **Daily LNAPL mass removal peaked on 05 May 2015 at 12,760 lbs/day**
- **LNAPL recovery is 6.0% of the peak on average for 09 Feb to 07 Mar 2016 (766 lbs/day)**

Site ST012 SEE System
Daily Mass Removal - Vapor





- **Daily vapor mass removal peaked on 14 May 2015 at 12,009 lbs/day**
- **Vapor mass removal rates are 12.9% of the peak on average from 09 Feb to 07 Mar 2016 (1,550 lbs/day)**

Site ST012 Mass Removal Contribution from Outside TTZs

- **Lines of evidence indicating mass removal is primarily from outside the TTZs:**
  - **Jar testing indicates greater LNAPL quantities in perimeter wells than interior wells**
  - **Calculated benzene concentrations higher in perimeter wells than interior wells**
  - **Mass removal rates have stabilized over last 30 days**
  - **Benzene fraction in LNAPL not depleting which indicates LNAPL originating from outside the TTZ**
  - **Pressure cycling does not result in significantly increased vapor concentrations**

Site ST012 Mass Removal Contribution from Outside TTZs (cont)

- **Lines of evidence indicating mass removal is primarily from outside the TTZs:**
  - **NAPL recovery decreases during pressurization and increases during depressurization**
  - **Mass removal at ~2,000 pounds per day currently. This represents 0.08% of total removed to date**
  - **LNAPL removal at <1,000 pounds per day. This represents 0.04% of total removed to date**
  - **Current mass removals are similar to rates ~30 November 2014 (before subsurface was significantly heated)**

Pressure Cycling

ED_005025_00005750-00035

Site ST012 SEE System
SEE to EBR Transition Criteria Progress

Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

Completion of Pressure Cycling

Parameter	Target Criteria	Basis for Target Criteria	Description
Completion of Pressure Cycling	Completion of multiple pressure cycles in each area	Pressure cycling has been demonstrated at other sites to improve mass removal beyond that achieved by uniform heating only.	Once the TTZ temperatures have stabilized, further mass removal improvement can be achieved by releasing steam pressure to cause volatile LNAPL constituents to rapidly vaporize for subsequent collection by MPE wells. The process of building and releasing the pressure is repeated until no additional significant increases in effluent vapor phase concentrations occur when steam pressure is reduced.

Pressure Cycling Status

- **Operational data reviewed to determine initiation of pressure cycling:**
  - **Multi-phase Extraction (MPE) Well Vapor Extraction Temperature**
  - **Temperature Monitoring Point Data**
  - **Calculated MPE Well Formation Temperature**
  - **Pressure cycling initiated to enhance vapor phase recovery within the TTZ**
  - **Pressure cycling status and data reviewed on 2 Mar 2016 prior to initiation of depressurization**
  - **Pressure cycling status reviewed monthly on BCT calls**
  - **Pressure cycling currently synchronized in all zones**

Pressure Cycling Status by Zone:

Pressurization or Depressurization Initiation Dates

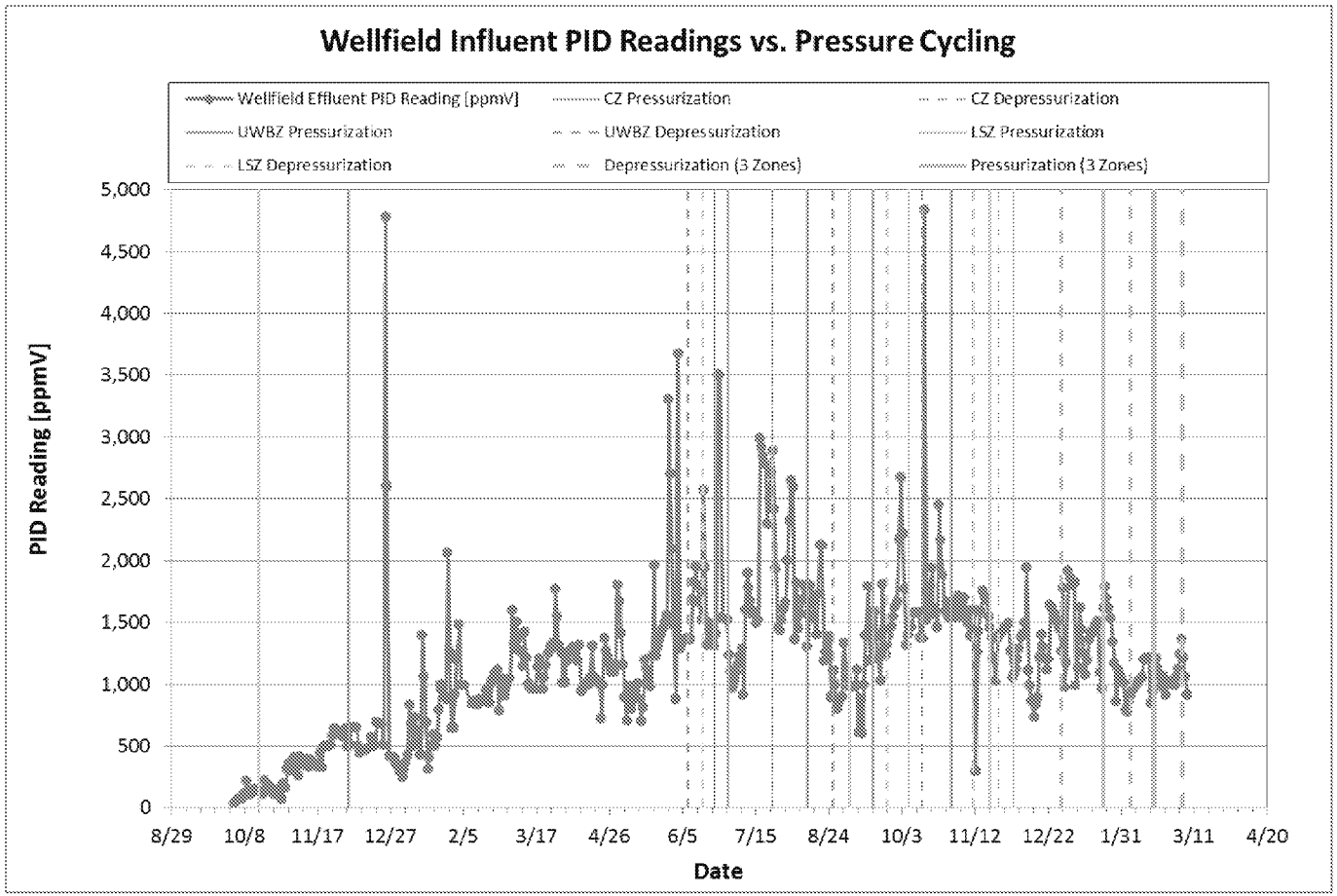
	2014		2015																				2016				# Cycles
CZ						6/30				9/17				10/7			11/11	11/20	11/25	12/3	12/28	1/21	2/5	2/18	3/4	5
UWBZ		12/4	6/8		6/22		7/24	8/12	8/26	9/17		10/2	10/3		10/14	10/30			11/25	12/3	12/28	1/21	2/5	2/18	3/4	9
LSZ	10/16			6/16			7/24	8/12	9/4		9/25			10/7			11/11	11/20	11/25	12/3	12/27	1/21	2/5	2/18	3/4	7

**Please note that the mini-pressurization/depressurization occurring in the CZ and LSZ on 11/20 and 11/25, respectively, have not been added as full pressure cycles to the zone counts*

Pressurization
Depressurization

Pressure Cycling and Vapor Concentrations Over Time

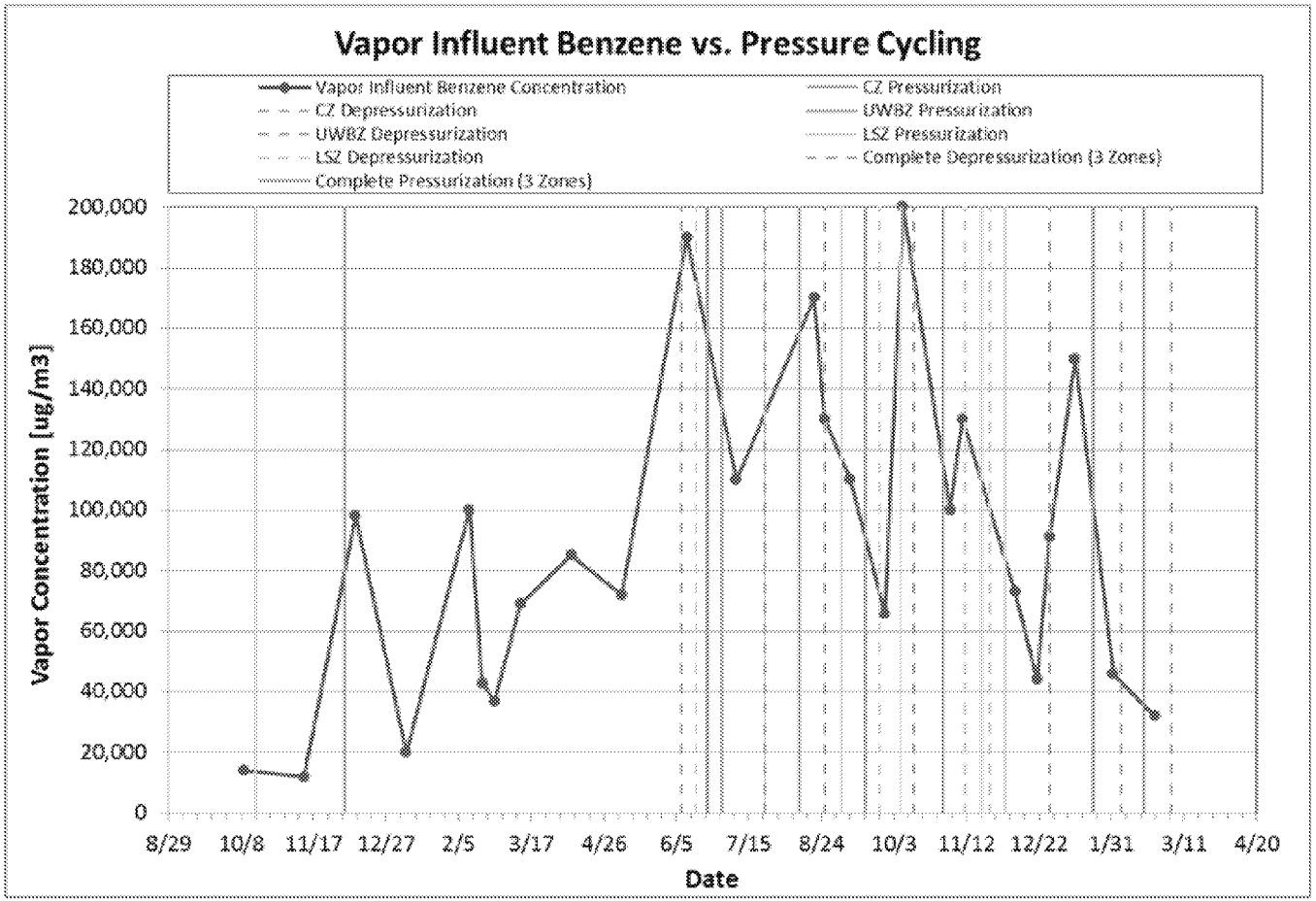
Wellfield Vapor Influent PID Concentrations over Time



- **Wellfield PID concentrations remain relatively stable during site-wide pressurization and depressurization events**

Pressure Cycling and Benzene Vapor Concentrations Over Time

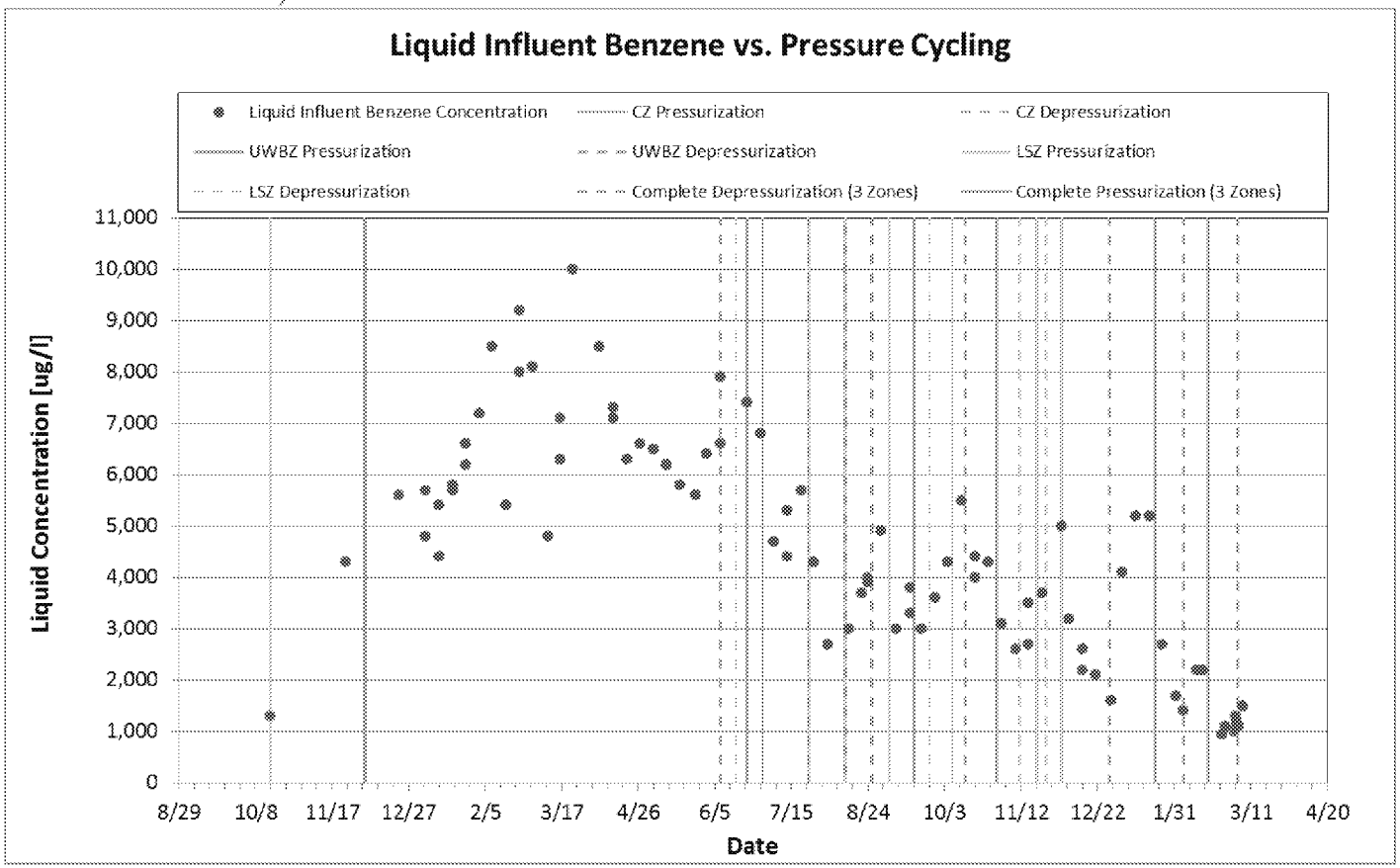
Extracted Vapor Benzene Concentrations over Time
(measured at thermal accelerator influent [includes air stripper effluent] by EPA Method TO-15)



- **Benzene concentrations have fluctuated during pressure cycling**

Pressure Cycling and Benzene Liquid Concentration Over Time

Extracted Liquid Benzene Concentrations over Time (measured at air stripper influent by EPA Method 8260B)



- **Benzene concentrations have declined**
- **Benzene concentrations have approached pre-heating concentrations**

Please note: Final laboratory reports have not yet been issued for liquid sample results collected on 12, 15, 25, 27 Feb and 2, 3, 4, 7 Mar 2016.

Benzene Concentrations

Site ST012 SEE System
SEE to EBR Transition Criteria Progress

Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

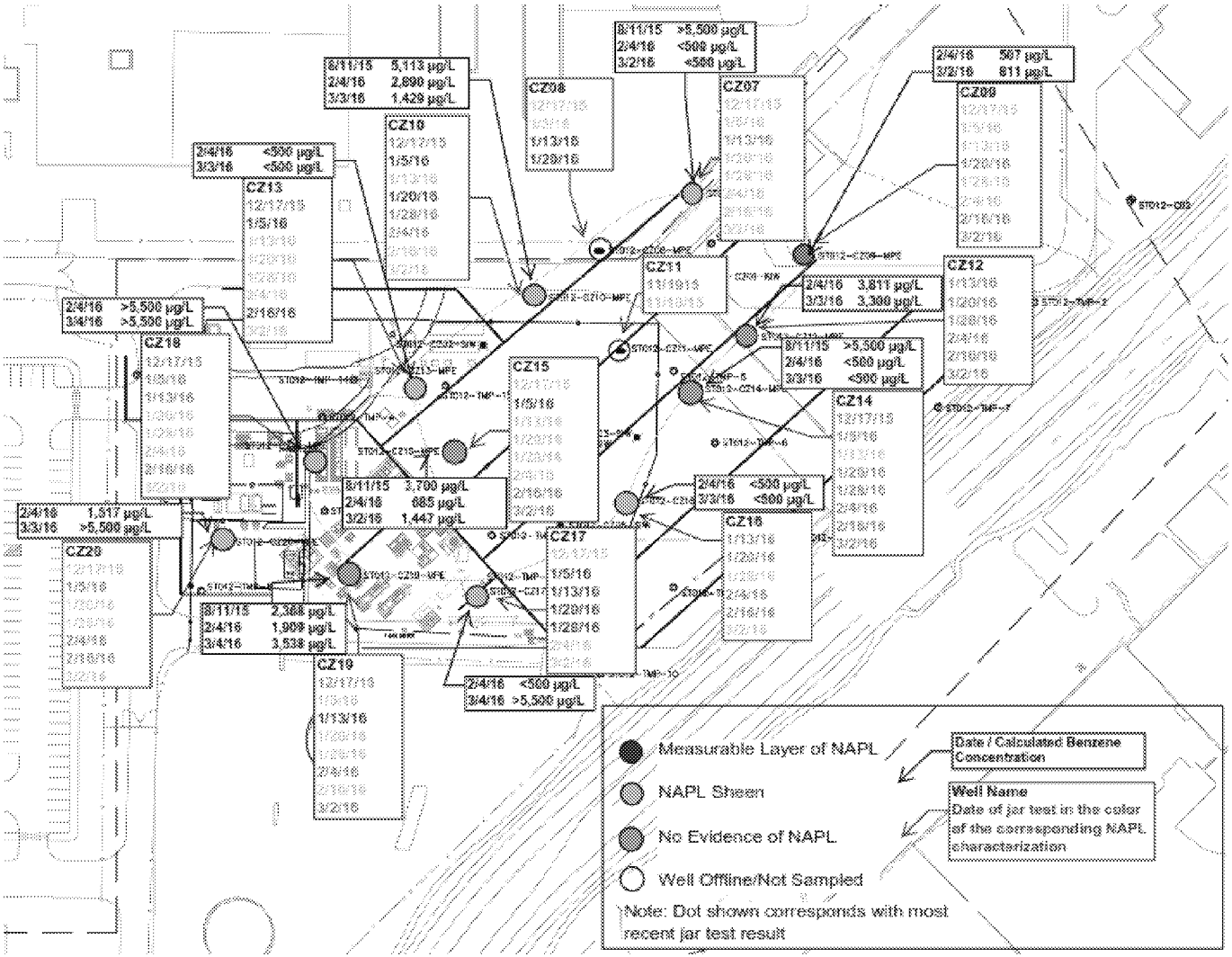
Benzene Concentrations

Parameter	Target Criteria	Basis for Target Criteria	Description
Benzene concentrations:	100 to 500 µg/L	Concentration range where natural attenuation can complete degradation within the remedy time frame.	Benzene concentrations in extracted groundwater provide an indication of the amount of benzene remaining in the TTZ. These concentrations will be monitored against a target benzene concentration in the 100 to 500 µg/L range within the TTZ. This concentration range is predicted to achieve cleanup levels within the 20-year remedial timeframe based on modeling of groundwater contaminant attenuation outside the TTZs after active EBR (Appendix E). Benzene located around the perimeter of the TTZ and the perimeter/interior extraction wells will be evaluated for benzene concentrations to identify any perimeter influx that may mask benzene removal within the TTZ. It is expected that lower benzene concentrations within this range will be achieved in the interior of the TTZs than at the perimeter.

Site ST012 SEE System Benzene Concentrations

- Goal for transition to natural attenuation: 100 to 500 µg/L in interior wells.
- Goal for transition to EBR: 500 to 5,500 µg/L in interior wells (based on RD/RAWP model)
  - Depletion of LNAPL in TTZ interior leaves mainly dissolved phase BTEX
  - Sulfate injected at perimeter will migrate and contribute to reductions in TTZ interior
  - EBR treatment of perimeters will reduce further perimeter contributions to TTZ interior
  - Additional sulfate can be injected in TTZ if necessary
- Groundwater concentrations above 500 µg/L may remain at TTZ perimeters because of known contamination outside of TTZ
- Perimeter contribution enhanced by elevated temperatures in the heated zone (increased dissolution/solubility and reduced viscosity)

NAPL Screening Results and Calculated Benzene Concentrations – Cobble Zone August 2015 – March 2016



- Site wide pressurization initiated 18 Feb 2016
- Site wide depressurization initiated 04 Mar 2016
- NAPL screening results showed decrease in measurable layers of NAPL and NAPL sheens post-pressurization

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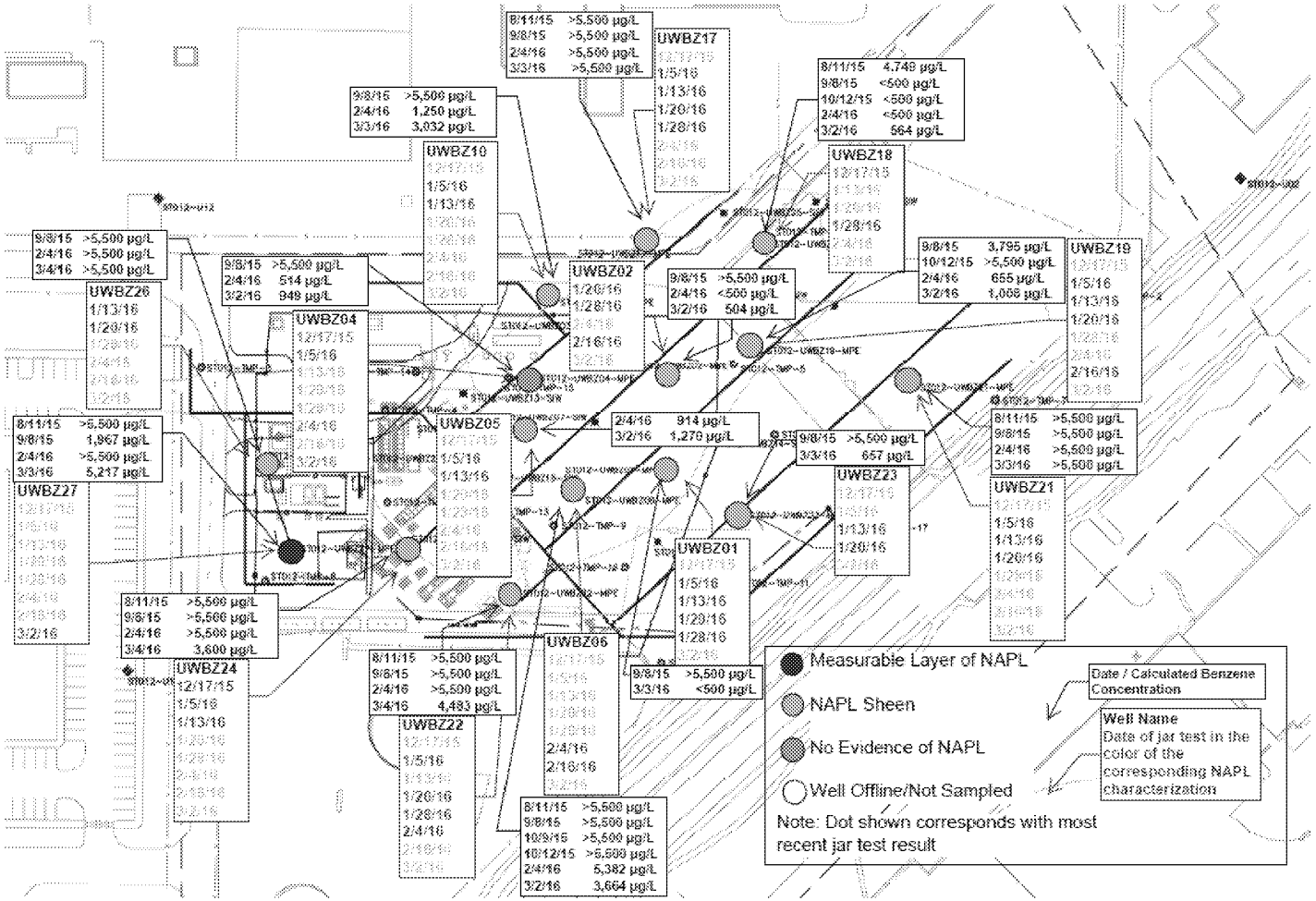
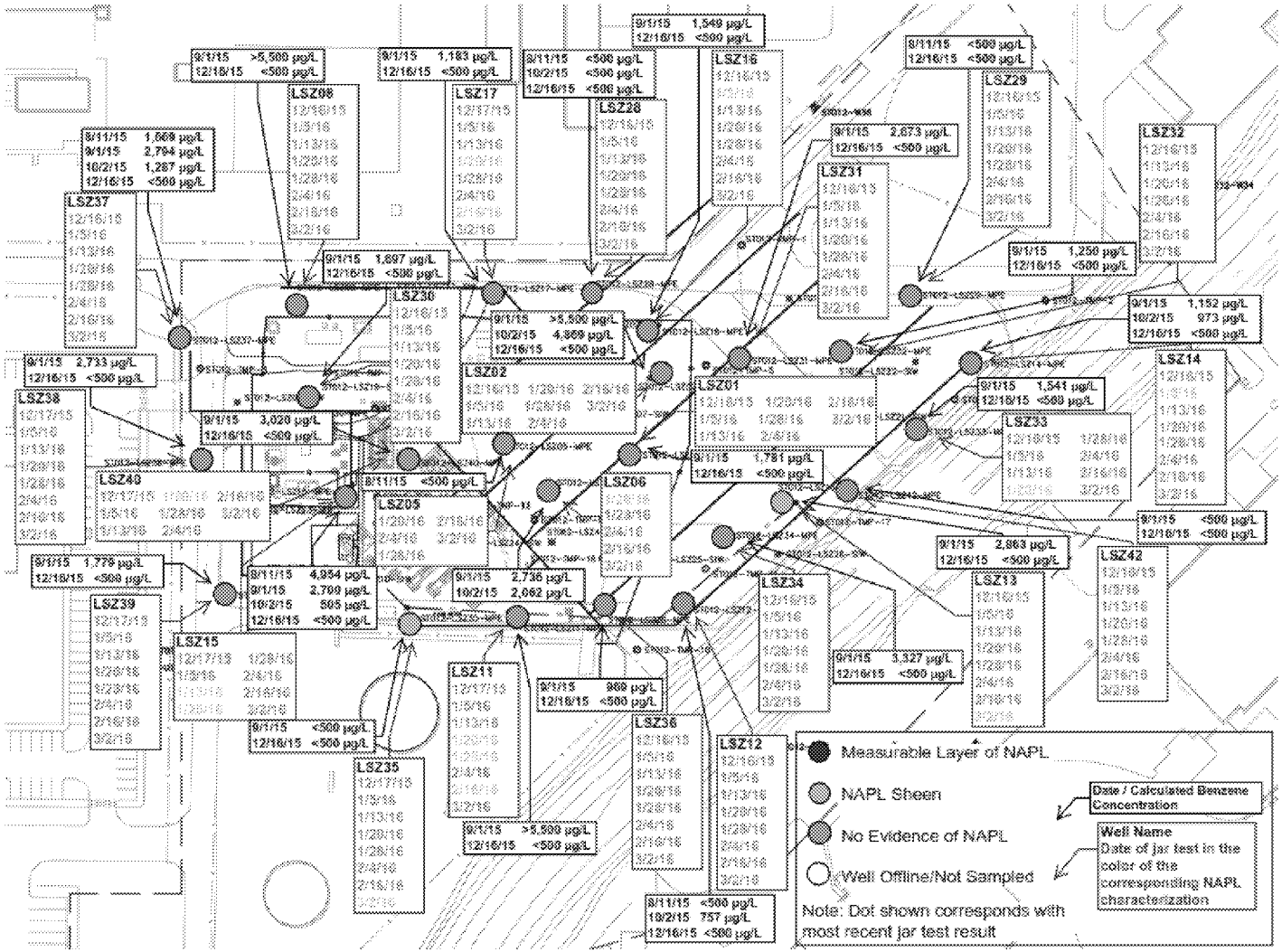
NAPL Screening Results and Calculated Benzene Concentrations – Upper Water Bearing Zone August 2015 – March 2016



- Site wide pressurization initiated 18 Feb 2016
- Site wide depressurization initiated 04 Mar 2016
- NAPL screening results showed increase in measurable layers of NAPL and NAPL sheens post-depressurization

NAPL Screening Results and Calculated Benzene Concentrations – Lower Saturated Zone August 2015 – March 2016



- Calculated benzene concentrations <500 µg/L at all locations for 16 Dec 2015 event
- Site wide pressurization initiated 18 Feb 2016
- Site wide depressurization initiated 04 Mar 2016
- NAPL screening results show no increase in measurable layers of NAPL

Steam Injection (Guideline)

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Site ST012 SEE System
SEE to EBR Transition Criteria Progress

Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

Steam Injection (Guideline)

Parameter	Target Criteria	Basis for Target Criteria	Description
Steam injection (guideline)	319,357,000 lbs	Numerical thermal modeling of TTZs.	A targeted total of 319,357,000 lbs of steam is expected to be injected into the TTZ over the course of operations. This represents an average flushing of the TTZ pore volume of 1.6 pore volumes of steam as water throughout operation. Actual steam required to achieve the other criteria may be more or less than this estimate. Because this parameter does not directly measure remediation performance its primary use will be as a guideline to measure progress compared to the design.

ST012 SEE System Pore Volume Flush

- **Operational target = average pore volume flush of 1.6 throughout the TTZ**
- **Estimated pore volume flush (as water) for each of the zones and the average for the site is shown below:**

Zone	Area	Treatment Depth	Depth	Volume	Porosity Volume	Steam injected	Pore volumes
	[ft^2]	[ft]	[ft]	[cy]	[cy]	[lbs]	[-]
CZ	71,923	145-160 ft bgs	15	39,957	11,987	32,342,549	1.6
UWBZ	71,923	160-195 ft bgs	35	93,234	27,970	82,344,993	1.7
LPZ	128,474	195-210 ft bgs	15	71,374	21,412	0	0.0
LSZ	185,025	210-240 ft bgs	30	205,583	61,675	187,687,807	1.8
Total (assuming LPZ is included)				410,149	123,045	302,375,349	1.5
Total without the LPZ				338,774	101,632	302,375,349	1.8

- **On average (not including the LPZ) the TTZ has been flushed 1.8 times**

Site ST012 Path Forward

- **Criteria met for transition to EBR**
- **Post-SEE extraction has been initiated**

Transition Criteria	Progress
Target Temperature Achievement	• Target temperature achieved in all zones (LSZ above 235 ft bgs) • Steam breakthrough observed at all interior MPE wells
Mass Removal Status	• Total mass removal is 10.3% of peak (average) – mass removal rates are diminishing • Mass removal approaching target, further progress limited by perimeter contribution
Pressure Cycling Status	• Multiple pressure cycles have been completed in each zone (CZ = 5, UWBZ = 9, LSZ = 7)
Benzene Concentrations	• Benzene concentrations <500 µg/L in LSZ; suitable for transition to natural attenuation • Benzene concentrations at interior CZ and UWBZ locations <5,500 µg/L; suitable for transition to EBR
Steam Injection Status (guideline)	• 302.4 MM lbs injected versus 320 MM operations guide (94%) • Achieved average TTZ flushing of 1.8 pore volumes as water

EBR Addendum

Site ST012 EBR Treatment

- Mobile LNAPL (pre-SEE) was mostly within TTZs
- SEE was the primary LNAPL removal technology in the remedy; however, in the FFS it was noted that LNAPL may be present at some locations at the SEE perimeter
- EBR was identified in the RD/RAWP as the technology to address areas outside the SEE perimeter
- Natural Source Zone Depletion (NSZD) has been demonstrated for LNAPL Sources
  - EBR approach will accelerate these processes by addressing limitation of available TEA
  - Sulfate degradation of fuel compounds is demonstrated
  - Heating increases solubility and accelerates biological processes
  - Biosurfactant affects can promote LNAPL dissolution
  - Some components of LNAPL will be poorly soluble and will not be addressed by degradation mechanism in dissolved phase. These components will also not contribute to groundwater contamination.

Site ST012 Residual vs Mobile LNAPL

- Residual LNAPL is defined as LNAPL that will no longer flow to a well under ambient (Pre-SEE) conditions

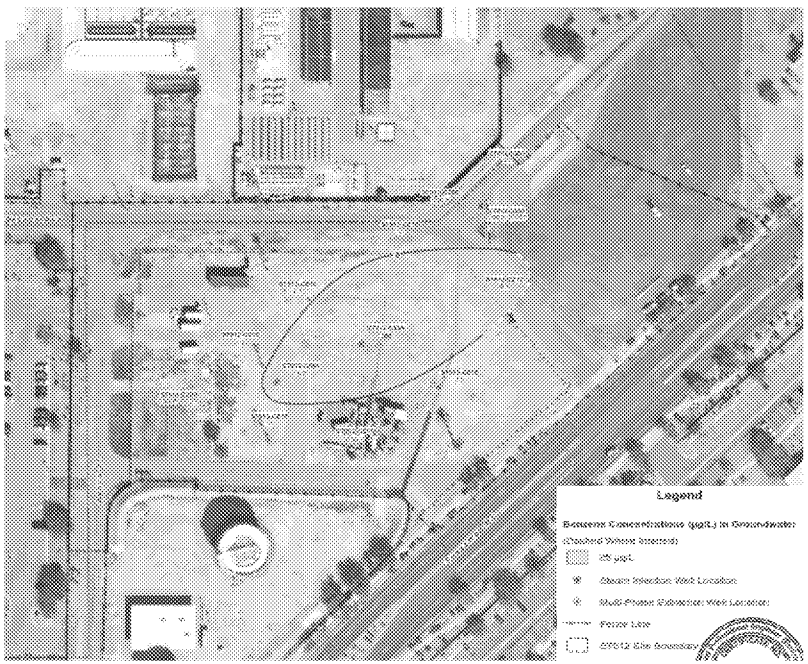
- Mobile LNAPL is defined as LNAPL that will flow to and accumulate in a well under ambient (Pre-SEE) conditions

- Observed mobile LNAPL Pre-SEE
  - CZ – none observed
  - UWBZ – within or close to TTZ
  - LSZ – At LSZ perimeter in some locations (e.g., W37)

- LNAPL that flows to MPE wells under SEE likely includes LNAPL that is mobilized due to viscosity changes with increased temperature (i.e., some recovery and depletion of residual LNAPL) or hydraulic pressure changes due to groundwater extraction

Site ST012 Mobile LNAPL - CZ

- **Pre-SEE Conditions**
  - **No observed mobile LNAPL**
  - **Low (< 500 µg/L) benzene concentrations**



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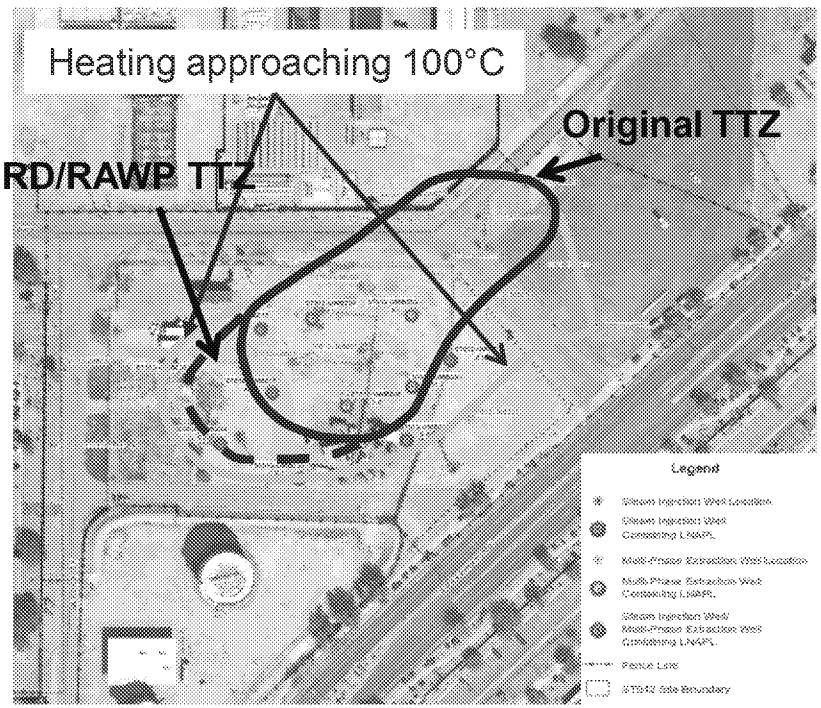
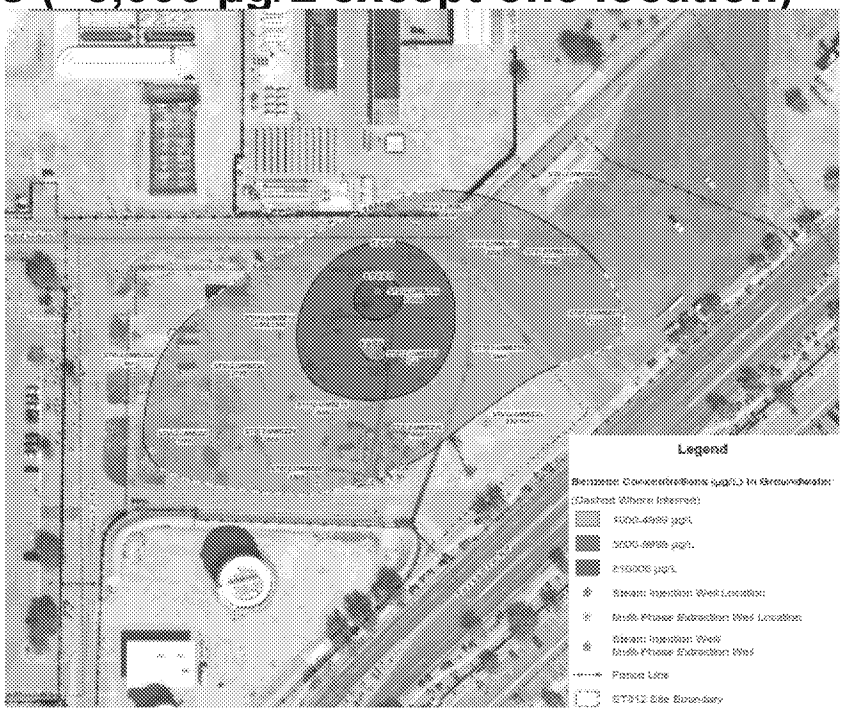
Site ST012 Mobile LNAPL - UWBZ

Pre-SEE Conditions

- Mobile LNAPL within or at perimeter of TTZ
- Mobile LNAPL within heated zone
- Mobile LNAPL not bounded to south
- Moderate benzene concentrations (<5,000 µg/L except one location)





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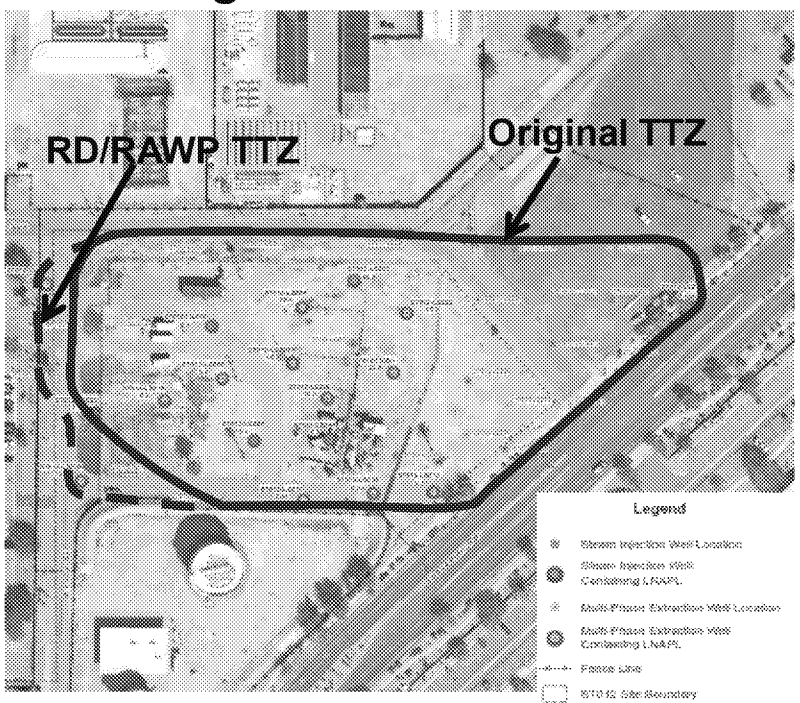
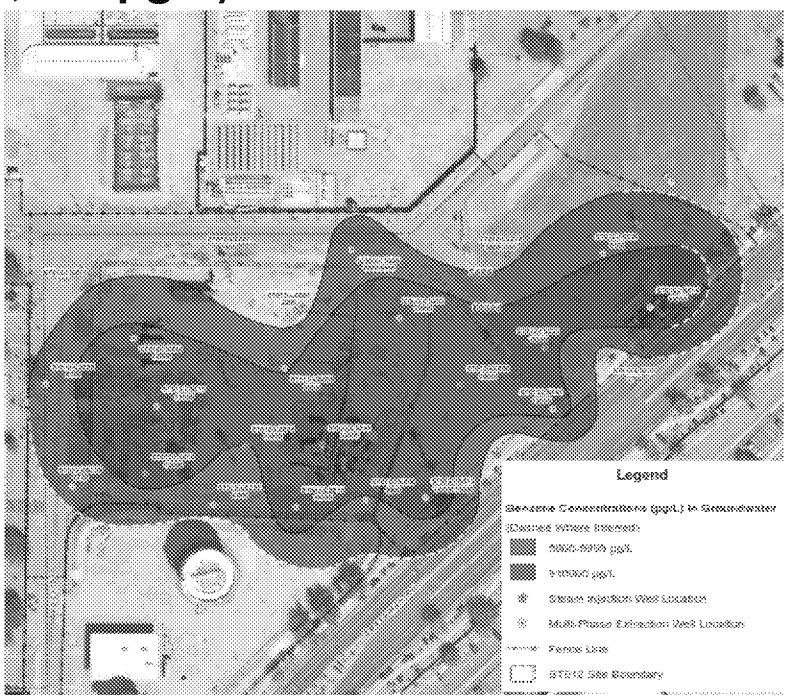
Site ST012 Mobile LNAPL - LSZ

Pre-SEE Conditions

- Mobile LNAPL within or at perimeter of TTZ
- Mobile LNAPL within heated zone
- Mobile LNAPL not bounded south and west
- High benzene concentrations (>10,000 µg/L)





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Site ST012 Dissolved Mass

- Increased solubility of BTEX+N with heat has made more mass currently available for EBR in dissolved phase

- Dissolved Phase Examples
  - CZ – 5,000 µg/L, 300 ft x 600 ft x 15 ft, n*~0.25 = 210 pounds of benzene
  - UWBZ – 5,000 µg/L, 400 ft x 700 ft x 35 ft, n~0.25 = 760 pounds of benzene
  - LPZ – 5,000 µg/L, 500 ft x 1,000 ft x 15 ft, n~0.25 = 290 pound of benzene
  - LSZ – 500 µg/L, 500 ft x 1,000 ft x 35 ft, n=0.25 = 136 pounds of benzene
  - 1,396 pounds of benzene potentially currently available in the dissolved phase (> 25% of estimated benzene mass present)

*n = porosity

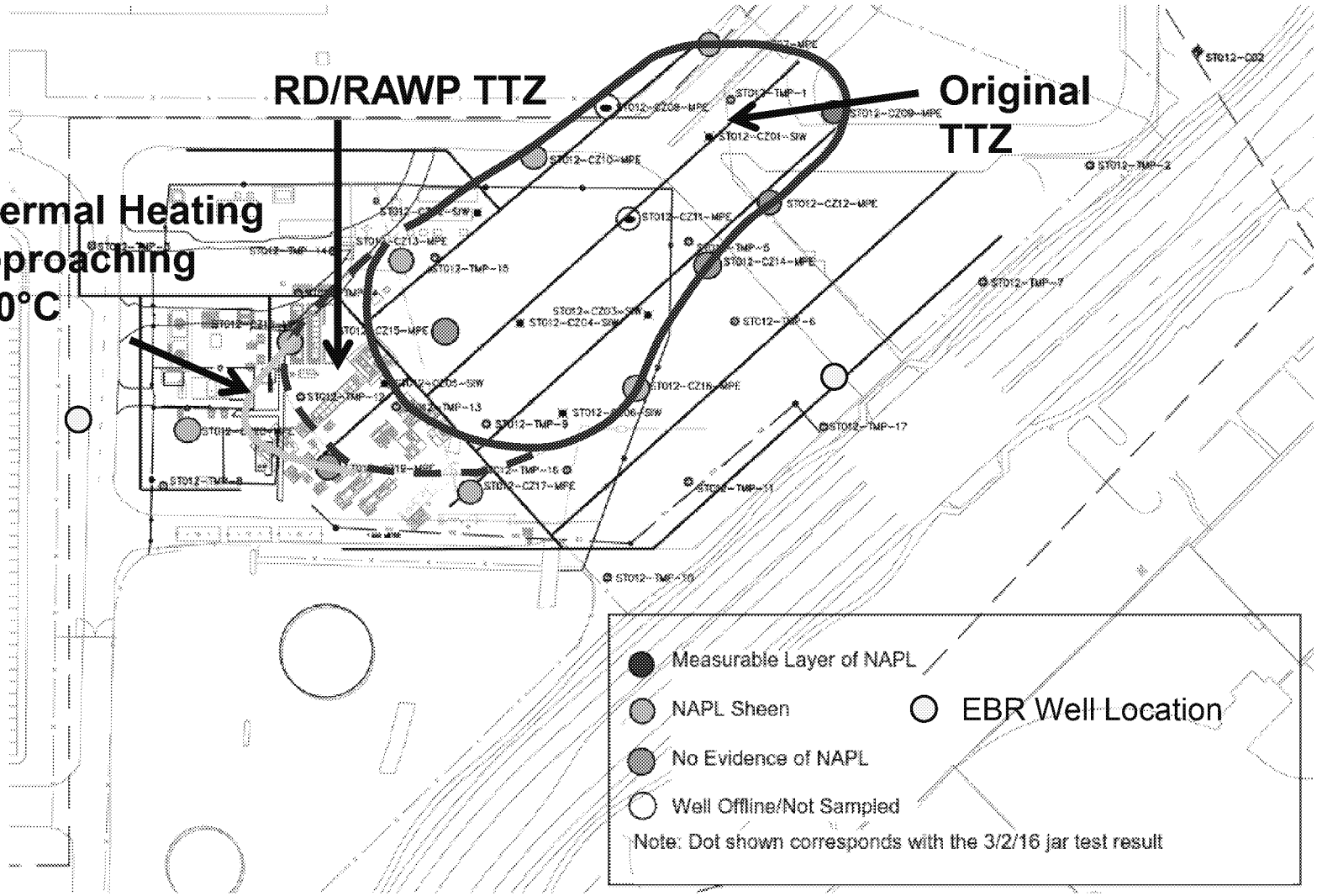
Site ST012 Comparison of SEE/EBR mass removal

- **SEE Treatment**
  - Currently removing ~2,000 pounds/day (average 1 Feb – 7 Mar)
  - Equates to ~730,000 pounds/year
- **EBR Treatment**
  - Overall
    - Estimated mass remaining post SEE ranges from ~330,000 to ~1,600,000 pounds
    - Target duration of EBR is 3 years
    - Represents an average of ~400,000 pounds removed per year or 1,200,000 pounds for three year duration
  - Phase 1 (six months)
    - 840 tons of sulfate injection in Phase 1
    - Sodium sulfate is 67.6 % sulfate
    - Theoretical 5 pounds of sulfate to degrade 1 pound of JP-4
    - 227,000 pounds of JP-4 could be degraded by Phase 1 sulfate addition

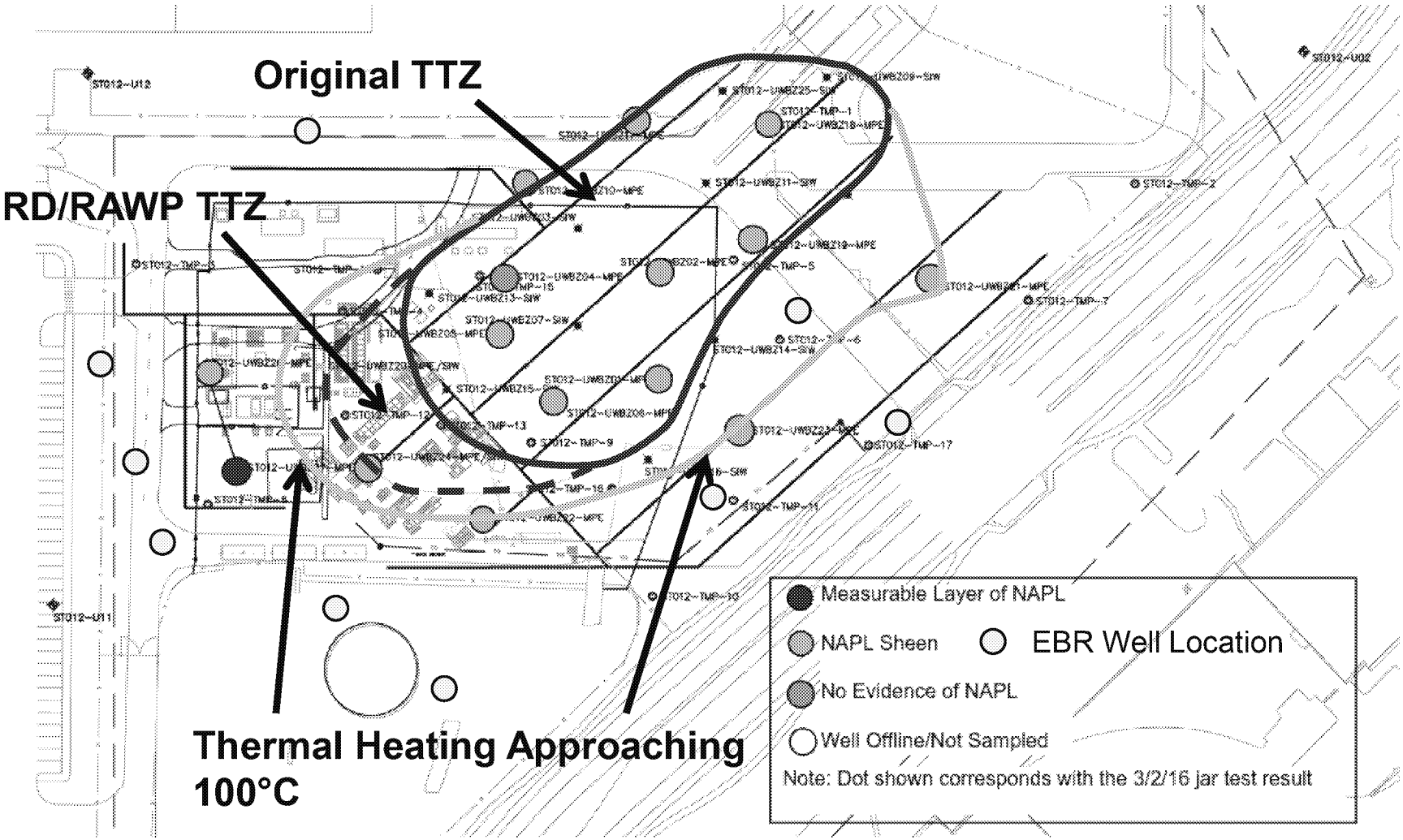
Site ST012 LNAPL Characterization

- LNAPL Characterization has been refined at each step
  - PDI (11 new locations, sonic)
  - Full-Scale Drilling (64 new locations, 23/41-sonic/ARCH)
  - EBR Phase 1 (20 locations, sonic) (next step)
- EBR Phase 1 drilling will improve characterization
- Future EBR phases will further characterize as necessary
- Characterization does not need to be complete to proceed with EBR

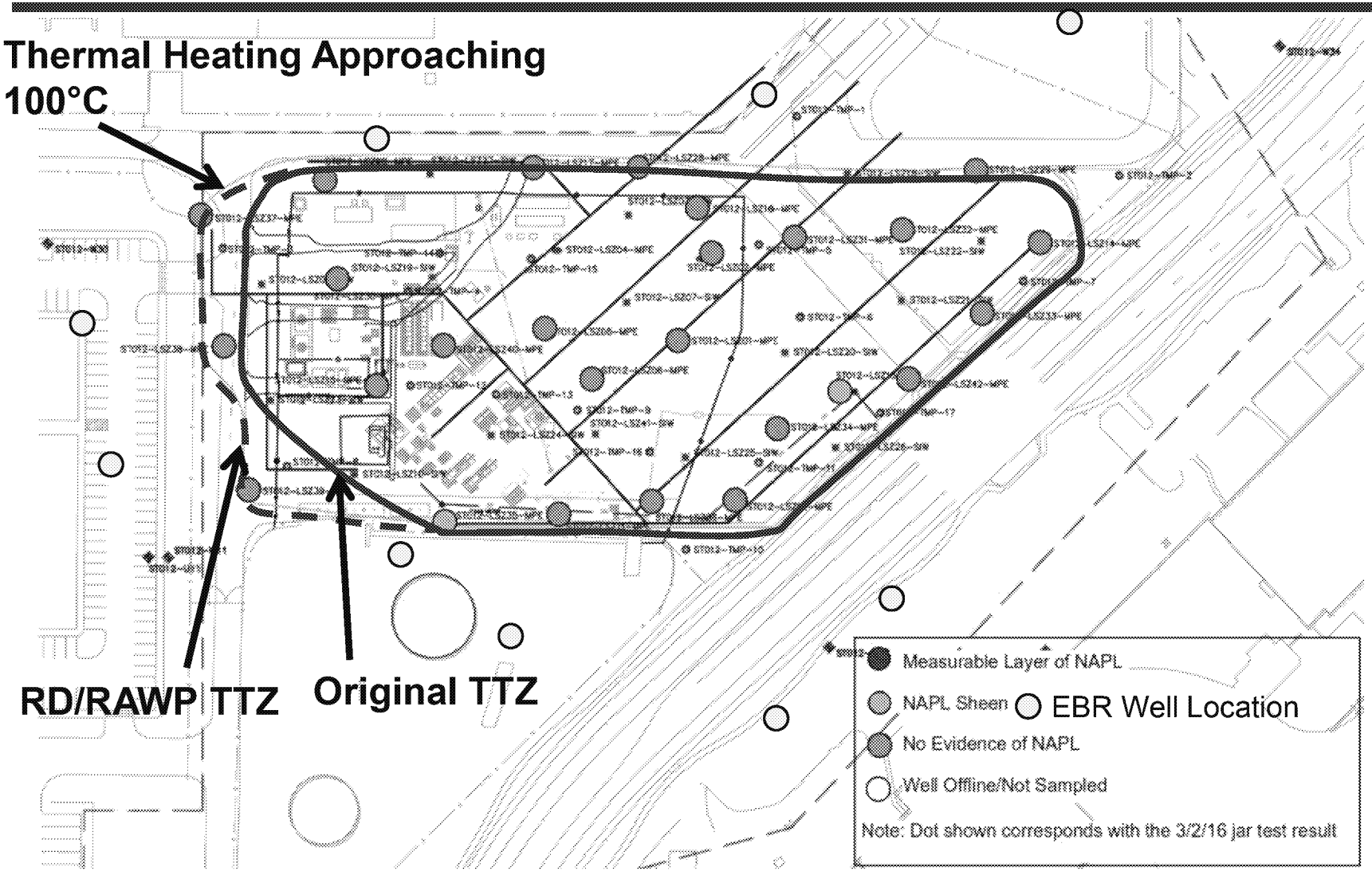
Cobble Zone – EBR Well Locations



Upper Water Bearing Zone – EBR Well Locations



Lower Saturated Zone – EBR Well Locations



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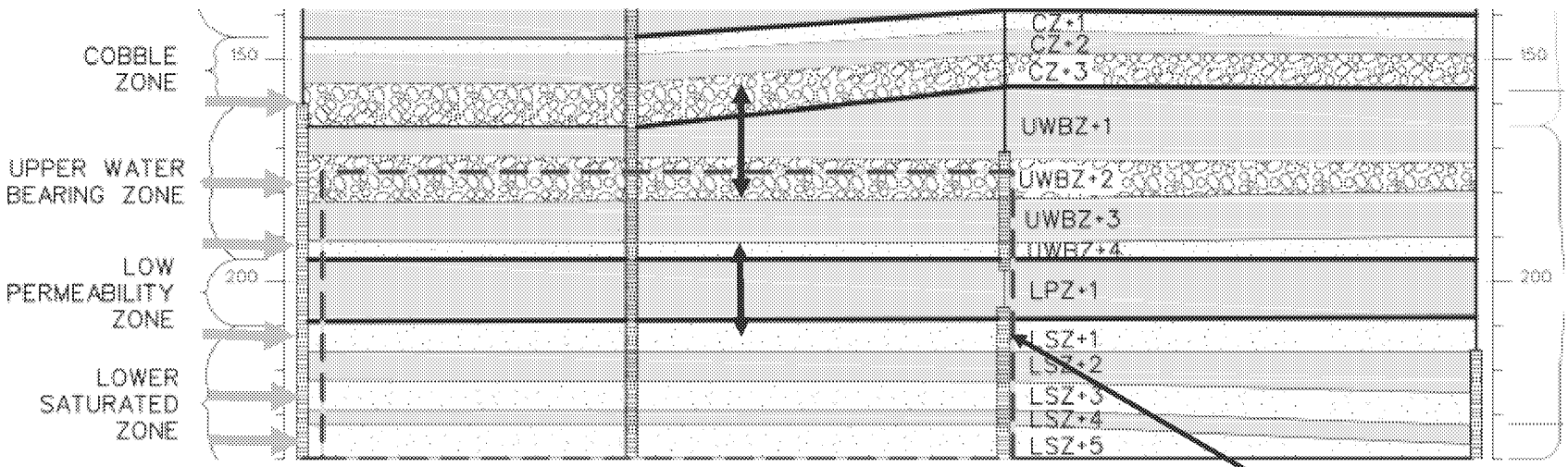
Site ST012 Mass Flux

- LNAPL mass in low-permeability zones will have limited direct interaction with active EBR
- Mass flux from these layers will control long-term compliance with ROD groundwater cleanup goals
- When contaminant mass flux from these layers is less than available TEA flux, compliance at monitoring wells will be achieved

Site ST012 Mass Flux

■ Simplified Conceptual Model



Contaminant flux (back diffusion) from low-permeability zones

Well screens intercept groundwater mostly from higher permeability zones. Contaminant flux mixes with cleaner groundwater and degrades with support of TEA flux.

EBR Amendments and TEA Flux

Air Force Civil Engineer Center

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FORMER WILLIAMS AIR FORCE BASE

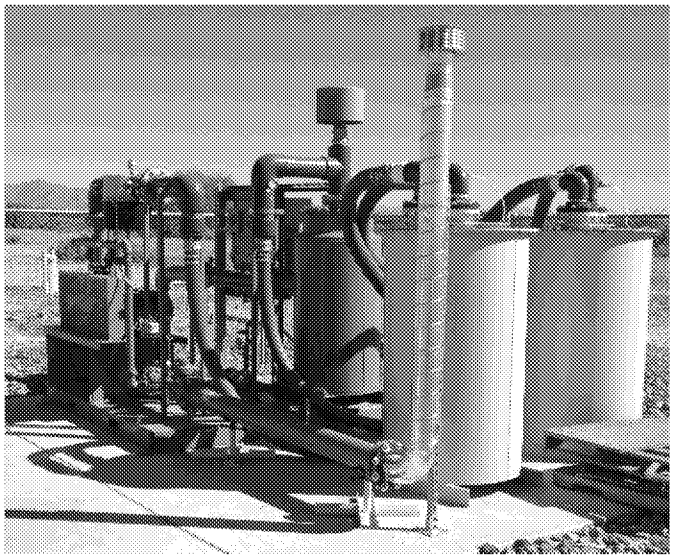
Site LF004 Landfill Remedial Action

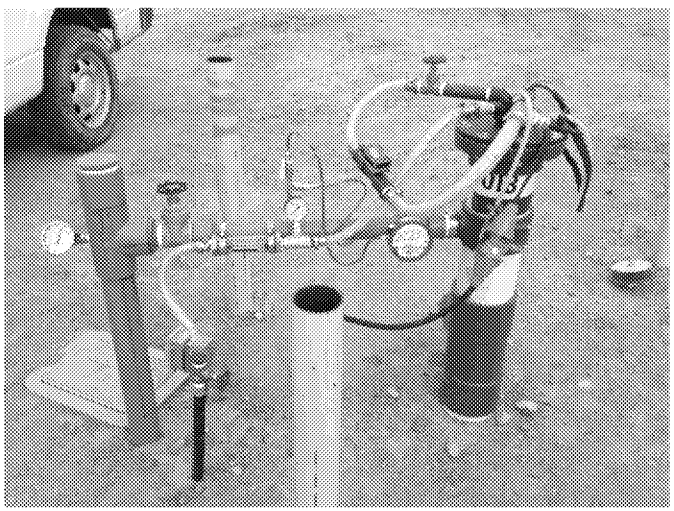
BRAC Cleanup Team Meeting
15 March 2016

Site LF004
LF01-W17 Area IWAS System Update

Operations Summary through 4 Mar 2016

- Began operation 29 Aug 2014 (18 months of operation)
- Average 99% operational uptime for Feb 2016 reporting period
- TCE and PCE concentrations in extracted vapor are 200 and 110 micrograms per cubic meter ($\mu g/m^3$), respectively (Jan 2016); extracted vapor concentrations remain low. Air sparging shut down in Aug 2015 to increase soil gas mass removal (extracted vapor concentrations higher without air sparging)
- Estimated 6.8 pounds of TCE and PCE removed by vapor extraction; 0.3 pound since 5 Feb 2016
- All remediation wells operating





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Site LF004
Southeast Landfill SVE System Update

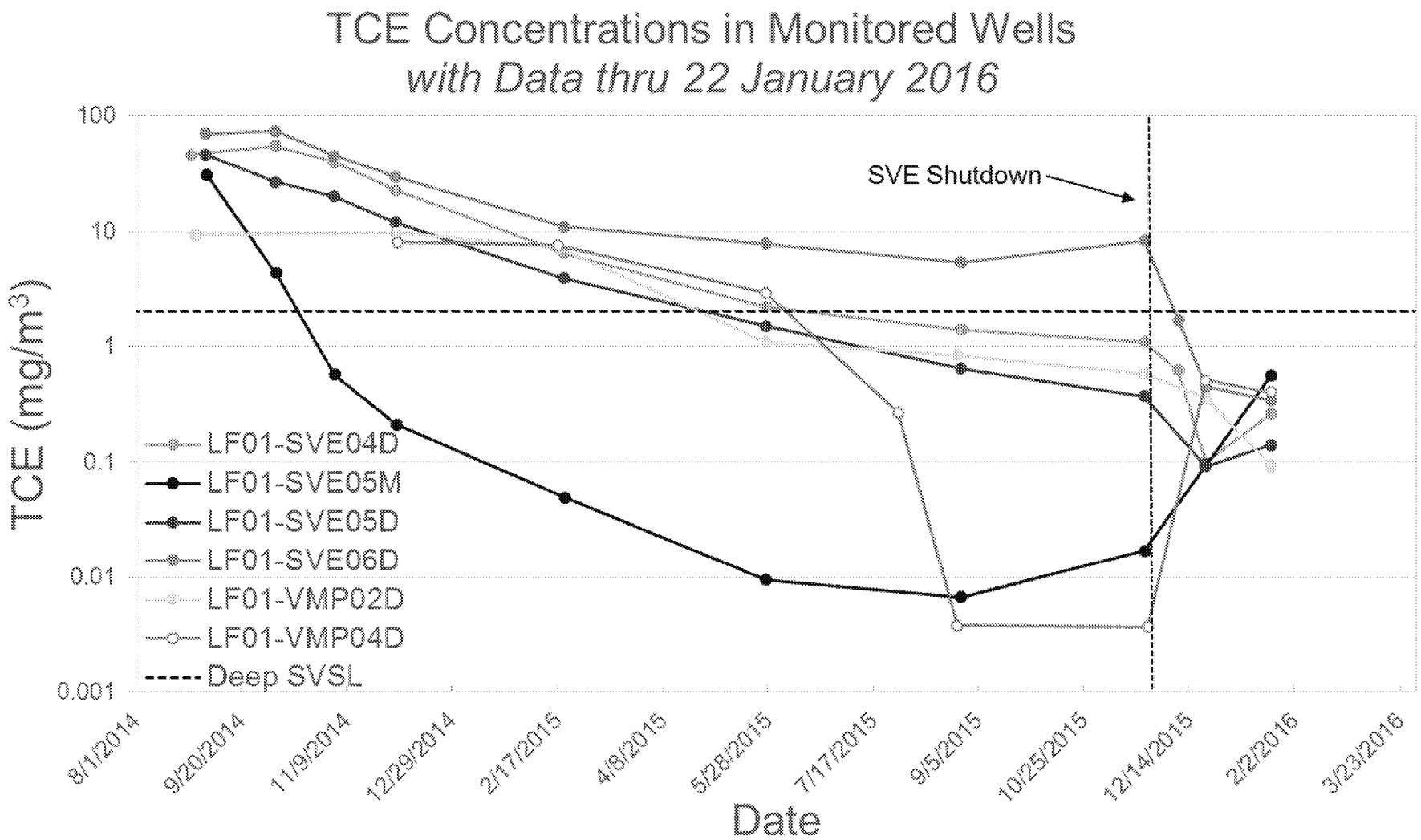
Operations Summary through 4 Mar 2016

- Began operation 12 Sep 2014 (15 months of continuous operation)
- Shutdown for 2 months for rebound testing
- System restarted (SVE7-D, RW02-A) following rebound test sampling on 22 Jan 2016. SVE7-M started in Mar 2016.
- PCE and TCE concentrations in extracted vapor are 1,700 and 320 $\mu g/m^3$, respectively (Jan 2016). PCE > than 95% reduction from peak; TCE >95% reduction from peak
- Estimated 33.9 pounds of PCE and TCE removed by SVE; 0.2 pound from 5 Feb 2016 thru 4 Mar 2016

Site LF004
Former AST and SE Landfill
SVE System Update

- **Rebound Testing**
  - Conducted site wide quarterly soil vapor testing on 23 Nov 2015
  - Shutdown Former AST and SE Landfill SVE systems on 30 Nov 2015 for the Rebound Test
  - Following shutdown, PID concentrations were monitored at target SVE wells on a weekly basis
  - For the AST Area: collected samples from SVE4-D and SVE6-D on 9 Dec 2015 (1 week after shutdown), 22-23 Dec 2015 (3 weeks after shutdown) and 22 Jan 2016 (8 weeks after shutdown)
  - For the SE Landfill Area: collected samples from SVE7-D and VMP5-D on 23 Dec 2015 and 22 Jan 2016

Site LF004
Former AST SVE System Update



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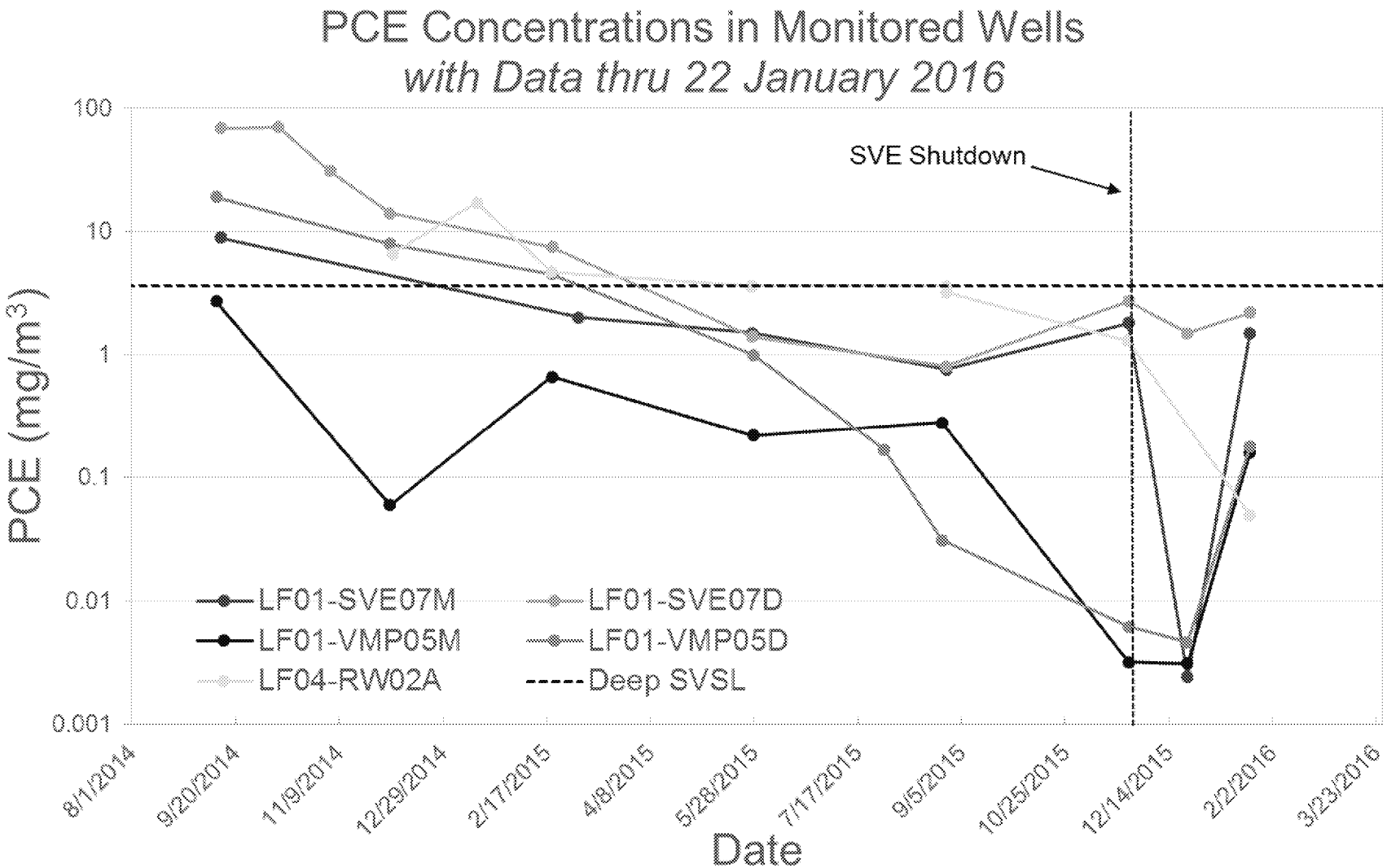
Site LF004
SE Landfill SVE System Update



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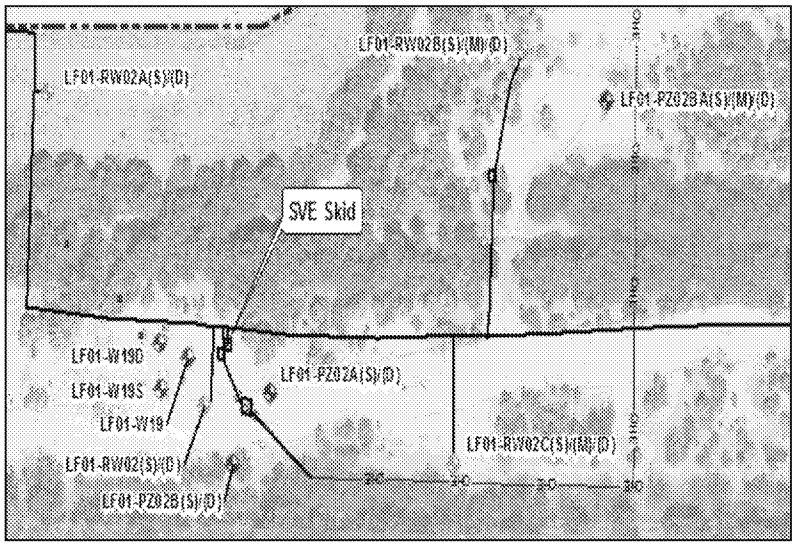
Site LF004
Former AST and SE Landfill
SVE System Update

- **Assessment of Results**
  - Analytical data indicates TCE and PCE concentration declines in most wells (notably at SVE4-D and SVE6-D in AST area, the wells with the highest concentrations)
  - TCE concentrations increased at SVE5-M and VMP4-D in the AST area and SVE7-M, VMP5-M and VMP5-D in SE area but not above the Deep SVSL as of the end of Jan 2016
- **Path Forward**
  - Restarted Former AST and SE Landfill SVE System at completion of test while awaiting receipt and evaluation of Mar 2016 sampling results
  - Focus extraction operations at SVE4-D ,VMP4-D, and SVE6-D in Former AST and SVE7-D and RW02-A in SE Landfill. Several additional wells may be operated in Mar 2016.

Site LF004
Southern Area Oxidant Injection

Activity Summary through 4 Mar 2016

- Began operation 15 Sep 2014 (18 months of operation)
- Additional oxidant injection completed week of 27 Feb 2016 at LA06-S and W19-S
- Presence of oxidant (field screening) following oxidant injection observed at piezometers in shallow zone at LA06-S and W19-S areas



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Site LF004 Remediation System Recent and Upcoming Activities

- Operation of IWAS and Southern Area remediation wells will continue
- Semi-annual groundwater monitoring event scheduled for May 2016
- SVE restarted with focused extraction at SVE4-D (AST), SVE6-D (AST), VMP4-D (AST) SVE7-D (SE), and RW02-A (SE). SVE will also occur at SVE5-M and SVE5-D (AST) and SVE7-M (SE).
- Vapor monitoring scheduled for end of Mar 2016
- Landfill inspection report under AF review
- Posting of analytical data to Sharepoint will continue as results are received; available data through Feb 2016 will be posted by 18 Mar 2016
- LF004 Operating Properly and Successfully report in preparation. Anticipated submittal is May 2016.

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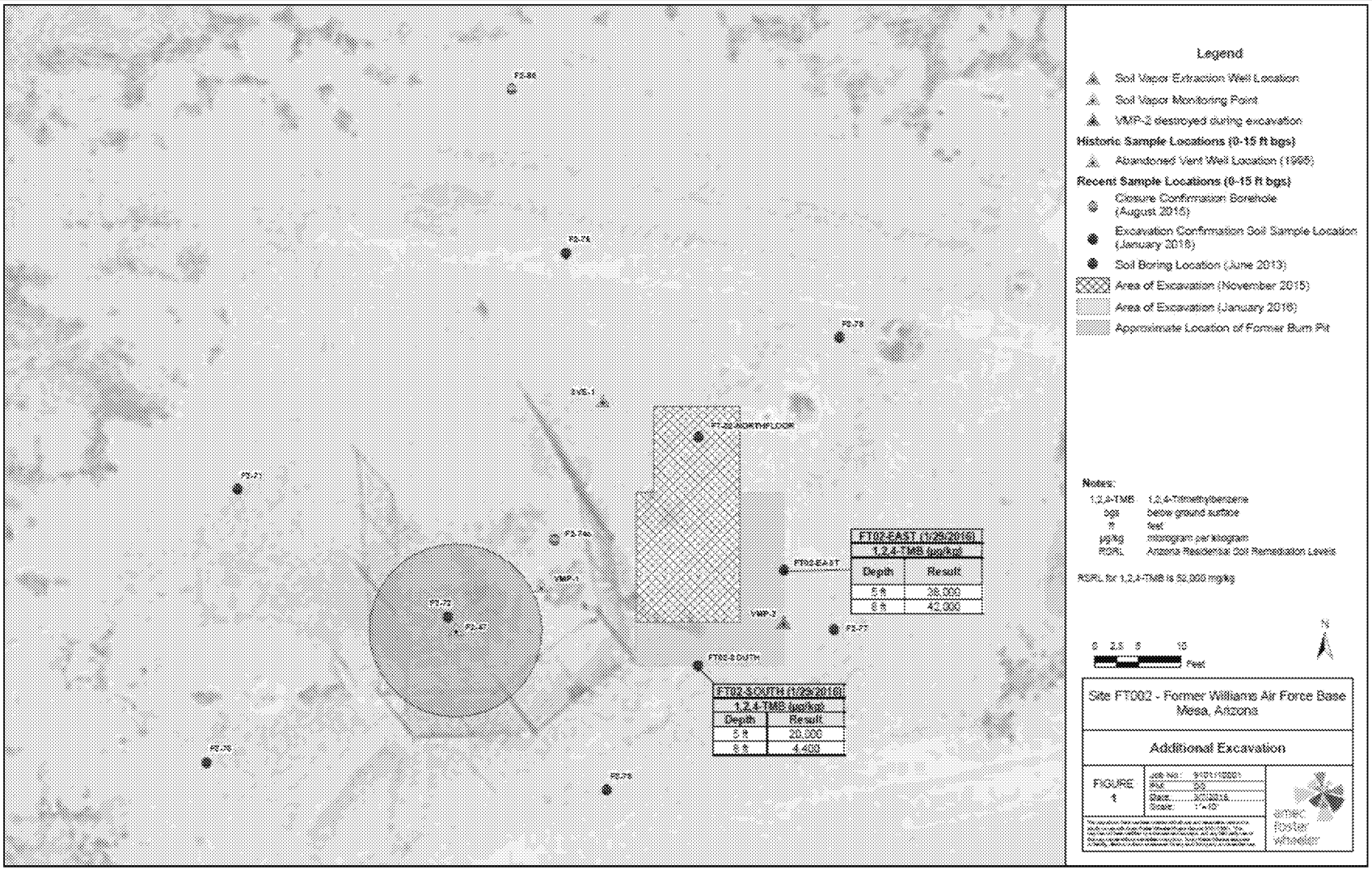
Site FT002
Fire Training Area
Remedial Action

BRAC Cleanup Team Meeting
15 March 2016

Site FT002 Update

- The south half of the excavation was extended approximately 8 feet to the east and south on 28 Jan 2016. The excavation remained open and secured by the fence until analytical results were received and confirmed that RSRL for 1,2,4-TMB has been achieved.
- An additional confirmation sample was collected from North floor in original excavation. Analytical results are pending.
- Confirmation soil samples for DoD certified analysis were collected from the east and south walls at 5 and 8 feet deep.
- Analytical results for the soil samples indicated that the RSRL for 1,2,4-TMB was achieved.
- The excavation was backfilled on 26 Feb 2016

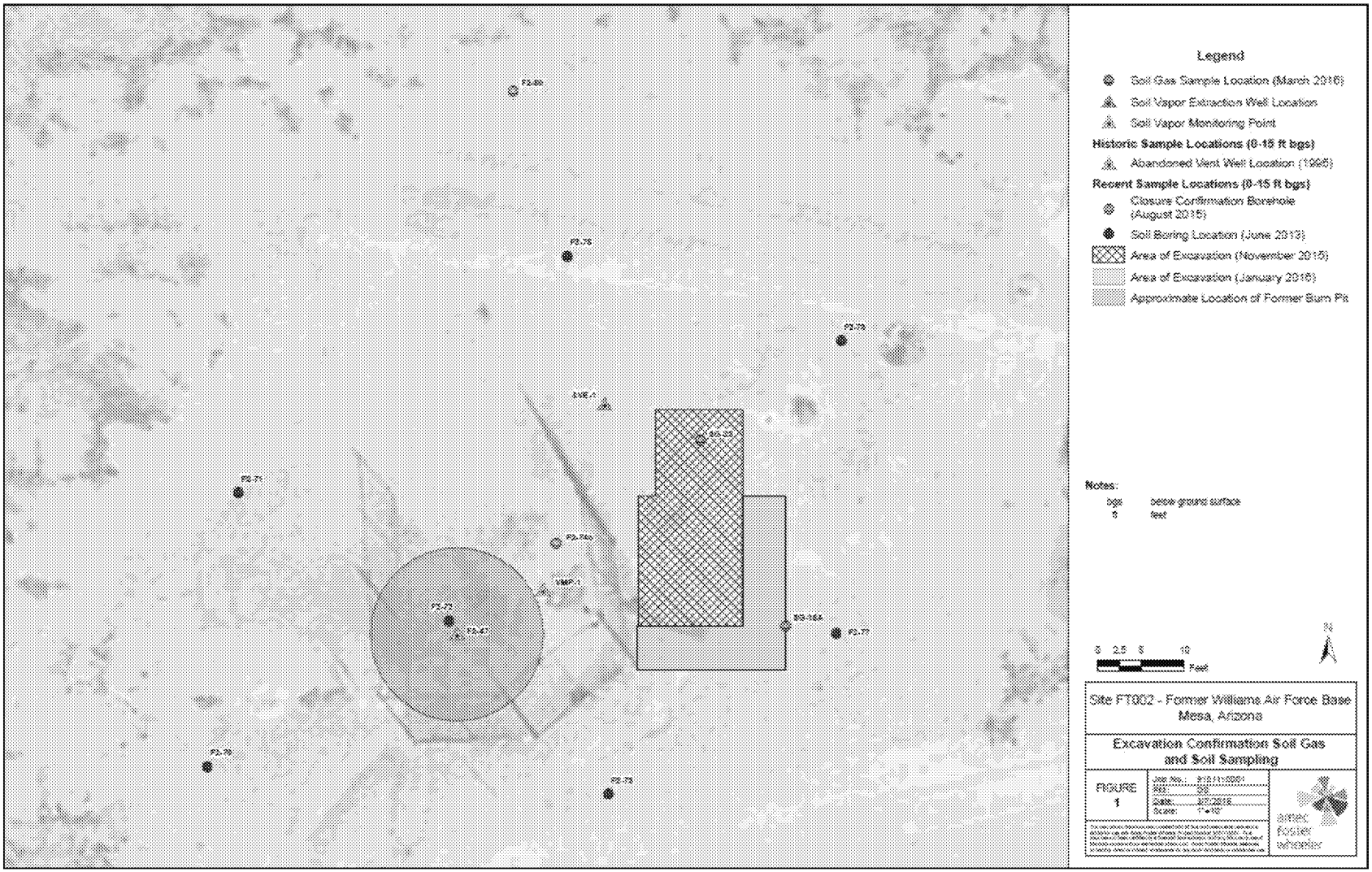
Site FT002 – Additional Excavation Confirmation Soil Sampling Jan/Feb 2016



Site FT002 Path Forward

- Confirmation soil gas samples were collected (9 Mar 2016) at 6 ft bgs from VMP-1 and temporary probes SG-18A (former location of VMP-2), and SG-23 (location of former boring F2-76C). Samples were submitted for analysis by DoD certified Method TO-15.
- If 1,2,4-TMB is below the Sub-Slab Soil Vapor Remediation Goal (SSSVRG) of 8 parts per million by volume (ppmv), then the Closure Report will be completed and submitted.

Site FT002 –Confirmation Soil Gas Sampling Mar 2016



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Site SS017

Old Pesticide/Paint Shop

BRAC CleanupTeam Meeting
15 March 2016

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Five-Year Review

BRAC Cleanup Team Meeting
15 March 2016

Five-Year Review

- Fourth five-year review initiated
  - Review period
    Sep 2015- Sep 2016
- Site inspections completed in Dec 15/Jan 16
- Public notice published on Dec 17 and 24 2015 in the East Valley Tribune, San Tan/Queen Creek Independent, East Mesa Independent, and Daily News-Sun

Five-Year Review Path Forward

- Conduct Survey participation
  - RAB members
  - BCT members
  - Key Stakeholders (PMGAA, GRIC, ASU, City of Mesa, City of Gilbert)
- Participation will be made available via in-person interviews, telephone interviews, or online survey tools
- Tentative schedule
  - Draft submittal in May 2016
  - Agency review May/Jun 2016
  - Comment resolution Jun/Jul 2016 (A Draft Final is not anticipated but would be submitted in July 2016 if warranted)
  - Final in Aug 2016

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Parcel N
PFC PA/SI Update

BRAC CleanupTeam Meeting
15 March 2016

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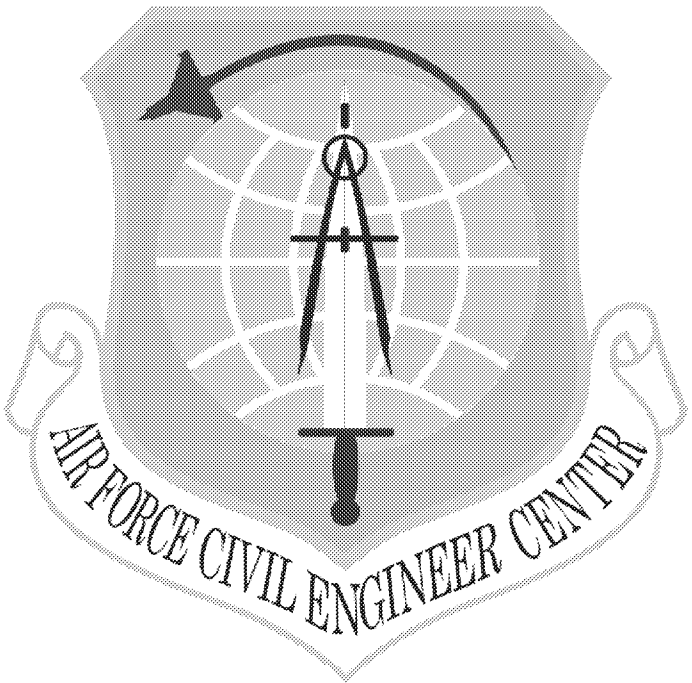

2016 BCT MEETINGS/CONFERENCE CALLS SCHEDULE

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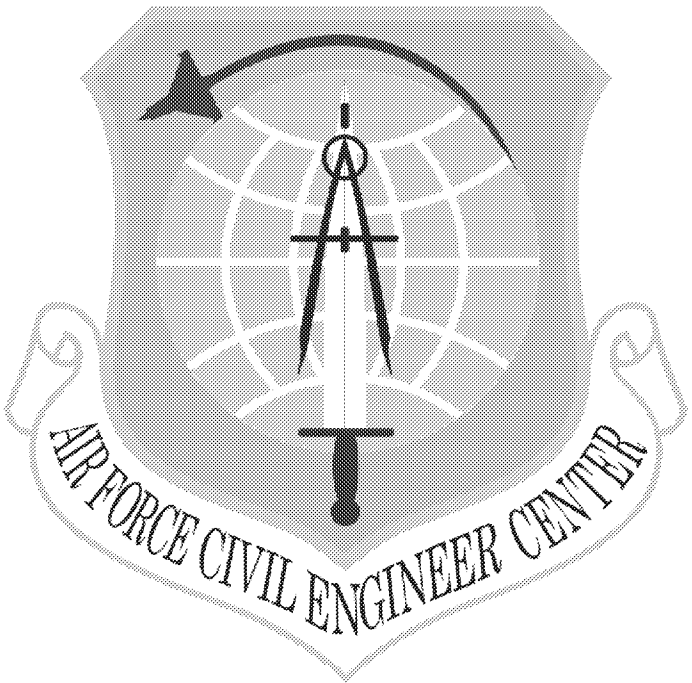

BCT GENERAL UPDATE

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ACTION ITEMS

89