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23 March 2011

William Welling
Remedial Bureau E, Section D
Div. Environmental Remediation
NYSDEC
625 Broadway, 12th Floor
Albany, NY 12233-7017

RE: Evaluation of Groundwater Remediation Actions at Chem-Core Site
Contract/WA No: D004441-02
Site/Spill No/Pin: Chem-Core Site, Buffalo, New York (915176)

Dear Mr. Welling:

EA Engineering, P.C. and its affiliate EA Science and Technology (EA) have been tasked to evaluate the groundwater remediation actions ongoing at the Chem-Core site located in Buffalo, New York. EA has been performing Operation, Maintenance, and Monitoring (OM&M) at the site since March 2008 under Work Assignment #D004441-02. Under the existing Work Assignment, EA is conducting quarterly groundwater monitoring, performing monthly OM&M site visits, and report preparation.

The Chem-Core site is currently an active remediation site utilizing a bedrock groundwater extraction process to provide plume containment and a system to treat contaminated groundwater for discharge to the local sanitary sewer system. The specific remediation goals and objectives for the Chem-Core site are outlined in the New York State Department of Environmental Conservation (NYSDEC) Record of Decision (ROD)[1]. EA has prepared this letter to summarize the evaluation of the groundwater remediation efforts at the site and provide recommendations for future management of the site.

SITE HISTORY

The Chem-Core company had used the site since the early-1930s as a chemical-handling facility, with several business and commercial tenants operating within rented portions of the former site structure. During the initial operation of the company, a significant percentage of the business was related to supplying acids to metal fabrication industries. During the 1950s, sales involved chlorinated solvents for the dry cleaning industry. In the 1970s and 1980s, the company sold chlorinated degreasing solvents.

Until 1980, Chem-Core received shipments via a rail spur located directly west of the building. During the 1970s and until 1988, the company received bulk liquid materials at an off-loading station on the north side of the building. The materials were transferred into 55 gal drums by a gravity operated drum filling machine connected to the truck with a hose. The company had a United States

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1. NYSDEC. 2003. *ROD, Chem-Core Site, Buffalo, Erie County, New York, Site Number 915176*. January.

Environmental Protection Agency hazardous waste identification number and was classified as a Resource Conservation and Recovery Act small quantity generator.

Several environmental investigations reported soil contamination at the site exceeding the soil cleanup goals established by the NYSDEC. Areas of highest concentrations in soil included the former tanker loading area at the north end of the former building and the former solvent above ground storage tank area inside of the loading dock area near the center of the building. Both areas of concern had elevated volatile organic compound (VOC) concentrations and were believed to be sources for groundwater contamination, as contaminants were identified primarily at the soil-bedrock interface.

Groundwater analyses showed that significant VOC contamination existed in groundwater at the site. It was evident that source contamination from on-site soil had migrated to the bedrock aquifer. In February 2000, the Chem-Core site was designated as a Class 2 site signifying that the contamination at the site posed a significant threat to human health and the environment, and required action.

After completion of a Remedial Investigation and Feasibility Study, NYSDEC issued a ROD for the site in January 2003. Elements of the ROD included building demolition, excavation, and disposal of contaminated soil; and groundwater extraction and treatment.

Remedial History

Remedial construction activities conducted at the site consisted of building demolition, on-site soil excavation and disposal, site backfilling and restoration, extraction well and monitoring well installation, installation of an infiltration gallery intended for use in an on-site *in-situ* bioremediation effort, and groundwater treatment system installation and start-up. The remedial construction activities were performed by Horizon Environmental Services (HES), under the oversight/direction of URS Corporation (URS) also serving as the remedial design engineers, and NYSDEC acting as the contracting authority.

In addition to the on-site remedial construction activities, URS was contracted by NYSDEC to conduct an off-site *in-situ* bioremediation pilot study as an element to address groundwater remediation as defined in the ROD. The objective of the pilot study was to evaluate the effectiveness for *in-situ* bioremediation and implement a full-scale remediation of off-site groundwater, if necessary. URS performed the off-site *in-situ* bioremediation pilot study during the remedial action construction process.

The ROD also included an evaluation of the groundwater extraction and treatment system after a 5 year operation period. If the results of the evaluation indicated that groundwater VOC concentrations had been reduced sufficiently, implementation of an enhanced bioremediation or another available technology would be considered to have achieved groundwater standards to the extent practical.

GROUNDWATER REMEDIATION ACTIONS

As indicated in the previous section, the ROD issued for the Chem-Core site included the following elements for groundwater containment and remediation.

- Install groundwater recovery wells at the site to extract and control off-site migration of contaminated groundwater.
- Install and operate a treatment system at the site to treat the extracted groundwater for disposal into the sanitary sewer system.
- Evaluate the results from the 5-year operation of groundwater extraction and treatment. If concentrations have been reduced sufficiently, implement enhanced bioremediation or another available technology to achieve groundwater standards to the extent practicable.
- Implement a bioremediation pilot study for off-site groundwater contamination (south of site), to occur during construction of the remedy. Based on the results from the pilot study, implement a full-scale remediation of off-site groundwater, if necessary.
- Implement a long-term OM&M program for the groundwater extraction system.

***In-Situ* Bioremediation Pilot Study – URS Corporation 2005 - 2007**

URS finalized a work plan and began implementation of the off-site bioremediation pilot study in April 2005. The bioremediation pilot study lasted for just over a 1-year period and was conducted in area located approximately 200 ft south of the site-proper. The pilot study injection wells were installed approximately 20 ft into the bedrock formation and 40 ft below ground surface (bgs) in a layout that covered approximately 4,000 ft^2. The pilot study area was selected based on its downgradient location and relative concentration range of total VOCs (1-2 parts per million [ppm]). VOCs consisted primarily of chlorinated VOCs, specifically tetrachloroethene (PCE), trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-DCE), *trans*-1,2-dichloroethene (*trans*-DCE), and vinyl chloride (VC).

After a review of two potential substrate products, URS selected emulsified oil substrate (EOS™) due to its low viscosity, the slow release nature of the substrate, the availability of the substrate as a pre-mixed emulsion that could be blended with a B12 supplement to enhance bioremediation, and the fact that there was no special handling or mixing requirements. In total, URS applied 110 gal of EOS™ within the treatment area using a water-to-substrate mixture ratio of 33.3:1. In addition, 500 milliliters of vitamin B12 were added to each 55-gal drum of EOS™ concentrate. URS also added sodium sulfite as an oxygen scavenger to reduce the introduction of oxygen to the EOS™ solution during injection. The substrate solution was delivered to the target treatment zone via the injection wells utilizing a direct pressurized injection system with hydraulic pump and pneumatic packer assembly. The injections typically lasted between 5 and 15 minutes at three successive 6–7 ft bedrock intervals, starting at the bottom of each rock open intake. The injection period lasted 1 week and was followed by the collection of groundwater samples from eight wells within the treatment area during five sampling events.

URS/NYSDEC authored a technical paper in March 2007 describing the pilot study and its results, concluding that a single EOS™ injection event induced strong reducing conditions and generally sustained favorable geochemical conditions for anaerobic reductive dechlorination to occur within the pilot study area for a period of approximately 1 year. The post-injection monitoring results indicated that PCE and TCE, and their daughters products, were successfully degraded at an accelerated rate to innocuous end products while sufficient substrate was available within the bedrock aquifer. It was reported that between the third and fourth sampling event, geochemical conditions became less favorable for the complete dechlorination of PCE and TCE.

Groundwater Extraction & Treatment System Installation and Start-up (2006 – 2007)

During the remedial construction activities, HES installed the groundwater extraction and treatment system in accordance with the remedial design plans and specifications. The purpose of the groundwater extraction system was to contain impacted groundwater onsite and to prevent, to the extent practicable, further contaminant migration offsite. Based on pump tests and analysis performed by URS, it was expected that containment could be achieved at a pumping rate between 2 and 6 gal per minute (gpm). The groundwater extraction and treatment system was designed for a maximum capacity of 10 gpm to allow for a factor of safety.

The groundwater extraction system consists of two 6-in. extraction wells installed to a depth of 50 ft bgs and approximately 31.5–33 ft into the bedrock formation. Each extraction well is equipped with a submersible pump capable of 5 gpm capacity. The extraction wells are hard piped back to the treatment facility, located in the southwest corner of the site.

HES contracted Maple Leaf Environmental Equipment (MLEE) to fabricate, assemble, and deliver the groundwater treatment system components to the Chem-Core site. The groundwater treatment facility includes a pre-treatment process using a deposit control agent (polymer – Redux 380) via a metering pump, then onto an equalization tank prior to being pumped through four bag filters for the removal of suspended solids, and then to the final process stage through an air stripper for VOC removal. Once the groundwater has been treated, it is discharged to the local sewer system via gravity. A catalytic oxidizer was initially used to treat the vapor stream process from the air stripper due to vapor phase VOC concentrations.

HES provided the first 6 months of OM&M of the treatment system at the Chem-Core site beginning in March 2007. The groundwater treatment system ran approximately 89 percent of the time during the first 5 months of operation. Due to operational issues associated with maintaining the required temperature for the catalytic oxidizer, the system did not operate during the last month of the start-up phase (August 2007). The groundwater treatment system treated approximately 152 gal per hour (gph) or 2.5 gpm during the first 5 months of operation. Treatment system discharge was in compliance with the Buffalo Sewer Authority (BSA) permit requirements throughout the start-up phase.

EOS™ Application in the On-site Infiltration Galleries – URS Corporation (2008 – 2009)

In October 2008, URS applied approximately 55 gal of EOS™ concentrate mixed with 1,500 gallons of potable water at the three infiltration galleries onsite. The substrate mixture was gravity discharged from a high-density polyethylene (HDPE) mixing tank at the ground surface. No groundwater monitoring was performed prior to or after the application by URS. The application dosing within the on-site infiltration galleries was an approximate water-to-substrate ratio of 27.3:1. This mixture ratio (slightly higher than the off-site pilot test) was utilized to potentially compensate for the higher groundwater concentrations of the target VOCs. The infiltration gallery was designed to provide access for application to the top of the bedrock interface and not directly into the bedrock groundwater aquifer via injection wells, as was done during the off-site pilot study. Therefore, this delivery system relied on gravity, hydraulic gradient, and fractures within the bedrock formation to distribute the substrate mixture to the bedrock groundwater system. It would be expected that the on-site extraction wells would provide a downward vertical gradient to the substrate material should the material enter the groundwater system.

In addition to the infiltration gallery application, a re-application of EOS™ was conducted in the pilot study area. Prior to the re-application, URS collected groundwater samples from eight wells within the pilot study area. Analytical results of the baseline groundwater sampling event indicated that VOCs (including PCE, TCE, *cis*-DCE, and VC) were reported at concentrations above site standards, criteria, and guidance (SCGs) values offsite. In total, seven of eight monitoring well locations reported VOCs above the SCGs. Based on the analytical data summary tables provided, *cis*-DCE and VC were the most commonly detected VOCs and reported higher concentration values than PCE in all but one well location (MW-12). This VOC concentration ratio is typically a good indicator of successful reductive dechlorination. The re-application occurred on 13-14 October 2008, when approximately 4.5 gal of EOS™ concentrate was mixed with 150 gallons of potable water and gravity discharged into each of the 24 injection wells from the ground surface. EA did not have access to or review any post re-application data at the off-site pilot study location. In a summary letter to NYSDEC in January 2009, URS indicated that additional sampling was to be performed in February 2009.

Operation, Maintenance, & Monitoring – EA Engineering, P.C. (2008 – May 2010)

EA has been providing OM&M services to NYSDEC at the Chem-Core site since March 2008. Under the initial phase of the Work Assignment, and after the initial site visit and document review, EA performed minor system upgrades and repairs prior to re-starting the groundwater extraction and treatment system. These upgrades and repairs include the installation of an air discharge stack to allow bypass of the catalytic oxidizer during periods when vapor phase VOC concentrations remain low, installation of a new multi-media interface on the catalytic oxidizer unit, and repair of several minor gas leaks on the fuel supply gas line to the catalytic oxidizer. EA restarted the groundwater treatment system on 19 March, 2008.

EA has performed monthly site visits from system restart (March 2008) until system shut down (May 2010), which included groundwater treatment system inspections, maintenance, collection of system performance data, and sampling and analyses of both process and discharge treatment water monitoring data. In addition, EA sampled on-site monitoring wells (MW-20, MW-21, and MW-22) on a quarterly basis during the first year of the OM&M. Beginning in 2009, EA has incorporated a majority (between 13 and 21) of the existing site monitoring wells into the quarterly groundwater sampling program.

The groundwater extraction and treatment system operated for 18 months post-EOS™ application at the infiltration galleries. EA noted EOS™ substrate (white) mixture within the treatment system components in February 2009, approximately 4 months after the application. At the request of NYSDEC, EA shut the groundwater extraction and treatment system down in May 2010 in order to evaluate the effectiveness of the bioremediation effort. In July 2010, monitored natural attenuation parameters were added to the list of analytes under the quarterly sampling program to evaluate site geochemistry for dechlorination potential.

As part of OM&M, EA has prepared quarterly groundwater monitoring reports, as well as quarterly OM&M reports for review and approval by NYSDEC. In addition to the quarterly reporting requirements, EA has developed and submitted a draft Periodic Review Report (PRR) in January 2010 and handles the semi-annual reporting for the Publicly Owned Treatment Works (POTW) discharge permit with BSA when the groundwater extraction and treatment system is operational. EA has maintained the permitting requirements with BSA and plans to renew the discharge permit in April 2011.

The summaries of the analytical results for the quarterly system process data, quarterly groundwater monitoring program, and groundwater extraction and treatment system performance monitoring are provided in the following sections.

SUMMARY OF GROUNDWATER REMEDIATION EVALUATION

Groundwater Extraction and Treatment System

The groundwater extraction and treatment system was designed and constructed to meet the remedial objectives defined in the ROD for the Chem-Core site. The primary objective of the system was to provide containment for on-site groundwater contamination via groundwater extraction and treatment prior to discharge to the sanitary sewer system. An evaluation of the groundwater extraction and treatment system was to be performed after 5 years of operation to evaluate the potential for secondary groundwater remediation utilizing enhanced bioremediation or another available technology to achieve groundwater standards to the extent practicable. This evaluation was premised on sufficient reduction of groundwater contamination concentrations via the groundwater extraction and treatment system process.

To date, the groundwater extraction and treatment system has operated for a period of 29 months or approximately 2.5 years. HES operated the system for 5 months during the start-up and prove-out process beginning in February 2007 until August 2007. EA was then tasked to provide long-term OM&M services at the site from March 2008 until May 2010 when the system was shut down at the request of NYSDEC. At the direction of the NYSDEC, the treatment system was also manually turned off for the period between 3 December 2008 and 27 January 2009. Based on the operational time achieved since installation, the system would need to be operated for an additional 31 months (or until approximately November 2013) in order to fulfill the recommended 5 years of operation described in the ROD.

The groundwater extraction and treatment system has operated approximately 60 percent of the time since installation was completed in February 2007. A number of the system shut downs were not due to operational issues, but short-term intentional shut down periods used to evaluate groundwater contamination under static hydraulic conditions. However, intermittent operation of the extraction and treatment system can result in unstable hydrogeologic equilibrium conditions that are frequently changing/adjusting to imposed conditions and likely results in increased data variability.

In general, groundwater extraction rates have steadily decreased over the operational period. At system start-up under HES, groundwater was extracted and treated at an average of 2.5 gpm during the first 5 months of operation. The maximum design capacity of the treatment system is 10 gpm. However, in order to maintain on-site groundwater containment, pump tests and analysis performed during pre-design phase activities indicated extraction and treatment at 2-6 gpm would be sufficient. Since EA began OM&M, the system has only operated above 2 gpm during 4 months of operation and each of those months were recorded before the EOS™ application. Figure 1 presents the extraction rates of the system since February 2007. Based on the data plotted in Figure 1, flow rates have decreased since the initial start-up. However, it appears that after the EOS™ application, extraction rate capacity at the wells decreased substantially. One of the limitations of EOS™ technology is that permeability changes can result within the subsurface environment due to biomass growth and accumulation, which could directly affect the capacity to recover and process groundwater. Effectively addressing extraction rate issues of the system would significantly increase the operational efficiency and mass removal rates of the treatment system, and would aid in maintaining hydraulic control of on-site groundwater and limiting the potential for off-site migration.

EA also evaluated the overall mass removal rates for the groundwater extraction and treatment system based on the historical total VOCs influent concentrations and gallons of treated groundwater per month. Figure 2 illustrates the cumulative VOC mass removal since system start-up in February 2007. As depicted in Figure 2, the treatment system has removed approximately 212 lbs of VOCs during its operation. Figure 3 shows the monthly VOC mass removal rates since start-up. As shown, the monthly VOC mass removal rates mimic the extraction rate chart provided as Figure 1.

Treatment system process monitoring data has continuously documented that the treatment system effluent continuously meets the discharge criteria set forth in the BSA permit. Analytical results from process sampling and BSA sampling confirm that the treatment system is in compliance and is effectively removing VOC contaminant mass. VC removal rates monitored via the air discharge line have also been continuously below the mass loading effluent limit. As a result, the catalytic oxidizer has not been utilized since installation of the by-pass discharge stack.

On-site Groundwater

Groundwater at the site has been identified as an unconfined aquifer within the bedrock unit, typically encountered approximately 30 ft bgs. Based on groundwater level data collected at the site, generally groundwater flow appears to be westerly, towards Black Rock Canal, with a southwesterly component in the shallow bedrock as confirmed by off-site groundwater VOC concentrations. Groundwater flow conditions observed when the groundwater extraction and treatment system is operating vary widely. Figures 4 and 5 depict the interpreted groundwater flow conditions observed in 2009 (Figure 4) and 2010 (Figure 5), under conditions when the groundwater extraction and treatment system was operating and when it was shut down. Preferably, when the system is operational, the groundwater flow patterns should indicate/depict an inward hydraulic gradient towards the center of the site surrounding extraction wells GEW-01 and GEW-02. An inward hydraulic gradient would ensure that operation of the system, regardless of extraction rates, is capable of maintaining containment for on-site groundwater contamination. Based on groundwater flow interpretation shown in the figures, variation in groundwater flow direction (April and October) at the site was evident in 2009, indicating a slight inward hydraulic gradient in July 2009. During 2010, groundwater gauging data indicated that an inward hydraulic gradient was occurring under system operating and non-operating conditions. The variations in gauging data and groundwater flow regimes are sometimes indicative of bedrock groundwater systems; however, additional investigation into understanding the flow patterns during system operational periods is crucial to meeting the requirements of the ROD and remedial goals at the Chem-Core site.

Under minimum design criteria, the groundwater extraction and treatment system would operate at 2 gpm to maintain hydraulic control (20 percent of design capacity). Operating at a 2 gpm extraction rate, the system would have treated an estimated 4.2 million gal of groundwater through February

2011. When the system was shut down in May 2010, the combined totalizer flow meter reading was approximately 1.9 million gal or roughly 45 percent of expected treatment volume. Contaminant mass removal during the initial operational period of groundwater pump and treat systems are crucial to successful remediation efforts. Anticipated OM&M costs are typically lower during the first 5 years of operation and the systems are expected to perform at a higher mass removal efficiency rate when groundwater concentrations are expected to be higher.

Prior to the implementation of the remedial activities at the site, total VOC concentrations (September 2004) in on-site groundwater typically ranged between approximately 3 and 46 ppm. Based on the latest round of on-site groundwater monitoring data (January 2011), total VOC concentrations were reported between approximately 2 and 47 ppm. A trend graph illustrating the total VOC concentrations in on-site monitoring wells is provided as Figure 6. The total VOC concentration trend since the groundwater extraction and treatment system became operational has been erratic on a quarterly basis; however, the total concentration ranges have remained steady. Figures 7 through 12 illustrate the total VOC concentrations in on-site groundwater monitoring wells and use a linear regression evaluation to depict the concentration trend over time. As shown in the figures, only monitoring well MW-21 shows a decreasing trend in on-site groundwater VOC concentrations over time. Monitoring well MW-21 is located in the central portion of the site in-between the groundwater extraction wells and is likely to be highly influenced by the extraction system and treatment.

The on-site application of EOS™ does not appear to have had a significant effect on groundwater VOC concentrations; although, it should be noted that *in-situ* bioremediation treatment technology is most effective when VOC concentrations have declined and are at lower levels typically in the 1–5 ppm range. In addition, the key to success of *in-situ* bioremediation technology is to effectively deliver the substrate material to the contaminated interval within the aquifer, and provide sufficient amount of material and contact time for the desired biological activity to occur. The infiltration galleries at the site do not allow for direct delivery to the groundwater aquifer, but rather rely on gravity, vertical bedrock fracture intervals, and extraction well pumping to induce vertical movement into groundwater.

Off-site Groundwater

It was determined during the historical investigations at the site that the majority of the dissolved-phase VOC contaminant mass was located onsite beneath the former Chem-Core structure. Off-site groundwater VOC impacts were significantly lower than on-site concentrations and were delineated to areas south and southwest of the site. Total VOC concentrations ranged from approximately >1 ppm to 3 ppm in off-site groundwater samples collected in 2002 and 2004. During the latest quarterly groundwater sampling event (January 2011), total VOC concentrations were reported below 1 ppm with the exception of monitoring well MW-18 (1.2 ppm).

Off-site groundwater trends depicted in Figures 13 through 16 generally show a decreasing trend offsite and at each monitoring well location. Specific VOC concentrations of contaminants of concern are moving towards groundwater standards and are likely approaching asymptotic values. The current conditions have the potential to be considered remediated to the extent practicable should the potential for migration of on-site groundwater contamination be determined to be unlikely. In addition, active natural attenuation processes appear to be continuing in off-site groundwater. Higher concentrations of *cis*-DCE and VC, rather than PCE and TCE, have consistently been reported during the quarterly sampling events. The EOS™ pilot study and re-application appear to have induced stronger reducing conditions when much of the initial reductive dechlorination occurred during periods when geochemical conditions were augmented via injection.

Currently, no site data exist on the structure and ubiquity of native microorganisms that are capable of readily degrading chlorinated VOCs *in situ*. Utilizing enhanced anaerobic bioremediation as a remedial approach would typically require an evaluation/verification that the appropriate microbial communities are stable and active within the subsurface environment. There is potential that native microorganism communities present within the subsurface are not capable of complete reductive dechlorination and a stall in the dechlorination process can occur at *cis*-DCE and VC. A microbial evaluation may be warranted to determine if off-site groundwater is capable of attaining groundwater standards without augmentation.

RECOMMENDATIONS FOR FUTURE MANAGEMENT

The following bullets for future management of the Chem-Core site are intended to support the most efficient and cost effective path forward for meeting the remedial goals at the site.

- In order to maintain compliance with the ROD, the site groundwater extraction and treatment system should be re-started immediately to ensure that containment of on-site groundwater contamination continues.

- Inspection and cleaning of groundwater extraction equipment should be conducted on a quarterly basis in-lieu of the current semi-annual basis, and consideration should be placed on the potential for extraction well redevelopment.

- Increasing extraction rate performance may potentially be a more cost effective remedial approach at the Chem-Core site. As extraction rates increase and stabilize hydraulic control of on-site groundwater contaminants, the need for off-site sampling and monitoring would be reduced and/or eliminated as off-site groundwater impacts continue to degrade over time. As identified in the off-site groundwater section, the *in-situ* bioremediation pilot study and re-application appear to have contributed to the dechlorination of parent VOC compounds and groundwater concentrations have met or are trending towards site SCGs.

- Due to the variations in groundwater elevation data that have been recorded at the site, a survey of the existing monitoring well network should be performed to provide consistent interpretation of gauging data and groundwater extraction effectiveness.

- Conduct a remedial system optimization for the Chem-Core site.

- Implement a complete evaluation of the potential for bioremediation at the site should NYSDEC agree to pursue this as a secondary groundwater treatment alternative.

- If additional *in-situ* bioremediation efforts are to be employed or evaluated for on-site groundwater, additional data requirements should be collected prior to implementation. For example, no site data currently exist on the structure and ubiquity of native microorganisms that are capable of readily degrading chlorinated VOCs *in situ*. Utilizing *in-situ* bioremediation as a remedial approach would require an evaluation/verification that the appropriate microbial communities are stable and active within the subsurface environment.

Sincerely yours,

EA ENGINEERING, P.C.

James C. Hayward

James Hayward, P.E.
Project Manager

EA ENGINEERING, P.C.

Christopher J. Canonica

Chris Canonica, P.E.
Vice President

Figure 1

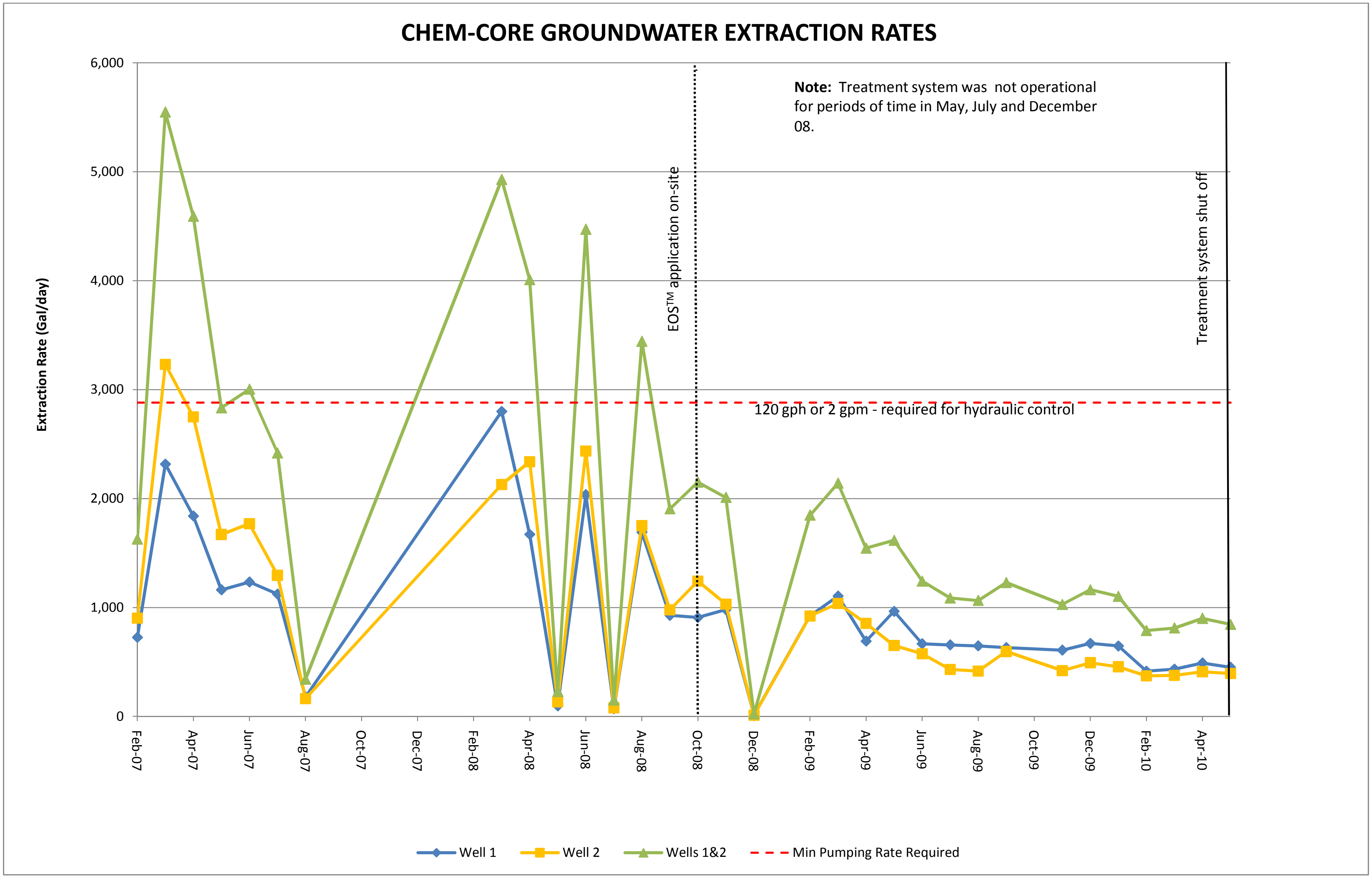
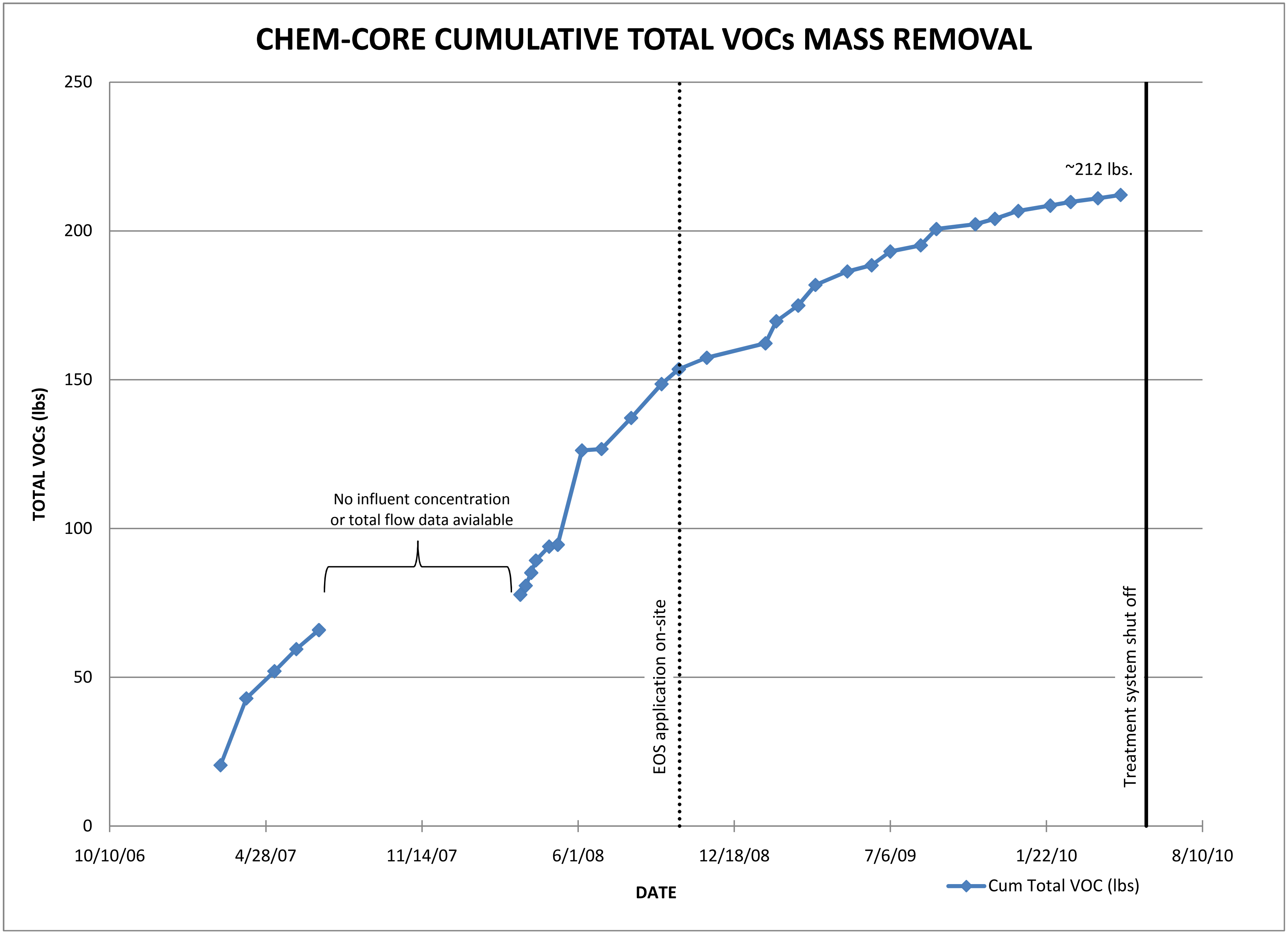
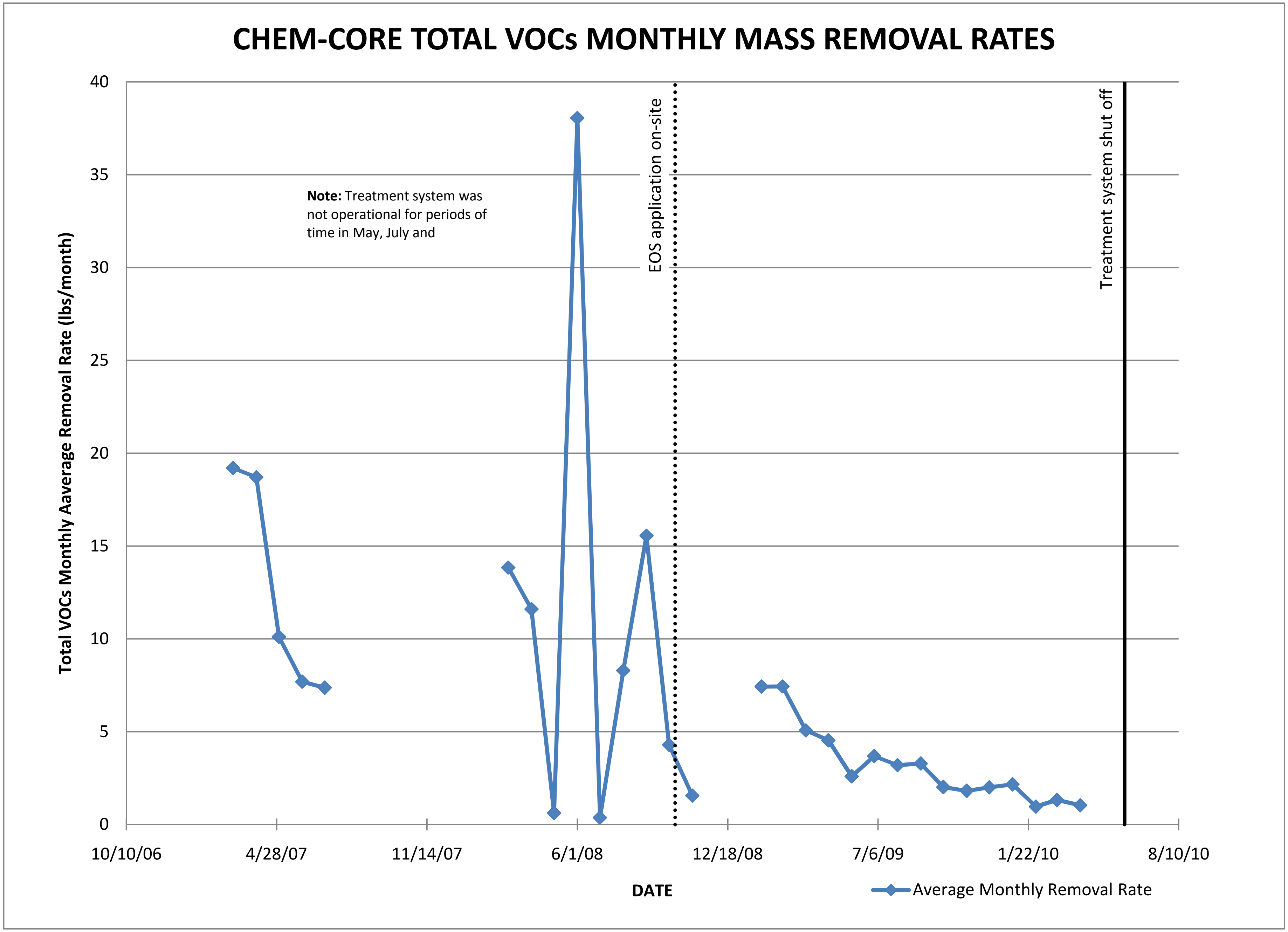

CHEM-CORE GROUNDWATER EXTRACTION RATES
Extraction Rate (Gal/day)
6,000
5,000
4,000
3,000
2,000
1,000
0
Feb-07
Apr-07
Jun-07
Aug-07
Oct-07
Dec-07
Feb-08
Apr-08
Jun-08
Aug-08
Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09
Oct-09
Dec-09
Feb-10
Apr-10
Note: Treatment system was not operational for periods of time in May, July and December 08.
EOS™ application on-site
Treatment system shut off
120 gph or 2 gpm - required for hydraulic control
Well 1
Well 2
Wells 1&2
Min Pumping Rate Required

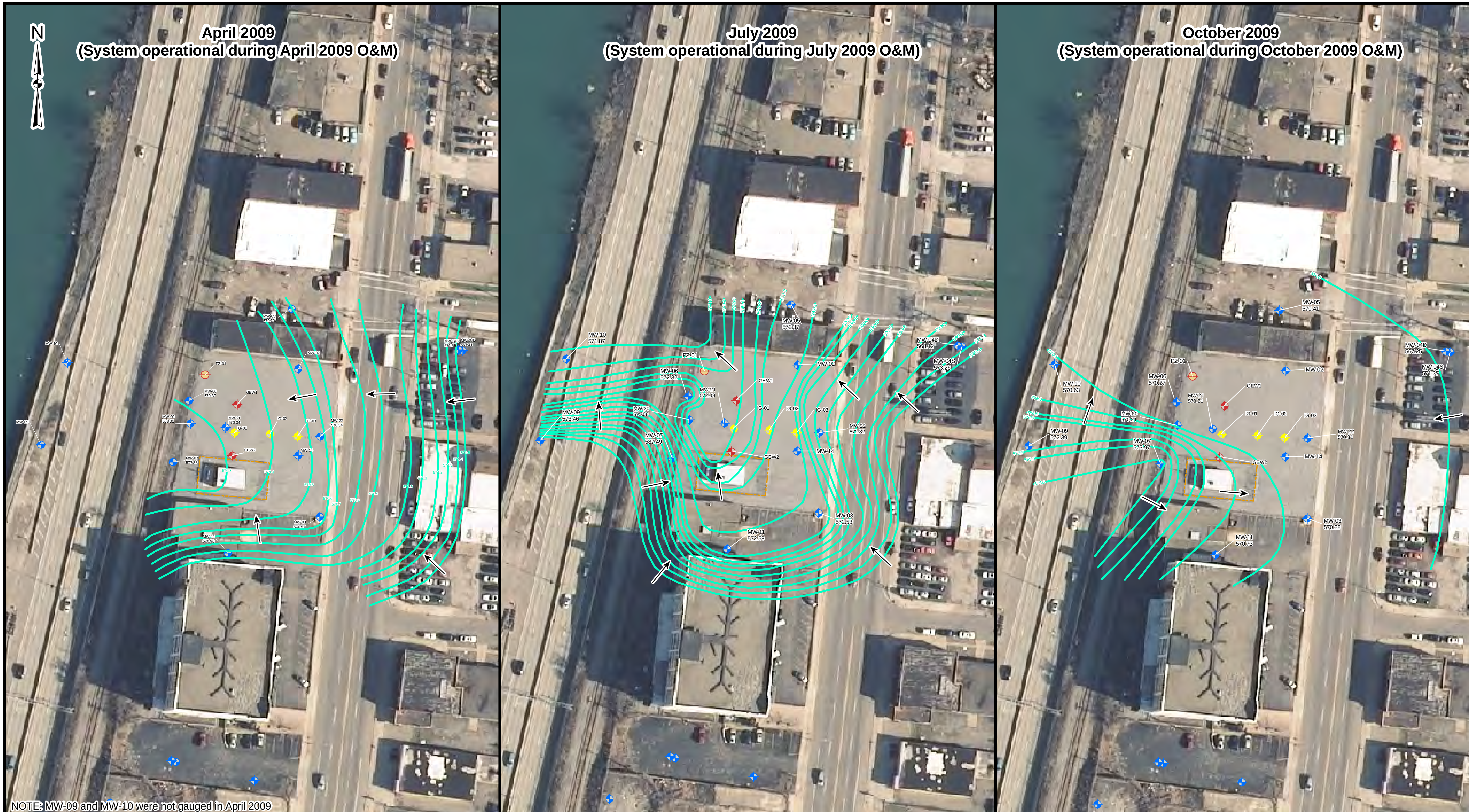
Figure 2

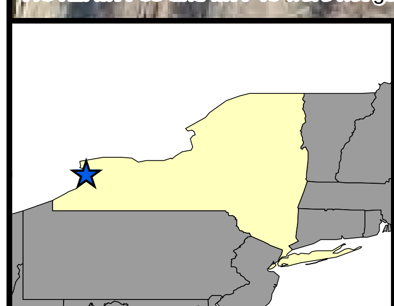


CHEM-CORE CUMULATIVE TOTAL VOCs MASS REMOVAL
TOTAL VOCs (lbs)
250
200
150
100
50
0
10/10/06
4/28/07
11/14/07
6/1/08
12/18/08
7/6/09
1/22/10
8/10/10
DATE
No influent concentration
or total flow data avialable
EOS application on-site
Treatment system shut off
~212 lbs.
Cum Total VOC (lbs)

Figure 3


CHEM-CORE TOTAL VOCs MONTHLY MASS REMOVAL RATES
Total VOCs Monthly Aaverage Removal Rate (lbs/month)
40
35
30
25
20
15
10
5
0
Note: Treatment system was not operational for periods of time in May, July and
EOS application on-site
Treatment system shut off
10/10/06
4/28/07
11/14/07
6/1/08
12/18/08
7/6/09
1/22/10
8/10/10
DATE
Average Monthly Removal Rate





Legend

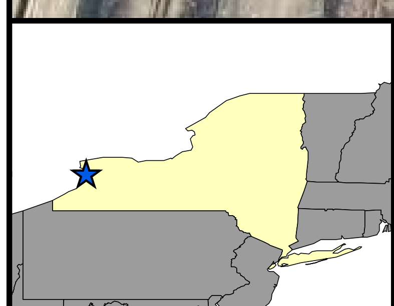
- System Facility Fenceline
- Extraction Wells
- Injection Wells
- Monitoring Wells
- Piezometer
- Groundwater Contour
- Inferred Groundwater Flow Direction

CHEM-CORE SITE (915176)
BUFFALO, NEW YORK

FIGURE 4
INTERPRETED GROUNDWATER CONTOUR MAPS
2009

0 200 Feet

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
JCH	JCP	JCP	JAV	AS SHOWN	MARCH 2011	1447402	GIS/PROJECTS/ FIGUREX.MXD



Legend

- System Facility Fenceline
- Extraction Wells
- Injection Wells
- Monitoring Wells
- Piezometer
- Groundwater Contour
- Inferred Groundwater Flow Direction

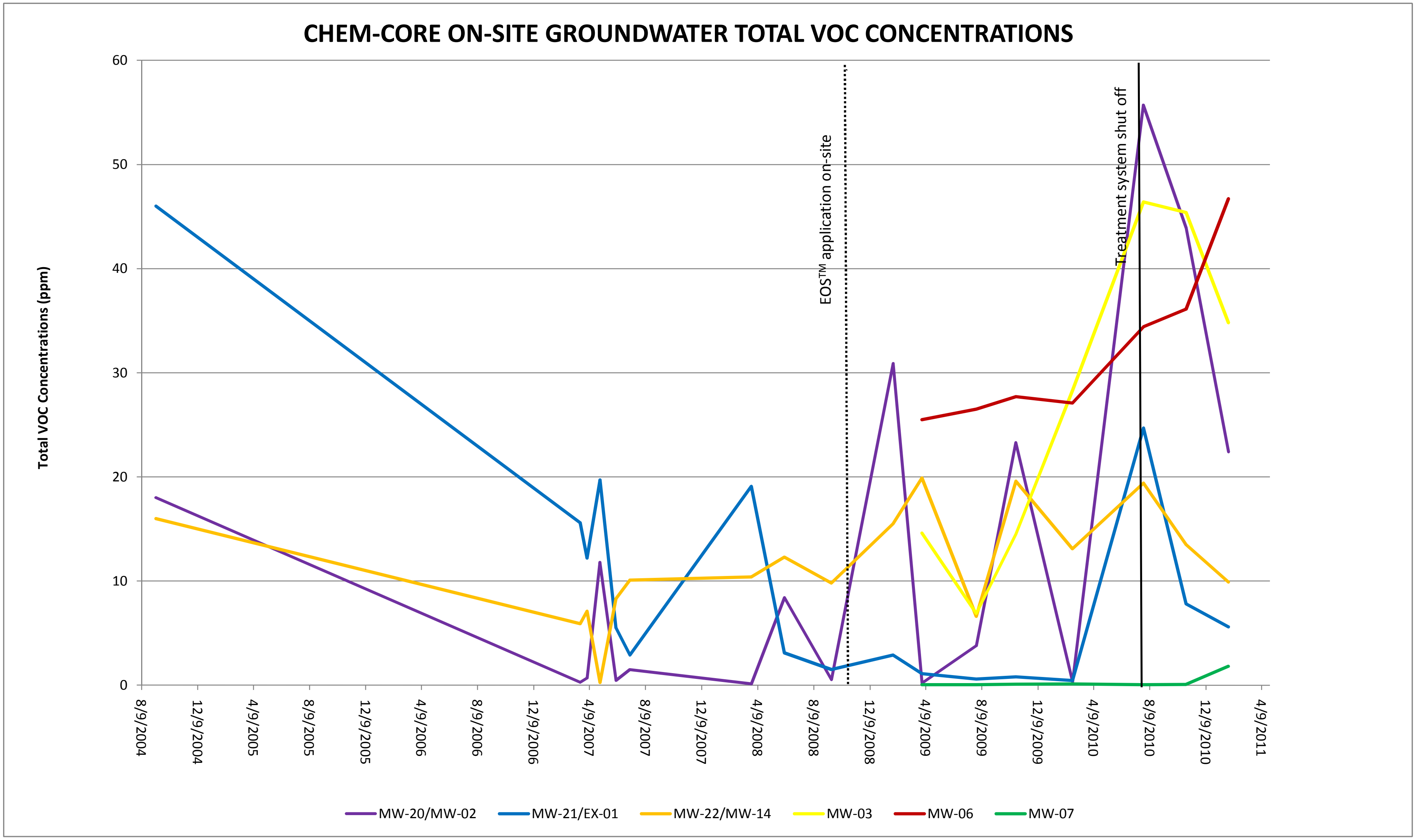
CHEM-CORE SITE (915176)
BUFFALO, NEW YORK

FIGURE 5
INTERPRETED GROUNDWATER
CONTOUR MAPS
2010

0 200
Feet

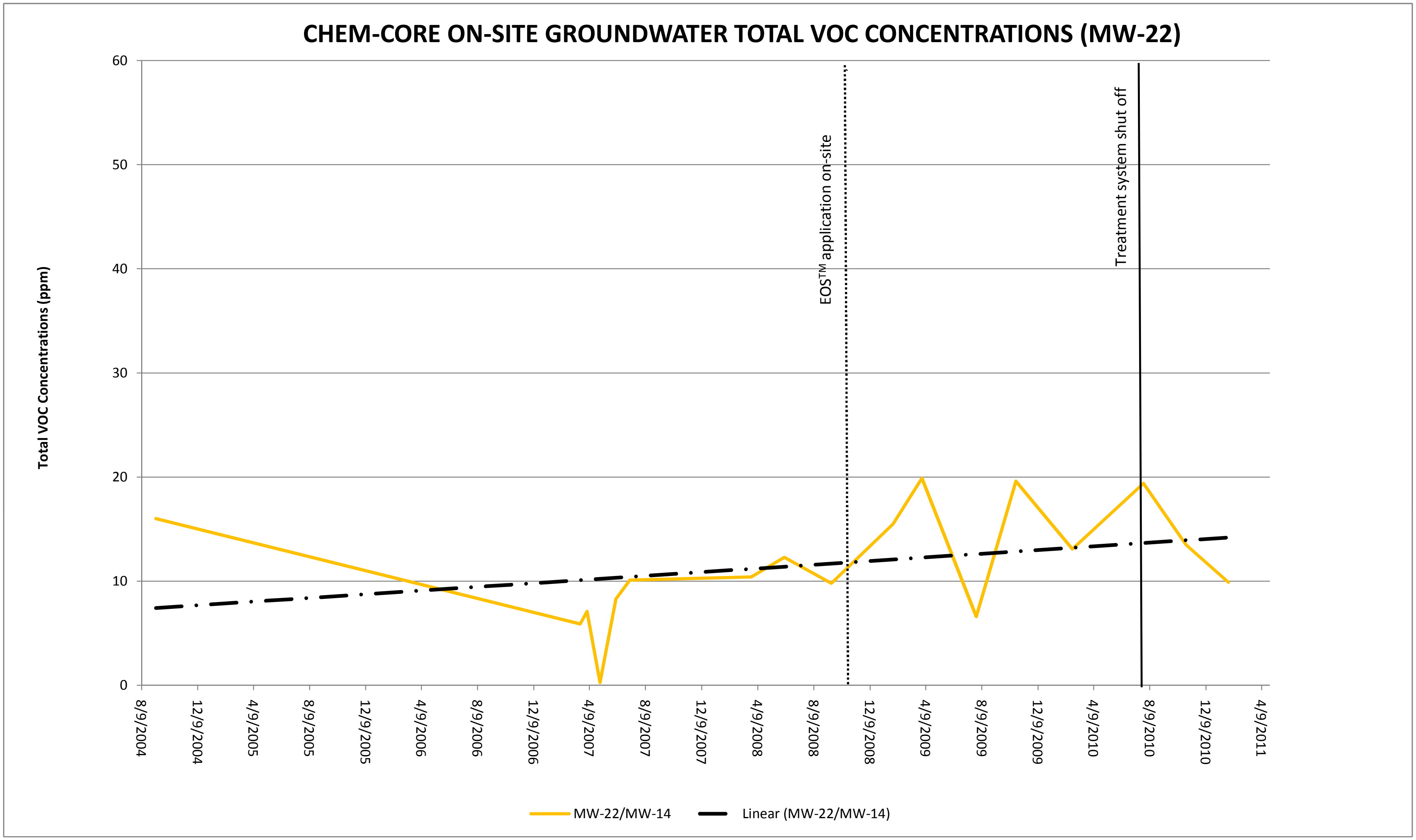
PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
JCH	JCP	JCP	JAV	AS SHOWN	MARCH 2011	1447402	GIS/PROJECTS/ FIGUREX.MXD

Figure 6



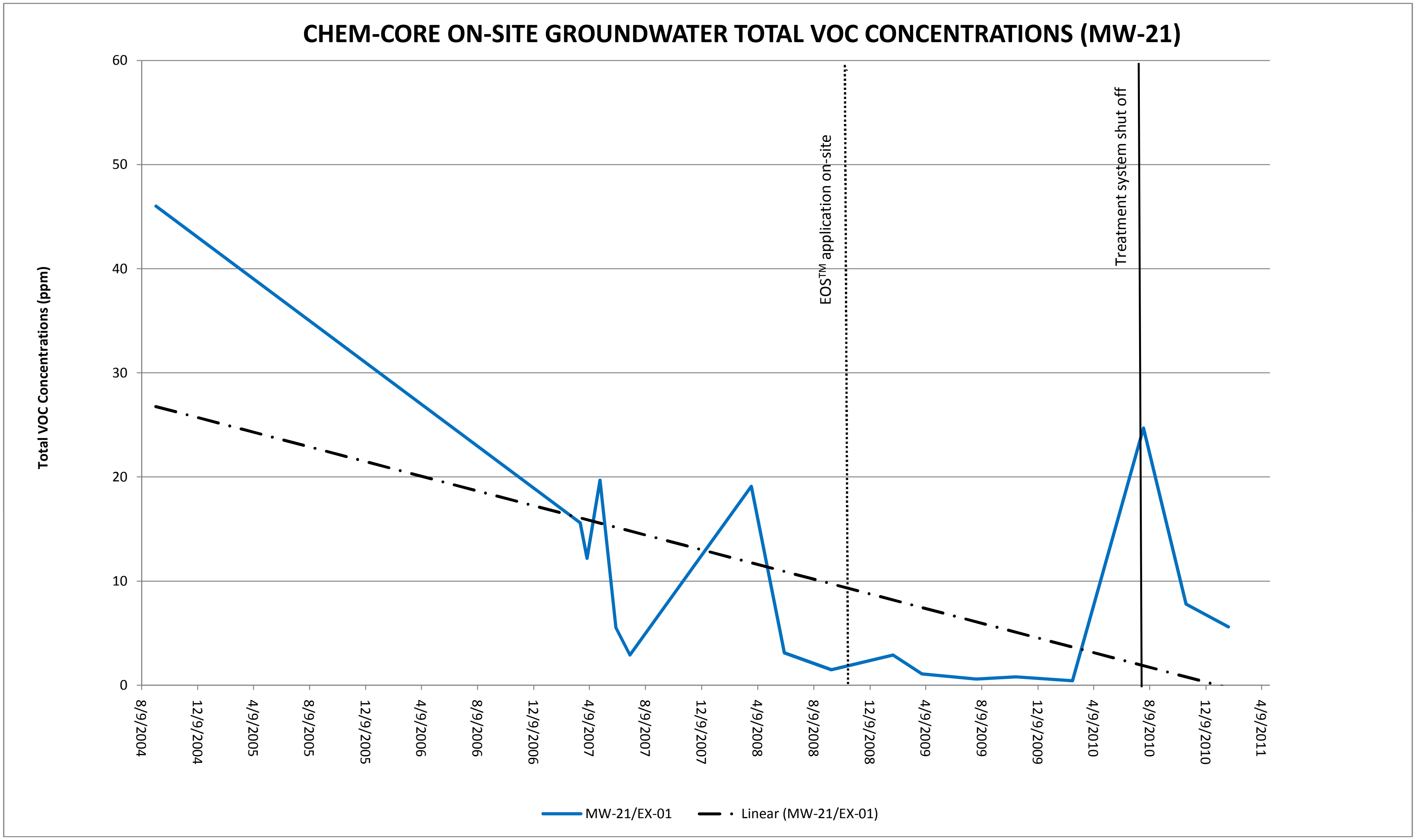
CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS
Total VOC Concentrations (ppm)
0
10
20
30
40
50
60
EOS™ application on-site
Treatment system shut off
8/9/2004
12/9/2004
4/9/2005
8/9/2005
12/9/2005
4/9/2006
8/9/2006
12/9/2006
4/9/2007
8/9/2007
12/9/2007
4/9/2008
8/9/2008
12/9/2008
4/9/2009
8/9/2009
12/9/2009
4/9/2010
8/9/2010
12/9/2010
4/9/2011
MW-20/MW-02
MW-21/EX-01
MW-22/MW-14
MW-03
MW-06
MW-07

Figure 7



CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-22)
Total VOC Concentrations (ppm)
60
50
40
30
20
10
0
EOSTM application on-site
Treatment system shut off
8/9/2004
12/9/2004
4/9/2005
8/9/2005
12/9/2005
4/9/2006
8/9/2006
12/9/2006
4/9/2007
8/9/2007
12/9/2007
4/9/2008
8/9/2008
12/9/2008
4/9/2009
8/9/2009
12/9/2009
4/9/2010
8/9/2010
12/9/2010
4/9/2011
MW-22/MW-14
Linear (MW-22/MW-14)

Figure 8



CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-21)
Total VOC Concentrations (ppm)
60
50
40
30
20
10
0
EOS™ application on-site
Treatment system shut off
8/9/2004
12/9/2004
4/9/2005
8/9/2005
12/9/2005
4/9/2006
8/9/2006
12/9/2006
4/9/2007
8/9/2007
12/9/2007
4/9/2008
8/9/2008
12/9/2008
4/9/2009
8/9/2009
12/9/2009
4/9/2010
8/9/2010
12/9/2010
4/9/2011
MW-21/EX-01
Linear (MW-21/EX-01)

Figure 9

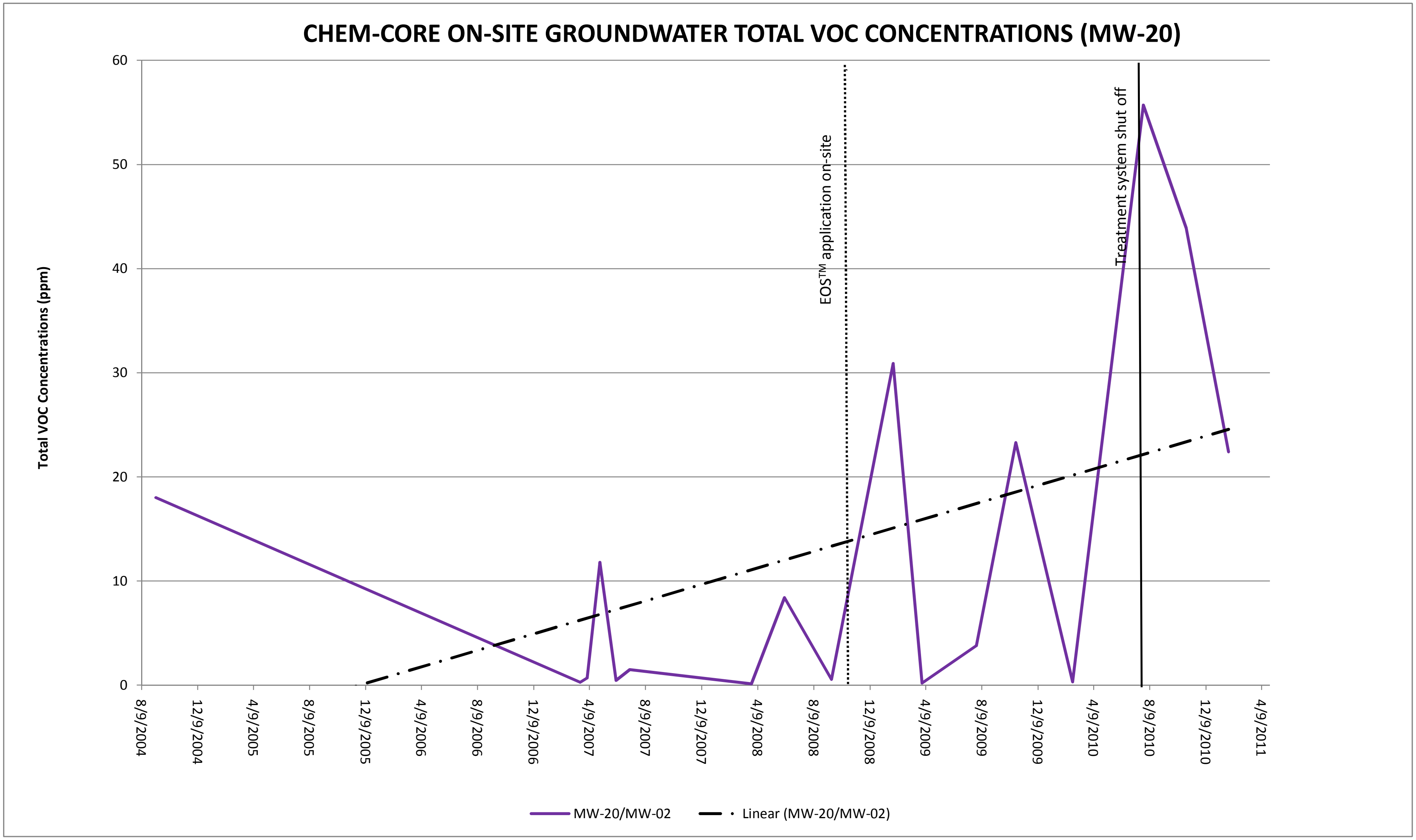

CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-20)
Total VOC Concentrations (ppm)
0
10
20
30
40
50
60
8/9/2004
12/9/2004
4/9/2005
8/9/2005
12/9/2005
4/9/2006
8/9/2006
12/9/2006
4/9/2007
8/9/2007
12/9/2007
4/9/2008
8/9/2008
12/9/2008
4/9/2009
8/9/2009
12/9/2009
4/9/2010
8/9/2010
12/9/2010
4/9/2011
EOS™ application on-site
Treatment system shut off
MW-20/MW-02
Linear (MW-20/MW-02)

Figure 10

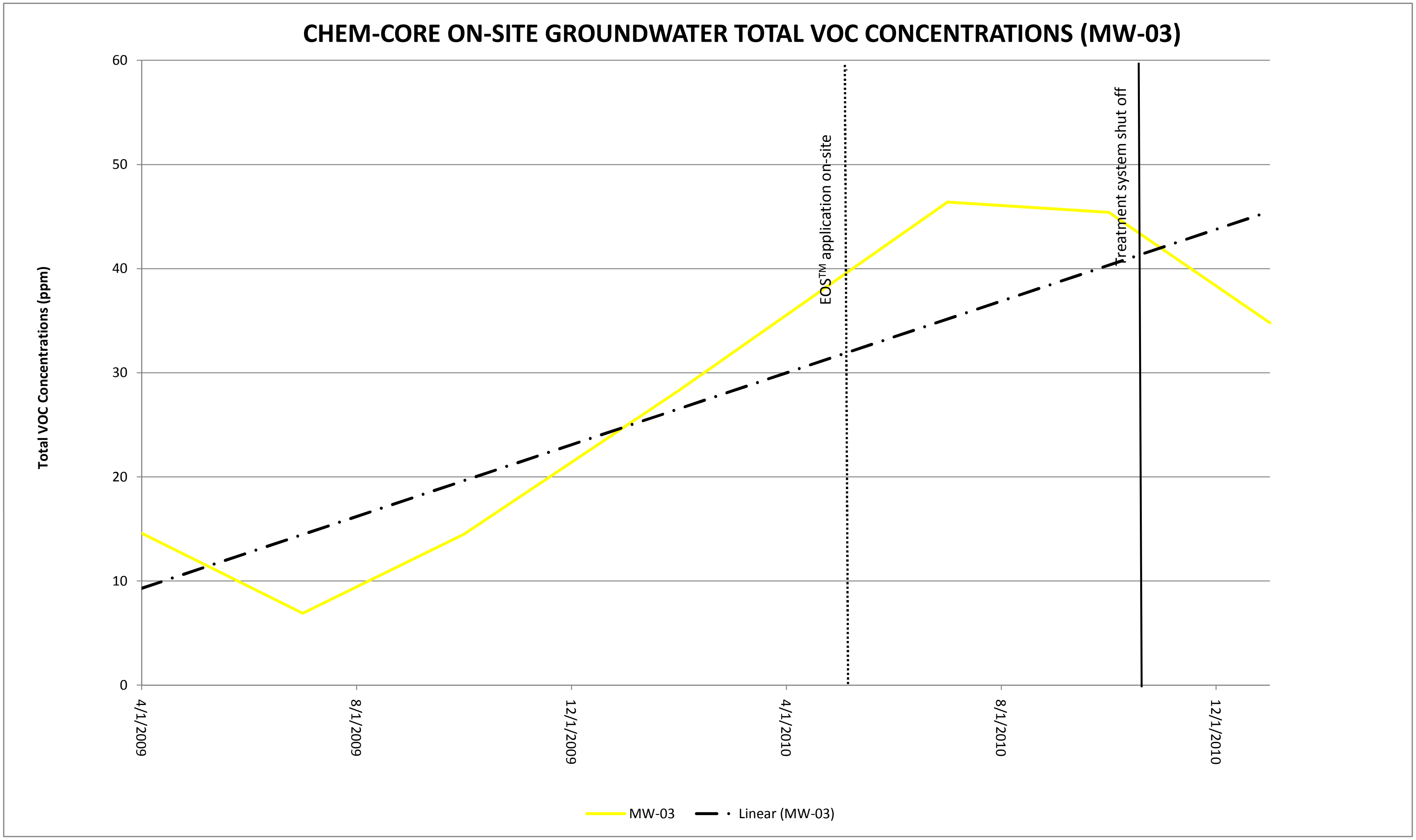

CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-03)
Total VOC Concentrations (ppm)
0
10
20
30
40
50
60
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
EOS™ application on-site
Treatment system shut off
MW-03
Linear (MW-03)

Figure 11

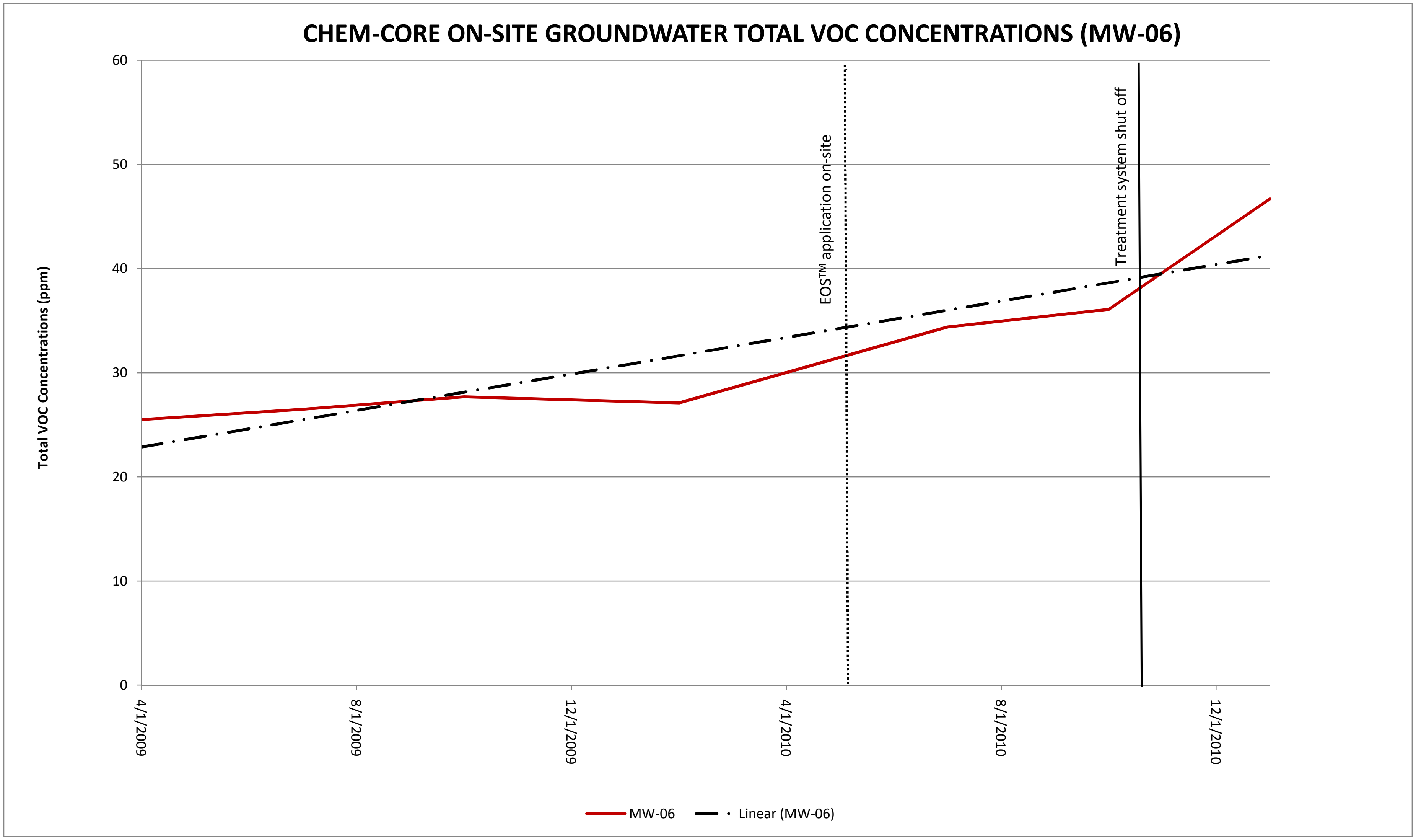
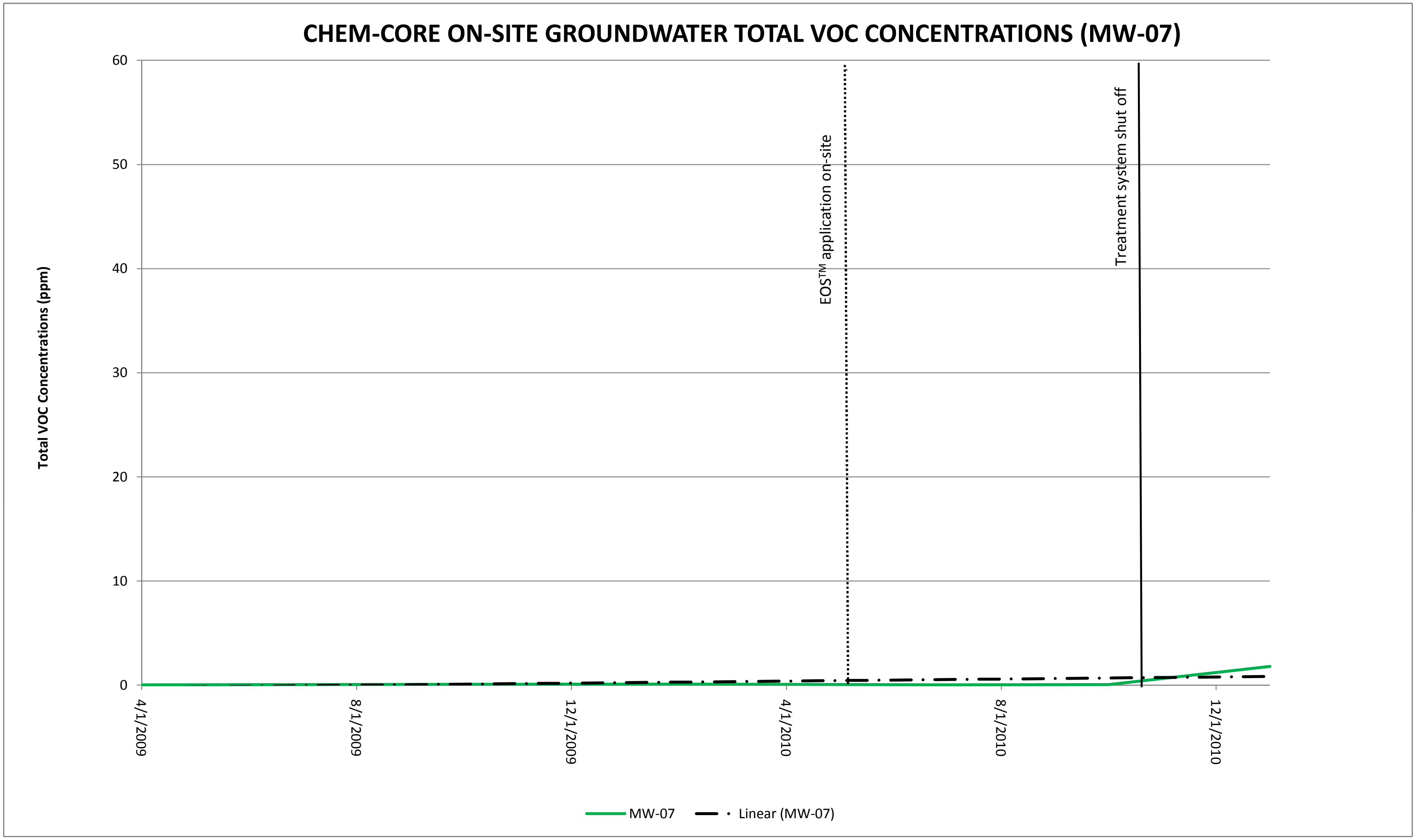

CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-06)
Total VOC Concentrations (ppm)
60
50
40
30
20
10
0
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
EOSTM application on-site
Treatment system shut off
MW-06
Linear (MW-06)

Figure 12



CHEM-CORE ON-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-07)
Total VOC Concentrations (ppm)
60
50
40
30
20
10
0
EOSTM application on-site
Treatment system shut off
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
MW-07
Linear (MW-07)

Figure 13

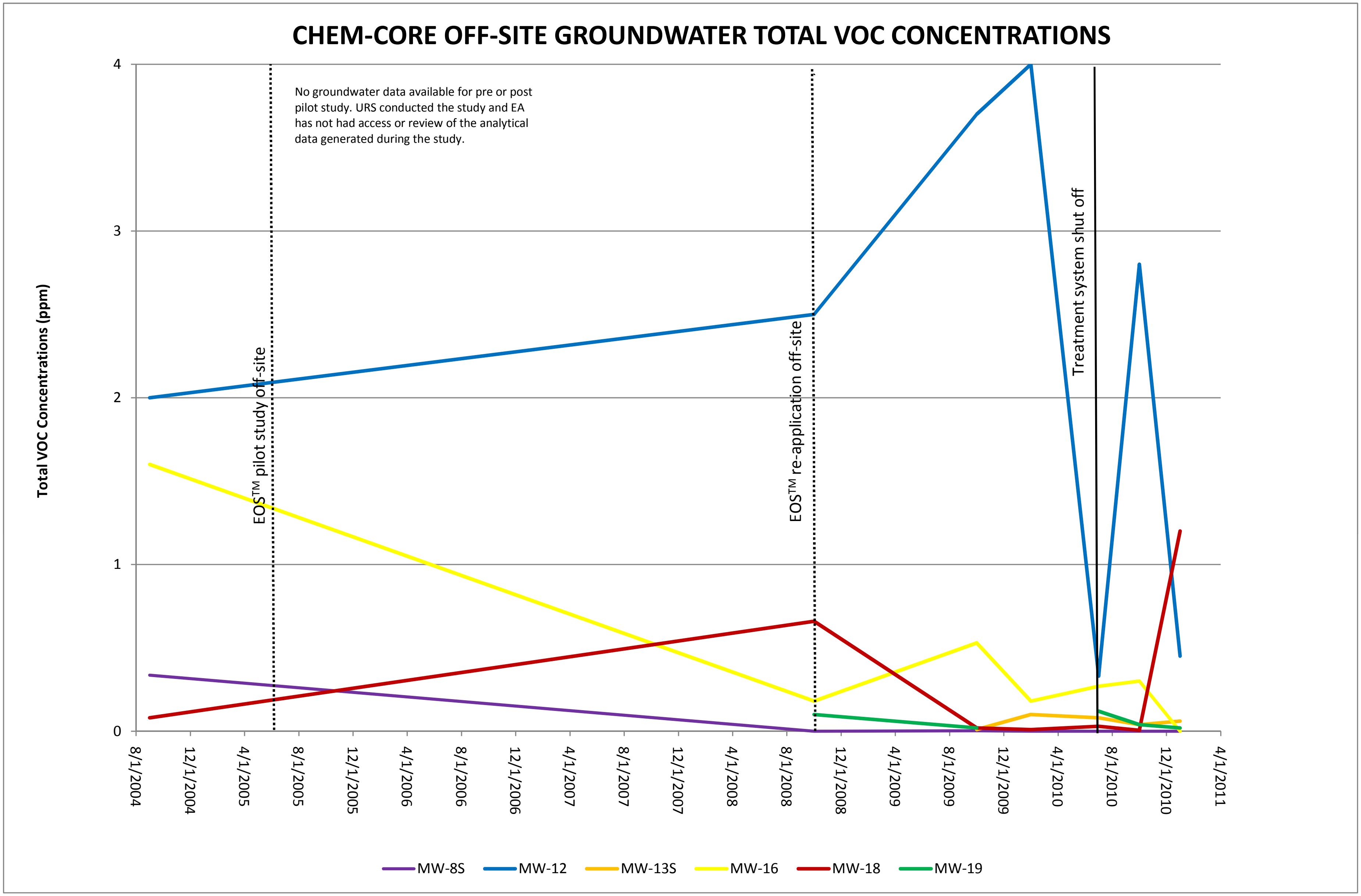
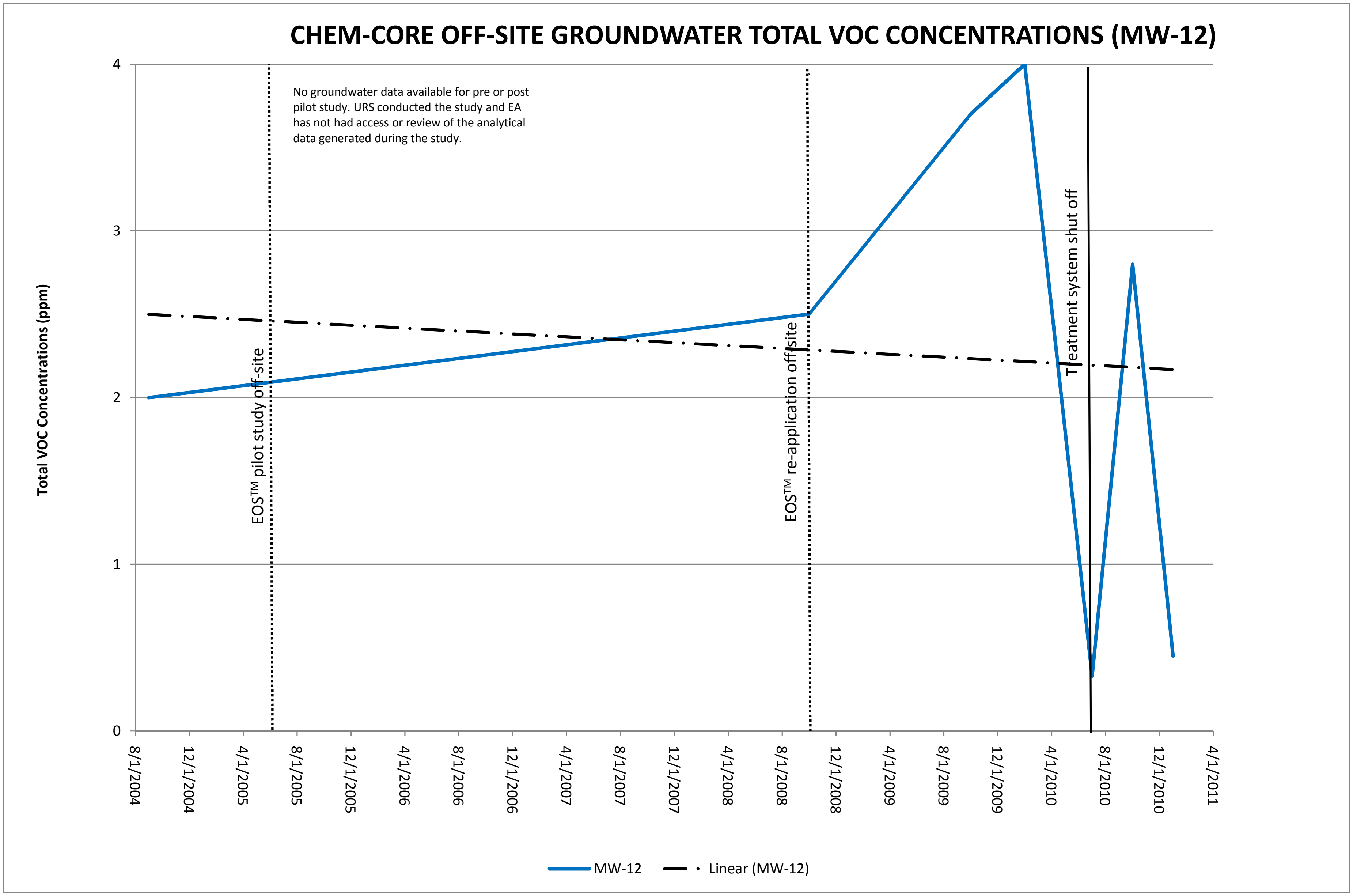

CHEM-CORE OFF-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS
No groundwater data available for pre or post pilot study. URS conducted the study and EA has not had access or review of the analytical data generated during the study.
EOSTM pilot study off-site
EOSTM re-application off-site
Treatment system shut off
Total VOC Concentrations (ppm)
0
1
2
3
4
8/1/2004
12/1/2004
4/1/2005
8/1/2005
12/1/2005
4/1/2006
8/1/2006
12/1/2006
4/1/2007
8/1/2007
12/1/2007
4/1/2008
8/1/2008
12/1/2008
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
4/1/2011
MW-8S
MW-12
MW-13S
MW-16
MW-18
MW-19

Figure 14



CHEM-CORE OFF-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-12)
Total VOC Concentrations (ppm)
0
1
2
3
4
No groundwater data available for pre or post pilot study. URS conducted the study and EA has not had access or review of the analytical data generated during the study.
EOSTM pilot study off-site
EOSTM re-application off-site
Treatment system shut off
8/1/2004
12/1/2004
4/1/2005
8/1/2005
12/1/2005
4/1/2006
8/1/2006
12/1/2006
4/1/2007
8/1/2007
12/1/2007
4/1/2008
8/1/2008
12/1/2008
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
4/1/2011
MW-12
Linear (MW-12)

Figure 15

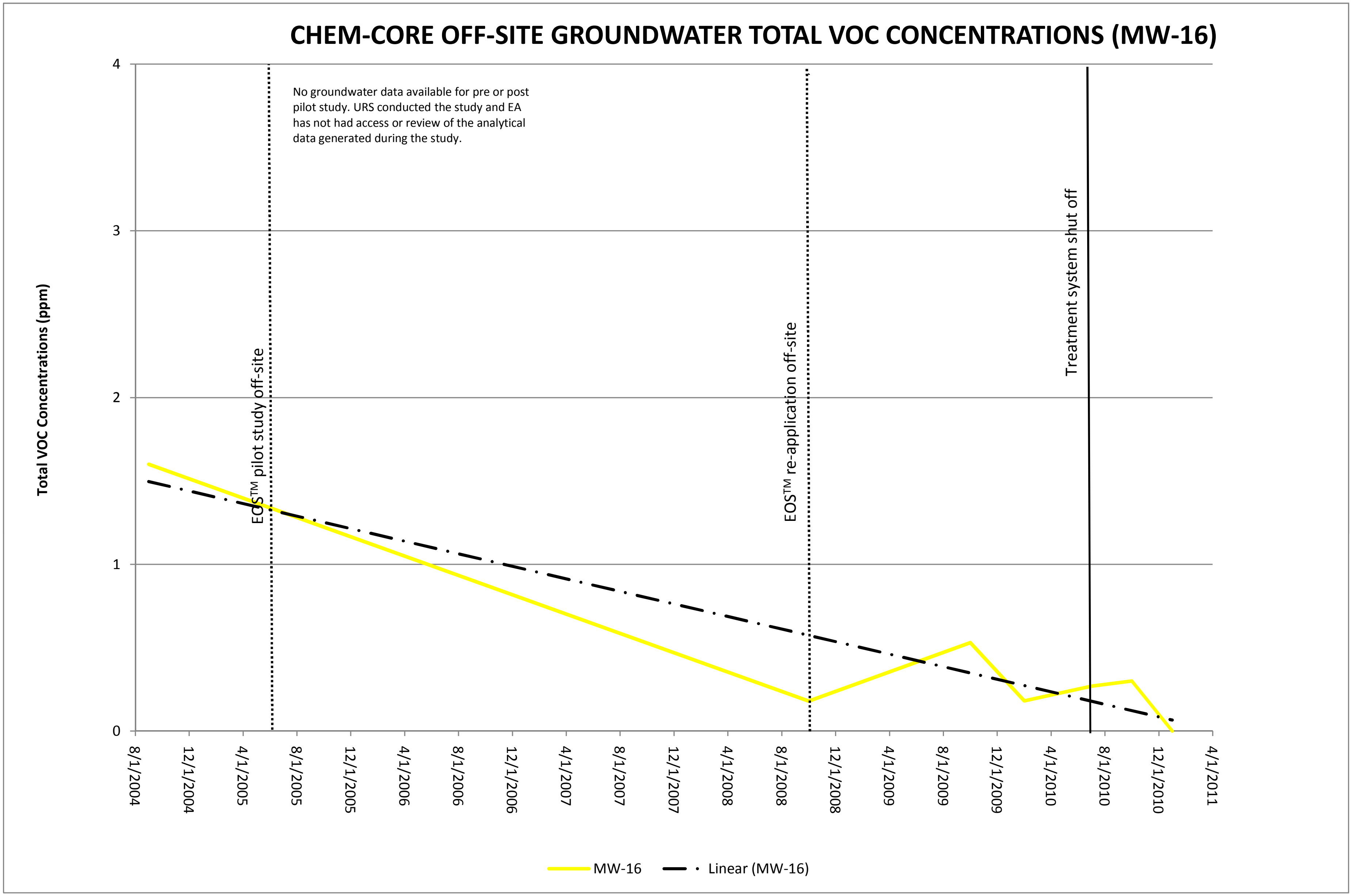
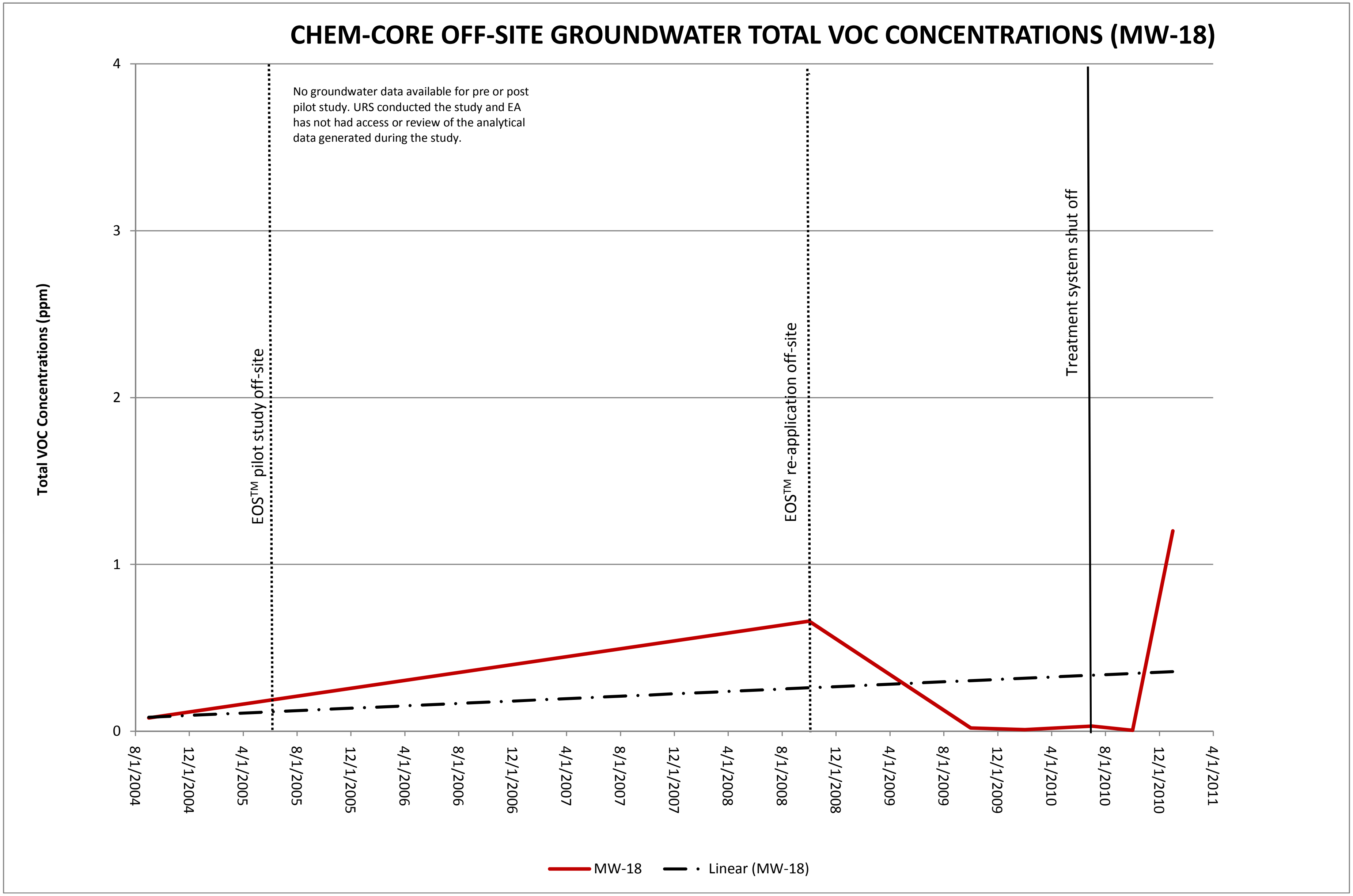

CHEM-CORE OFF-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-16)
Total VOC Concentrations (ppm)
0
1
2
3
4
No groundwater data available for pre or post pilot study. URS conducted the study and EA has not had access or review of the analytical data generated during the study.
EOSTM pilot study off-site
EOSTM re-application off-site
Treatment system shut off
8/1/2004
12/1/2004
4/1/2005
8/1/2005
12/1/2005
4/1/2006
8/1/2006
12/1/2006
4/1/2007
8/1/2007
12/1/2007
4/1/2008
8/1/2008
12/1/2008
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
4/1/2011
MW-16
Linear (MW-16)

Figure 16


CHEM-CORE OFF-SITE GROUNDWATER TOTAL VOC CONCENTRATIONS (MW-18)
Total VOC Concentrations (ppm)
4
3
2
1
0
No groundwater data available for pre or post pilot study. URS conducted the study and EA has not had access or review of the analytical data generated during the study.
EOSTM pilot study off-site
EOSTM re-application off-site
Treatment system shut off
8/1/2004
12/1/2004
4/1/2005
8/1/2005
12/1/2005
4/1/2006
8/1/2006
12/1/2006
4/1/2007
8/1/2007
12/1/2007
4/1/2008
8/1/2008
12/1/2008
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
4/1/2011
MW-18
Linear (MW-18)