2013 Annual Report
AOC-05 Remedial Action
Enhanced Anaerobic Biodegradation of Gasoline-Range Petroleum Hydrocarbons
Boeing Developmental Center
Tukwila, Washington

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Prepared for

The Boeing Company
Seattle, Washington

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

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1.0 INTRODUCTION

This document presents a 2013 annual report for the anaerobic bioremediation remedial action performed at Area of Concern (AOC)-05 of The Boeing Company's (Boeing) Developmental Center (DC) in Tukwila, Washington (Figure 1). Remedial action is performed to stimulate anaerobic biodegradation of gasoline contamination resulting from a 1985 release from a former leaking underground storage tank (UST) near injection well BDC-103. AOC-05 wells and site features are shown on Figure 2. Remediation activities and preparation of this report were performed under Boeing Purchase Order No. 1102821220. Anaerobic bioremediation remedial action was performed in general accordance with the *Remedial Action Work Plan* (Work Plan, Landau Associates 2007a).

This annual report summarizes the activities and results for March 2013 through February 2014. A single nitrate injection event was conducted during this period. Nitrate solution was injected to well BDC-103 in November 2013.

Following this introductory section, the report is organized into five main sections. Sections 2 and 3 provide an overview of the remedial approach and a summary of prior work, as context to activities and results in the current reporting period. Section 4 documents activities during the reporting period and Section 5 presents discussion of reporting period results. Section 6 provides a summary and describes planned activities.

2.0 OVERVIEW OF REMEDIAL APPROACH

Anaerobic bioremediation at AOC-05 is accomplished through stimulation of micro-organisms present in the aquifer to degrade petroleum hydrocarbons. The addition of nitrate (electron acceptor) allows the native bacteria to utilize petroleum as food (electron donor).

Biodegradation of total petroleum hydrocarbons (TPH) occurs through microbially mediated reactions whereby micro-organisms obtain energy by oxidation-reduction (redox) reactions. TPH is used as the electron donor together with various electron acceptors [oxygen, nitrate, manganese (IV), ferric iron, sulfate, and carbon dioxide]. These redox reactions can be compared to the process whereby humans obtain energy through consumption of food (electron donor) and oxygen (electron acceptor). Bacteria obtain the greatest energy yield by using oxygen as an acceptor, as it is highly oxidized and, therefore, can be easily reduced and to a large extent. When oxygen is depleted, bacteria sequentially use the less oxidized electron acceptors in the following order: nitrate, manganese (IV), ferric iron, sulfate, and carbon dioxide.

Biodegradation of petroleum hydrocarbons can occur under both aerobic and anaerobic conditions. Stimulation of anaerobic degradation can be the preferred approach in naturally anaerobic aquifers (such as the one at the DC) where stimulation of aerobic conditions is unlikely to be effective due to high natural oxygen demand (Wiedemeier et al. 1999). During anaerobic biodegradation of TPH, nitrate (or sulfate) functions as the electron acceptor for microbial degradation of the TPH electron donor. In addition to the work being performed at the Boeing DC, nitrate amendment to enhance anaerobic biodegradation has been successfully implemented on other full-scale remediation projects for gasoline-range and fuel oil-range TPH, both nationally (Lozier and Hicks 2005; Wasserman et. al. 2005) and in Washington State (Landau Associates 2012a).

3.0 SUMMARY OF PREVIOUS WORK

Full-scale anaerobic bioremediation began in 2008 and followed bioremediation pilot testing performed in 2007. Pilot testing performed in 2007 using a single injection well (BDC-103; Landau Associates 2007b) was expanded to full-scale treatment in 2008 utilizing existing injection well BDC-103 and new injection well BDC-104. Following baseline groundwater monitoring, and prior to the current reporting period, nitrate was injected eight times, as follows:

- three times in 2008 (both wells)
- twice in 2009 (both wells)
- once in 2010 (BDC-103 only)
- twice in 2012 (BDC-103 only).

3.1 PILOT TESTING

Bioremediation pilot testing at AOC-05 was performed in 2007, which demonstrated degradation of petroleum hydrocarbons resulting from a one-time addition of ammonium nitrate (Landau Associates 2007b). Post-injection monitoring showed that concentrations of TPH in the gasoline range (TPH-G) decreased by about 50 percent compared to baseline over 4 months of post-injection monitoring, while benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds decreased as much as 98 percent (Landau Associates 2007b). As expected, contaminant concentrations rebounded upon depletion of injected nitrate due to groundwater returning to equilibrium with sorbed mass and non-aqueous phase liquid (NAPL) mass remaining in the aquifer.

3.2 WELL INSTALLATION AND BASELINE MONITORING

Full-scale implementation began with installation of one additional injection well (BDC-104) and baseline monitoring of all four AOC-05 wells (BDC-101, BDC-102, BDC-103, and BDC-104) in February 2008. The new well was installed somewhat upgradient (east) and cross-gradient (north) of existing injection well BDC-103, to enhance treatment coverage during nitrate injections. BDC-103 is located within the tank pit of the former UST. BDC-104 is located near the known upgradient edge of contamination associated with the former UST (Landau Associates 2004). Injection of both wells allowed for groundwater transport of injected nitrate solution to the area of highest contamination. The well locations and their estimated radii of injection (ROIs) are shown relative to the area of groundwater contamination on Figure 2.

Baseline monitoring was performed prior to full-scale treatment to determine starting contaminant concentrations and aquifer redox conditions at the four AOC-05 wells (BDC-101, BDC-102,

BDC-103, and BDC-104). Full-scale baseline monitoring indicated nitrate- to sulfate-reducing conditions at source zone wells BDC-103 and BDC-104, nitrate- to iron-reducing conditions at downgradient well BDC-102, and aerobic to nitrate-reducing conditions at downgradient well BDC-101; the same conditions as indicated by pre-pilot test baseline monitoring (Landau Associates 2006). Prior to full-scale treatment, baseline (February 2008) concentrations of TPH-G were in excess of the preliminary screening level at source zone wells BDC-103 and BDC-104, and the baseline benzene concentrations also exceeded the preliminary screening level at BDC-103; preliminary screening levels in use at that time were developed in a prior DC site summary report (Landau Associates 2002). TPH-G and BTEX were not detected at downgradient wells BDC-101 and BDC-102 during baseline sampling. Full results of baseline monitoring are included in the data summary presented in Table 1. Proposed cleanup levels developed in 2013 (Landau Associates 2013a) are presented in Table 1 for comparison to data; contaminant concentrations above proposed cleanup levels (PCUL) are boxed.

3.3 PRIOR FULL SCALE INJECTIONS AND PERFORMANCE RESULTS

Nitrate solution was injected eight times prior to the current reporting period. Following baseline groundwater monitoring, nitrate solutions were injected to wells BDC-103 and BDC-104 three times during 2008 (February, June, and November) and twice during 2009 (June and November). In 2010, a single nitrate injection was performed in September at BDC-103 only. There were no injections in 2011. In 2012, two nitrate injections were performed in February and November at BDC-103 only. In accordance with the work plan (Landau Associates 2007a), the standard dose of nitrate was 6,500 gallons of 1,000 milligrams per liter (mg/L) nitrate solution [225 mg/L as nitrogen (mg-N/L)]. Detailed analysis of groundwater sampling results for 2008 through February 2013 can be found in previous annual reports (Landau Associates 2009a, 2010, 2011, 2012b, 2013b).

Prior performance results from 2008 through February 2013indicated effective treatment of TPH-G and BTEX at source zone wells BDC-103 and BDC-104, while maintaining low to non-detect contaminant levels at downgradient wells BDC-101 and BDC-102. Cumulative performance monitoring results are presented in Table 1 and performance results highlights are described below:

- Nitrate was consumed rapidly following the first two injection events.
- After the third injection event (November 2008), monitoring indicated slower consumption of injected nitrate and a partial rebound in concentrations of petroleum hydrocarbons at source zone well BDC-103, despite the presence of adequate nitrate for continued treatment. This rebound of contaminant concentration, despite adequate nitrate, suggested that biodegradation in AOC-05 had become nutrient-limited.
- During the fourth injection event (June 2009), ammonium phosphate was added to the injection fluid to overcome the observed treatment slowdown thought to be caused by a deficiency of the macro-nutrient phosphorus. The amount of phosphate added to the injection

solution was based on a nitrogen-to-phosphorus ratio of 10:1, which is commonly cited as the optimal nutrient ratio (Metcalf and Eddy 2002). The amount of yeast extract (which provides micro-nutrients) was also increased from 2 lbs to 4 lbs per well. During this single injection event, the nitrate concentration injected was decreased by two thirds to 330 mg/L nitrate (75 mg-N/L) to limit the amount of additional nitrate while evaluating the effects of the ammonium phosphate addition.

- Data from the July 2009 sampling event suggested that consumption of nitrate and bioremediation of contaminants had resumed following the addition of ammonium phosphate to the injection solution. Based on these results, ammonium phosphate was added to subsequent injection solutions.
- During the fifth injection (November 2009), nitrate was increased back to the standard concentration at well BDC-103. Although TPH-G and BTEX were not detected during prior sampling events in July or September 2009 at well BDC-104, a half-concentration injection [500 mg/L nitrate (112 mg-N/L)] was performed at that well to treat contamination previously characterized to the north and east of well BDC-103 that may not have been within the ROI of BDC-103.
- Contaminant concentrations fell substantially following the fifth injection, with results from the February 2010 sampling event showing TPH-G and benzene concentrations below preliminary screening levels at BDC-103 for the first time since monitoring began in 2001.
- Contaminant concentrations at BDC-103 rebounded again in May and August 2010 as nitrate was consumed, prompting a sixth injection (September 2010).
- Contaminant concentrations decreased again to historical lows at source zone well BDC-103 in February 2011. All contaminant concentrations were below reporting limits and/or screening levels at all four AOC-05 monitoring wells during this event.
- In May 2011, TPH-G concentrations fell below the laboratory reporting limit of 0.25 mg/L at well BDC-103 for the first time since monitoring began in 2001.
- A substantial rebound in contaminant concentrations was observed in November 2011 resulting from cessation of treatment due to nitrate depletion, likely compounded by high water table conditions. The higher water table would cause groundwater to contact higher portions of the contaminant smear zone not treated by prior injection events. This rebound prompted a seventh injection at BDC-103 (February 2012). Sampling following the February 2012 injection showed substantial decreases in contaminant concentrations at BDC-103 and abundant nitrate for resumed treatment.
- Contaminant concentrations at BDC-103 rebounded in September 2012 as nitrate was consumed, prompting an eighth injection.
- With the exception of a low level detection of o-xylene, TPH, and BTEX concentrations at BDC-103 were all below reporting limits in February 2012. These were the lowest concentrations observed at well BDC-103 since monitoring began in 2001.

Per the Work Plan (Landau Associates 2007a), detection of nitrate above the action level imposed by the Washington State Department of Ecology (Ecology) for AOC-05 remedial action (10 mg-N/L) at either downgradient well BDC-101 or BDC-102 for two consecutive sampling events triggers implementation of additional groundwater monitoring at wells located farther downgradient. Nitrate

concentrations have exceeded the action level at downgradient wells BDC-101 or BDC-102 during prior reporting periods, as follows:

- The action level was first exceeded at well BDC-101 for two consecutive sampling events in July 2009, where nitrate remained above the action level through August 2011, with the exception of September 2009 and November 2010, before decreasing below the action level in November 2011 and February 2012. The action level was exceeded from May 2012 to August 2013, and then decreased below the action level from November 2013 to February 2014.
- At well BDC-102, the action level was first exceeded for two consecutive sampling events in August 2011, but dropped below the action level during the November 2011 and February 2012 sampling events. The action level was exceeded the next two quarters, before dropping below the action level in November 2012, and then increased again above the action level in February 2013.
- Semiannual nitrate monitoring began at downgradient wells MW-17A, MW-18A, MW-21A, and BDC-05-04 (Figure 2) in November 2009 (Landau Associates 2009b), triggered by the two consecutive sampling events at BDC-101 with nitrate above the action level (May and July 2009). All nitrate detections in these four wells located farther downgradient have remained below the 10 mg-N/L action level.

Per the Work Plan (Landau Associates 2007a), semiannual monitoring for nitrate will continue at the four downgradient wells for 1 year after nitrate at wells BDC-101 and/or BDC-102 decreases below 10 mg-N/L. Cumulative downgradient nitrate monitoring results are included in Table 2.

Results for the current reporting period of March 2013 through February 2014 are summarized in Section 4.0 below.

4.0 INJECTION AND PERFORMANCE MONITORING DURING THIS REPORTING PERIOD

This section describes injection activities and monitoring results for the current reporting period of March 2013 through February 2014. In this reporting period, nitrate solution was injected once (in November 2013) to well BDC-103. Well BDC-104 was not injected; with the exception of low level detections in February 2014, TPH and BTEX have remained below reporting limits at well BDC-104 since May 2009. The reporting period includes four quarterly monitoring events. A summary of the results for the four AOC-05 wells is presented in Table 1.

The November 2013 injection event at BDC-103 consisted of a standard concentration injection with a 50 percent increase in volume, as proposed in the *2011 Annual Report* (Landau Associates 2012b), to extend the ROI and increase the longevity of treatment. Other aspects of the injection were in accordance with the Work Plan (Landau Associates 2007a) and as modified in 2009 to include ammonium phosphate and the double dose of yeast extract (Landau Associates 2010). Approximately 132 lbs of CAN-27 ammonium nitrate fertilizer, 21.5 lbs of ammonium phosphate, and 5 lbs of yeast extract were mixed with potable water and injected to BDC-103. Approximately 9,530 gallons of potable water was used to mix the injection solution, which resulted in the standard injection solution concentration of approximately 1,000 mg/L nitrate.

During the November 2013 injection event, as during both 2012 events, a higher injection flow rate was used in an effort to create more mounding of injection fluid above the water table. Prior injections were typically performed at flow rates of 20 to 40 gallons per minute (gpm). In November 2013, the injection solution was injected at an average of 96 gpm and a peak of 159 gpm. Near the end of the injection period, with approximately 740 gallons remaining, injection fluid began to seep from seams in the concrete pavement located 15 to 20 feet (ft) downgradient of the injection well, confirming distribution of injectate to at least that distance from the injection well. This limited seepage was contained and collected for disposal from the pavement using a wet-dry shop vacuum. The injection rate was then reduced to 16 gpm for the remainder of the injection event, with no further seepage. The observed seepage through the pavement confirms that the higher volume and injection flow rate resulted in the desired mounding above the water table, typically present at 11 to 12 ft below ground surface (BGS). Mounding of injection fluid above the water table is intended to contact and treat contamination that may remain in a higher portion of the smear zone, which can contribute to contaminant rebound in groundwater during periods of higher groundwater.

The progress of petroleum hydrocarbon biodegradation was evaluated during this reporting period through quarterly performance groundwater monitoring at the four AOC-05 wells (BDC-101 through BDC-104). Monitoring was performed in May, August, and November 2013, and in February

2014. In accordance with the Work Plan (Landau Associates 2007a), samples were analyzed for contaminant concentrations (TPH-G and BTEX) and parameters indicative of aquifer redox conditions [dissolved oxygen (DO), oxidation-reduction potential (ORP), nitrate, ferrous iron, sulfate, and pH]. Samples were also analyzed for nitrite.

Semiannual monitoring for nitrate continued in May and November 2013 at the four monitoring wells located farther downgradient of AOC-05 (MW-17A, MW-18A, MW-21A, and BDC-05-04). Nitrate sampling of BDC-05-04 was missed during the May 2013 event.

TPH-G, BTEX, nitrate, nitrite, and sulfate, were analyzed in the laboratory, while other parameters (DO, ORP, ferrous iron, and pH) were measured in the field. Laboratory analysis was performed by Eurofins Lancaster Laboratories Environmental (LLI).

5.0 DISCUSSION OF RESULTS DURING THIS REPORTING PERIOD

Performance monitoring results for the current reporting period from March 2013 through February 2014 indicate continued effective treatment of TPH-G at AOC-05. Some highlights are as follows, with additional details provided in subsequent sections:

- Contaminant concentrations at BDC-101, BDC-102, and BDC-104 were below laboratory reporting limits during all four quarterly sampling events conducted within the reporting period.
- August 2013 groundwater monitoring results at BDC-103 showed a substantial decrease in nitrate (from 161 mg-N/L to 17.8 mg-N/L) coincident with an increase in contaminant concentrations. These results prompted the ninth injection event in November 2013.
- Contaminant concentrations at BDC-103 remained much lower during the reporting period than the higher concentrations observed in November 2011 resulting from depleted nitrate and higher water table conditions. However, contaminant concentrations rebounded, with concentrations of TPH-G, benzene, and ethylbenzene above PCULs in May, August, and November 2013. Following the nitrate injection in November 2013, all contaminants (excepting xylenes) decreased to below reporting limits in February 2013, just as they had been in February 2012.
- AOC-05 groundwater elevations were lower during the reporting period than the prior high levels observed in May 2011 and February 2012. This indicates that the rebound in contaminant concentrations observed at well BDC-103 in May, August, and November 2013, was not the result of water table rise into a higher portion of the smear zone. Water table rise into the high smear zone in May 2011 was considered the primary reason for substantial contaminant rebound observed at BDC-103 in November 2011.

Monitoring results are presented on Figures 3 through 11, summarized in Table 1, and discussed further in the following sections. TPH-G and BTEX concentrations at BDC-103 and BDC-104, starting with the period of nitrate pilot testing and extending through full-scale treatment, are plotted against time on Figures 3 and 4, respectively. Concentrations of TPH-G and benzene (the compounds which have most commonly exceeded PCULs) are plotted since monitoring began in June 2001 on Figures 5 through 8 for wells BDC-101 through BDC-104. Concentrations of nitrate, TPH-G, and benzene are plotted against time for wells BDC-103 and BDC-104 on Figures 9 and 10, respectively. A plot of groundwater elevations with time at the four AOC-05 wells is presented on Figure 11. Cumulative monitoring results for AOC-05 wells are summarized in Table 1 with PCULs (Landau Associates 2013a) for comparison; contaminant concentrations above PCULs are boxed.

5.1 TPH-G AND BTEX

In February 2014, at well BDC-103, TPH-G and BTEX concentrations were below laboratory reporting limits, with the exception of low level xylenes. February 2014 was the second time that these contaminants have been below reporting limits since monitoring began in 2001, indicating reductions of

99.6 to 99.9 percent from 2008 baseline conditions. Changes in contaminant concentrations from groundwater sampled at this well over the reporting period are as follows:

- TPH-G was below the reporting limit during May 2013 and February 2014. The reporting limit of 0.25 mg/L is a decrease of 99.6 percent from the 2008 baseline concentration of 66 mg/L. The TPH-G concentration increased in August to 2 mg/L coincident with decreased nitrate. Following the November injection event, TPH-G increased again in November (5.9 mg/L) before decreasing again in February.
- The February 2014 benzene result was below the reporting limit [1.0 micrograms per liter (µg/L)], which represents a 99.9 percent reduction from the 2008 baseline concentration of 1,100 µg/L. Benzene concentrations increased in May and August 2013, then decreased in November after the November injection event until reaching the laboratory reporting limit in February 2014.
- Toluene remained below the PCUL (1,294 µg/L) throughout the reporting period and was not detected in May 2013 or February 2014. The reporting limit represents a 99.9 percent reduction compared to the 2008 baseline concentration of 2,600 µg/L.
- Ethylbenzene was below the reporting limit of 1.0 µg/L in May 2013 and February 2014. The reporting limit represents a 99.9 percent reduction compared to the 2008 baseline concentration of 700 µg/L. Concentrations were above the PCUL (1.7 µg/L) in August and November 2013, with the highest concentration (47 µg/L) occurring in August prior to the November injection.
- Total xylenes remained below the PCUL of 1,546 µg/L during the entire reporting period. In May 2013, total xylenes concentration was 6.2 µg/L, and rose to a peak concentration of 940 µg/L before the November injection. After the injection event, total xylenes decreased to 8.5 µg/L in February 2014. The reporting limit represents a 99.9 percent decrease from the 2008 baseline of 9,400 µg/L.

Contaminant concentrations were below the reporting limits during the entire reporting period at the other three wells (BDC-101, BDC-102, and BDC-104).

5.2 NITRATE AND NITRITE

Nitrate injected at BDC-103 was monitored at the four AOC-05 wells and at the four downgradient wells. Nitrite was also monitored at the four AOC-05 wells.

Aquifer nitrate concentrations decreased at well BDC-103 from May (161 mg-N/L) to August 2013 (17.8 mg-N/L), which indicates consumption of nitrate due to biodegradation. After the November 2013 injection, nitrate at BDC-103 peaked in November (154 mg-N/L) before declining in February 2014 (79.9 mg-N/L). Following the November 2013 injection, nitrate concentrations were adequate for continued treatment. As previously observed, data from this reporting period show that stimulation of biotreatment resulting from elevated nitrate concentrations coincides with decreasing contaminant concentrations.

Per the Work Plan (Landau Associates 2007a), detection of nitrate above the action level of 10 mg-N/L at either BDC-101 or BDC-102 for two consecutive sampling events triggers implementation of additional groundwater monitoring in farther downgradient wells MW-17A, MW-18A, MW-21A, and BDC-05-04. Downgradient monitoring, which began in November 2009, continued through this reporting period. Nitrate concentrations at BDC-101 exceeded the action level during May 2013 and August 2013 sample events, and were below the action level during the November 2013 and February 2014 sampling events. Nitrate concentrations at well BDC-102 remained above the action level throughout the reporting period.

Semiannual nitrate monitoring at downgradient wells MW-17A, MW-18A, MW-21A, and BDC-05-04 continued during this reporting period. All downgradient detections remained below the 10 mg-N/L action level, with the highest detection occurring at MW-17A (2.9 mg-N/L) in May 2013. Nitrate sampling of BDC-05-04 was inadvertently missed in May 2013. Per the Work Plan, semiannual monitoring for nitrate will continue at the four downgradient wells for 1 year after nitrate at wells BDC-101 and BDC-102 drops below 10 mg-N/L. Cumulative monitoring results for downgradient wells are summarized in Table 2 and presented on Figure 12.

Detection of low levels of nitrite is a result of nitrate reduction. Nitrite is a highly reactive, short-lived compound that is further reduced through nitrous oxide and nitric oxide to nitrogen gas (Environment Agency 2005). Nitrite has been commonly detected at injection wells since the start of full-scale injection activities. The maximum nitrite concentration detected during this reporting period was 2.6 mg-N/L at injection well BDC-103 seven days after the November injection; by February 2014, nitrite had decreased substantially to 0.15 mg-N/L. Nitrite was not detected at well BDC-104 or at downgradient wells BDC-101 and BDC-102 during this reporting period. This data confirms that nitrite continues to be reduced in the treatment area.

6.0 SUMMARY AND PLANNED ACTIVITIES

Anaerobic biodegradation of petroleum hydrocarbons continues to be enhanced at AOC-05, with substantial reductions in TPH-G and BTEX concentrations during this reporting period. In February 2014, contaminant concentrations at well BDC-103 were below reporting limits for all analytes, with the exception of low level xylenes. This was the second time that these contaminants have been below reporting limits since monitoring began in 2001. Contaminant concentrations for the three other AOC-05 wells were below laboratory reporting limits. Indigenous denitrifying bacteria have been stimulated by injected ammonium nitrate and have biodegraded TPH-G and BTEX in the source area, resulting in contaminant concentration reductions of more than 99 percent compared to 2008 baseline conditions. These results confirm that bioremediation is providing effective remediation of contaminants. Nitrate concentrations exceeded the action level at downgradient wells BDC-101 and BDC-102, but nitrate concentrations at farther downgradient monitoring wells remained below the action level.

Additional nitrate injections at AOC-05 will continue, as needed, to treat remaining aqueous-phase, sorbed-phase, and NAPL contamination until contaminant concentrations remain consistently below PCULs and it has been demonstrated that substantial rebound of contaminant concentrations will not occur. It is understood that rebound will continue to occur as long as contaminant mass remains in the sorbed-phase or as NAPL within the aquifer or in upper portions of the smear zone that are periodically contacted by the water table. Upon depletion of nitrate in the aquifer, groundwater concentrations will return to equilibrium with remaining TPH mass present in non-aqueous phase. Treatment will be complete when rebound no longer occurs upon depletion of injected nitrate.

Results through February 2014 do not indicate that another injection is needed at this time; however, additional injections will be scheduled based on monitoring results showing nitrate depletion and/or rebound of contaminant concentrations. Modification of the injection approach will be evaluated on an ongoing basis, based on the most current monitoring data. Ammonium phosphate (to prevent a nutrient stall), higher injection rates (to achieve mounding for contact with higher portions of the smear zone), and the larger injection volume (to extend the ROI and increase the longevity of treatment) will likely continue to be utilized for future injections.

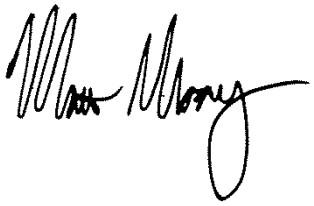
Groundwater monitoring will continue at the four AOC-05 wells and at the four downgradient wells. AOC-05 groundwater sampling is planned to continue on a quarterly basis through 2014 to evaluate contaminant treatment and nitrate consumption. The four AOC-05 wells will continue to be sampled for the parameters indicated in the Work Plan and for nitrite. Semiannual monitoring for nitrate only at downgradient wells MW-17A, MW-18A, MW-21A, and BDC-05-04, triggered by nitrate concentrations at wells BDC-101 and BDC-102, will continue per the Work Plan (Landau Associates 2007a).

7.0 USE OF REPORT

This annual evaluation report has been prepared for the exclusive use of The Boeing Company for specific application to the Boeing Developmental Center. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

LANDAU ASSOCIATES, INC.



Matt Moroney
Staff Engineer

Clinton L. Jacob, P.E., L.G.
Principal Engineer

MM/CLJ/tam

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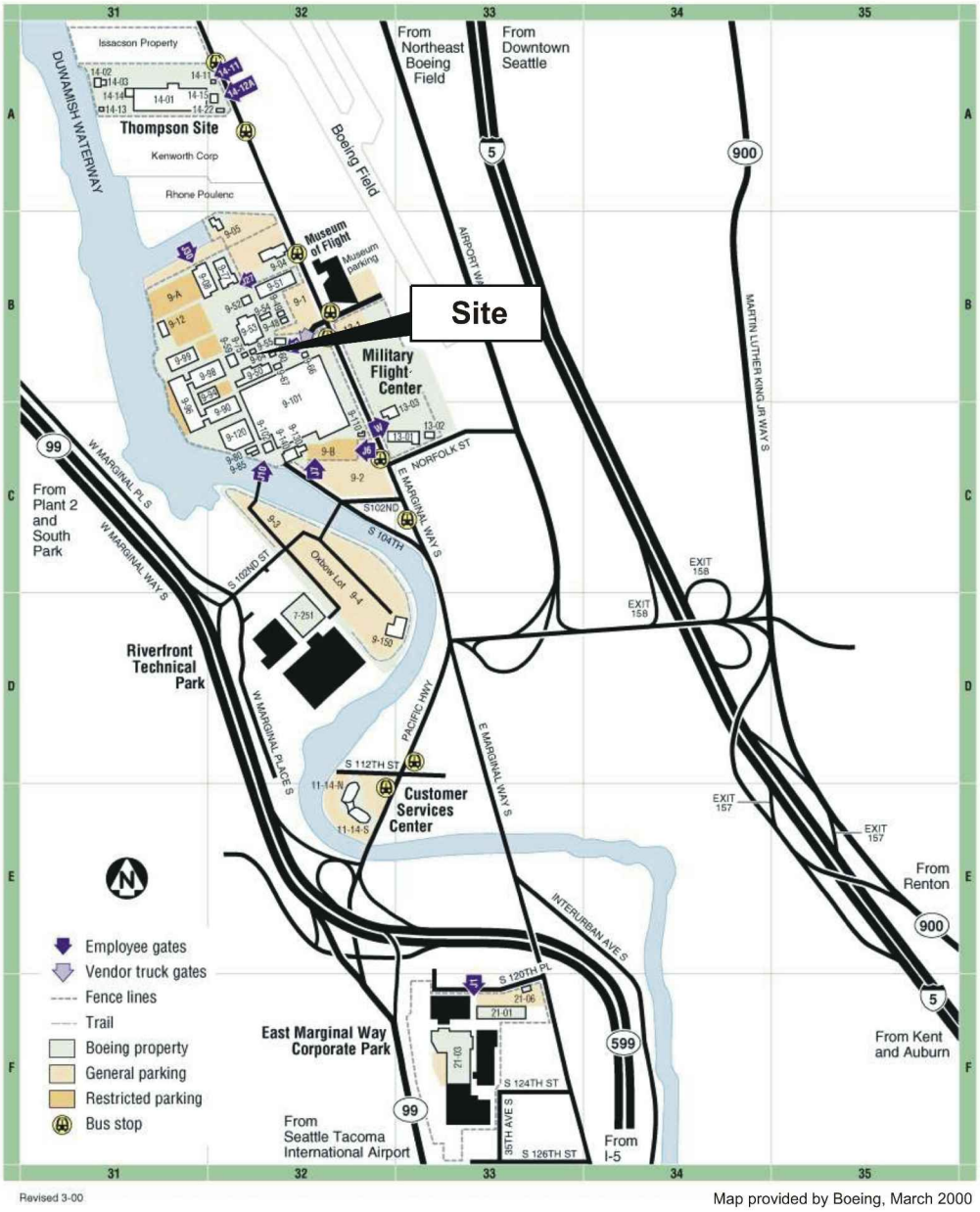
Washington – Developmental Center

9725 East Marginal Way South, Seattle, WA 98108



Revised 3-00

Map provided by Boeing, March 2000

Not To Scale

Boeing Development Center Tukwila, Washington	**Site Location Map**	Figure 1

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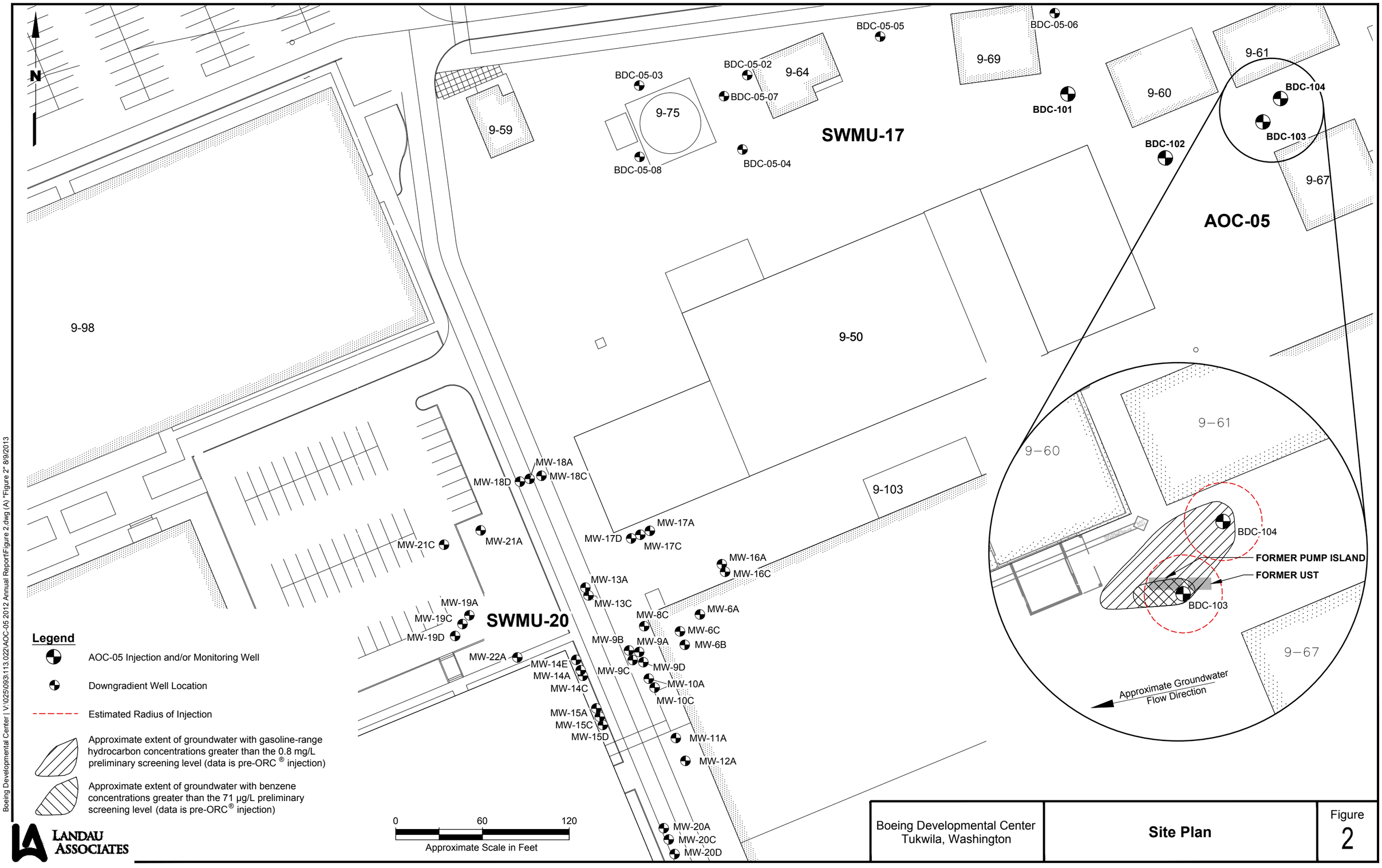

Boeing Developmental Center | V:\025\093\113.022\AOC-05 2012 Annual Report\Figure 2.dwg (A) "Figure 2" 8/9/2013

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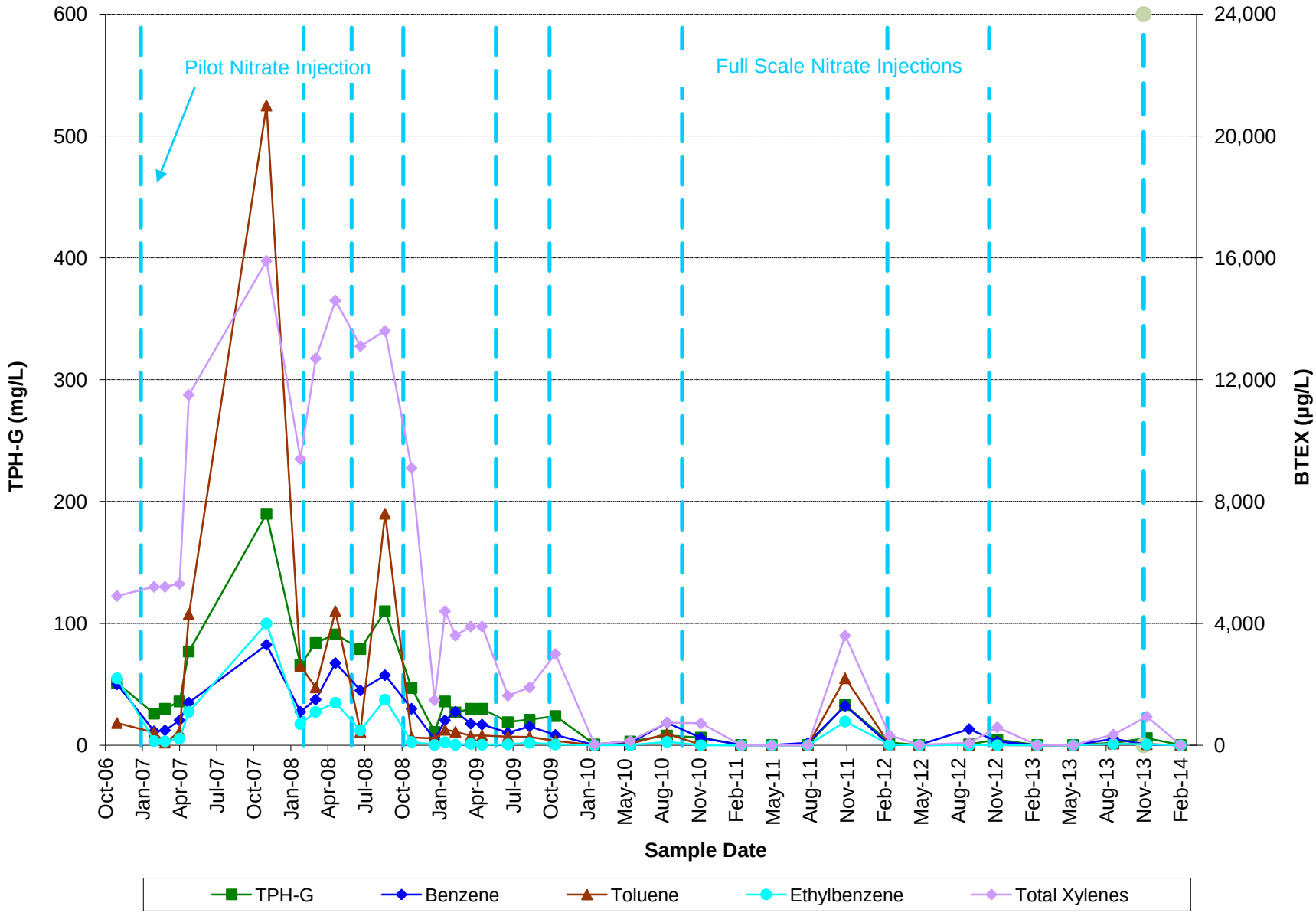
Boeing Developmental Center Tukwila, Washington	**Site Plan**	Figure 2

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



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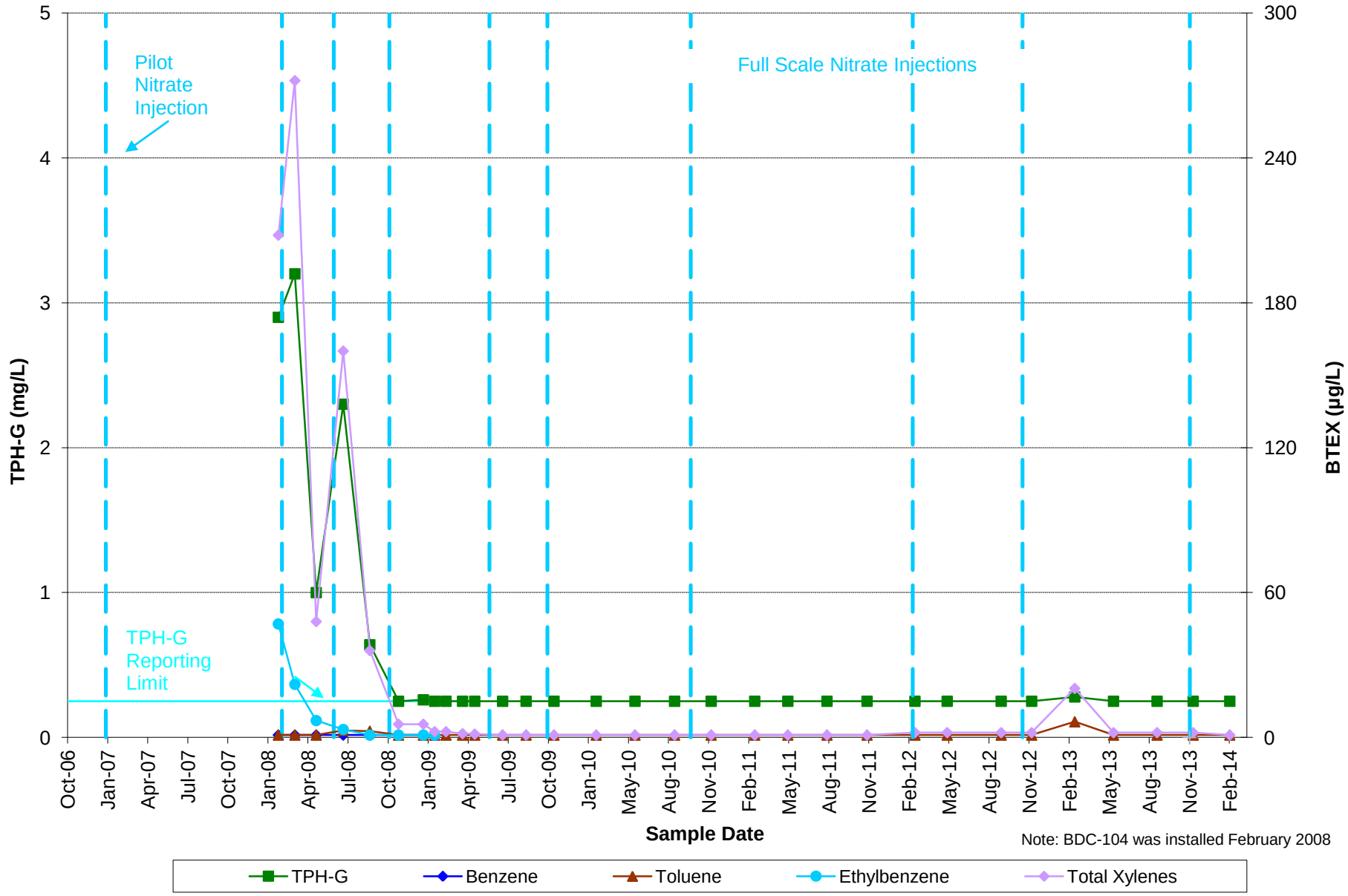
Boeing Developmental Center
Tukwila, Washington

BDC-103 TPH-G and BTEX Concentrations Beginning with 2007 Pilot Testing

Figure
3

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



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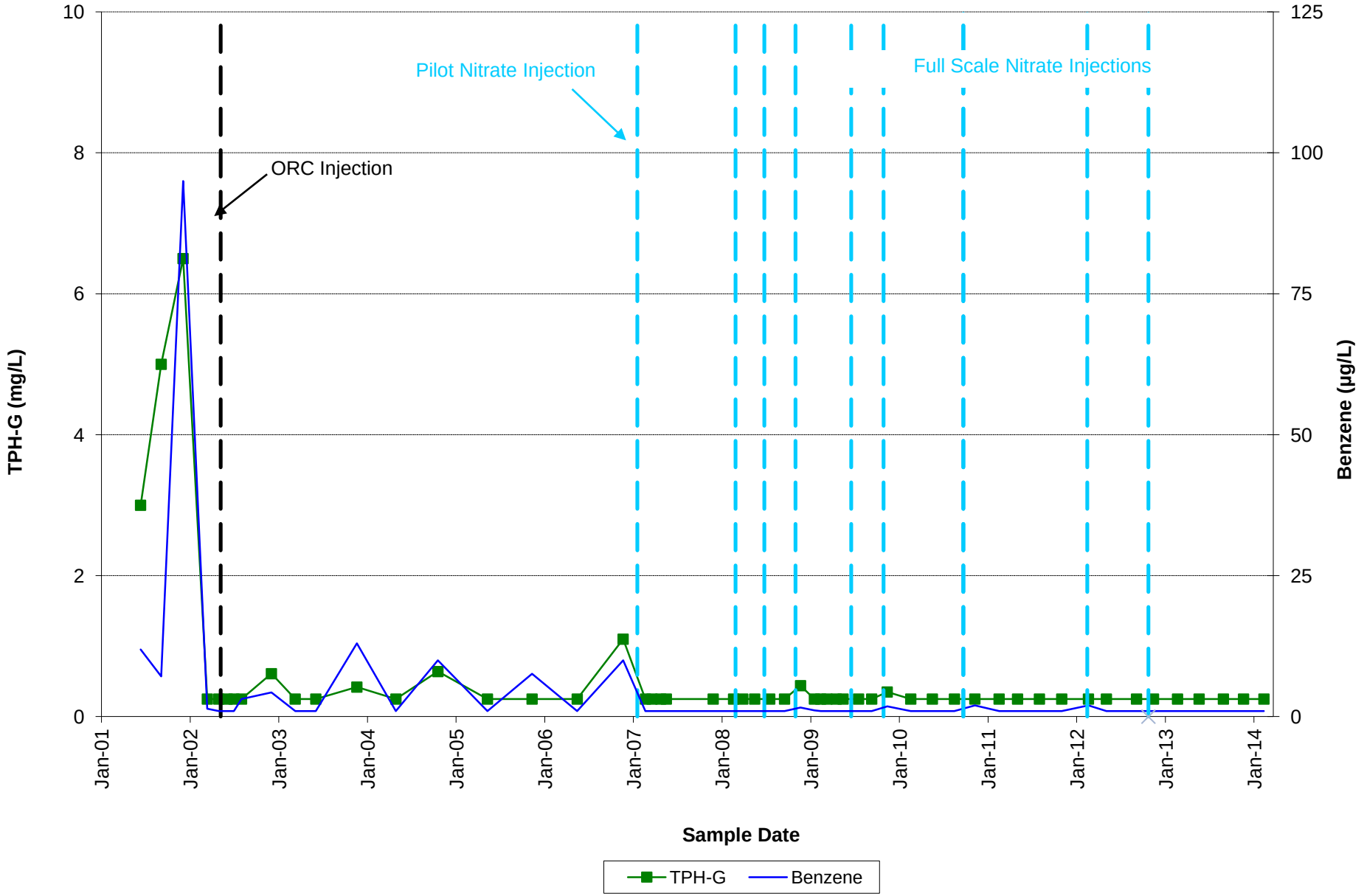
Boeing Developmental Center
Tukwila, Washington

BDC-104 TPH-G and BTEX Concentrations Beginning with 2007 Pilot Testing

Figure
4

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



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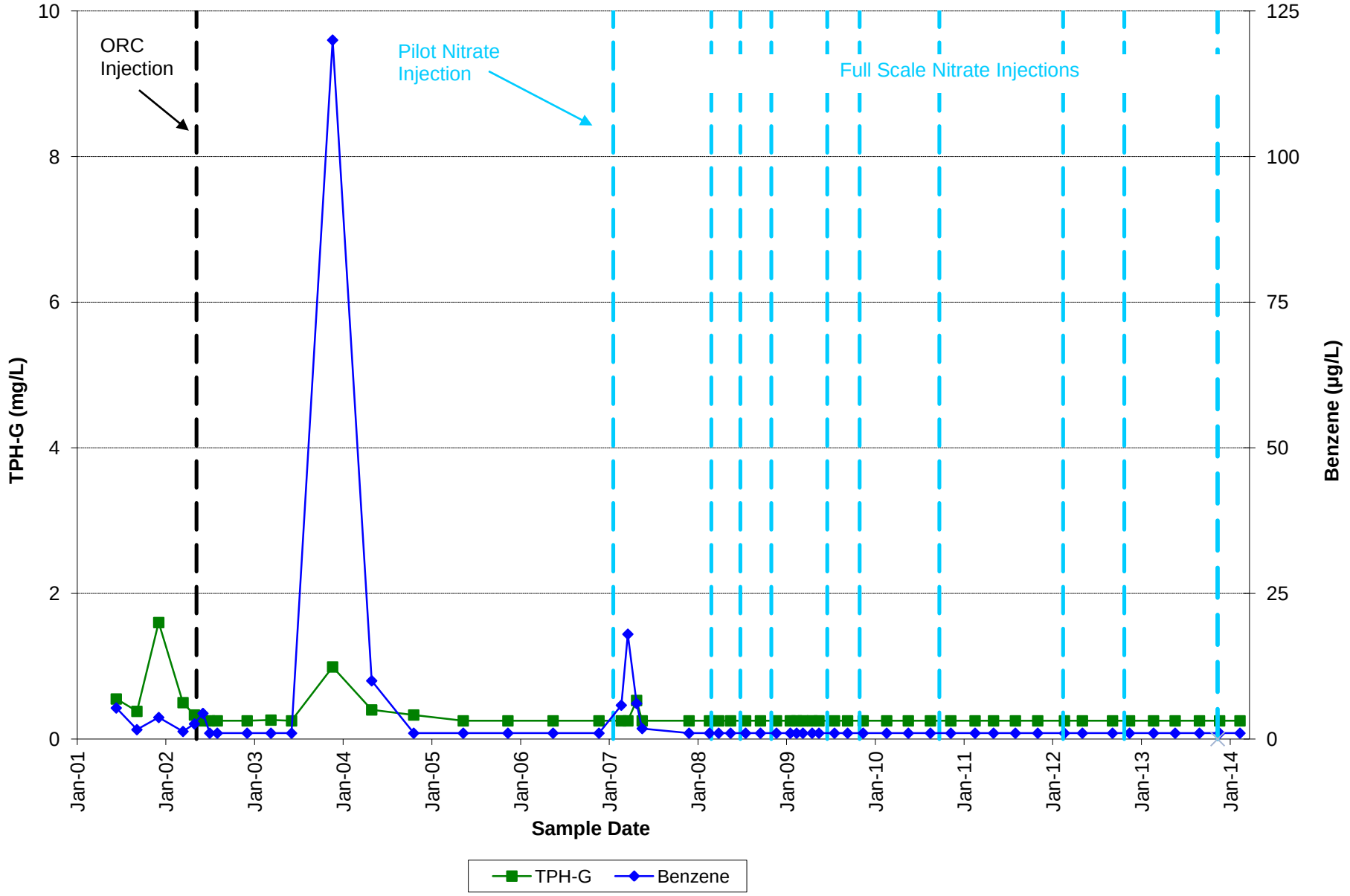
Boeing Developmental Center
Tukwila, Washington

BDC-101 TPH-G and Benzene Concentrations Since 2001

Figure
5

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



Boeing Developmental Center
Tukwila, Washington

BDC-102 TPH-G and Benzene Concentrations Since 2001

Figure
6

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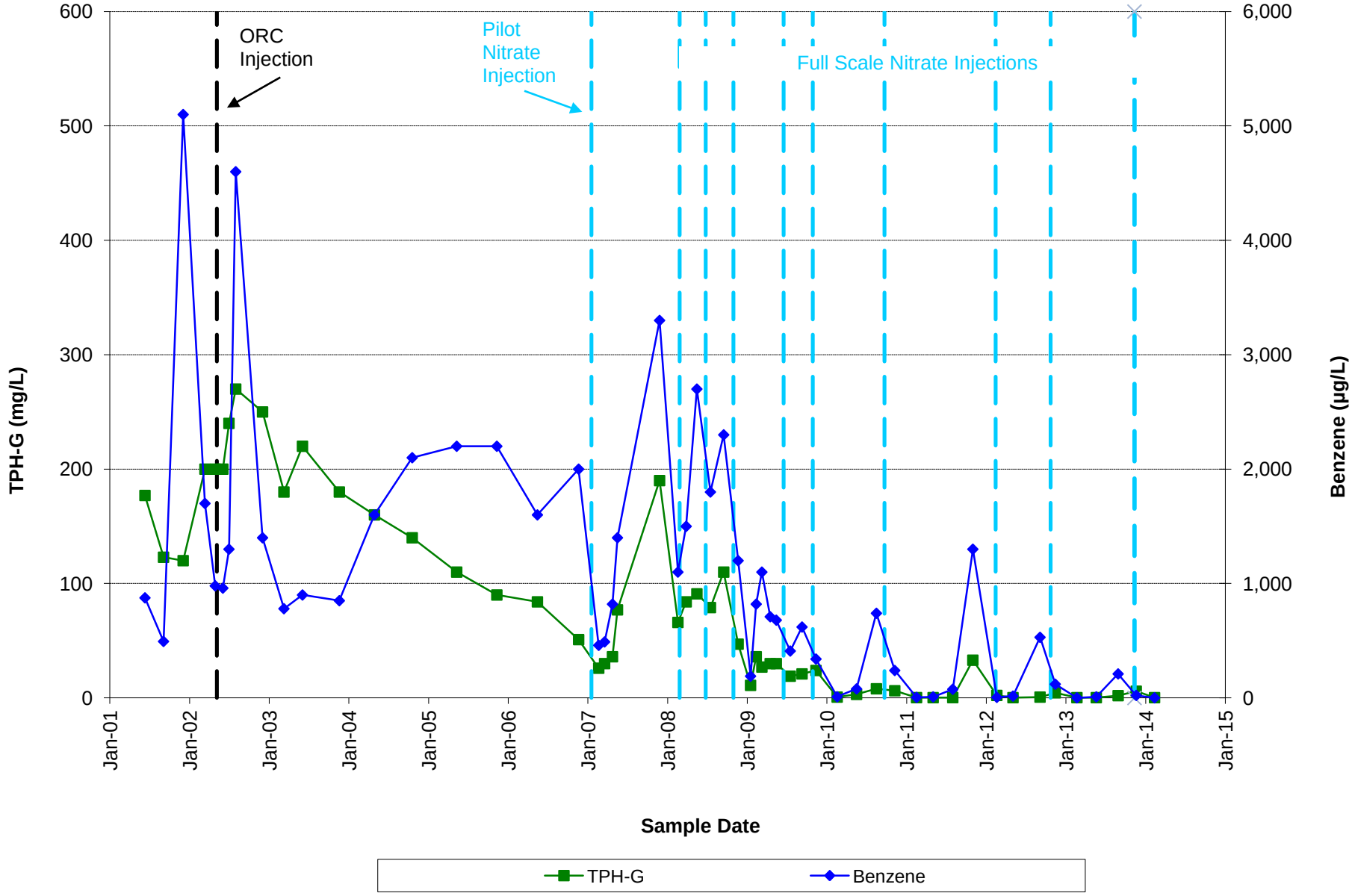
Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



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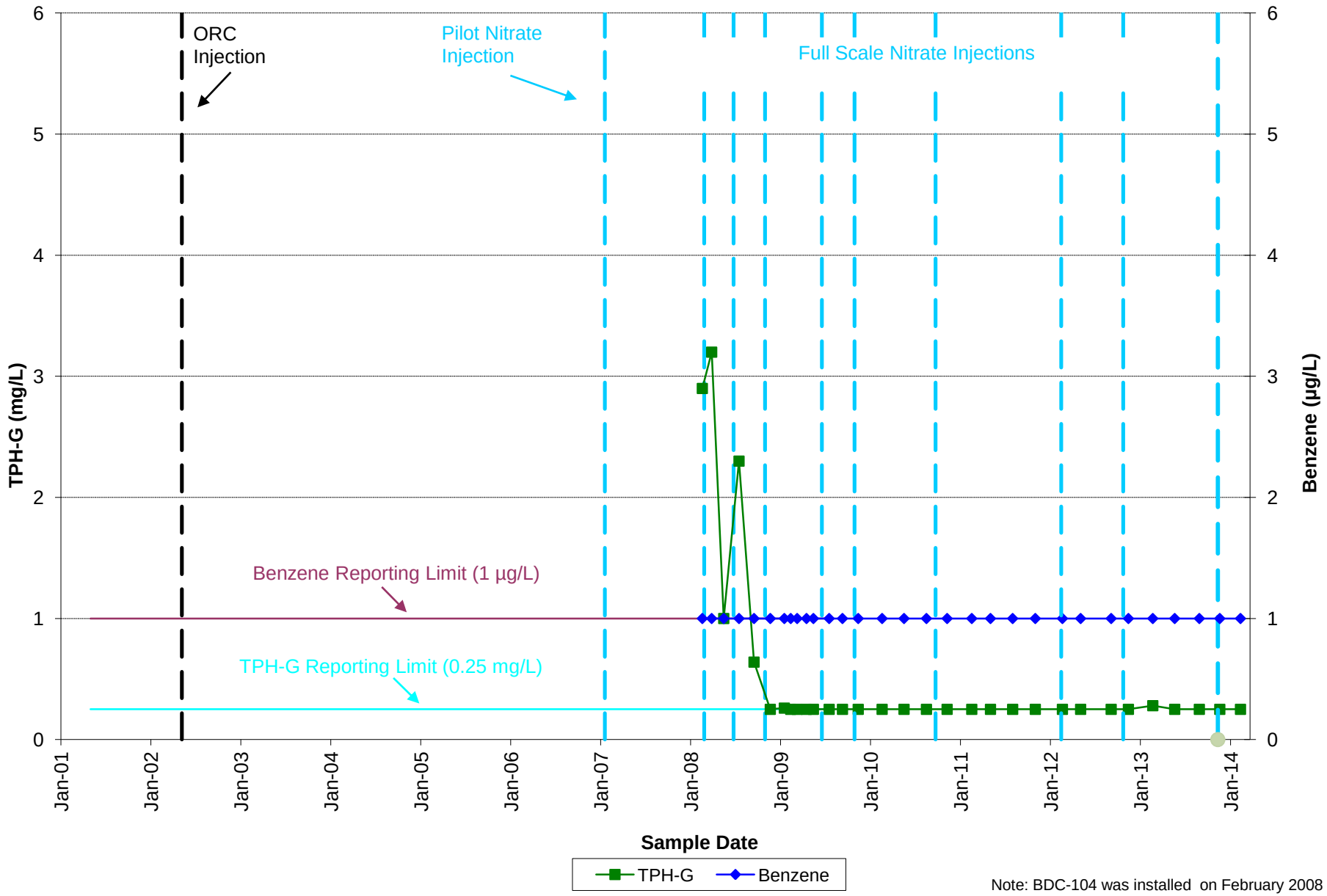
Boeing Developmental Center
Tukwila, Washington

BDC-103 TPH-G and Benzene Concentrations Since 2001

Figure
7



Note: BDC-104 was installed on February 2008

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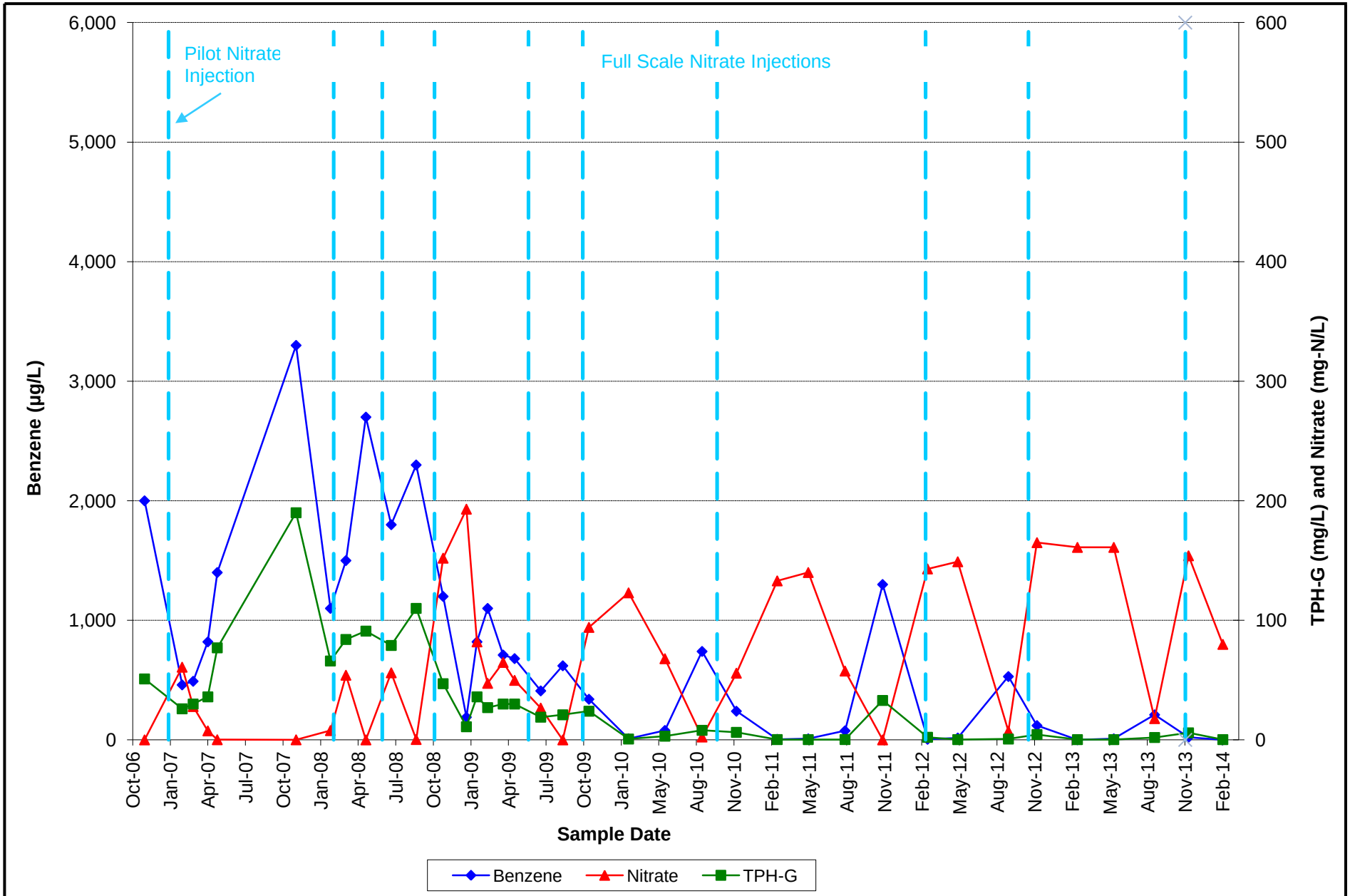
Boeing Developmental Center
Tukwila, Washington

BDC-104 TPH-G and Benzene Concentrations Since 2001

Figure
8

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



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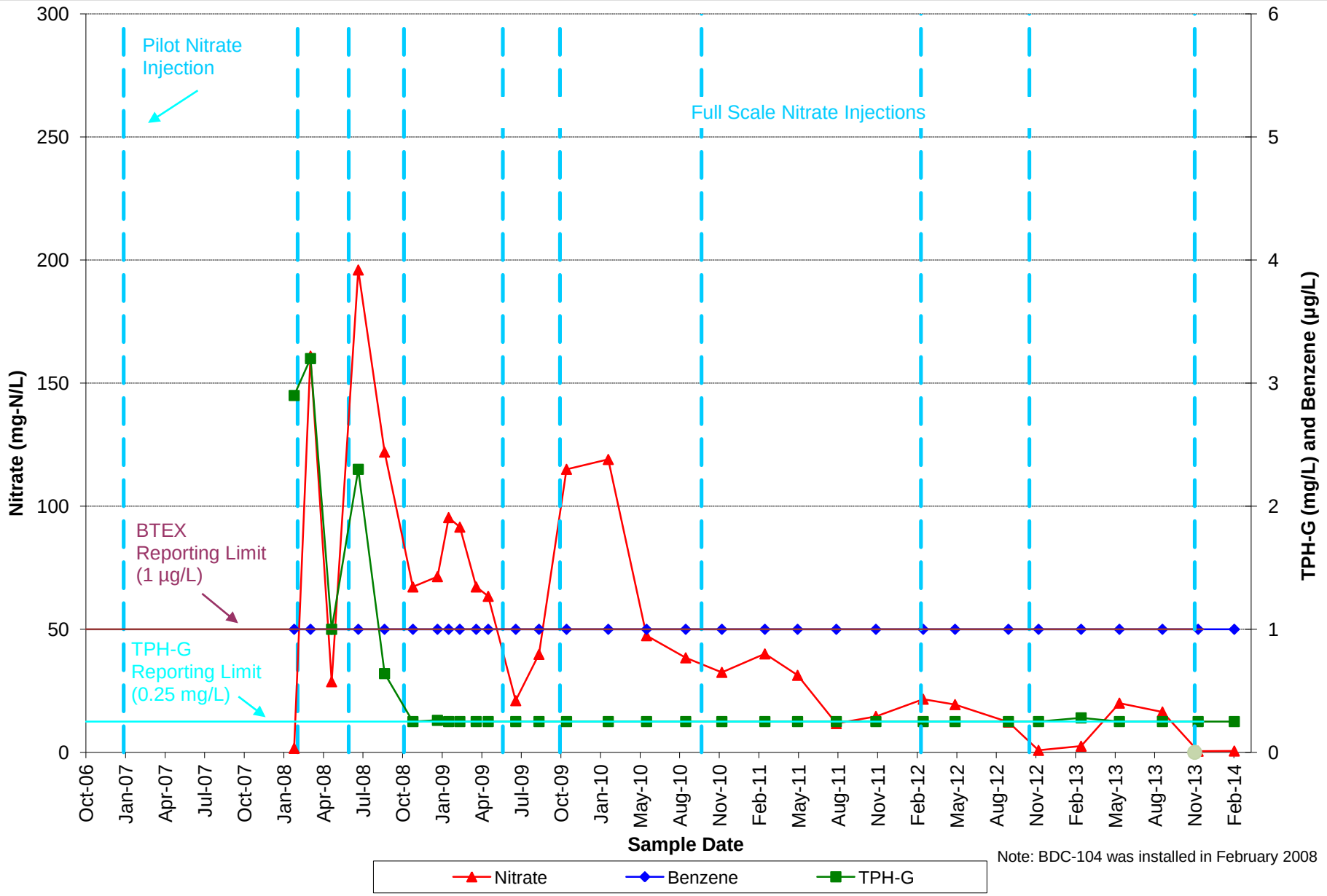
Boeing Developmental Center
Tukwila, Washington

BDC-103 Nitrate, TPH-G, and Benzene Concentrations

Figure
9

Source: P:\025\093\WIP\T\AOC-5\AOC-5 cleanup action tables MASTER.xlsx



Note: BDC-104 was installed in February 2008

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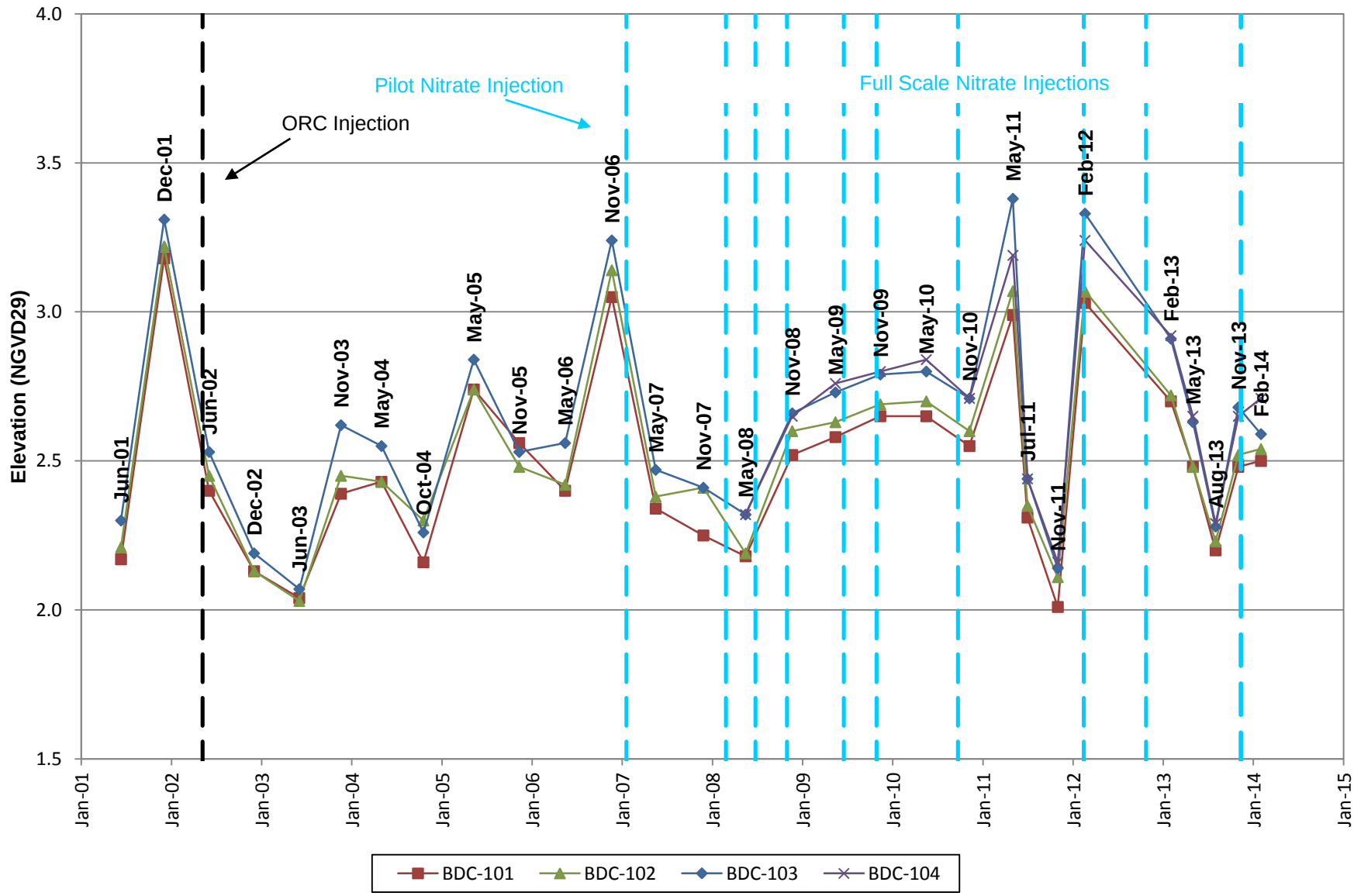
Boeing Developmental Center
Tukwila, Washington

BDC-104 Nitrate, TPH-G, and Benzene Concentrations

Figure
10



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Tukwila, Washington

Groundwater Levels

Figure
11

N

9-99

9-98

9-96

9-94

9-90

9-59

9-75

9-64

9-69

9-60

9-61

9-55

9-42

7-444

9-66

9-62

9-67

9-50

9-101

9-65

BDC-05-03

BDC-05-02

BDC-05-05

BDC-05-06

BDC-05-07

BDC-05-08

BDC-101

BDC-102

BDC-103

BDC-104

SWMU-17

AOC-05

SWMU-20

MW-21A	
11/12/09	<0.1
5/17/10	0.2
11/8/10	<0.1
5/3/11	0.2
8/1/11	0.1
11/1/11	<0.1
5/3/12	0.17
9/4/12	<0.1
11/13/12	0.16
5/20/13	0.1
11/19/13	<0.1

MW-18A	
11/12/09	0.8
5/17/10	1.0
11/8/10	0.1
5/3/11	<0.1
8/1/11	1.1
11/1/11	0.7
5/3/12	<0.1
9/4/12	<0.1
11/13/12	<0.1
5/20/13	<0.1
11/19/13	<0.1

MW-17A	
11/12/09	0.9
5/17/10	1.6
11/8/10	0.1
5/3/11	1.6
8/1/11	0.5
11/1/11	0.3
5/3/12	4.4
9/4/12	2.0
11/13/12	0.59
5/20/13	2.9
11/19/13	1.3

BDC-05-04	
11/13/09	2.2
2/16/10	<0.1
5/18/10	<0.1
8/17/10	<0.1
11/9/10	<0.1
2/15/11	<0.1
5/2/11	<0.1
11/2/11	<1.0
5/3/12	NA
9/4/12	<0.1
11/13/12	<0.1
5/23/13	NA
11/19/13	<0.1

MW-18D
MW-18C
MW-17C
MW-17D
MW-21C
MW-13C
MW-13A
MW-16A
MW-16C
MW-8C
MW-6A
MW-6C
MW-6B
MW-19A
MW-19C
MW-19D
MW-9B
MW-9C
MW-9A
MW-9D
MW-10C
MW-22A
MW-14E
MW-14A
MW-14C
MW-15A
MW-15C
MW-15D
MW-10A
MW-11A
MW-12A
MW-20A
MW-20C
MW-20D
MW-23A

Legend

- AOC-05 Monitoring Well Location
- Downgradient Well Location
- MW-21A / 11/12/10 / <0.1 — Designation; Nitrate Concentration (mg/L); Date

NA = Not Analyzed; Nitrate sampling was inadvertently missed during May 2012 Sampling.

0 100 200

Approximate Scale in Feet

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Tukwila, Washington

Nitrate Concentrations at Downgradient Monitoring Locations

Figure 12

Boeing Developmental Center | V:\025\093\113.022\AOC-05 2012 Annual Report\Figure 12.dwg (A) "Figure 12" 8/9/2013

TABLE 1
DATA SUMMARY
DEVELOPMENTAL CENTER GROUNDWATER MONITORING

		ORC	Pilot	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale																		
		Injection	Injection	Injection 1	Injection 2	Injection 3	Injection 4	Injection 5	Injection 6	Injection 7	Injection 8	Injection 9	Volatile Organic Compounds (all units in ug/L)							Aquifer Redox Conditions							Donor Indicators		
		Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	TPH-G (mg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	m,p-Xylene (µg/L)	o-Xylene (µg/L)	Total Xylenes (µg/L)	DO (mg/L)	Nitrate (mg-N/L)	Nitrite (mg-N/L)	Iron II (mg/L)	Sulfate (mg/L)	Methane (µg/L)	ORP (mV)	TOC (mg/L)	pH	
													Proposed Groundwater Cleanup Levels (a)	**0.8**	**2.0**	**1294**	**1.7**	**NA**	**NA**	**1546**										
Well	Date																													Comments
BDC-101	6/11/2001												3.0	11.9	<1.0	113.1			109.2											
BDC-101	9/4/2001												5.0	7.13	10.7	50.4			53.8											
BDC-101	12/3/2001												6.5	95	1.6	750			650											
BDC-101	3/13/2002												<0.25	1.4	<1.0	4.4			<1.0											
BDC-101	4/29/2002	-8											<0.25	<1.0	<1.0	2.2	<1.0	<1.0	<1.0											
BDC-101	6/3/2002	27											<0.25	1.0	<1.0	<1.0	<1.0	<1.0	<1.0											
BDC-101	7/1/2002	55											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0											
BDC-101	8/1/2002	86											<0.25	3.1	<1.0	2.4	<1.0	<1.0	<1.0											
BDC-101	12/2/2002	209											0.61	4.3	<1.0	21	27	6.4	33.4											
BDC-101	3/10/2003	307											<0.25	1.0	<1.0	4.5	3.2	<1.0	3.2											
BDC-101	6/3/2003	392											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0											
BDC-101	11/19/2003	561											0.42	13	<1.0	15	35	<1.0	35	0.36	1.1	0.010	0.2	16	240	120.3				
BDC-101	4/28/2004	722											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0											
BDC-101	10/18/2004	895											0.64	10	<1.0	15	43	<1.0	43											
BDC-101	5/10/2005	1099											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0											
BDC-101	11/10/2005	1283											0.25	7.6	<1.0	2.6	42	<1.0	42	0.96	4.4			34.3		259	2.05			
BDC-101	5/15/2006	1469											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.78	17.8	0.059	0.0	64.1		80				
BDC-101	11/20/2006	1658	-59										1.1	10	<1.0	15	72.0	<1.0	72	0.92	0.122	0.016	2.4	8.7		174				
BDC-101	2/20/2007	1750	33										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.39	15.0	0.047	0.2	50.0		277		6.63		
BDC-101	3/19/2007	1777	60										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.97	8.83	0.037	0.5	38.5		213		6.60		
BDC-101	4/24/2007	1813	96										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.09	9.59	0.041	0.5	34.1		136		6.46		
BDC-101	5/17/2007	1836	119										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.35	9.95	0.046	0.4	35.7		297		6.55		
BDC-101	11/26/2007	2029	312										<0.25	<1.0	<1.0	2.1	6.5	<1.0	6.5	2.30	5.88	0.032	0.0	26.8		287				
BDC-101	2/18/2008	2113	396	-8									<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.55	8.10	0.040	0.0	31.5		341		6.29		
BDC-101	3/27/2008	2151	434	30									<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.19	9.3	<0.10	0.2	40.0		506				
BDC-101	5/15/2008	2200	483	79	-40								<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.57	6.8	<0.10	0.0	24.6		176		6.44		
BDC-101	7/16/2008	2262	545	141	22								<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.34	5.3	<0.10	0.0	21.8		-232		6.52		
BDC-101	9/15/2008	2323	606	202	83	-45							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.22	5.33	0.023	0.0	28.7		153				
BDC-101	11/20/2008	2389	672	268	149	21							0.44	1.6	<1.0	<1.0	<1.0	<1.0	<1.0	1.45	2.9	0.1	0.8	17.1		-22		6.65		
BDC-101	1/16/2009	2446	729	325	206	78							<0.25	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	0	4.40	0.042	0.4	29.5		-245		6.50		
BDC-101	2/11/2009	2472	755	351	232	104							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.62	8.5	<0.1	0.4	39.6		-16		6.43		
BDC-101	3/9/2009	2498	781	377	258	130							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.93	9.4	<0.1	0.0	46.8		54		6.54		
BDC-101	4/16/2009	2536	819	415	296	168							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.69	9.0	<0.1	0.0	36.0		131		6.61		
BDC-101	5/14/2009	2564	847	443	324	196	-34						<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.00	13.0	<0.1	0.0	44.4		68		6.81		
BDC-101	7/17/2009	2628	911	507	388	260	30						<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.80	12.6	<0.1	0.0	49.0		19		7.17		
BDC-101	9/9/2009	2682	965	561	442	314	84	-49					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.25	6.2	<0.1	0.0	31.7		179		6.90		
BDC-101	11/12/2009	2746	1029	625	506	378	148	15					0.35	1.8	<1.0	6.6	16	<1.0	16	1.37	11.3	<0.1	0-0.2	36.7		124		6.53	Very faint iron measurement	
BDC-101	2/17/2010	2843	1126	722	603	475	245	112					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.86	13.9	<0.1	0.0	48.7		640		6.55		
BDC-101	5/17/2010	2932	1215	811	692	564	334	201					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.20	20.7	<1.0	0.0	58.7		372		6.86		
BDC-101	8/16/2010	3023	1306	902	783	655	425	292	-37				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.21	15.6	<0.1	0.0	56.9		76		7.21		
BDC-101	11/8/2010	3107	1390	986	867	739	509	376	47				<0.25	2.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.02	2.2	<0.1	0.4	14.7		145		6.97		
BDC-101	2/16/2011	3207	1490	1086	967	839	609	476	147				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.46	23.9	<0.1	0.0	68.2		161		7.30		
BDC-101	5/3/2011	3283	1566	1162	1043	915	685	552	223				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.57	23.7	<0.1	0.0	66.2		208		6.99		
BDC-101	8/1/2011	3373	1656	1252	1133	1005	775	642	313				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.50	17.9	<0.1	0.0	48.1		150		7.07		
BDC-101	11/1/2011	3465	1748	1344	1225	1097	867	734	405	-105			<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	6.69	6.1	<0.1	0.0	24.8		40		7.23		
BDC-101	2/19/2012	3575	1858	1454	1335	1207	977	844	515	5			<0.25	2.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.53	6.6		0.3	27.7		12		6.81		
BDC-101	5/3/2012	3649	1932	1528	1409	1281	1051	918	589	79			<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	3.75	15.9		0.0	51.2		263		6.60		
BDC-101	9/4/2012	3773	2056	1652	1533	1405	1175	1042	713	203	-49		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.88	13.8	<0.10	0.0	36.0		154		6.97		
BDC-101	11/13/2012	3843	2126	1722	1603	1475	1245	1112	783	273	21		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.41	10.3	<0.10	0.0	40.4		150		6.90		
BDC-101	2/20/2013	3942	2225	1821	1702	1574	1344	1211	882	372	120		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	2.55	21.3	<0.10	0.2	68.0		73		6.83		
BDC-101	5/20/2013	4031	2314	1910	1791	1663	1433	1300	971	461	209		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	3.35	17	<0.10	0.0	52.9		-190		6.72		
BDC-101	8/28/2013	4131	2414	2010	1891	1763	1533	1400	1071	561	309	-76	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	1.99	10.5	<0.10	0.0	41.5		-277		6.46		
BDC-101	11/19/2013	4214	2497	2093	1974	1846	1616	1483	1154	644	392	7	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	2.53	7.6	<0.10	0.0	28.3		-173		6.67		
BDC-101	2/11/2014	4298	2581	2177	2058	1930	1700	1567	1238	728	476	91	<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.65	7.7	<0.10	0.0	29.1		-223		6.80		

TABLE 1
DATA SUMMARY
DEVELOPMENTAL CENTER GROUNDWATER MONITORING

		ORC	Pilot	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale															
		Injection	Injection	Injection 1	Injection 2	Injection 3	Injection 4	Injection 5	Injection 6	Injection 7	Injection 8	Injection 9	Volatile Organic Compounds (all units in ug/L)							Aquifer Redox Conditions							Donor Indicators	
		Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	TPH-G	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	Total Xylenes	DO	Nitrate	Nitrite	Iron II	Sulfate	Methane	ORP	TOC	pH	
													(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg-N/L)	(mg-N/L)	(mg/L)	(mg/L)	(µg/L)	(mV)	(mg/L)		
												Proposed Groundwater Cleanup Levels (a)	**0.8**	**2.0**	**1294**	**1.7**	**NA**	**NA**	**1546**										
Well	Date																												Comments
BDC-102	6/11/2001												0.55	5.33	<1.0	<1.0			<1.0										
BDC-102	9/4/2001												0.38	1.61	1.89	<1.0			1.87										
BDC-102	12/3/2001												1.6	3.7	<1.0	<1.0			3.49										
BDC-102	3/13/2002												0.50	1.3	<1.0	<1.0			<1.0										
BDC-102	4/29/2002	-8											0.33	2.6	<1.0	<1.0	1.1	<1.0	1.1										
BDC-102	6/3/2002	27											<0.25	4.4	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	7/1/2002	55											0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	8/1/2002	86											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	12/2/2002	209											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	3/10/2003	307											0.26	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	6/3/2003	392											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	11/19/2003	561											0.99	120	<1.0	8.5	<1.0	<1.0	<1.0	0.38	0.19	0.011	5.5	46	1100	122.2			
BDC-102	4/28/2004	722											0.40	10	<1.0	<1.0	3.0	<1.0	3.0										
BDC-102	10/18/2004	895											0.33	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	5/10/2005	1099											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0										
BDC-102	11/10/2005	1283											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.82	4.4			34.0		122	18.4		
BDC-102	5/15/2006	1469											<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.21	4.72	0.175	2.2	35.7		-11			
BDC-102	11/20/2006	1658	-59										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.25	<0.250	<0.250	2.2	9.2		163			
BDC-102	2/20/2007	1750	33										<0.25	5.8	<1.0	<1.0	<1.0	<1.0	<1.0	0.47	0.749	0.027	3.0	25.3		-145		6.54	
BDC-102	3/19/2007	1777	60										<0.25	18	<1.0	<1.0	32	<1.0	32	0.88	0.938	0.072	3.0	31.0		-98		6.67	
BDC-102	4/24/2007	1813	96										0.53	6.1	<1.0	3.1	100	<1.0	100	1.20	1.94	0.051	2.8	40.4		-93		6.51	
BDC-102	5/17/2007	1836	119										<0.25	1.8	<1.0	<1.0	7.4	<1.0	7.4	0.84	2.78	0.108	2.6	33.9		286		6.52	
BDC-102	11/26/2007	2029	312										<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.29	1.03	0.247	3.0	55.7		46			
BDC-102	2/18/2008	2113	396	-8									<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.51	3.91	0.054	2.8	42.8		431		5.97	
BDC-102	3/27/2008	2151	434	30									<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.85	1.3	<0.10	2.5	17.9		233			
BDC-102	5/15/2008	2200	483	79	-40								<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.40	3.0	<0.10	3.5	19.2		-115		6.56	
BDC-102	7/16/2008	2262	545	141	22								<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.46	2.5	<0.10	3.2	13.7		-312		6.67	
BDC-102	9/15/2008	2323	606	202	83	-45							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.22	4.28	0.056	3.0	31.6		191			
BDC-102	11/20/2008	2389	672	268	149	21							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.70	0.40	<0.10	2.0	5.6		-70		6.69	
BDC-102	1/16/2009	2446	729	325	206	78							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.00	<0.100	0.200	2.5	8.3		-235		6.70	
BDC-102	2/11/2009	2472	755	351	232	104							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.65	2.4	<0.1	3.0	20.4		-70		6.61	
BDC-102	3/9/2009	2498	781	377	258	130							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.00	0.9	<0.1	3.0	8.7		-46		6.65	
BDC-102	4/16/2009	2536	819	415	296	168							<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.30	0.6	<0.1	3.0	8.3		-7		6.66	
BDC-102	5/14/2009	2564	847	443	324	196	-34						<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.29	0.9	<0.1	3.4	9.8		-35		6.78	
BDC-102	7/17/2009	2628	911	507	388	260	30						<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.66	4.9	<0.1	2.2	28.6		-11		6.46	
BDC-102	9/9/2009	2682	965	561	442	314	84	-49					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.91	0.4	<0.1	2.7	5.5		2.8		6.66	
BDC-102	11/12/2009	2746	1029	625	506	378	148	15					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.93	0.2	<0.1	3.2	2.4		-42.0		6.49	
BDC-102	2/17/2010	2843	1126	722	603	475	245	112					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.90	3.4	0.2	2.8	17.2		892		6.56	
BDC-102	5/17/2010	2932	1215	811	692	564	334	201					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.35	8.4	<1.0	3.0	30.1		440		6.61	
BDC-102	8/16/2010	3023	1306	902	783	655	425	292	-37				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.61	8.9	<0.1	3.0	27.8		82		6.60	
BDC-102	11/8/2010	3107	1390	986	867	739	509	376	47				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.34	0.4	<0.1	2.0	6.9		45		7.09	
BDC-102	2/16/2011	3207	1490	1086	967	839	609	476	147				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.68	3.5	<0.1	2.2	43.3		399		6.88	
BDC-102	5/3/2011	3283	1566	1162	1043	915	685	552	223				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.60	12.1	<0.1	2.0	32.4		40		6.70	
BDC-102	8/1/2011	3373	1656	1252	1133	1005	775	642	313				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.01	13.6	<0.1	2.1	28.7		11		6.88	
BDC-102	11/1/2011	3465	1748	1344	1225	1097	867	734	405	-105			<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.45	9.8	<0.1	1.5	30.9		-48		7.19	
BDC-102	2/19/2012	3575	1858	1454	1335	1207	977	844	515	5			<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.25	2.4		1.0	15.4		21		6.60	
BDC-102	5/3/2012	3649	1932	1528	1409	1281	1051	918	589	79			<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.22	11.3		2.5	40.2		248		6.44	
BDC-102	9/4/2012	3773	2056	1652	1533	1405	1175	1042	713	203	-49		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.20	13.2	<5.0	1.5	39.2		130		6.63	
BDC-102	11/13/2012	3843	2126	1722	1603	1475	1245	1112	783	273	21		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.10	1.7	<0.10	1.6	27.7		48		6.77	
BDC-102	2/20/2013	3942	2225	1821	1702	1574	1344	1211	882	372	120		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.17	18.4	<0.10	1.0	58.5		92		6.60	
BDC-102	5/20/2013	4031	2314	1910	1791	1663	1433	1300	971	461	209		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.49	20	<0.10	1.5	62.2		-280		7.31	
BDC-102	8/28/2013	4131	2414	2010	1891	1763	1533	1400	1071	561	309	-76	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	1.93	12.2	<0.10	1.0	39.1		-341		6.45	
BDC-102	11/19/2013	4214	2497	2093	1974	1846	1616	1483	1154	644	392	7	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	3.89	10.6	<0.10	1.2	43.4		-254		6.54	
BDC-102	2/11/2014	4298	2581	2177	2058	1930	1700	1567	1238	728	476	91	<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.16	19.6	<0.10	2.2	63		-246		6.67	

TABLE 1
DATA SUMMARY
DEVELOPMENTAL CENTER GROUNDWATER MONITORING

		ORC	Pilot	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale															
		Injection	Injection	Injection 1	Injection 2	Injection 3	Injection 4	Injection 5	Injection 6	Injection 7	Injection 8	Injection 9	Volatile Organic Compounds (all units in ug/L)							Aquifer Redox Conditions							Donor Indicators	
		Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	TPH-G	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	Total Xylenes	DO	Nitrate	Nitrite	Iron II	Sulfate	Methane	ORP	TOC	pH	
													(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg-N/L)	(mg-N/L)	(mg/L)	(mg/L)	(µg/L)	(mV)	(mg/L)		
													Proposed Groundwater Cleanup Levels (a)	**0.8**	**2.0**	**1294**	**1.7**	**NA**	**NA**	**1546**										
Well	Date																												Comments
BDC-103	6/11/2001												177	875	12,010	1,985			11,430										
BDC-103	9/4/2001												123	494	3,760	419			2,636										
BDC-103 (c)	12/3/2001												120	5,100	2,300,000	10,000			3,400,000										
BDC-103	3/13/2002												200	1,700	17,000	4,900			26,400										
BDC-103	4/29/2002	-8											200	980	16,000	5,400	20,000	7,000	27,000										
BDC-103	6/3/2002	27											200	960	17,000	5,100	20,000	7,100	27,100										
BDC-103	7/1/2002	55											240	1,300	16,000	5,200	20,000	6,800	26,800										
BDC-103	8/1/2002	86											270	4,600	18,000	5,200	19,000	6,600	25,600										
BDC-103	12/2/2002	209											250	1,400	15,000	5,000	22,000	6,900	28,900										
BDC-103	3/10/2003	307											180	780	13,000	5,200	20,000	6,700	26,700										
BDC-103	6/3/2003	392											220	900	10,000	5,000	20,000	6,600	26,600										
BDC-103	11/19/2003	561											180	850	8,300	4,500	18,000	5,500	23,500	0.38	0.012	0.011	5.5	53	630	-75.9			
BDC-103	4/28/2004	722											160	1,600	6,600	3,900	16,000	5,100	21,100										
BDC-103	10/18/2004	895											140	2,100	5,500	3,700	15,000	4,400	19,400										
BDC-103	5/10/2005	1099											110	2,200	5,500	3,800	14,000	3,200	17,200										
BDC-103	11/10/2005	1283											90	2,200	3,500	3,700	12,000	2,500	15,000	0.72	<1.0			11.9		147	15.4		
BDC-103	5/15/2006	1469											84	1,600	3,800	3,100	10,000	2,200	12,000	0.92	<0.010	0.054	3.5	15.2		106			
BDC-103	11/20/2006	1658	-59										51	2,000	730	2,200	3,900	1,000	4,900	1.23	<0.10	<0.10	2.4	28.3		202			
BDC-103	2/20/2007	1750	33										26	460	420	140	3,600	1,600	5,200	0.31	60.8	11.1	0.5	99.2		109		6.54	
BDC-103	3/19/2007	1777	60										30	490	88	130	3,500	1,700	5,200	0.63	27.9	8.28	0.4	141		4		6.79	
BDC-103	4/24/2007	1813	96										36	820	440	220	3500	1800	5300	0.84	7.54	3.56	2.4	59.2		-14		6.70	
BDC-103	5/17/2007	1836	119										77	1,400	4,300	1,100	8,300	3,200	11,500	0.61	0.138	0.079	3.6	169		244		6.82	
BDC-103	11/26/2007	2029	312										190	3,300	21,000	4,000	11,000	4,900	15,900	3.37	0.063	0.049	3.6	49.1		-118			
BDC-103	2/18/2008	2113	396	-8									66	1,100	2,600	700	7,500	1,900	9,400	2.06	7.75	0.134	2.8	163		552		5.97	
BDC-103	3/27/2008	2151	434	30									84	1,500	1,900	1,100	9,700	3,000	12,700	1.60	54.1	18	4.0	115.0		182			
BDC-103	5/15/2008	2200	483	79	-40								91	2,700	4,400	1,400	11,000	3,600	14,600	1.38	<0.10	<0.10	3.2	192		-138		7.11	
BDC-103	7/16/2008	2262	545	141	22								79	1,800	440	490	10,000	3,100	13,100	1.61	56.1	16.6	2.8	149		-226		6.72	
BDC-103	9/15/2008	2323	606	202	83	-45							110	2,300	7,600	1,500	10,000	3,600	13,600	0.48	0.330	0.218	3.2	218		189			
BDC-103	11/20/2008	2389	672	268	149	21							47	1,200	260	110	7,000	2,100	9,100	0.21	152	12.5	2.0	120		-1.2		6.66	
BDC-103	1/16/2009	2446	729	325	206	78							11	190	220	12	1,000	480	1,480	0.24	193	2.32	0.6	62.5		-181		6.19	
BDC-103	2/11/2009	2472	755	351	232	104							36	820	510	<100	2,900	1,500	4,400	1.66	82.0	6.7	0.8	178		-65		6.69	
BDC-103	3/9/2009	2498	781	377	258	130							27	1100	440	18	2,400	1,200	3,600	0	47.3	2.4	0.4	192		17		6.80	
BDC-103	4/16/2009	2536	819	415	296	168							30	710	310	<50	2,700	1,200	3,900	0.95	64.8	5.6	0.2-0.4	194		62		6.77	
BDC-103	5/14/2009	2564	847	443	324	196	-34						30	680	320	20	2,400	1,500	3,900	0.48	49.8	4.8	0.8	222		20		6.85	
BDC-103	7/17/2009	2628	911	507	388	260	30						19	410	280	32	630	1,000	1,630	2.60	26.6	2.0	1.0	104		29		6.98	
BDC-103	9/9/2009	2682	965	561	442	314	84	-49					21	620	270	83	700	1200	1,900	0.88	<0.1	<0.1	2.5	134		2.8		7.01	
BDC-103	11/12/2009	2746	1029	625	506	378	148	15					24	340	140	27	1,800	1,200	3,000	1.42	94.1	7.7	0.4	71.7		117		6.11	
BDC-103	2/17/2010	2843	1126	722	603	475	245	112					0.73	10	<1.0	<1.0	3.1	22	25	1.45	123	1.1	0.0	60.3		939		6.22	
BDC-103	5/17/2010	2932	1215	811	692	564	334	201					3.1	79	44	5.2	60	86	146	1.56	67.9	2.6	0.4	71.6		436		6.63	
BDC-103	8/16/2010	3023	1306	902	783	655	425	292	-37				8.0	740	380	110	420	320	740	2.24	2.4	0.1	2.0	72.5		184		6.96	
BDC-103	11/8/2010	3107	1390	986	867	739	509	376	47				6.3	240	11	1.7	180	540	720	7.46	55.8	1.5	0.0	123		199		7.05	
BDC-103	2/16/2011	3207	1490	1086	967	839	609	476	147				0.28	4.6	<1.0	<1.0	<1.0	5.4	5.4	5.18	133	0.6		74.6		508		6.52	
BDC-103	5/3/2011	3283	1566	1162	1043	915	685	552	223				<0.25	9.1	<1.0	<1.0	<1.0	2.2	2.2	2.15	140	0.2	0.0	74.4		393		6.35	
BDC-103	8/1/2011	3373	1656	1252	1133	1005	775	642	313				0.30	76	<1.0	1.8	7.8	2.5	10.3	5.67	57.6	<0.1	0.2	63.2		168		7.09	
BDC-103	11/1/2011	3465	1748	1344	1225	1097	867	734	405	-105			33	1300	2200	780	2300	1300	3,600	1.72	<0.1	<0.1	1.2	8.1		-226		7.38	
BDC-103	2/19/2012	3575	1858	1454	1335	1207	977	844	515	5			2.2	5.1	31	19	260	69	329	0.21	143		0.3	57.1		36		6.41	
BDC-103	5/3/2012	3649	1932	1528	1409	1281	1051	918	589	79			<0.25	16	1.4	<1.0	3.6	14	17.6	0.11	149	0.83	0.0	56.2		239		6.49	
BDC-103	9/4/2012	3773	2056	1652	1533	1405	1175	1042	713	203	-49		0.72	530	24.0	9.4	40	42	82	0.45	7.2	<0.10	0.4	66.9		146		6.80	
BDC-103	11/13/2012	3843	2126	1722	1603	1475	1245	1112	783	273	21		4.5	120	9.5	3.7	210	380	590	1.02	165	2.8	0.4	93.6		108		6.50	
BDC-103	2/20/2013	3942	2225	1821	1702	1574	1344	1211	882	372	120		<0.25	<1.0	<1.0	<1.0	<2.0	3.4	3.4	0.14	161	0.60	0.2	51.6		109		6.42	
BDC-103	5/20/2013	4031	2314	1910	1791	1663	1433	1300	971	461	209		<0.25	9.3	<1.0	<1.0	4.4	1.8	6.2	0.29	161	<0.10	0.0	47.1		-281		7.47	
BDC-103	8/28/2013	4131	2414	2010	1891	1763	1533	1400	1071	561	309	-76	2	210	56	47	260	91	351	1.6	17.8	0.16	0.6	54.2		-290		6.83	
BDC-103	11/19/2013	4214	2497	2093	1974	1846	1616	1483	1154	644	392	7	5.9	22	37	31	590	350	940	4.42	154	2.60	0.0	51		-222		6.48	
BDC-103	2/11/2014	4298	2581	2177	2058	1930	1700	1567	1238	728	476	91	<0.25	<1.0	<1.0	<1.0	4.9	3.6	8.5	2.81	79.9	0.15	0.0	99.2		-254		6.77	

TABLE 1
DATA SUMMARY
DEVELOPMENTAL CENTER GROUNDWATER MONITORING

		ORC	Pilot	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale	Full Scale															
		Injection	Injection	Injection 1	Injection 2	Injection 3	Injection 4	Injection 5	Injection 6	Injection 7	Injection 8	Injection 9	Volatile Organic Compounds (all units in ug/L)							Aquifer Redox Conditions							Donor Indicators	
		Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	Elapsed Time from Injection (days)	TPH-G (mg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	m,p-Xylene (µg/L)	o-Xylene (µg/L)	Total Xylenes (µg/L)	DO (mg/L)	Nitrate (mg-N/L)	Nitrite (mg-N/L)	Iron II (mg/L)	Sulfate (mg/L)	Methane (µg/L)	ORP (mV)	TOC (mg/L)	pH
													Proposed Groundwater Cleanup Levels (a)	**0.8**	**2.0**	**1294**	**1.7**	**NA**	**NA**	**1546**									
Well	Date																										Comments
BDC-104	2/18/2008	2113	396	-8									2.9	<1.0	<1.0	47	180	28	208	2.09	1.63	0.072	3.0	18.7		598		
BDC-104	3/27/2008	2151	434	30									3.2	<1.0	<1.0	22	220	52	272	1.34	161	0.1	0.5	52.2		259		
BDC-104	5/15/2008	2200	483	79	-40								1.0	<1.0	<1.0	7.0	26	22	48	1.24	28.7	0.7	0.4	26.6		94		6.69
BDC-104	7/16/2008	2262	545	141	22								2.3	<1.0	2.9	3.3	110	50	160	1.56	196	0.4	0.0	74.7		-221		7.17
BDC-104	9/15/2008	2323	606	202	83	-45							0.64	<1.0	2.6	<1.0	20	16	36	0.06	122	0.729	0.0	38.4		191		
BDC-104	11/20/2008	2389	672	268	149	21							<0.25	<1.0	<1.0	<1.0	1.4	4.1	5.5	0.96	67.2	<0.10	0.2	24.3		-27		7.46
BDC-104	1/16/2009	2446	729	325	206	78							0.26	<1.0	<1.0	<1.0	<1.0	5.5	5.5	0.05	71.4	0.204	0.6	34.6		-164		6.86
BDC-104	2/11/2009	2472	755	351	232	104							<0.25	<1.0	<1.0	<1.0	1.3	1.1	2.4	1.78	95.4 J	0.1	0.2	20.1		-75		6.68
BDC-104	3/9/2009	2498	781	377	258	130							<0.25	<1.0	<1.0	<1.0	1.3	1.1	2.4	0	91.5	<0.1	0.0	19.2		20		6.67
BDC-104	4/16/2009	2536	819	415	296	168							<0.25	<1.0	<1.0	<1.0	<1.0	1.6	1.6	0.34	67.2	<0.1	0.0	21.6		67		6.63
BDC-104	5/14/2009	2564	847	443	324	196	-34						<0.25	<1.0	<1.0	<1.0	<1.0	1.4	1.4	0.51	63.4	<0.1	0.0	20.1		6		6.70
BDC-104	7/17/2009	2628	911	507	388	260	30						<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.41	21.0	0.5	1.0	30.8		-3		7.30
BDC-104	9/9/2009	2682	965	561	442	314	84	-49					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.63	39.8	0.1	0.8	41.6		61		7.20
BDC-104	11/12/2009	2746	1029	625	506	378	148	15					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.99	115	1.4	0.0	24.1		68		6.49
BDC-104	2/17/2010	2843	1126	722	603	475	245	112					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.73	119	0.1	0.0	111		868		6.93
BDC-104	5/17/2010	2932	1215	811	692	564	334	201					<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.98	47.4	<1.0	0.6	30.5		482		6.74
BDC-104	8/16/2010	3023	1306	902	783	655	425	292	-37				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.59	38.4	0.2	2.5	23.6		76		6.92
BDC-104	11/8/2010	3107	1390	986	867	739	509	376	47				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.87	32.5	<0.1	0.0	18.6		115		7.23
BDC-104	2/16/2011	3207	1490	1086	967	839	609	476	147				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.48	40.0	<0.1	0.4	24.1		423		6.71
BDC-104	5/3/2011	3283	1566	1162	1043	915	685	552	223				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.19	31.3	<0.1	1.2	26.8		231		6.63
BDC-104	8/1/2011	3373	1656	1252	1133	1005	775	642	313				<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.10	11.7	<0.1	0.0	21.2		121		7.20
BDC-104	11/1/2011	3465	1748	1344	1225	1097	867	734	405	-105			<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.43	14.6	<0.1	0.0	18.7		-53		7.40
BDC-104	2/19/2012	3575	1858	1454	1335	1207	977	844	515	5			<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.26	21.6		0.0	29.2		66		6.23
BDC-104	5/3/2012	3649	1932	1528	1409	1281	1051	918	589	79			<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.06	19.4		1.5	26.5		207		6.78
BDC-104	9/4/2012	3773	2056	1652	1533	1405	1175	1042	713	203	-49		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.68	12.3	<0.10	0.5	22.1		130		7.11
BDC-104	11/13/2012	3843	2126	1722	1603	1475	1245	1112	783	273	21		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.24	0.80	<0.10		5.1		64		7.19
BDC-104	2/20/2013	3942	2225	1821	1702	1574	1344	1211	882	372	120		0.28	<1.0	6.5	<1.0	17	3.3	20.3	0.44	2.5	<0.10	0.2	3.6		82		6.96
BDC-104	5/20/2013	4031	2314	1910	1791	1663	1433	1300	971	461	209		<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	2.01	20.0	<0.10	0.0	20.8		-230		7.16
BDC-104	8/28/2013	4131	2414	2010	1891	1763	1533	1400	1071	561	309	-76	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	0.52	16.4	<0.10	1.0	35.3		-322		6.82
BDC-104	11/19/2013	4214	2497	2093	1974	1846	1616	1483	1154	644	392	7	<0.25	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0	8.09	0.5	<0.10	0.0	3.1		-35		7.16
BDC-104	2/11/2014	4298	2581	2177	2058	1930	1700	1567	1238	728	476	91	<0.25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	6.11	0.5	<0.10	0.0	3.4		-135		7.04

CUL = Cleanup Level
BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes
TPH-G = Total Petroleum Hydrocarbon-Gasoline
DO = Dissolved Oxygen
ORP = Oxidation Reduction Potential
TOC = Total Organic Carbon
NA = Not Applicable, not available
µg/L = micrograms pr liter
mg/L = milligrams per liter
mg-N/L = milligrams per liter as nitrogen
mV = millivolts
NA = Not Analyzed
= No sample collected or sample not analyzed for specified constituent.
Box = Exceedance of proposed CUL

(a) Landau Associates 2013
(b) BTEX data questionable for this event. Concentrations inconsistent with TPH-G data for indicated event and BTEX data from other events.

2/19/12 = LLI 1290767, 1291164

Injection dates

5/7/2002	ORC
1/18/2007	Pilot -scale nitrate
2/26/2008	1st full scale injection
6/24/2008	2nd full scale injection
10/30/2008	3rd full scale injection
6/17/2009	4th full scale injection (start ammonium phosphate, 1/3 ammonium nitrate dose to both wells)
10/28/2009	5th full scale injection (103 full dose, 104 half dose)
9/22/2010	6th full scale injection (103 only full dose)
2/14/2012	7th full scale injection (103 only full dose)
10/23/2012	8th full scale injection (103 only 1.5x volume dose)
11/12/2013	9th full scale injection (103 only 1.5x volume dose)

TABLE 2
NITRATE CONCENTRATIONS AT DOWNGRADIENT MONITORING LOCATIONS
AOC-05 ANAEROBIC BIOREMEDIATION REMEDIAL ACTION
BOEING DEVELOPMENTAL CENTER

				Aquifer Redox Conditions					
				DO	Nitrate	Iron II	Sulfate	Methane	ORP
Area	Well	Date		(mg/L)	(mg-N/L)	(mg/L)	(mg/L)	(mg/L)	(mV)
SWMU-17	BDC-05-04	5/15/2006	Natural Redox Baseline		12.3	2.6	33.4		
SWMU-17	BDC-05-04	10/23/2008		2.45	7.6	0.1	31.0	0.29	73.5
SWMU-17	BDC-05-04	11/2/2008		0.59	4.5	0.8	25,2	0.05	-16
SWMU-17	BDC-05-04	12/16/2008		0.55	5.5	1.0	30.4	1.61	-98
SWMU-17	BDC-05-04	1/16/2009		0.06	4.3	1.0	21.8	1.48	-192
SWMU-17	BDC-05-04	2/11/2009		2.45	5.9	1.0	31.8	1.06	-54
SWMU-17	BDC-05-04	3/9/2009		0.27	4.8	1.5	30.1	0.20	35
SWMU-17	BDC-05-04	4/16/2009		1.48	5.9	1.4	33.6	<0.0007	68
SWMU-17	BDC-05-04	5/13/2009		0.33	4.5	1.6	26.6	0.37	49
SWMU-17	BDC-05-04	8/16/2009		0.86	5.4	2.2	30.6	<0.0007	93
SWMU-17	BDC-05-04	11/13/2009	Downgradient Monitoring Triggered	0.56	2.2	3.0	18.4	2.44	109
SWMU-17	BDC-05-04	2/16/2010		0.88	<0.1	3.3	24.6	1.49	899
SWMU-17	BDC-05-04	5/18/2010		0.75	<0.1	3.0	25.4	1.32	473
SWMU-17	BDC-05-04	8/17/2010		1.00	<0.1	2.8	17.1	3.53	108
SWMU-17	BDC-05-04	11/9/2010		2.21	<0.1	2.2	21.3	3.00	101
SWMU-17	BDC-05-04	2/15/2011		2.50	<0.1	2.4	19.4	4.46	93
SWMU-17	BDC-05-04	5/2/2011		1.69	<0.1	2.2	18.0	1.75	49
SWMU-17	BDC-05-04	11/2/2011		1.52	<1.0	1.2	<1.0		-3
SWMU-17	BDC-05-04	5/7/2012		0.16		2.0	21.5		98
SWMU-17	BDC-05-04	9/4/2012		0.21	<0.10		16.6		96
SWMU-17	BDC-05-04	11/13/2012		0.03	<0.10	1.8	16.9		64
SWMU-17	BDC-05-04	5/23/2013		0.49		1.5	13.7		-310
SWMU-17	BDC-05-04	11/19/2013		2.56	<0.10	1.0	13.2		-259
SWMU-20	MW-17A	05/15/2006	Natural Redox Baseline		1.37	0.0	27.0		
SWMU-20	MW-17A	11/12/2009	Downgradient Monitoring Triggered		0.9				
SWMU-20	MW-17A	5/17/2010			1.6	0.2	21.0		
SWMU-20	MW-17A	11/8/2010			0.1	2.1	15.7		
SWMU-20	MW-17A	5/3/2011			1.6	0.0	19.8		
SWMU-20	MW-17A	8/1/2011			0.5	0.0	20.5		
SWMU-20	MW-17A	11/1/2011			0.3	0.0	23.2		
SWMU-20	MW-17A	5/3/2012			4.4	0.0			
SWMU-20	MW-17A	9/4/2012			2.0		26.8		
SWMU-20	MW-17A	11/13/2012			0.59	0.0	22.9		
SWMU-20	MW-17A	5/20/2013			2.9		26.8		
SWMU-20	MW-17A	11/19/2013			1.3	0.4	23.9		
SWMU-20	MW-18A	05/15/2006	Natural Redox Baseline		0.154	0.4	64.8		
SWMU-20	MW-18A	11/12/2009	Downgradient Monitoring Triggered		0.8				
SWMU-20	MW-18A	05/17/2010			1.0	0.4	32.2		
SWMU-20	MW-18A	11/08/2010			0.1	0.0	14.2		
SWMU-20	MW-18A	5/3/2011			<0.1	0.0	31.5		
SWMU-20	MW-18A	8/1/2011			1.1	0.0	42.2		
SWMU-20	MW-18A	11/1/2011			0.7	0.0	93.3		
SWMU-20	MW-18A	5/3/2012			<0.10	0.0			
SWMU-20	MW-18A	9/4/2012			<0.10		19.5		
SWMU-20	MW-18A	11/13/2012			<0.10	0.0	21.5		
SWMU-20	MW-18A	5/20/2013			<0.10		19.6		
SWMU-20	MW-18A	11/19/2013			<0.10	0.6	15.0		
SWMU-20	MW-21A	05/15/2006	Natural Redox Baseline		0.136	0.4	54.9		
SWMU-20	MW-21A	11/12/2009	Downgradient Monitoring Triggered		<0.1				
SWMU-20	MW-21A	05/17/2010			0.2	0.0	11.9		
SWMU-20	MW-21A	11/08/2010			<0.1	0.0	5.9		
SWMU-20	MW-21A	5/3/2011			0.2	0.0	52.1		
SWMU-20	MW-21A	8/1/2011			0.1	0.0	26.7		
SWMU-20	MW-21A	11/1/2011			<0.1	0.0	9.3		
SWMU-20	MW-21A	5/3/2012			0.17	0.0			
SWMU-20	MW-21A	9/4/2012			<0.10		6.7		
SWMU-20	MW-21A	11/13/2012			0.16	0.0	18.5		
SWMU-20	MW-21A	5/20/2013			0.10	0.5	13.5		
SWMU-20	MW-21A	11/19/2013			<0.10	0.0	15.6		
	= Not Analyzed								