APPENDIX I
OU III
BUILDING 96 GROUNDWATER TREATMENT SYSTEM SHUTDOWN PETITION (AOC 26B)

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SHUTDOWN PETITION

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EXECUTIVE SUMMARY

This Shutdown Petition has been prepared in accordance with the Exit Strategy discussed in the *Building 96 Groundwater Treatment System Operations and Maintenance Manual, BNL April 2002.* The Petition supports the proposed shutdown of the last operating recovery well at the OU III Building 96 Source Control Groundwater Treatment System (AOC 26B) at Brookhaven National Laboratory. These changes are being proposed because the one remaining operating well is not significantly reducing the volatile organic compound (VOC) concentrations in the continuing source (silty zone) and because the recent chemical oxidation injection performed in the silty zone were successful in reducing the concentration and mass of the main contaminant, tetrachloroethene (PCE). Specifically, the proposed shutdown actions are:

- Place the recovery well (RTW-1) nearest the high concentration silty zone source area in standby mode with continued monitoring,
- Continue to maintain the three downgradient recovery wells (RTW-2, -3, -4) in standby mode with monitoring,
- Perform additional localized injections of potassium permanganate to address remaining high PCE concentrations in the silty zone source area,
- Continue to monitor the degradation and natural attenuation of the VOCs in the groundwater both in the monitoring wells and the RTW wells for a period of up to two years to confirm the cleanup goals are being met before a Closure Petition is submitted to the regulatory agencies.

Review of the Building 96 treatment well influent and monitoring well data trends as well as mass of contaminant removal calculations from January 2001 through March 2005 indicate that the remedial effectiveness of RTW-1 had reached a plateau without significant impact on the high concentrations of a continuing source of VOCs located in the silty soil zone of the aquifer. A cleanup enhancement to the Building 96 Source Control Groundwater Treatment System consisting of potassium permanganate injection into the silty zone to oxidize some of the remaining PCE was proposed and described in the *Modification to the O&M Manual BNL, 2004* and in the *Building 96 Site Source*

Reduction Chemical Oxidation Scope of Work, BNL, November 2004. The Scope of Work also included the justification for the permanganate injection cleanup target of 90% mass and concentration reductions.

The potassium permanganate addition has been effective in reducing the silty zone VOC concentrations and has not increased the RTW-1 influent VOC concentration. Therefore, RTW-1 can be shut down and be placed in a standby maintenance condition.

This determination is based on the following results:

- Before the permanganate injection RTW-1 showed a long-term declining trend while monitoring wells upgradient in the silty zone showed steady or increasing trends. This demonstrates the minimal impact of RTW-1 on the cleanup of the high concentration source area and the need for additional action to meet the OU III Record of Decision (ROD) cleanup objectives.

- 84% of the new and existing monitoring wells installed in the silty zone have PCE and TCA concentrations less than the cleanup target of 380 ug/L following the permanganate injection.

- The RTW-1 long-term declining trend was enhanced by the permanganate addition. Current tetrachloroethene (PCE) concentrations in the RTW-1 influent of less than 30 ug/L are historically low in this well.

- Permanganate was observed in RTW-1 without a corresponding increase in VOC concentration. This means that RTW-1 does not need to remain in operation to capture VOCs potentially mobilized by the permanganate injection.

Other observations are listed below supporting the shut down of recovery well RTW-1 due to the partial destruction of the silty zone source area by application of permanganate.

- Although there is variability in the individual wells and some rebound has been observed, the average monitoring well concentration has shown a 44% decline over three months.

- Although there has been rebound in several new monitoring wells seven 7 of 12 wells have shown significant and continuing PCE declines.

- The permanent monitoring wells except for 095-294 have shown a significant and stable PCE concentration decline at or near ND; well below the cleanup objective.

- The mass of VOCs in the grid area has declined 44% from about 14.3 pounds before the permanganate addition to less than 9.5 pounds in three months.

- PCE daughter products began to appear after the injections, at very low concentrations in several new monitoring wells compared to their absence in the pre-injection samples. This demonstrates that oxidation occurred where permanganate was in contact with the VOCs.

- As expected, permanganate appears to have mobilized the 1,1,1-trichloroethane (TCA) from tight pore spaces. The concentration remained below the cleanup goal of 380 ug/L. TCA is predicted to naturally attenuate prior to migrating to Princeton Avenue. If low-level contaminants migrate beyond Princeton Avenue the OU III Middle Road Groundwater Treatment System will capture them within approximately10 years.

Based upon the results of the treatment of the Building 96 silty zone source by chemical oxidation, recovery well RTW-1 will be shut down and placed in standby mode. At this time no additional action other than spot injections of permanganate and monitoring are recommended at the Building 96 former scrap yard location to help achieve the OU III ROD cleanup objectives: to reach MCLs in the Glacial Aquifer within 30 years and to prevent or minimize plume growth.

The Building 96 groundwater treatment system will be maintained in standby condition as part of this shutdown. Contingency plans are in place to re-start RTW-1 (and any of the other recovery wells) if monitoring shows that the OU III ROD cleanup objectives will not be met.

1.0 INTRODUCTION

This Shutdown Petition has been prepared according to the Exit Strategy of the Building 96 O&M Manual to support proposed operational changes to the OU III Building 96 Source Control Groundwater Treatment System at Brookhaven National Laboratory. These changes are being proposed based upon the current status of the groundwater cleanup and the results of the potassium permanganate chemical oxidation. Specifically, the proposed changes are:

- To place the recovery well nearest the high concentration silty zone source area (RTW-1) in standby mode.
- To leave in stand-by mode, the three downgradient source control recovery wells (RTW-2, 3, and 4).
- Perform additional localized injections of potassium permanganate to address remaining high PCE concentrations in the silty zone source area,
- Continue to monitor the degradation and attenuation of the VOCs in the groundwater both in the monitoring wells and the RTW wells.

2.0 BACKGROUND

Building 96 area is located in the south central portion of the BNL site (Figure 1). Until January 1999, the area south of Building 96 was used as a scrap yard and truck wash. No definite date for the start of these activities is available, but is reported to have served this purpose since the 1960s. Prior to this time, the U.S. Army used the area for vehicle maintenance and repair.

The investigation of the Building 96 area was performed in accordance with the *Building 96 Scrapyard Pre-Design Characterization Work Plan, January 1999*, to identify high concentrations of VOCs in Operable Unit III (OU III) groundwater plume. Building 96 was designated as Area of Concern (AOC) 26B. To identify any potential buried sources of VOC contamination, soil and groundwater samples were analyzed and geophysical surveys were performed.

The Building 96 Source Control Groundwater Treatment System consisting of four recirculation wells and air-stripping treatment was designed and installed in 2000 as a source control measure to address the volatile organic compound (VOC) groundwater plume present in the Building 96 area. The system was designed to achieve a 50% reduction of the VOCs in the groundwater but not to meet MCLs. It was assumed that a continuing source of VOCs did not exist.

The VOC groundwater plume in the Building 96 area is primarily comprised of tetrachloroethene (PCE) and 1,1,1 trichloroethane (TCA). The three downgradient extraction wells have successfully remediated the downgradient portion of the Building 96 plume and were placed in standby mode in the Summer of 2004, while the influent concentrations in the extraction well nearest the source area (RTW-1) remained elevated but had stabilized in the range of approximately 50 to 90 ug/L. Monitoring wells upgradient of RTW-1 in the silty zone (085-335, 085-293) did not show significant declines in concentrations as high as 2,400 ug/L.

A Geoprobe investigation conducted in June 2004 confirmed elevated levels of VOCs in groundwater in the area to the north of RTW-1 within the zone of silty soils. The concentrations of PCE in groundwater in this area ranged from non-detected (ND) to 2,800 ug/L while the concentrations of TCA ranged from ND to 280 ug/L. The concentration in soil ranged from ND to 21 ug/Kg for PCE and ND to 2.8 ug/Kg for TCA.

Contrary to the previous assumptions in the OU III ROD the presence of elevated VOC concentrations in the silty zone was acting as a continuing source of VOCs to groundwater. This implied that the treatment system would need to operate much longer and less efficiently than had been assumed in the ROD. Therefore additional treatment action was proposed in the *Building 96 Site Source Reduction Chemical Oxidation Scope of Work, BNL, November 2004* to reduce the operating time of the Building 96 pump and treat system and to shut down well RTW-1.

As discussed in this Petition additional VOC source reduction was achieved using in-situ chemical oxidation, with potassium permanganate solution as the oxidant. The solution was

injected into the silty zone source area using geoprobe direct push technology (DPT). The source area is located 100 to 300 feet north of RTW-1 and 20 to 40 feet below land surface (see Figure 2). Details of the fieldwork are located in Appendix A of this petition.

3.0 SHUTDOWN CRITERIA GOALS OF CHEMICAL OXIDATION

The performance objectives for the Building 96 source control treatment system are to significantly reduce the highest concentration portions of the groundwater plume located beneath the former scrap yard to help achieve the overall OU III cleanup goals specified in the OU III ROD. The pump and treat system has been successful in achieving these goals in the downgradient portion of the scrap yard. However the upgradient area of the scrap yard has a continuing source of contaminants trapped in very fine geologic materials that are minimally affected by pumping from well RTW-1. As discussed in the *Building 96 Operations and Maintenance Manual Modification, BNL, 2004*, chemical oxidation was selected to treat this continuing source by degrading the tetrachloroethene and mobilizing contaminants from the very small pore spaces of the silty zone in the aquifer.

The oxidation reaction is expected to proceed as follows:

$$KMnO4 + PCE \rightarrow H2O + CO2 + KCl + MnO2$$

Daughter products of tetrachloroethene are not expected except in trace amounts due to the complete oxidation of the PCE concentrations to carbon dioxide, water and salts. The permanganate does not directly oxidize TCA but concentration reduction is enhanced by mobilization from the pore spaces induced by the chemical injection. Some resulting concentration and mass reductions are expected for TCA (Carus Chemical Co communication and Kim et. al. Non- Aqueous Phase TCE Degradation in the Presence of Permanganate Batch System, 2003
).

The density and location of injection points, potassium permanganate concentration and volumes, and other relevant parameters were designed with the objective of degrading at least 90% of the PCE retained in the silty zone. Specific concentration and mass reduction targets for the PCE in the aquifer were proposed in the *Chemical Oxidation Scope of Work, BNL November 2004* to evaluate the success of the chemical addition. These targets included the following:

3.1 Mass Reduction Goal

This objective of the chemical oxidation is to reduce the mass of PCE contaminants by approximately 90% in the injection zone as shown in Figure 2. The percentage is based on experience at other chemical oxidation cleanups that have been performed in similar geologic conditions as the Building 96 area and represents a practical goal for the technique. This percentage is also derived from calculations based on the geology and contaminants at Building 96. Prior to the permanganate injection the calculated mass from 12 new monitoring wells in the injection zone was approximately 14.3 pounds of VOCs, which results in a cleanup goal of 1.4 pounds or less remaining in the aquifer. The current status is discussed in Section 7.0 of this report.

3.2 Concentration Reduction Goal

This objective of the chemical oxidation is to reduce PCE concentrations in the injection zone by approximately 90% in the 12 newly installed monitoring wells and existing monitoring wells 095-84, 085-293, 095-294, and 085-335 shown on Figure 3. The percentage is based on experience at other chemical oxidation cleanups that have been performed in similar geologic conditions and represents a practical goal for the technique. This percentage is also derived from calculations based on the geology and contaminants at Building 96.

Prior to the injection, Geoprobe concentration data from June 2004 ranged from ND to 2,800 ug/L for PCE and from ND to 280 ug/L for TCA. Pre-injection data shown in Table 1 from the newly installed monitoring wells in December 2004 ranged up to 3,800 ug/L PCE and 160 ug/L TCA. The 90% injection reduction goal would result in 380 ug/l concentration or less for PCE.

For TCA, the concentration goal would also be 380 ug/L or less throughout the injection area. Mass transport predictions supporting this goal are discussed in the next section. The current status, three months after injection, is discussed in Section 7.0 of this report.

4.0 GROUNDWATER MODELING

In order to develop an appropriate chemical injection and monitoring strategy, a performance model of the Building 96 source control was run prior to finalizing the technical approach as discussed in this document. Previously, as discussed in the O&M Manual Modification, results of the modeling of a continuing source showed there was a need for the chemical injection. Currently, a finite-difference groundwater flow model (MODFLOW) was used along with the MT3D solute transport model to predict the future movement and concentration of the contaminants assuming 90% oxidation and a finite source after complete mobilization of the contaminants from small pore spaces within the source area. The continuing source was thereby replaced with a finite source for modeling purposes. Only dispersion and dilution (not degradation) were considered in the calculation of the contaminant concentrations.

Simulations of the migration and attenuation of the remaining contaminants were performed with the extraction well RTW-1 in standby but with the OU III Middle Road pump and treat system turned on. If 380 ug/L (10% of the highest recently-observed PCE concentration range) of both PCE and TCA are assumed to be mobilized and remain in the aquifer after the oxidation, and RTW-1 is placed in standby three months after the injection, concentrations of each compound are expected to reach MCLs within two to three years before moving to Princeton Avenue. Any remaining concentrations less than MCLs at Princeton Avenue are predicted to migrate to the downgradient OU III Middle Road groundwater treatment system where they will be captured and treated in approximately 12 to 15 years. The Middle Road System is expected to operate for about 25 years.

Sensitivity analysis was performed on the modeled starting concentration and dimensions of the source area. Almost doubling both the volume and concentration of the concentrations (up to 560 ug/L) did not significantly change the model predicted outcomes.

The details of the modeling are contained in *Chemical Oxidation Scope of Work, BNL, November 2000*.

5.0 POST-INJECTION MONITORING WELL DATA EVALUATION

As discussed in the November 2004 Work Plan, 12 new monitoring wells were installed in the silty zone as A/B clusters in the Building 96 former scrapyard. The A labeled wells are screened 20 to 25 feet bls and the B wells are screened 32 to 37 feet bls. MW-5 and MW-7 are not part of a cluster and both are screened 20 to 25 feet bls. Data from a pre-injection sampling round from the 12 new monitoring wells and four existing monitoring wells (095-84, 085-293, 095-294 and 085-335), are compared to post injection monitoring well data to determine the percent oxidation achieved by the permanganate injections. Post injection data are being collected every two weeks with dedicated centrifugal pumps from the monitoring wells for up to three months following the injection and are being analyzed for VOCs by EPA Method 524.2. Five post injection rounds and one pre-injection round have been collected and are presented in this Petition for Shutdown.

5.1 Concentration Trends

Concentration trends were evaluated for individual wells and for the average of all the wells in the injection area. The four pre-existing permanent wells are not included in the average because they have a longer monitoring record than the 12 new monitoring wells. Figures 4-1 to 4-12 show the individual well PCE and TCA concentration data trends.

5.1.1 Newly-Installed Permanent Monitoring Wells

The purple color of permanganate was observed initially in all monitoring wells but some were more affected than others. The color ranged from dark to light. In the later sampling rounds the color generally became lighter or clear (e.g. MW-5) and the deeper wells were impacted longer

than the shallow ones. After six rounds of data some wells (e.g. MW-3B) remain dark purple indicating that the permanganate oxidation of PCE is continuing in the area.

The average PCE concentration for the 12 new wells shown in Figure 5-1 showed an initial decline, one month after the injection, of 76% from 1,062 ug/L to 273 ug/L. As expected, after the initial decline these wells have shown an average rebound in the third month after injection, to a decline of 44% from the initial value of 1,062 ug/L to 594 ug/L. The TCA average concentration in Figure 5-2 showed that the concentration remained essentially unchanged with an increase in the latest round.

These results are expected for PCE, which is degraded by permanganate, and TCA, which is not. As permanganate diffuses outward from each injection point through the injection grid, both compounds are mobilized from pore spaces where they had been trapped. The percent decline for TCA was much less than for the PCE because the TCA is not degraded by the permanganate. Rather, it is mobilized from pore spaces by the addition of permanganate (concentration gradient). Later TCA should naturally attenuate as it migrates through the aquifer. Most of the TCA pre-injection concentrations were very low (less than 25 ug/L) except in three wells (MW-1A, MW-1B, MW-2B). Before and after the permanganate injection none of the wells exceeded the cleanup goal of 380 ug/L. Since these concentrations are predicted to degrade and dilute to less than MCLs before reaching Princeton Avenue, the fate of TCA is not an issue that needs to be addressed by the Building 96 treatment system.

Figures 6-1 and 6-2 are cross sections of the Building 96 former scrap yard showing the depths of the geologic materials. The most conspicuous geologic unit is “tight” silt that appears to bridge (straddle) the water table. This silt unit varies in thickness from approximately 10 feet at boring locations S-1 and S-4, 5 feet at S-2; and less than 2 feet at locations S-5 and S-6. This unit is not present at S-3. These data indicate that the silt unit is thickest in the northern part of the injection area and is very thin or absent to the south.

This silt unit will impede the downward movement of water to the water table and will mute the effects of a fluctuating water table. It is likely to have a higher horizontal hydraulic conductivity

than vertical conductivity due to the presence of more permeable fine sand lenses. However, this unit is at least one to two orders of magnitude less permeable than the fine to medium sands above and below it.

In the finer silt zone the concentration reduction responses to permanganate were much more pronounced than in the coarser materials because the permanganate was present longer at higher concentrations. Natural flushing of the permanganate is slower in the finer materials with smaller pore spaces. Similarly, the rebound in concentrations is greater and occurs more rapidly in the coarse materials than in the fine. This is expected because the fine materials would maintain a higher concentration of permanganate longer and would resist flushing by clean groundwater flow longer than the coarser materials.

Individually the new monitoring wells showed concentration declines to different degrees based on their screen locations. Two of the new wells showed significant increases. Figures 4-1 to 4-12 provide each well's change in concentration for the three-month time period for both TCA and PCE. Wells MW-1A screened in coarser material and MW-1B screened in finer material illustrate the two main trend results: 1) wells screened in finer material declined to ND with a smaller rebound and 2) wells screened in the coarser material had less of a decline and a larger rebound. Both wells had similar pre-injection concentrations of PCE (2,700 and 1,200 ug/L) and TCA (91 and 150 ug/L). The PCE concentration in MW- 1A declined from 2,700 ug/L to 1,000 ug/L initially and then gradually rebounded to 2,100 ug/L three months after injection. The PCE concentration in MW-1B dramatically declined from 1,200 ug/L to ND, remained there for two sample rounds, and then increased to 320 ug/L over three sample rounds. The TCA concentrations did not change significantly although there was some variability between the 2nd and 5th sample rounds.

The other wells exhibiting this pattern and also screened in similar materials are wells 2A and 2B, wells 3A and 3B (in well 3A both PCE and TCA increased before decreasing and have not yet shown any rebound), wells 4A and 4B (although MW-4B declined to ND for PCE in the 6th round), and wells 6A and 6B (6A is in fine materials and 6B is in the coarser materials; rebound was only seen in the 5th sample round in well 6B).

The two wells that exhibited different trends from the others are wells MW- 5 and MW -7. Although also screened in the finer materials where the pronounced permanganate impact is expected, both these wells showed significant increases for both PCE and TCA. These trends are likely the result of the wells' locations in the northern part of the injection grid, which was the last inner grid area to be injected during the program as the geoprobe rigs were moved in rows from south to north. The hydraulic mounding influence caused by the injections may be pushing PCE and TCA into these wells and partially canceling the oxidation effects. That the TCA concentration trends are increasing similar to the PCE trends while most other wells show the expected trend differences between PCE and TCA, lends support to this explanation.

5.1.2 Pre-Existing Permanent Monitoring Wells

The longer trends shown in Figures 7-1 to 7-3 for the pre-existing monitoring wells also demonstrate the results of the permanganate injection. Except for 095-294 the permanent well trends show that a significant break in the concentration trend occurred after the permanganate injection. The PCE concentrations in three of the four wells declined from up to 1,900 ug/L to ND after the first month and remained at essentially that level for the three subsequent sampling events.

Well 085-335 which is located in the south central part of the injection grid, shows an upward PCE trend above 2,000 ug/L until the permanganate injection when it rapidly falls to ND and remains at that concentration. Well 085-293, located just north of 085-335 shows the same PCE to ND trend as 085-335 but the TCA trend shows an increase after injection. Well 095-84 is located within the zone of influence of the recovery well and has been at ND levels during the permanganate injection. Well 095-294 is located outside the southwest corner of the grid, is screened above the silty zone and shows an increase in both PCE and TCA similar to wells 5 and 7 for the first five rounds but then a decline in the 6th. The increase was already in progress by June 2004 but may have been accelerated by the diffusion of permanganate at concentrations too low to significantly degrade the PCE. It should be noted that MW- 6A and 6B located about 20 feet east of well 095-294 showed post-injection PCE concentration declines to ND that were held

except for the 5th sample round when MW 6B increased. It is expected that the declining pattern of MW-6A and 6B will be observed in well 095-294. Some evidence for this has appeared in the 6th round decline of well 095-294.

5.1.3 Recovery Well RTW-1

During the first year of the Building 96 Source control system operation, total VOC concentrations well above 50 ug/L were consistently observed in treatment well RTW-1. By the end of the second year of operation (January 2003), concentrations in RTW-1, the most upgradient treatment well, had leveled off at approximately 50 ug/L total VOCs. In addition monitoring well 095-84, screened near the location and depth of RTW-1 (Figure 6-1, 6-2), has declined to ND in recent months. During the same time period the monitoring wells in the high concentration silty zone area (085-335 and 085-293) remained stable or were slightly increasing at up to 2,400 ug/L VOCs.

Based upon the reduction of influent VOC concentrations in RTW-1, on May 18, 2003, the system was de-activated to begin pulse pumping operation, as described in *BNL Modification OU III Bldg. 96-05*. Pulse pumping was performed in cycles with each cycle consisting of a six-week de-activation (shut-down) period followed by a 2-week period of operation. After two complete pulse cycles, a significant rebound of VOC concentrations was observed in RTW-1 and in well 095-84 (Figure 7-4). Therefore, on September 15, 2003, the system was placed back into full-time operation and concentrations began to slowly decline from about 150 ug/L to 90 ug/L by April 2004 while concentrations in the silty zone area remained unaffected.

Due to its lack of impact on the high concentration silt zone area, well RTW-1 was scheduled to be shut down again and placed in standby after the permanganate injection was performed. Well RTW-1 was to remain operating to provide hydraulic control and treatment for the VOCs if significant VOCs were mobilized by the permanganate addition.

RTW-1 shows a decline in PCE and TCA concentration from 89.6 to 26.0 and from 4.6 to 2.8, respectively from April 2004 through March 2005. Figure 8-1 shows the trends for the RTW-1.

A break in the trend showing a faster rate of decline can be seen in the last 6 data points which correspond to the pre- and post- injection sampling events. This decline was observed in the presence of a light purple permanganate color showing that PCE was degraded in the silty zone before migrating to the recovery well. Otherwise an increase in the VOC concentration would be expected within four months of the injections (based on 0.75 foot/day groundwater velocity and 100 feet to the recovery well from the grid.

This means that RTW-1 continues to have minimal impact on the concentrations in the silty zone and does not need to remain in operation to capture VOCs potentially mobilized by the permanganate injection.

5.2 Mass Removal

One of the two cleanup goal targets proposed in the *Building 96 Site Source Reduction Chemical Oxidation Scope of Work, BNL November 2004* is the removal of 90% of the pre-injection mass of contaminants from the aquifer. Based on the newly installed monitoring wells the total mass in the silty zone of the aquifer was 14.3 pounds before the permanganate injection. As of the March 24, 2004 sample round the mass removed from the aquifer is 6.3 pounds or 44%. This actual reduction falls short of the 90% goal but is a significant impact on the silty zone. The issue of additional mass removal is discussed in Section 7.0 of this report.

6.0 SYSTEM SHUTDOWN RECOMMENDATIONS

Based on the information gathered during the permanganate injection program the Building 96 RTW-1 recovery well can now be shut down and placed in standby mode. The results of the permanganate injection have been successful so that only additional spot injections and continued monitoring are necessary with the possible restart of the recovery well if the OU III ROD cleanup objectives will not be reached. Indicators of this situation would include concentrations rising above the cleanup goal of 380 ug/L in the pumping well or in monitoring well 095-84.

This recommendation is based on the following results of the permanganate addition:

- Before the permanganate injection RTW-1 showed a long-term declining trend while monitoring wells upgradient in the silty zone showed steady or increasing trends. This demonstrates the minimal impact of RTW-1 on the cleanup of the high concentration source area and the need for additional action to meet the OU III Record of Decision (ROD) cleanup objectives.

- 84% of the new and existing monitoring wells installed in the silty zone have PCE and TCA concentrations less than the cleanup target of 380 ug/L following the permanganate injection.

- The RTW-1 long-term declining trend was enhanced by the permanganate addition. Current tetrachloroethene (PCE) concentrations in the RTW-1 influent of less than 30 ug/L are historically low in this well.

- Permanganate was observed in RTW-1 without a corresponding increase in VOC concentration. This means that RTW-1 does not need to remain in operation to capture VOCs potentially mobilized by the permanganate injection.

Other observations are listed below supporting the shut down of recovery well RTW-1 due to the partial destruction of the silty zone source area by application of permanganate.

- Although there is variability in the individual wells and some rebound has been observed, the average monitoring well concentration has shown a 44% decline over three months.

- Although there has been rebound in several new monitoring wells seven 7 of 12 wells have shown significant and continuing PCE declines.

- The permanent monitoring wells except for 095-294 have shown a significant and stable PCE concentration decline at or near ND; well below the cleanup objective.

- The mass of VOCs in the grid area has declined 44% from about 14.3 pounds before the permanganate addition to less than 9.5 pounds in three months.

- PCE daughter products began to appear after the injections, at very low concentrations in several new monitoring wells compared to their absence in the pre-injection samples. This demonstrates that oxidation occurred where permanganate was in contact with the VOCs.

- As expected, permanganate appears to have mobilized the 1,1,1-trichloroethane (TCA) from tight pore spaces without degradation. The concentration remained below the cleanup goal of 380 ug/L. TCA is predicted to naturally attenuate prior to migrating to Princeton Avenue. If low-level contaminants migrate beyond Princeton Avenue the OU

III Middle Road Groundwater Treatment System will capture them within approximately10 years.

7.0 POST-SHUTDOWN ACTIVITIES

7.1 Groundwater Monitoring

An integral part of the shutdown of the Building 96 recovery well RTW-1 is the continued monitoring of the VOC concentrations in the groundwater beneath the Building 96 former scrap yard. The monitoring program currently in place for the previously shut down recovery wells RTW- 2, 3, and 4 will be expanded to include RTW-1 and the 12 new monitoring wells installed in the silty zone injection grid. The 16 wells that are being monitored as part of the permanganate injection program, including RTW- 1, will be sampled monthly while all other Building 96 wells will be monitored quarterly, including RTW-2, 3, and 4. Monthly monitoring will change to quarterly when concentration trends have stabilized. Prior to implementation, any schedule change will be discussed in the BNL Annual Groundwater Status Report. A BNL approved laboratory will analyze the wells for VOCs by USEPA method 524.2.

If, after shutdown of the system, up to two years of groundwater monitoring data indicate that TVOC contaminant concentrations in the monitoring wells are consistently below the cleanup goal of 380 ug/L for each chemical, then a formal petition for closure of the remediation system, system decommissioning, and termination of post-closure monitoring may be submitted to the regulatory agencies.

7.2 Permanganate Spot Injections

In addition to monitoring, the Building 96 silt zone area will have repeat injections of permanganate on an as-needed basis in locations where concentrations are not declining. This activity will be repeated until it is clear that the OU III ROD cleanup objectives will be met. A corresponding decline in the mass of contaminants should also be observed. The results of the injection(s) and any further recommendations will be reported in the BNL Annual Groundwater Status Report.

8.0 CONDITIONS FOR RE-START

Any of the Building 96 recovery wells can be restarted prior to the Petition for Closure and system decommissioning. Contingency plans have been established as a course of action should monitoring of the system indicate that degradation and attenuation are not progressing as expected. The plans identify potential deviations from the expected system performance, evaluate the likelihood that a deviation will occur, assess the potential impacts should a deviation occur, and define the appropriate course of action for specified deviations. The contingency plans are as follows:

- New sources are identified or plume distribution is different than originally characterized.

  Due to the large number of available monitoring wells in the area and an established monitoring program, the likelihood of new sources being identified or a change in the plume distribution is low. If this scenario were to occur, it would impact cleanup effectiveness and the schedule. The appropriate course of action would be to install additional monitoring wells or vertical profiles to further delineate the plume. RTW-1 could be re-started to continue to capture and treat the plume.

- Chemical oxidation does not perform as expected.

  The chemical oxidant injection was designed for the compounds and geologic conditions identified during the characterization and the maximum observed concentrations of those compounds. If the concentrations were to increase significantly to pre-injection levels because of rebound, if the 90% mass reduction goal appears unattainable, if the aquifer materials hinder the diffusion of the oxidant, or if the OU III ROD cleanup objectives will not be met RTW-1 could be re-started to provide interim hydraulic control and the air stripping treatment

system would remove the contaminants. Additional chemical oxidant could be applied to more effectively degrade the source.

- Changes in policies or guidance values from regulatory agencies.

  The chemical oxidation was designed using current policies and guidance values for remedial actions. If more stringent policies or guidance values from regulatory agencies become available, which were not available at the time of design, it would impact the efficiency and effectiveness of the injection to meet the clean-up criteria. The appropriate course of action would be to enhance the remedial approach or design a new system to meet the new performance criteria.

9.0 PHOTOGRAPHS

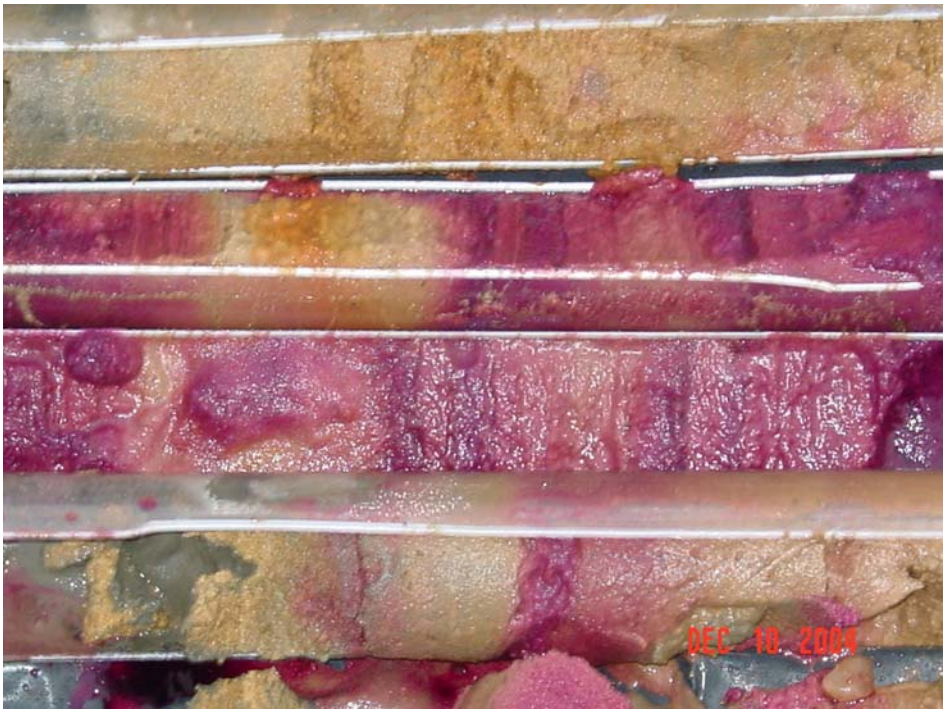
Liquid KMnO4 mixing and storage tanks.

KMnO4 and water mixing pump.

Portion of the injection grid with mixing tanks.

Geoprobe KMnO4 injection operation.

Portion of injection grid with air compressor and support vehicles.



Detail of split spoon samples showing typical injected KMnO4 distribution.

Table 1
Monitoring Well Concentrations

B96 MW-1A

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	91	38	96	40	43	340
PCE	2,700	1,000	1,400	1,400	1,700	2,100

B96 MW-1B

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	150	180	260	120	230	210
PCE	1,200	0	0	240	250	320

B96 MW-2A

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	23	17	6.4	9.9	12	8.6
PCE	820	630	230	450	490	340

B96 MW-2B

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	160	130	160	110	110	130
PCE	3,800	0	0	0	1.2	7.1

B96 MW-3A

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	0.70	4.30	3.4	2.6	1.4	1.2
PCE	44	79	88	89	44	60

B96 MW-3B

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	0.26	0	0	0	0	0
PCE	1,200	0	0	0	0	0.56

B96 MW-4A

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	7.6	4.9	5.7	5.6	0	0
PCE	310	240	980	300	220	250

B96 MW-4B

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	0.41	0.75	0	0	0	0
PCE	1,600	2.8	2,100	51	2400	0

B96 MW-5

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	9.5	39	99	100	93	230
PCE	180	930	2,700	3000	3000	3700

B96 MW-6A

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	21	13	21	19	19	19
PCE	490	0	1.9	5.8	3.2	0.86

B96 MW-6B

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	21	12	12	16	18	16
PCE	240	0.00	0	0	260	7.7

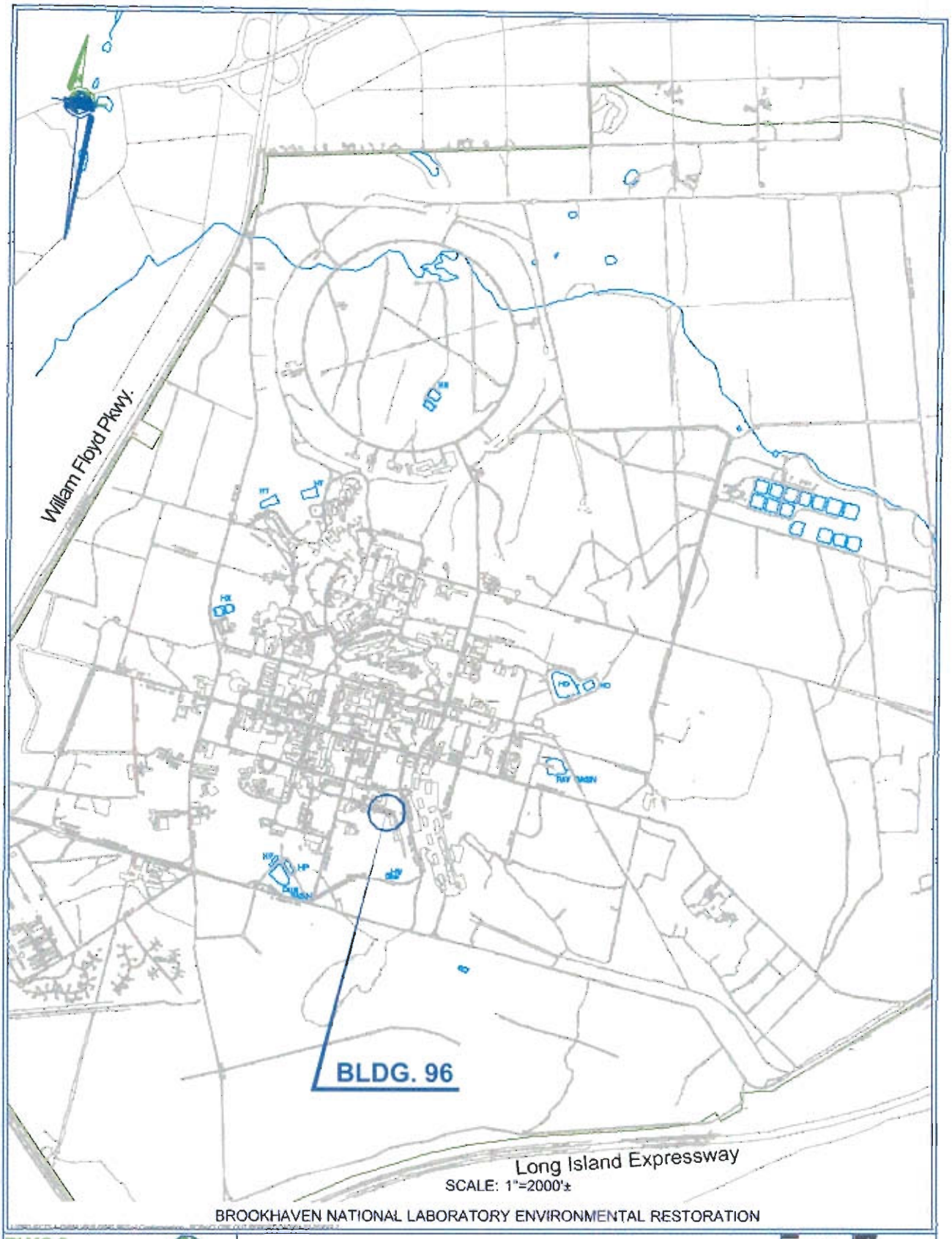
B96 MW-7

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	5.8	6.1	8.6	9.6	12	14
PCE	160	160	100	110	310	340

A MWs Average Concentrations

	12/3/2004	1/19/2005	2/8/2005	2/24/2005	3/10/2005	3/24/2005
TCA	40.86	37.09	56.01	36.06	44.87	80.73
PCE	1,062	253	633	470	723	594

Data collected bimonthly 1/05 - 3/05 from 12 new monitoring wells Building 96 permanganate injection.
Concentrations in ug/L.

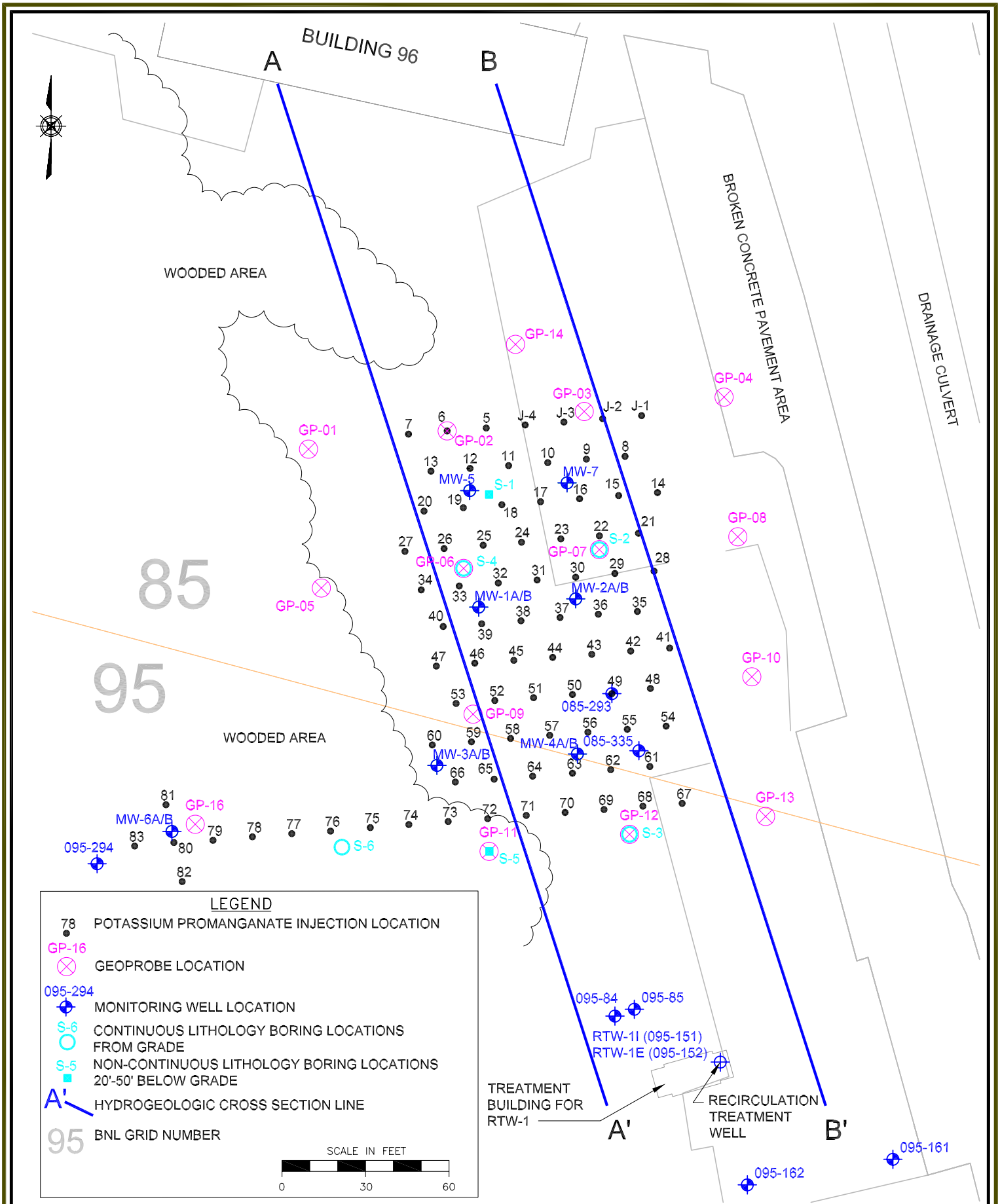


BROOKHAVEN NATIONAL LABORATORY ENVIRONMENTAL RESTORATION

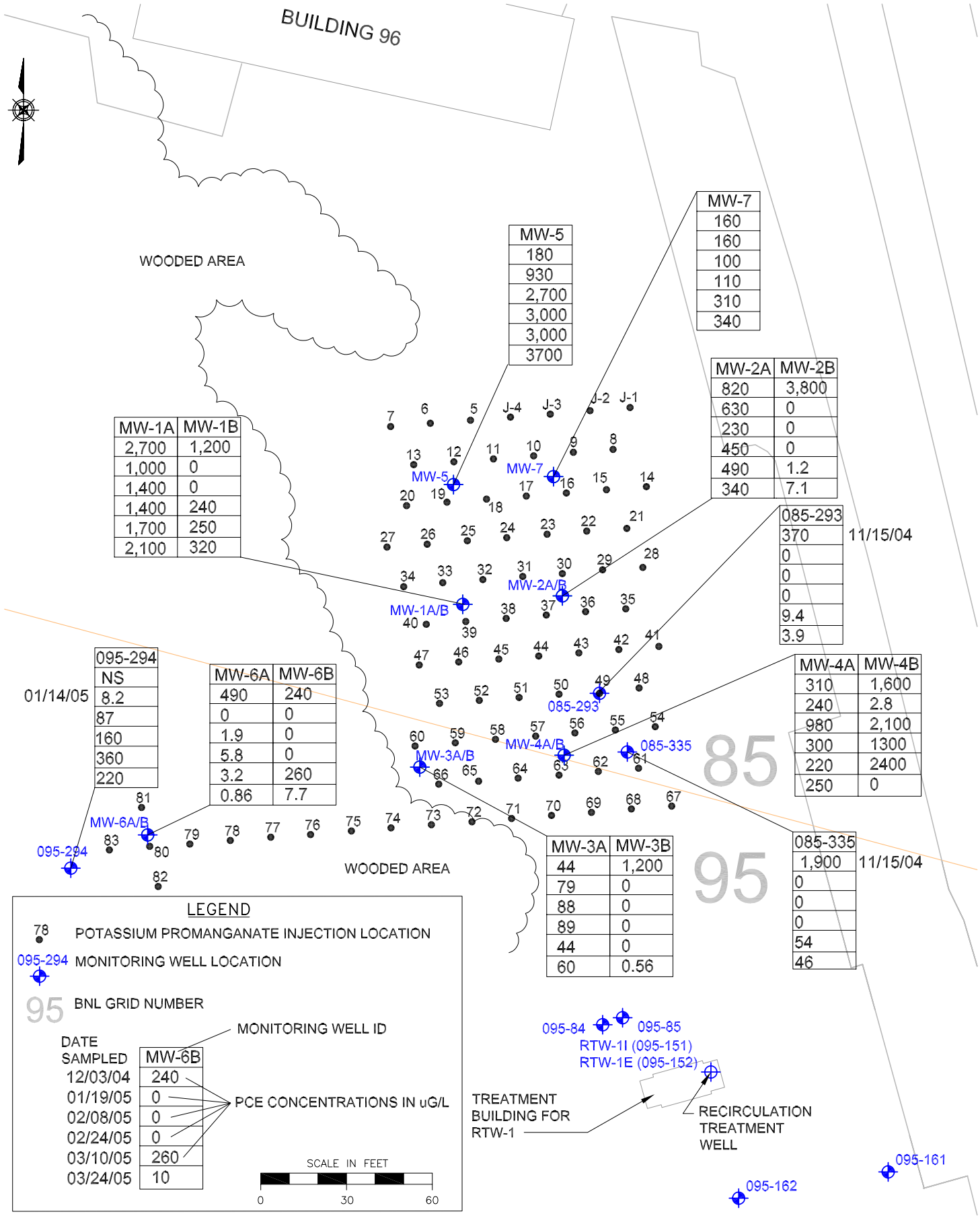
PWGC
Strategic Environmental & Engineering Solutions

BNL SITE & SURROUNDING AREA
BUILDING 96 PCB REMEDIATION

1



BROOKHAVEN NATIONAL LABORATORY EWMS DIVISION	TITLE: OU III BUILDING 96 AREA SITE PLAN PERMANGANATE INJECTION REPORT	DWN: SRW	VT: HZ.: –	DATE: 4/11/05	PROJECT NO.: –
		CHKD: WRD	APPD: MGH	REV.: 1	NOTES:
		FIGURE NO.: 2			



BROOKHAVEN NATIONAL LABORATORY

EWMS DIVISION

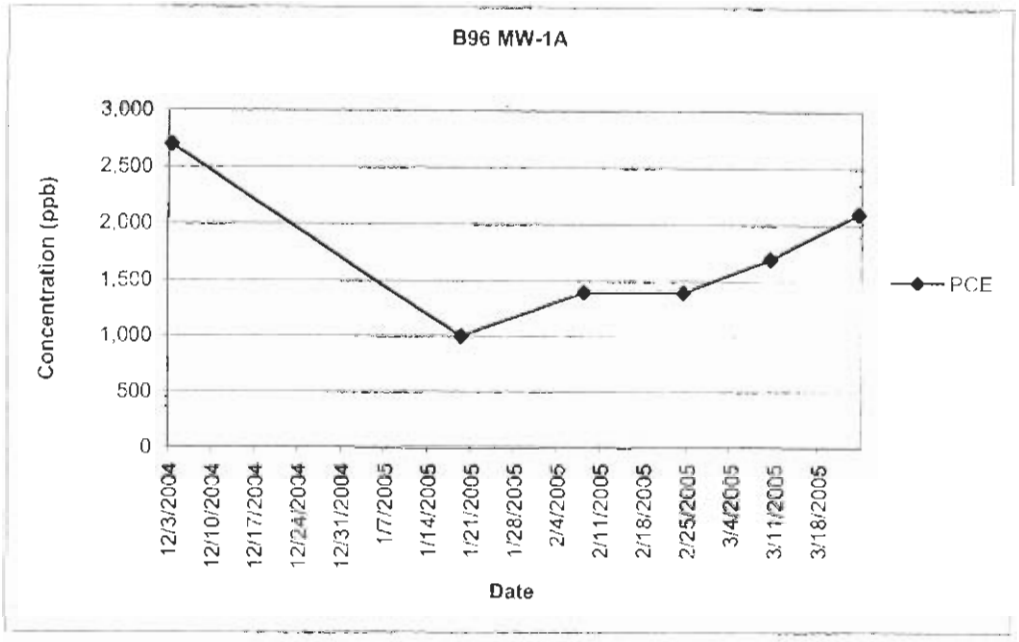
TITLE:

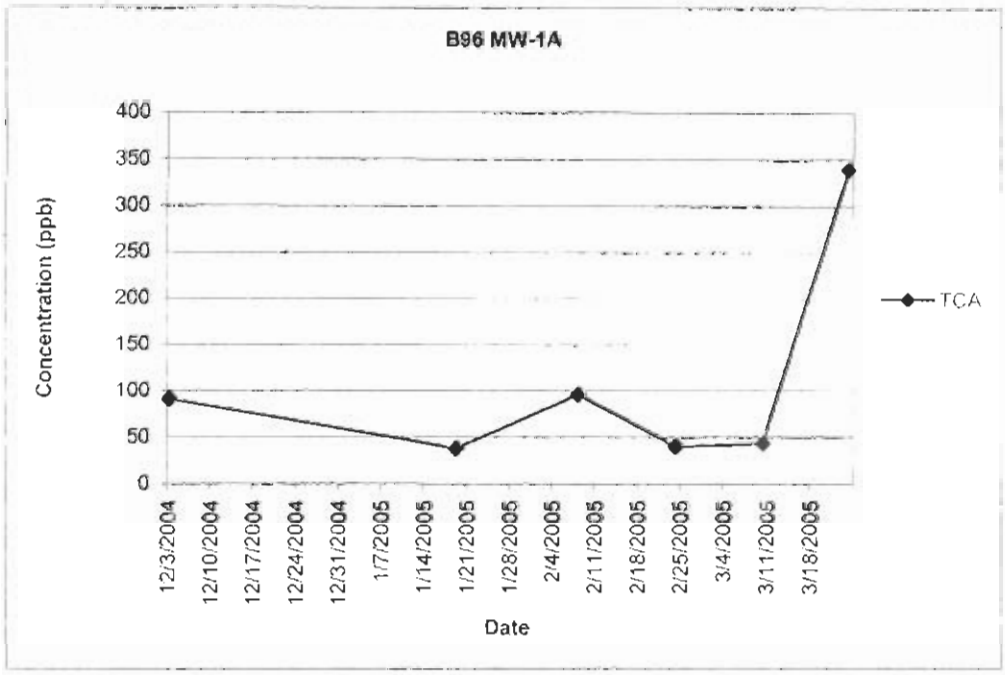
OU III BUILDING 96 AREA PCE CONCENTRATIONS

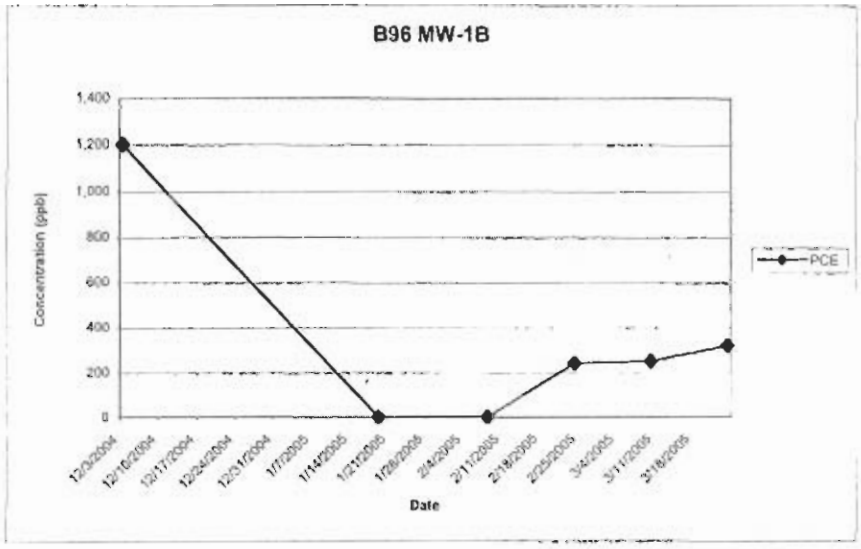
PERMANGANATE INJECTION REPORT

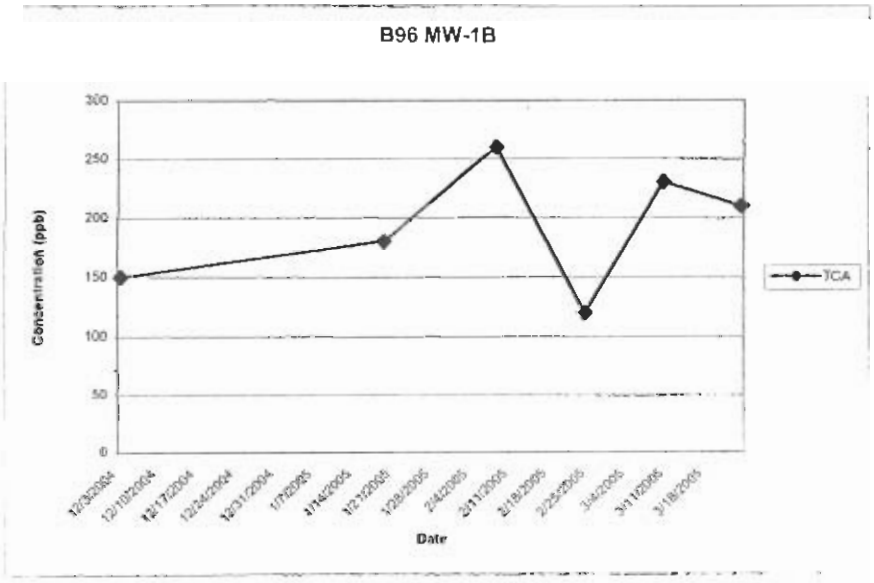
DWN:	VT: HZ.:	DATE:	PROJECT NO.:
SRW	–	4/11/05	–
CHKD:	APPD:	REV.:	NOTES:
MGH	–	–	

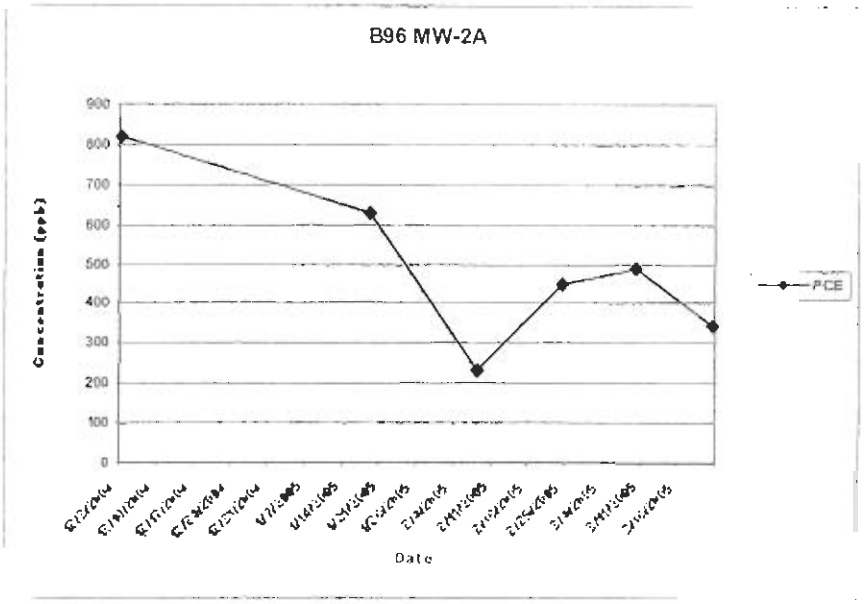
FIGURE NO.: 3


B96 MW-1A
Concentration (ppb)
3,000
2,500
2,000
1,500
1,000
500
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
PCE


B96 MW-1A
Concentration (ppb)
400
350
300
250
200
150
100
50
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
TCA


B96 MW-1B
1,400
1,200
1,000
800
600
400
200
0
Concentration (ppb)
PCE
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date


B96 MW-1B
300
250
200
150
100
50
0
Concentration (ppb)
TCA
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date


B96 MW-2A
Concentration (ppb)
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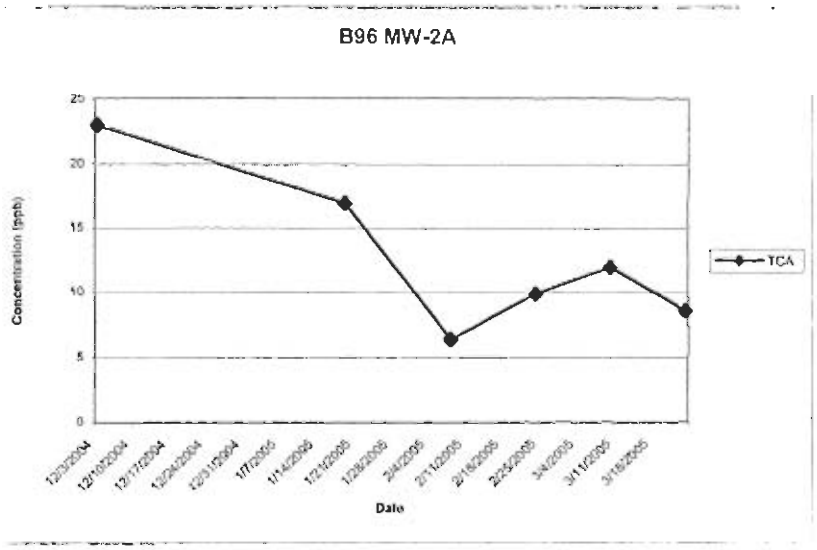
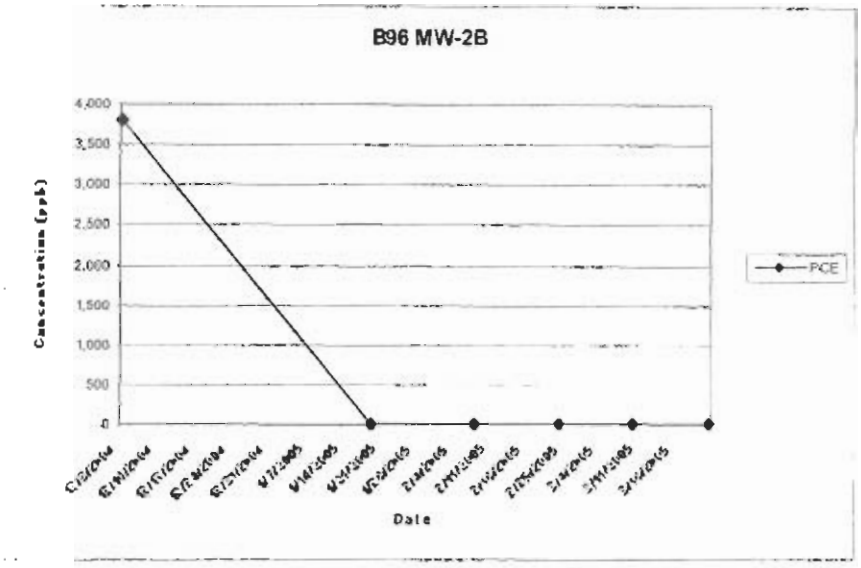
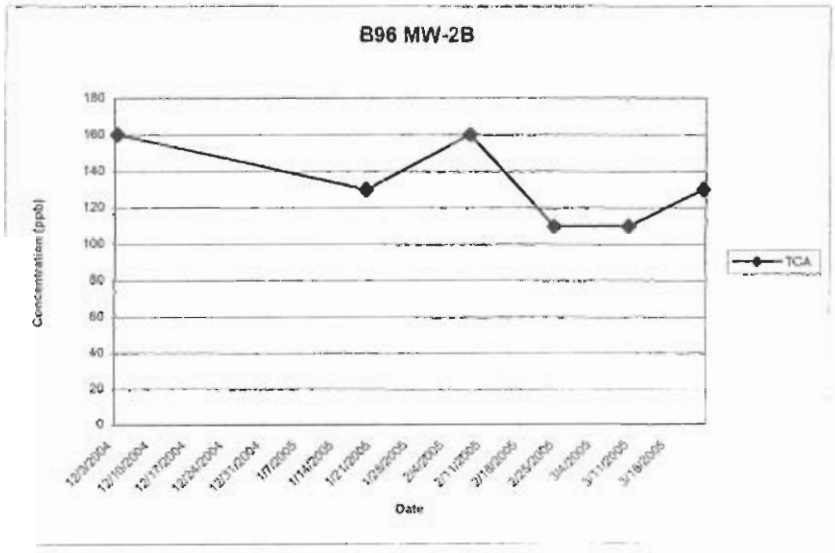
800
700
600
500
400
300
200
100
0
PCE
Date


B96 MW-2A
Concentration (ppb)
25
20
15
10
5
0
TCA
Date


B96 MW-2B
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Concentration (ppb)
PCE
Date


B96 MW-2B
180
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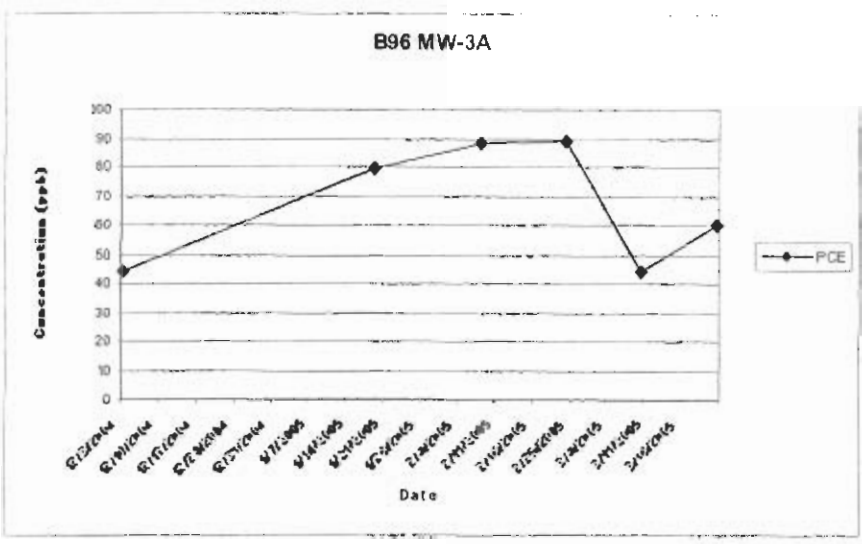
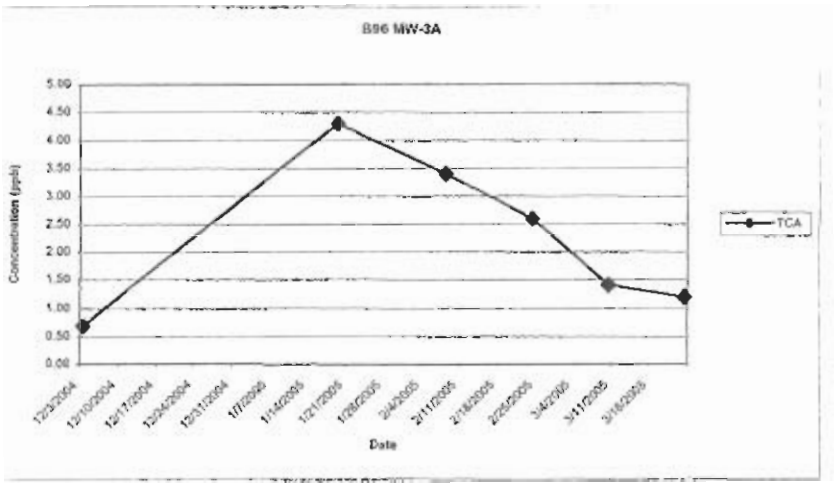
140
120
100
80
60
40
20
0
Concentration (ppb)
TCA
Date


B96 MW-3A
Concentration (ppb)
100
90
80
70
60
50
40
30
20
10
0
Date
PCE


B96 MW-3A
Concentration (ppb)
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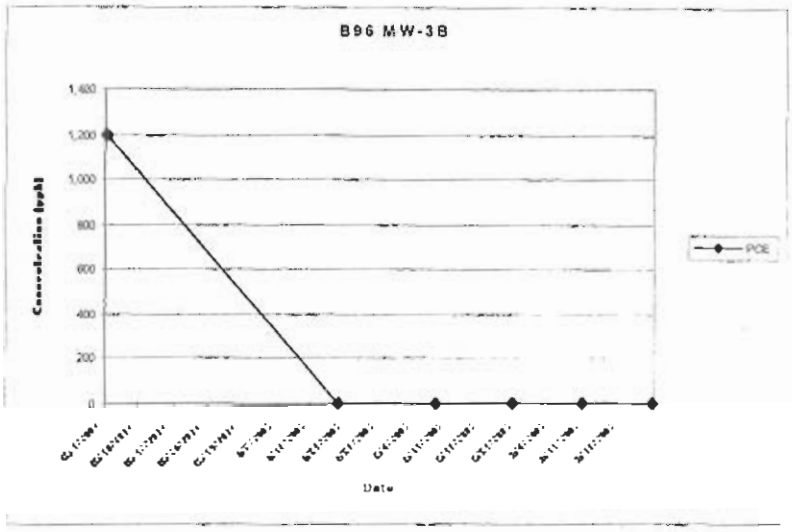
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Date
TCA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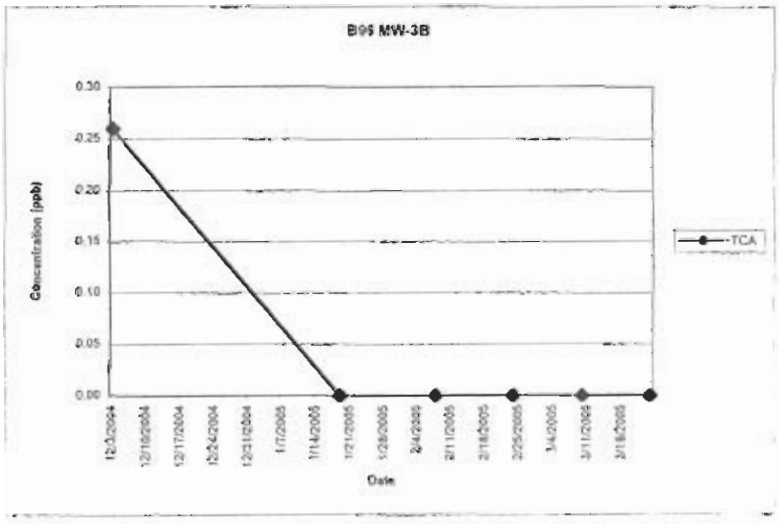
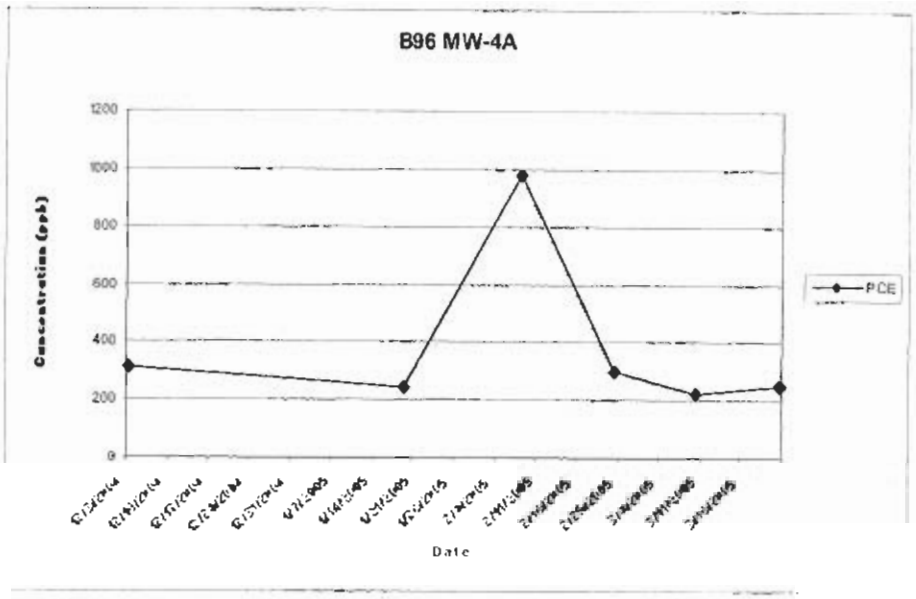
1,400
1,200
1,000
800
600
400
200
0
Concentration (ppb)
PCE
Date


B96 MW-3B
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration (ppb)
TCA
Date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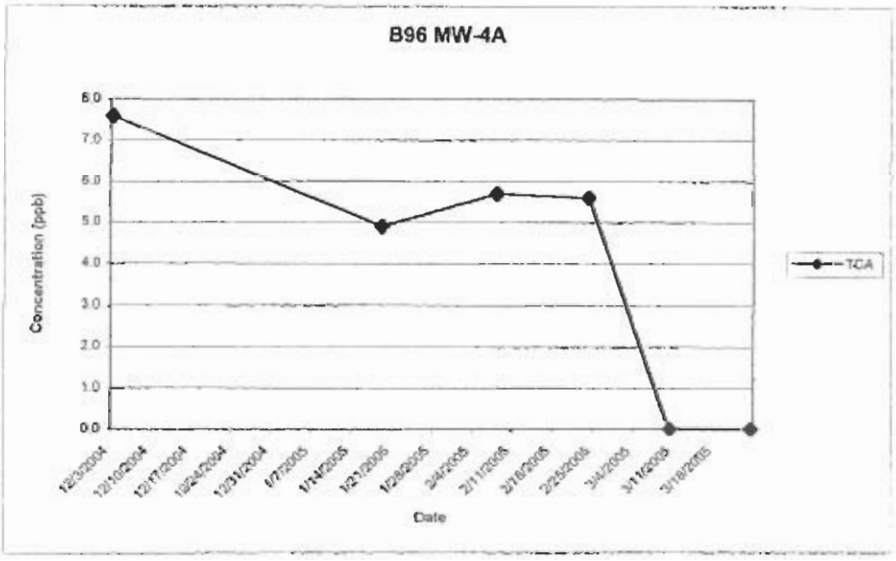
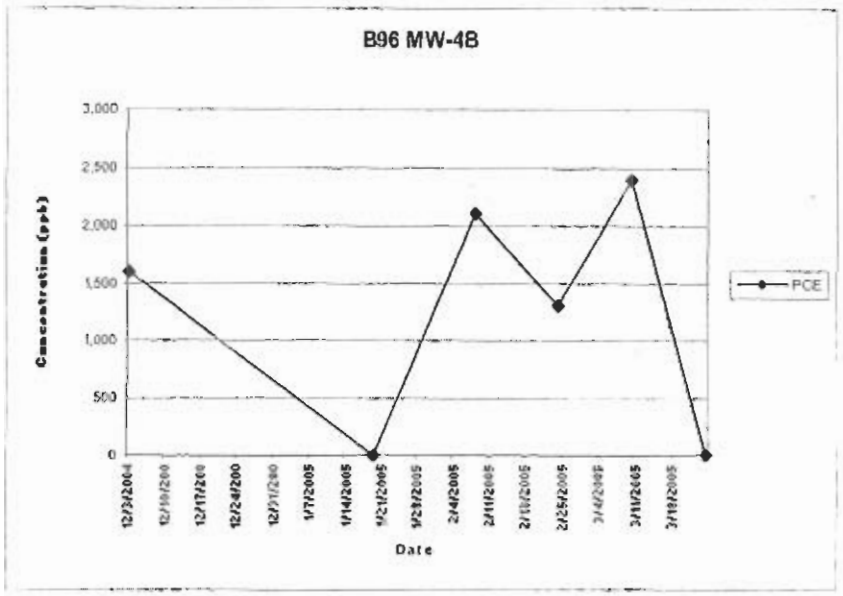
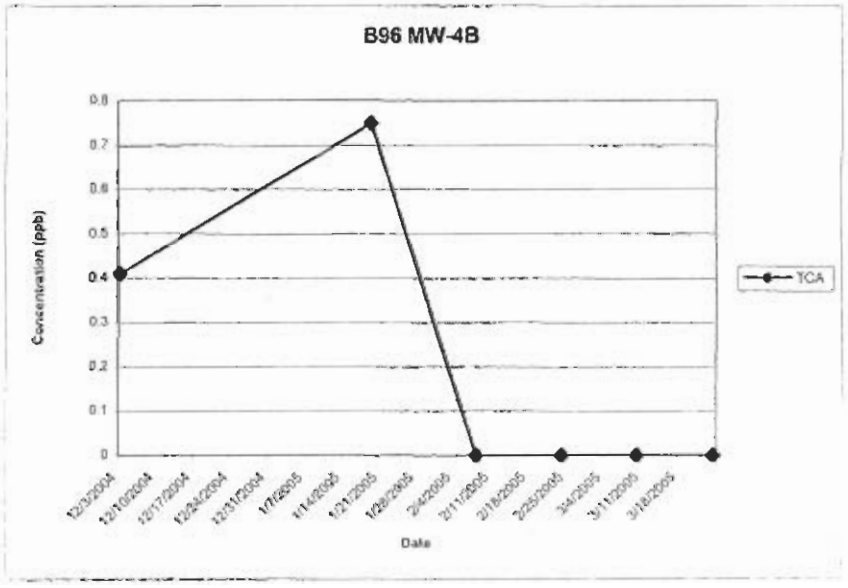
Concentration (ppb)
1200
1000
800
600
400
200
0
PCE
Date


B96 MW-4A
Concentration (ppb)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
TCA
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date


B96 MW-4B
Concentration (ppb)
3,000
2,500
2,000
1,500
1,000
500
0
Date
PCE


B96 MW-4B
Concentration (ppb)
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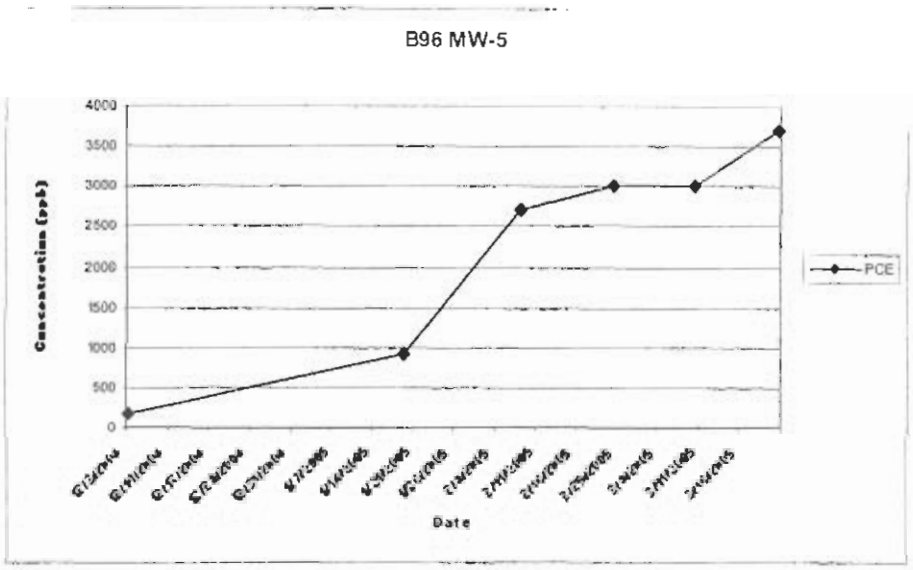
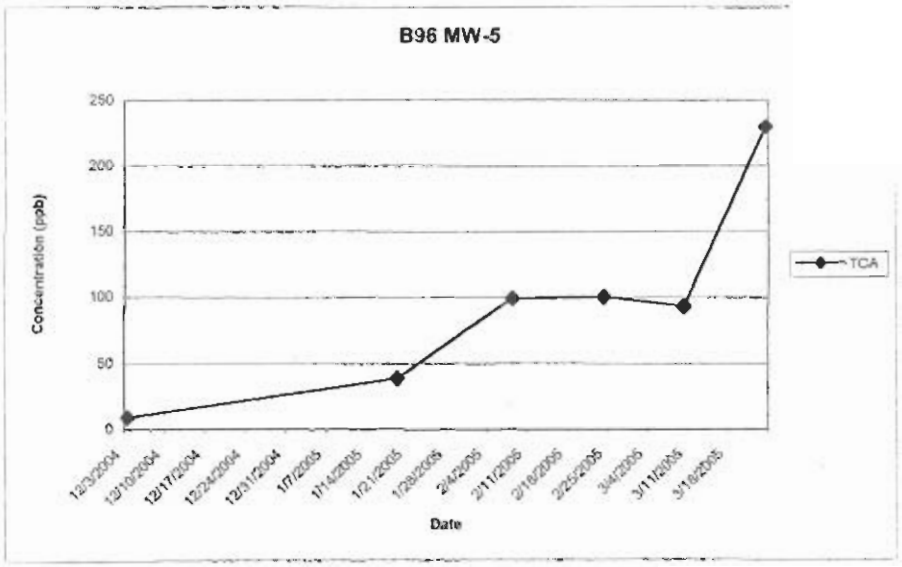
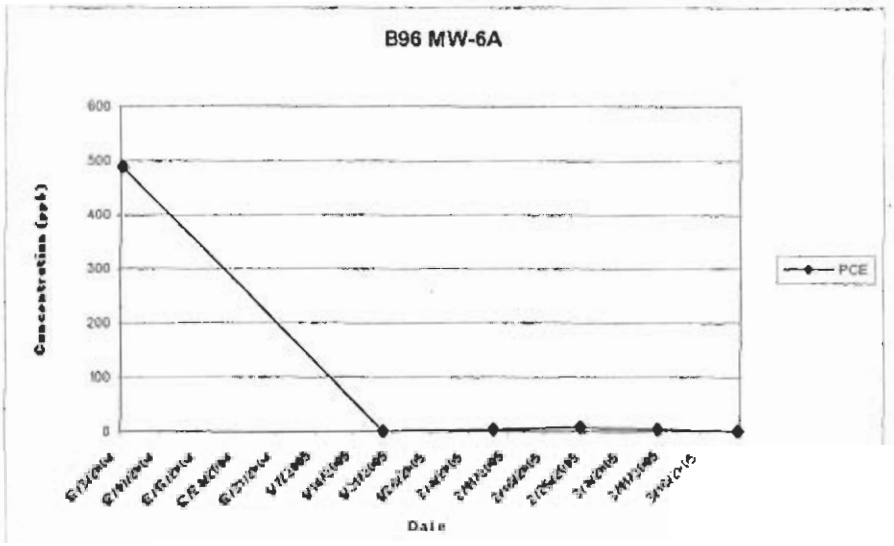
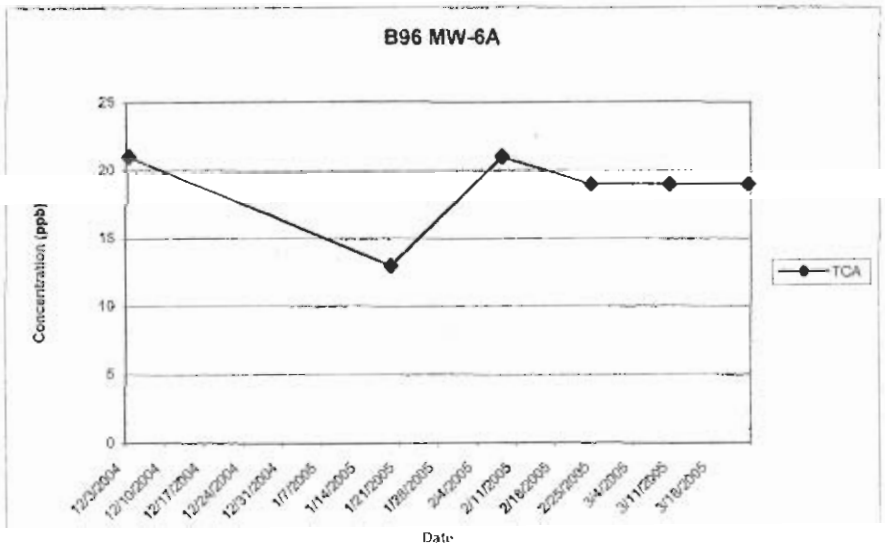
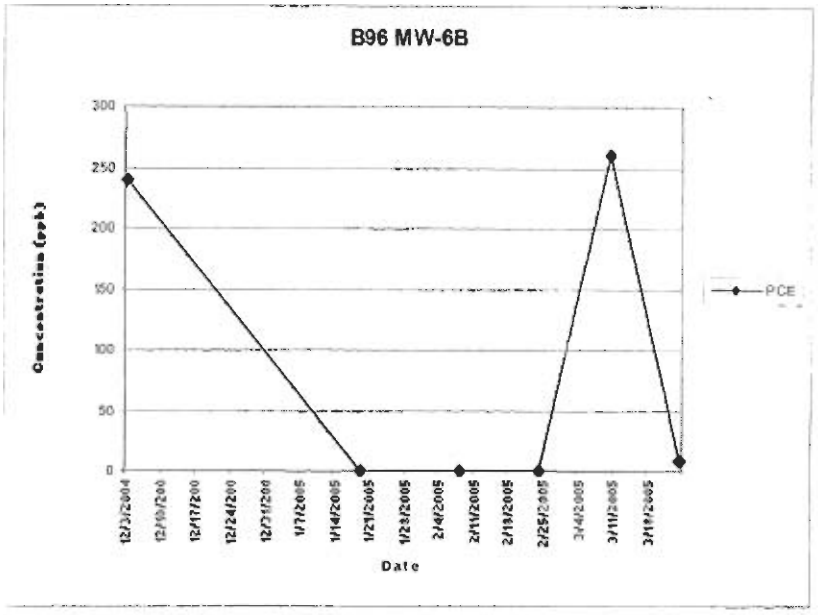
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Date
TCA

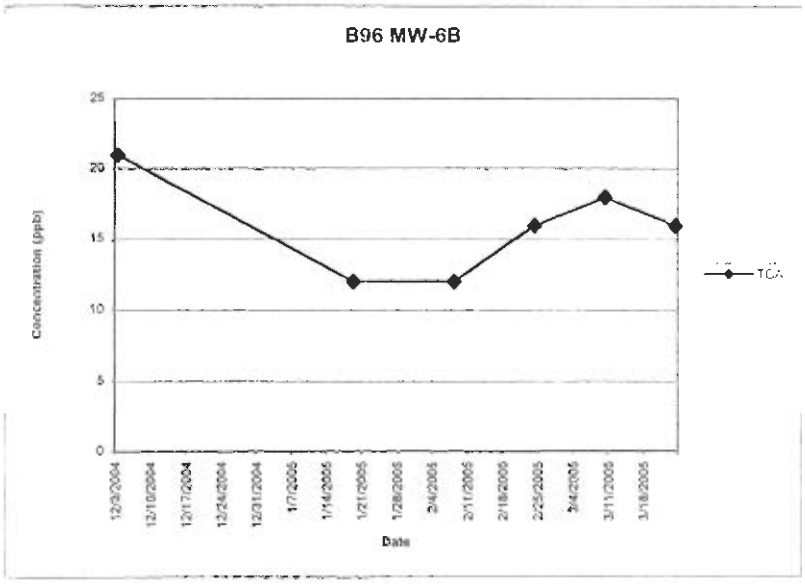

B96 MW-5
Concentration (ppb)
4000
3500
3000
2500
2000
1500
1000
500
0
PCE
Date

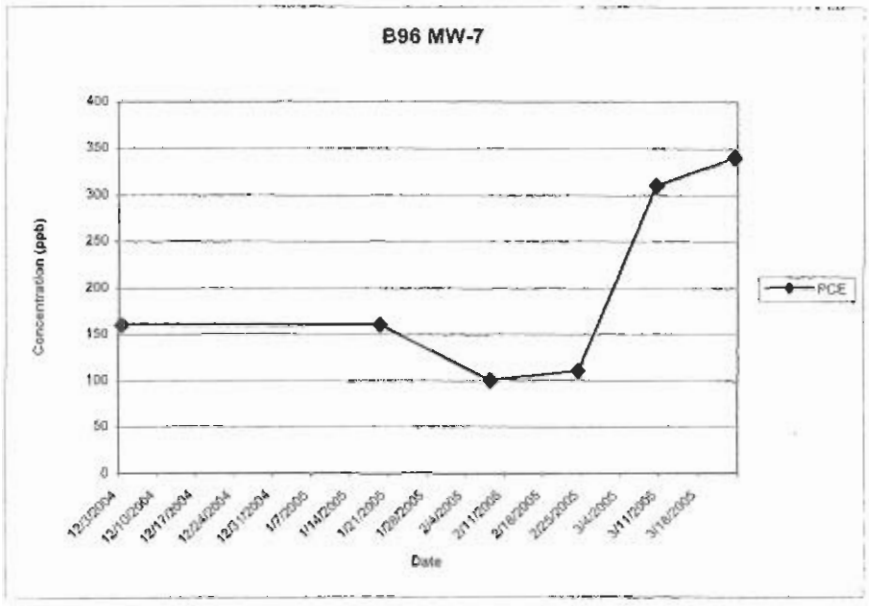

B96 MW-5
Concentration (ppb)
250
200
150
100
50
0
TCA
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date

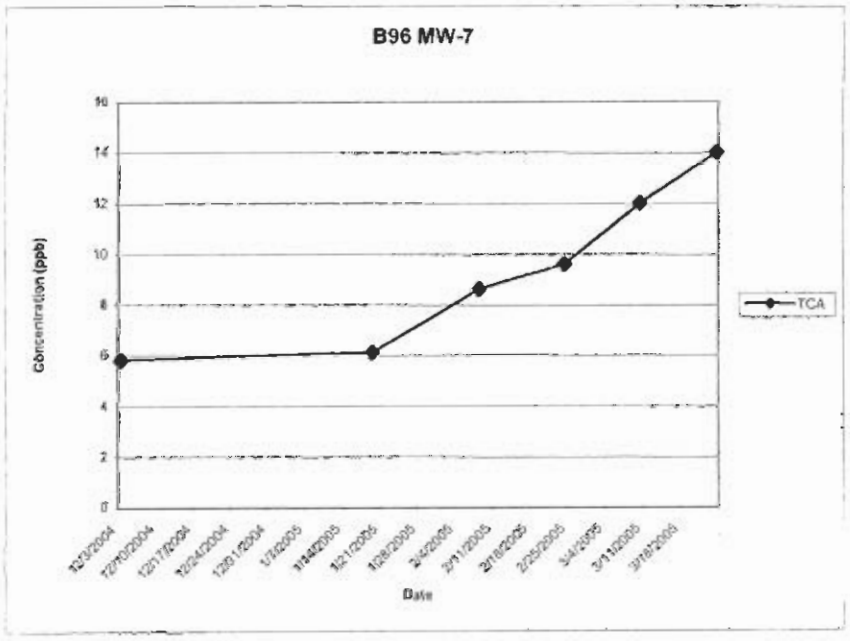

B96 MW-6A
Concentration (ppb)
600
500
400
300
200
100
0
PCE
Date


B96 MW-6A
Concentration (ppb)
25
20
15
10
5
0
TCA
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date


B96 MW-6B
Concentration (ppb)
300
250
200
150
100
50
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
PCE


B96 MW-6B
Concentration (ppb)
25
20
15
10
5
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
TCA


B96 MW-7
Concentration (ppb)
400
350
300
250
200
150
100
50
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
PCE


B96 MW-7
Concentration (ppb)
16
14
12
10
8
6
4
2
0
12/3/2004
12/10/2004
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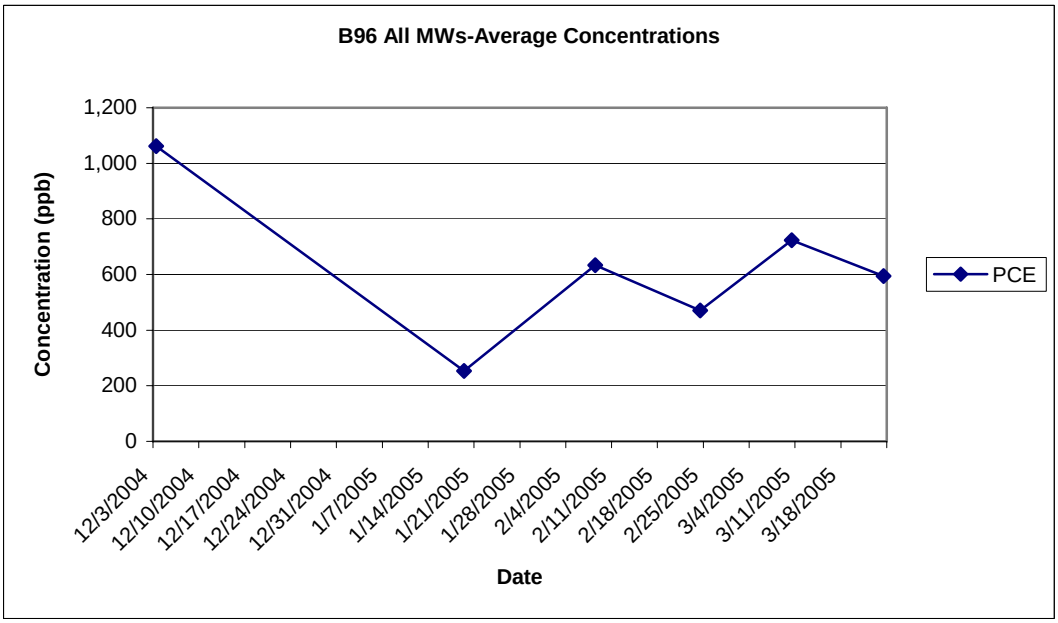
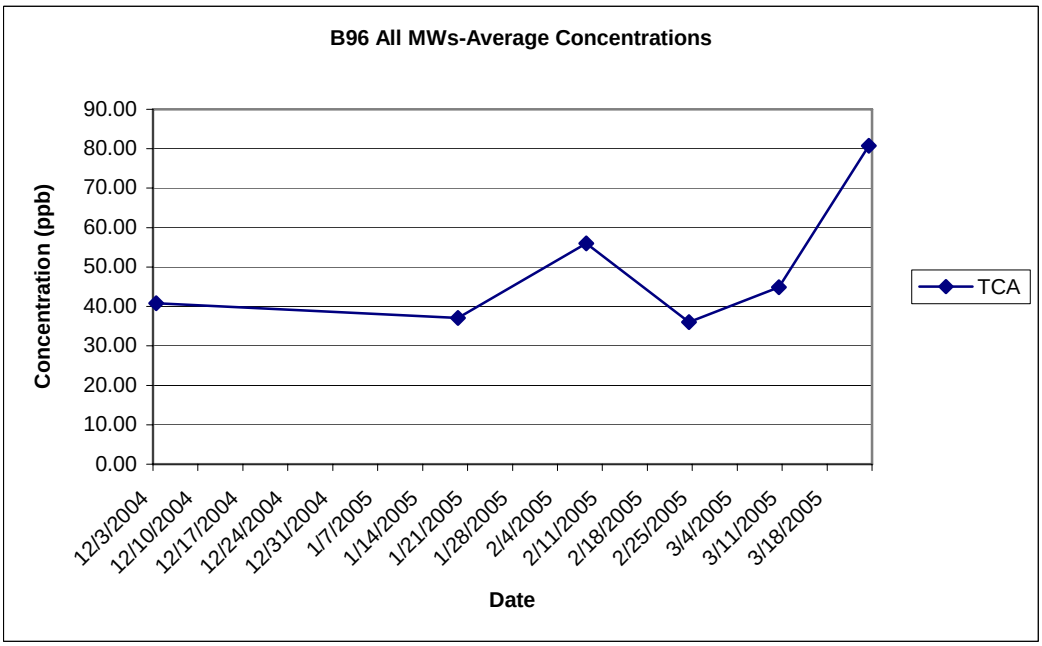
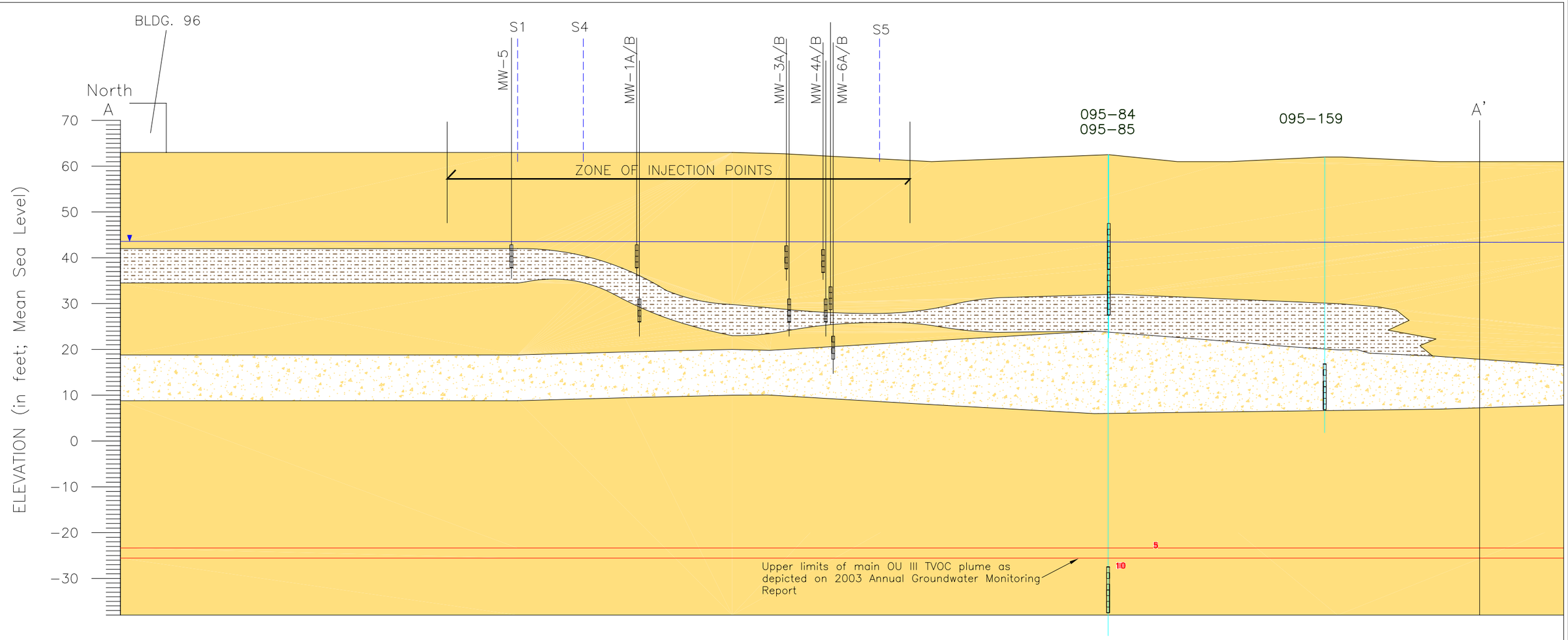
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
TCA


B96 All MWs-Average Concentrations
Concentration (ppb)
1,200
1,000
800
600
400
200
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
PCE


B96 All MWs-Average Concentrations
Concentration (ppb)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
TCA



LEGEND

- Fine to coarse sand, trace to little silt and/or fine to medium gravel.
- Very fine sand and/or silt, with silt and sand lenses interbedded.
- Coarse to very coarse sand, with or without gravel or gravel with sand.

122-02
MW 1A/1B — BNL Monitoring Well ID

S1 — Lithology boring locations

RTW-1 — Recirculation Well

Water Table As Of December 21-23, 2004

Monitoring Well Screen

Extraction Well Screen With Blank

0 30 FEET

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON LITHOLOGIC DATA COLLECTED JUNE 2004 FOR GP BORING DESIGNATIONS AND NOV. 2004 FOR S BORING DESIGNATIONS.

2) MW-6A/B PROJECTION LOCATION IS APPROXIMATE.

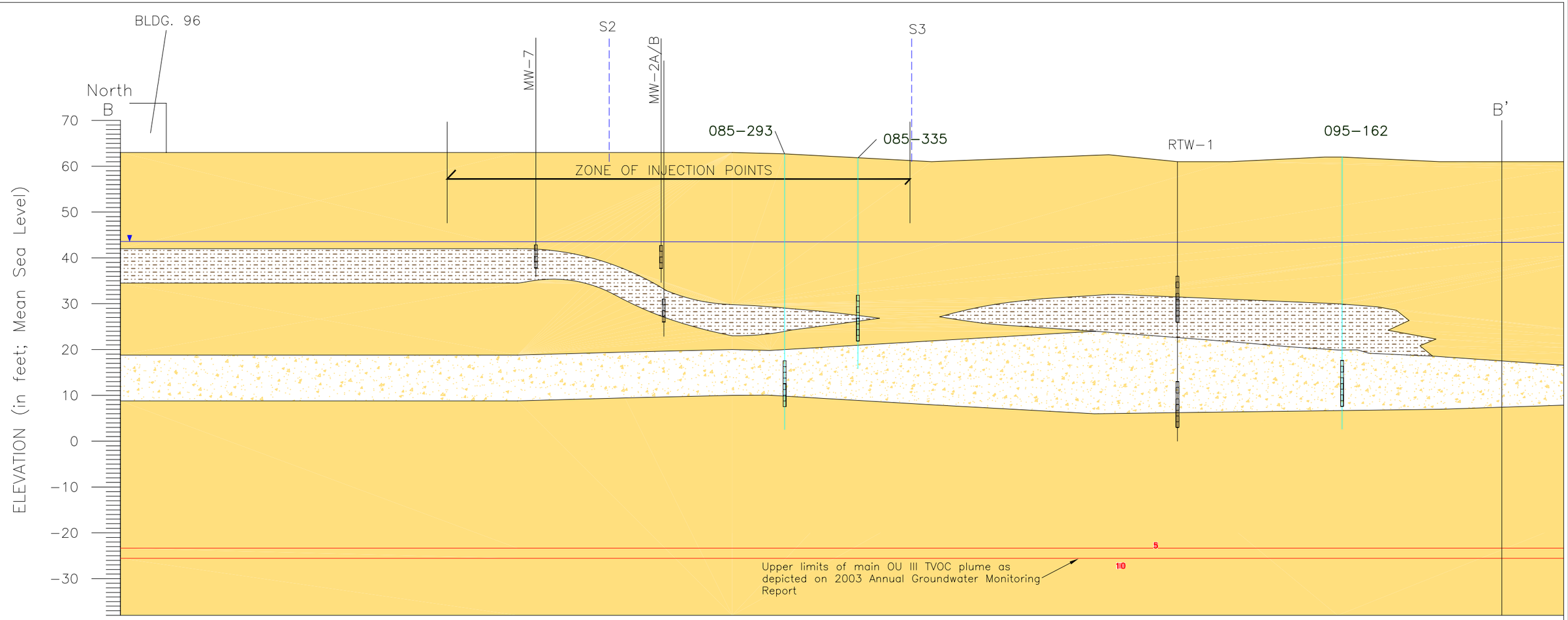
BROOKHAVEN NATIONAL LABORATORY
EWM SERVICES DIVISION

TITLE:

OU III BUILDING 96 AREA HYDROGEOLOGIC CROSS SECTION (A-A')

BLDG 96 PERMANGANATE INJECTION REPORT

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
SRW	2:3	4/11/05	07176
CHKD: MGH	APPD: –	REV.: –	NOTES: –
FIGURE NO.: 6-1			



LEGEND

- Fine to coarse sand, trace to little silt and/or fine to medium gravel.
- Very fine sand and/or silt, with silt and sand lenses interbedded.
- Coarse to very coarse sand, with or without gravel or gravel with sand.

122-02
MW 1A/1B — BNL Monitoring Well ID

S1 — Lithology boring locations

RTW-1 — Recirculation Well

Water Table As Of December 21-23, 2004

Monitoring Well Screen

Extraction Well Screen With Blank

0 30 FEET

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON LITHOLOGIC DATA COLLECTED JUNE 2004 FOR GP BORING DESIGNATIONS AND NOV. 2004 FOR S BORING DESIGNATIONS.

2) MW-6A/B PROJECTION LOCATION IS APPROXIMATE.

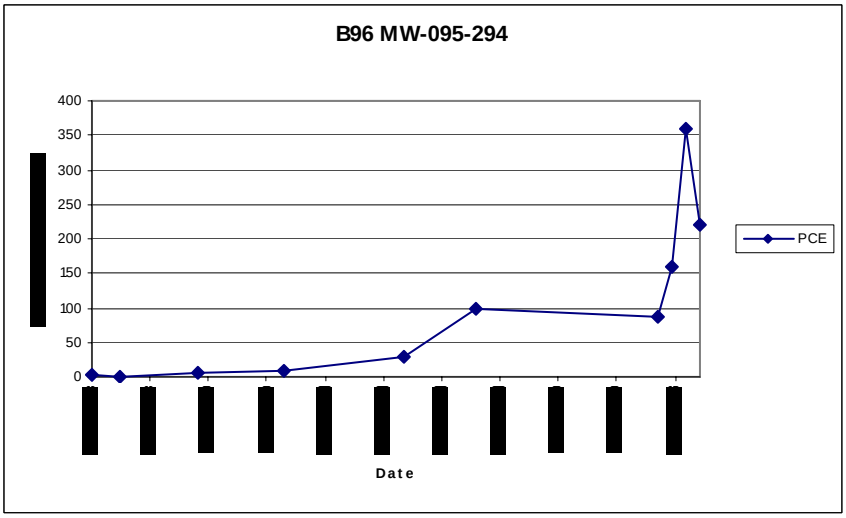
BROOKHAVEN NATIONAL LABORATORY
EWM SERVICES DIVISION

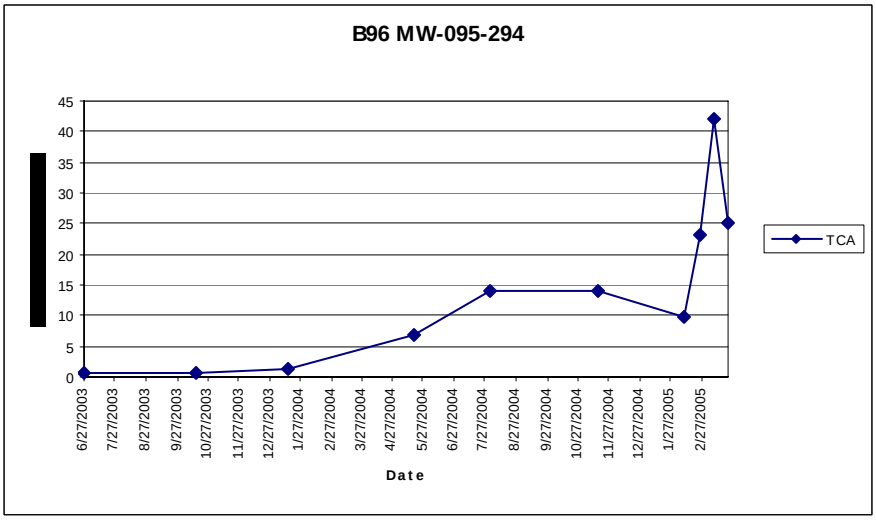
TITLE:

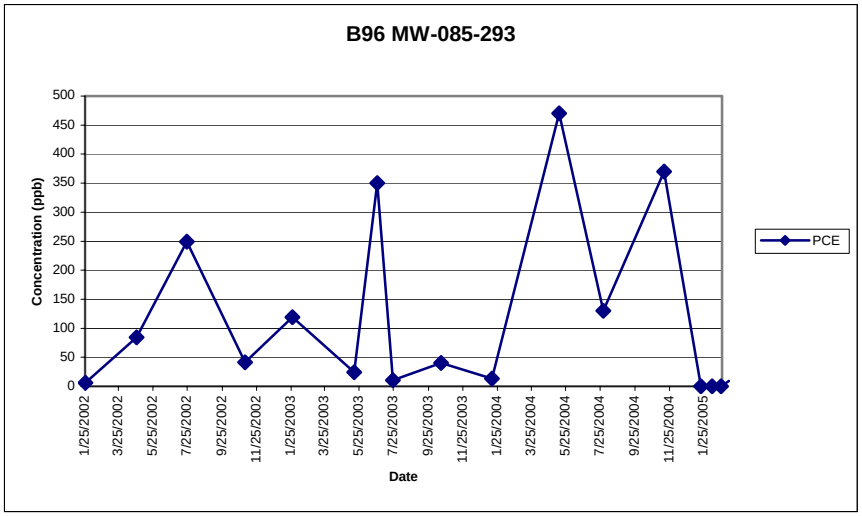
OU III BUILDING 96 AREA HYDROGEOLOGIC CROSS SECTION (B-B')

BLDG 96 PERMANGANATE INJECTION REPORT

DWN: SRW	VT:HZ.: 2:3	DATE: 4/11/05	PROJECT NO.: 07176
CHKD: MGH	APPD: –	REV.: –	NOTES: –
FIGURE NO.: 6-2			


B96 MW-095-294
400
350
300
250
200
150
100
50
0
PCE
Date


B96 MW-095-294
45
40
35
30
25
20
15
10
5
0
TCA
6/27/2003
7/27/2003
8/27/2003
9/27/2003
10/27/2003
11/27/2003
12/27/2003
1/27/2004
2/27/2004
3/27/2004
4/27/2004
5/27/2004
6/27/2004
7/27/2004
8/27/2004
9/27/2004
10/27/2004
11/27/2004
12/27/2004
1/27/2005
2/27/2005
Date


B96 MW-085-293
Concentration (ppb)
500
450
400
350
300
250
200
150
100
50
0
1/25/2002
3/25/2002
5/25/2002
7/25/2002
9/25/2002
11/25/2002
1/25/2003
3/25/2003
5/25/2003
7/25/2003
9/25/2003
11/25/2003
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3/25/2004
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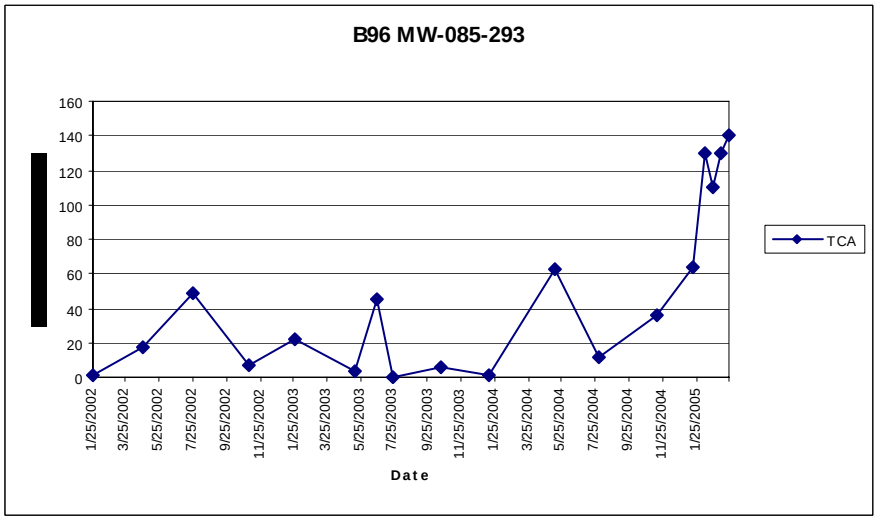
7/25/2004
9/25/2004
11/25/2004
1/25/2005
Date
PCE


B96 MW-085-293
160
140
120
100
80
60
40
20
0
1/25/2002
3/25/2002
5/25/2002
7/25/2002
9/25/2002
11/25/2002
1/25/2003
3/25/2003
5/25/2003
7/25/2003
9/25/2003
11/25/2003
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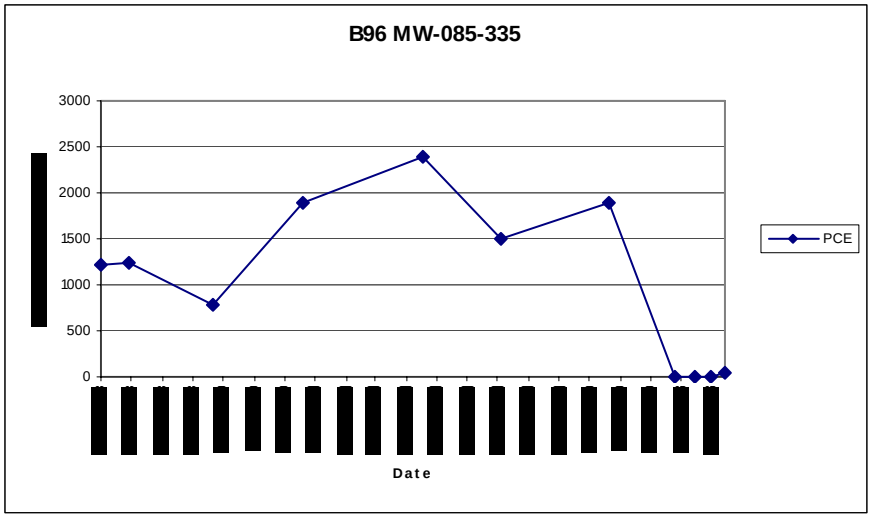
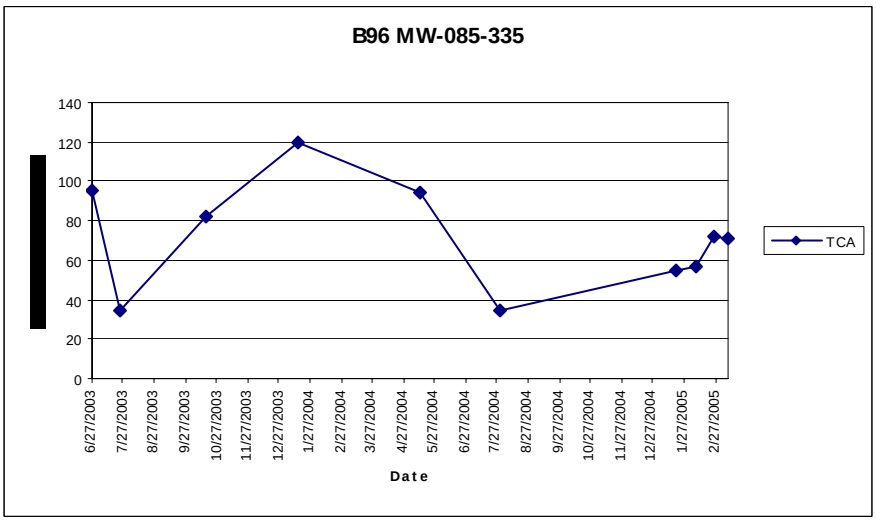
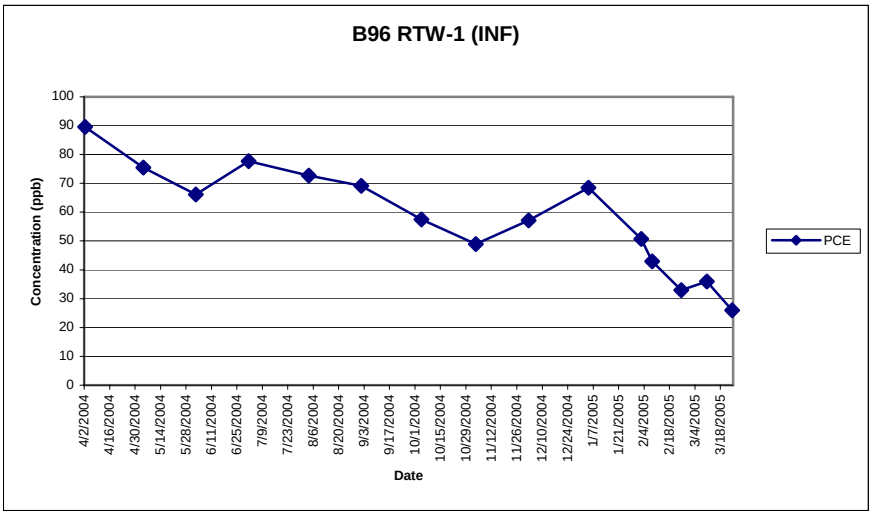
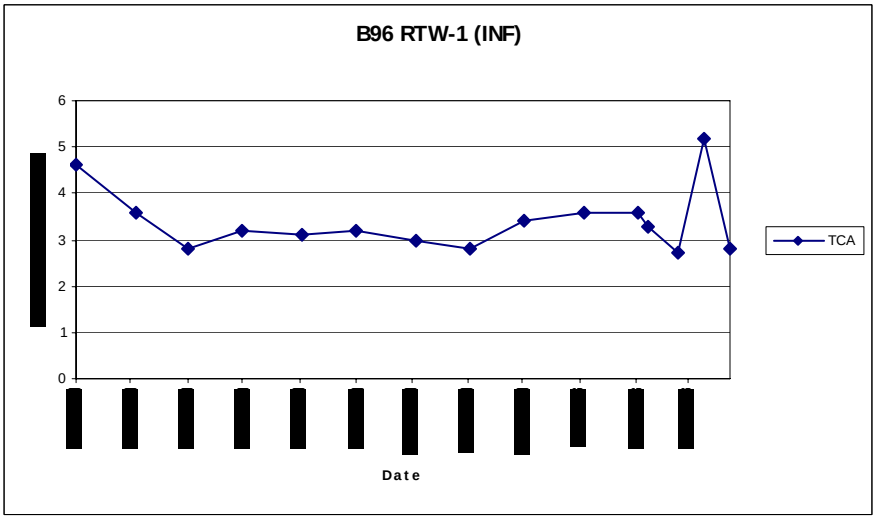
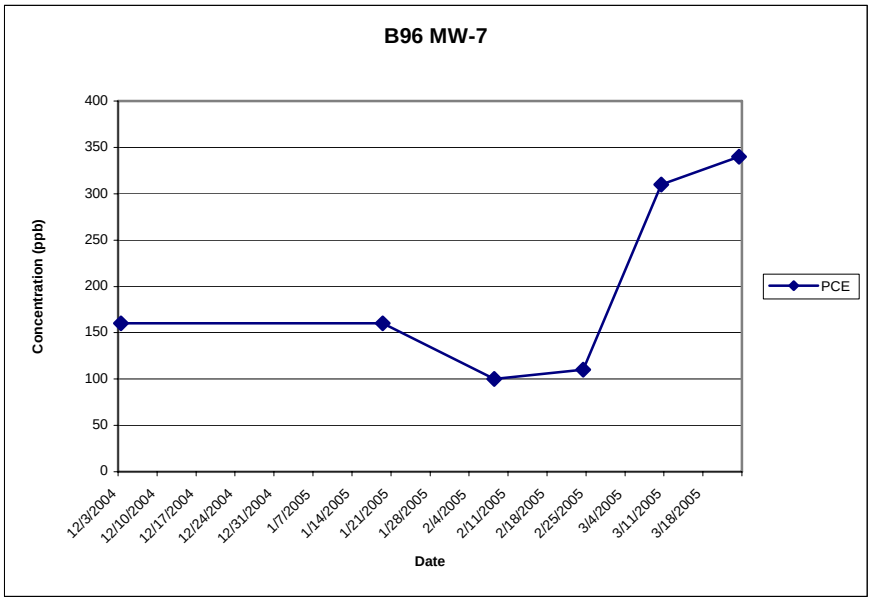
11/25/2004
1/25/2005
Date
TCA

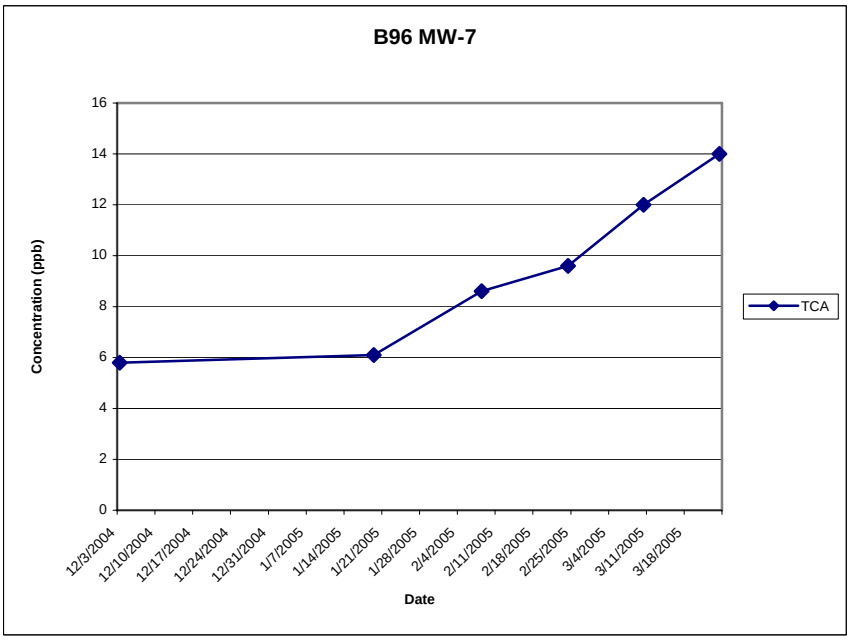

B96 MW-085-335
3000
2500
2000
1500
1000
500
0
PCE
Date

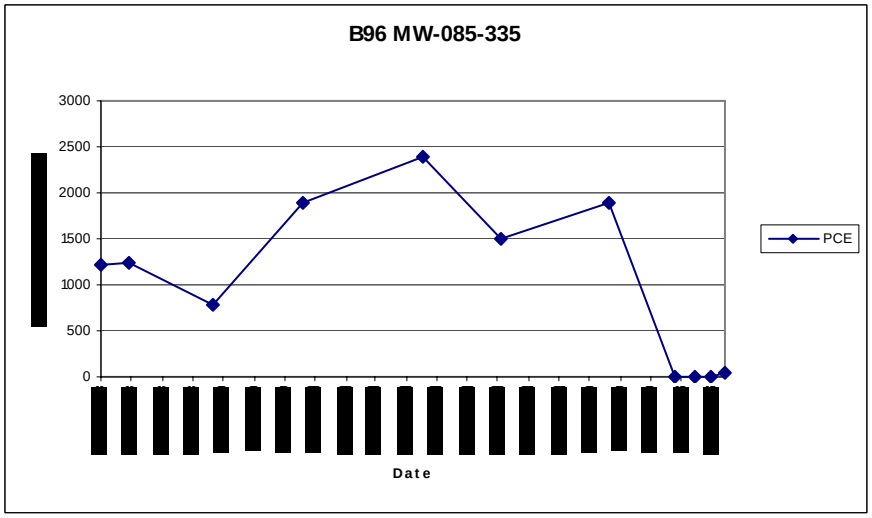

B96 MW-085-335
140
120
100
80
60
40
20
0
TCA
6/27/2003
7/27/2003
8/27/2003
9/27/2003
10/27/2003
11/27/2003
12/27/2003
1/27/2004
2/27/2004
3/27/2004
4/27/2004
5/27/2004
6/27/2004
7/27/2004
8/27/2004
9/27/2004
10/27/2004
11/27/2004
12/27/2004
1/27/2005
2/27/2005
Date

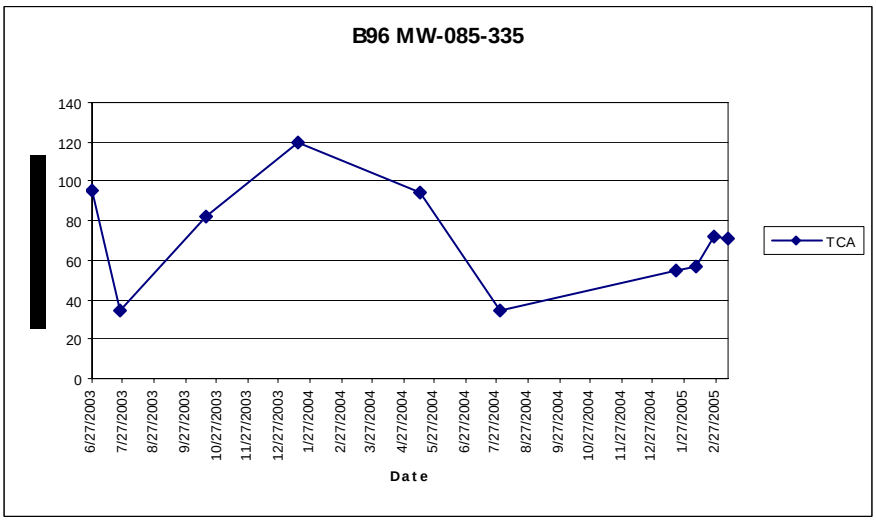

B96 RTW-1 (INF)
Concentration (ppb)
100
90
80
70
60
50
40
30
20
10
0
4/2/2004
4/16/2004
4/30/2004
5/14/2004
5/28/2004
6/11/2004
6/25/2004
7/9/2004
7/23/2004
8/6/2004
8/20/2004
9/3/2004
9/17/2004
10/1/2004
10/15/2004
10/29/2004
11/12/2004
11/26/2004
12/10/2004
12/24/2004
1/7/2005
1/21/2005
2/4/2005
2/18/2005
3/4/2005
3/18/2005
Date
PCE


B96 RTW-1 (INF)
6
5
4
3
2
1
0
Date
TCA


B96 MW-7
Concentration (ppb)
400
350
300
250
200
150
100
50
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
PCE


B96 MW-7
Concentration (ppb)
16
14
12
10
8
6
4
2
0
12/3/2004
12/10/2004
12/17/2004
12/24/2004
12/31/2004
1/7/2005
1/14/2005
1/21/2005
1/28/2005
2/4/2005
2/11/2005
2/18/2005
2/25/2005
3/4/2005
3/11/2005
3/18/2005
Date
TCA


B96 MW-085-335
3000
2500
2000
1500
1000
500
0
PCE
Date


B96 MW-085-335
140
120
100
80
60
40
20
0
TCA
6/27/2003
7/27/2003
8/27/2003
9/27/2003
10/27/2003
11/27/2003
12/27/2003
1/27/2004
2/27/2004
3/27/2004
4/27/2004
5/27/2004
6/27/2004
7/27/2004
8/27/2004
9/27/2004
10/27/2004
11/27/2004
12/27/2004
1/27/2005
2/27/2005
Date

Appendix A

1.0 PRE-INJECTION DATA COLLECTION

1.1 Lithology Boring Geologic Results

The most conspicuous geologic unit is "tight" silt that appears to bridge (straddle) the water table. This silt unit varies in thickness from approximately 10 feet at boring locations S-1 and S-4, 5 feet at S-2; and less than 2 feet at locations S-5 and S-6. This unit is not present at S-3. These data indicate that the silt unit is thickest in the northern part of the injection area and is very thin or absent to the south.

This silt unit will impede the downward movement of water to the water table and will mute the effects of fluctuating water table. It is likely to have a higher horizontal hydraulic conductivity than vertical conductivity due to the presence of more permeable fine sand lenses. However, this unit is at least one to two orders of magnitude less permeable than the fine to medium sands above and below it.

1.2 Monitor Well Installation

From November 19 to November 24, 2004 twelve (12) PVC monitor wells (2" diameter) were installed and developed. The wells are used to collect the pre-injection baseline and post-injection groundwater samples for analysis for VOCs by EPA Method 524.2 and for permanganate by visual inspection. Direct push technology was used to install the wells so that good hydraulic contact between the well screens and the aquifer could be achieved. Two (2) wells were screened at each of five (5) locations and two individual wells were installed in two locations. The screened intervals were determined by review of the more detailed geologic information from the new lithology boreholes. The shallow wells, including MW-5 and MW-7 are screened from 20 to 25 feet below land surface (bls) and the deeper wells are screened from 32 to 37 feet bls. Five-foot screen lengths were used. Monitoring well locations are indicated on Figure 3.

The new wells were installed at the greatest possible distance, about five (5) feet, from surrounding injection points within the injection grid (Figure 2) so that the contaminant zones furthest from the injection sites would be monitored. The rationale for this approach is that the oxidation process has the greatest chance of not reaching completion furthest from the injection points. Therefore this is a worst-case monitoring network for evaluating the injection results.

Installation of monitoring wells was conducted in accordance with BNL **EM-SOP-102**, *Installation of Groundwater Monitoring Wells and Piezometers* dated February 10, 2004. Sampling was conducted in accordance with BNL **EM-SOP-305**, Revision 2, *Collection of Groundwater Samples from Temporary Wells* dated June 24, 2003.

1.3 Groundwater Data Collection

Pre-injection groundwater samples were collected from the new monitor wells and from several existing monitor wells on December 3, 2004. BNL's low-flow sampling method was used in order to minimize purge water from the wells. The samples were sent to Severn Trent Laboratories, Inc. for VOC analysis using USEPA Method 524.2.

The results of the pre-injection baseline data round ranged from 13 ppb tetrachloroethylene (PCE) to 3,800 ppb PCE and from 0.26 ppb 1,1,1-trichloroethane (TCA) to 160 ppb TCA. The average concentration from the 12 wells was calculated to be 1,062.0 ppb PCE and 40.9 ppb TCA. Table 1 shows all the new monitoring well data through the most recent round. Trend plots for each well for PCE and TCA are shown in Figures 4-1 to 4-12**.** These results are discussed in Section 7.0 of this shutdown petition.

2.0 PERMANGANATE INJECTION FIELD PROGRAM

2.1 Fieldwork Narrative

The potassium permanganate injection fieldwork at the Building 96 former scrap yard began on December 8, 2004 and finished on January 14, 2005. Figure 2 shows the final configuration of the injection points throughout the silt zone/ high VOC concentration area. The injection work was performed along the outside of the grid before the center in the pattern proposed in the Scope of Work in order to minimize the potential spreading of the contaminants due to the volume of the injected permanganate. Point 3 on the north edge of the grid was the first to be injected followed by the points along the western edge of the grid. After that the points along the eastern and southern edges were completed. As the southern edge was completed the inner part of the grid was filled in rows from south to north. Individual exceptions to this approach occurred due to obstructions encountered in the field but these are not considered significant. The main pattern of moving from the outside of the grid inward was adhered to.

Based on the lithologic information the boreholes were spaced about 14 feet apart. The locations were measured in the field from known reference points such as the existing wells. Changes to the proposed locations were necessary due to conditions encountered in the field but as shown on Figure 2, the grid pattern was maintained.

2.2 Mixing of Potassium Permanganate

The dry potassium permanganate powder was prepared to the proper percent solution (1.2 %) by mixing the dry product with water in a contractor-supplied holding tank in compliance with BNL procedures and local regulations such as secondary containment.

Upon achieving the desired concentration the solution was injected into the direct push rods using an injection pump that is connected to the rods by dedicated hoses and fittings. Flow rates and line pressures were continuously monitored to insure proper injection volumes and safe

operating pressures. A variable speed pump should be used so that the pressure can be adjusted in the field.

2.3 Injection of Permanganate Using Direct Push Technology

Two geoprobe rigs were used at the same time to maintain an efficient work schedule. Each rig was set up on a particular point to pump approximately 1,000 gallons of the permanganate into the subsurface soils at each location. The first several locations from 12/8 to 12/10/2004 were injected with a one-foot PVC injection screen but this was not continued. The PVC screen became deformed by the injection pressure and made continued use impossible. While a replacement one-foot stainless steel injection screen was being manufactured, a four-foot stainless steel screen was used to perform the injections. On 12/15/2004 the stainless steel one-foot screens were put into service and were used for the remainder of the injections.

The injections were performed by first pushing the injection screen and rods to a depth of 40 feet below land surface (bls) with the geoprobe unit. Then approximately 50 gallons of the 1.2% permanganate solution were pumped into the formation at that depth. Then the rods were raised one foot and the process was repeated up to a depth of 20 feet bls. While the four-foot screens were being used the injection points were raised four feet after approximately 200 gallons were pumped. Variations in the amount of injected solution occurred because of the different permeabilities encountered in the formation but these were not considered significant as long as the total of about 1,000 gallons was injected at each location.

The goal of this technique was to perform a continuous injection of permanganate from 20 to 40 feet bls at each injection location. As discussed in the following section of this report, confirmation borings were installed around three of the injection locations to verify that the technique was achieving an acceptable degree of saturation of the subsurface soils with the permanganate.

The depth of the injection range (20 to 40 feet bls) was determined from the June 2004 geoprobe VOC data and from the MIP survey that was performed prior to the start of the injections. In the western locations of the grid the depths were 5 to 10 feet shallower than in the rest of the grid due to a topographic low in that area and the corresponding higher water table.

2.4 Collection of verification soil samples using direct push technology

Based on the predesign information, the permanganate solution should be pushed outward from the borehole immediately about two (2) feet by the hydraulic injection pressure during the injection. Over the following one (1) to three (3) months the permanganate solution was expected to diffuse through the aquifer materials an additional three (3) to five (5) feet outward from the borehole.

Immediately following the permanganate injection, as a check on the lateral penetration of the solution in the aquifer due to the injection pressure, soil samples were collected around each of four (4) initial injection locations. The samples were collected continuously from depths of twenty (20) feet to forty (40) feet BLS to confirm the radial extent of the permanganate solution

in the target zone by looking for the distinctive purple color of the material. To check on the longer-term outward diffusion of the permanganate solution, additional step-out borings were installed around several test locations about four (4) weeks after the injection, up to eight (8) feet laterally from the injection point. Visibly checking the lateral extent of the permanganate solution during the diffusion period will help determine the final size of the treated volume.

Table 1 summarizes the injection point with the confirmatory boring date and distance; boring locations are included in Figure 1. Initial confirmation borings were installed approximately two feet away from the injection point, final confirmation borings were spaced approximately eight feet from the injection point. If no evidence of $KMnO_4$ was observed, subsequent confirmation borings were spaced closer to the injection point.

Although the Scope of Work called for three initial confirmation borings around each of three injection points, confirmation borings were actually installed around four injection points (J-3, J-7, J-41 and J-68). During the initial stages of the injection project several different injection tool setups were used to determine which was the most efficient method of injection, therefore, confirmation borings were installed around an additional injection point to evaluate the effectiveness of the different tool setups used during the injection procedure. Injection point J-3 had three confirmation borings spaced around it. Confirmation boring J-3A was spaced approximately two feet away from the injection point, and exhibited no evidence of $KMnO_4$. Confirmation borings J-3B and J-3C were spaced approximately one foot from the injection point, and both exhibited some purple coloration. Injection point J-68 had three confirmation borings spaced around it. Confirmation boring J-68A was spaced one foot from the injection point, confirmation borings J-68B and J-68C were spaced approximately two feet from the injection point. The three confirmation borings around injection point J-68 each exhibited some purple coloration. Due to time constraints, only one confirmation boring was installed adjacent to each of injection points J-7 and J-41. Both confirmation borings were spaced approximately two feet from the injection point, and both borings exhibited some purple coloration.

The original scope of work called for an additional three final confirmation borings spaced eight feet from three injection locations approximately four weeks after the injection of $KMnO_4$. Based on time constraints, this was changed to two secondary confirmation borings per injection location. Secondary confirmation borings were installed around injection points J-7, J-64 and J-68. Confirmation borings J-68D and J-68E were spaced approximately eight feet from the injection point, and both exhibited some purple coloration. Confirmation borings J-7B and J-7C were installed approximately eight feet from the injection point, J-7B exhibited purple coloration, however, J-7C did not. Since no purple coloration was observed in J-7C, boring J-7D was installed approximately four feet from the injection point, and purple coloration was observed. Confirmation borings J-64A and J-64B were spaced approximately eight feet from the injection point, and both exhibited some purple coloration.

2.5 Decontamination

To minimize the potential for cross-contamination between locations, non-dedicated sampling equipment and drilling equipment was decontaminated using a potable water rinse between sampling locations. Decontamination of equipment was performed in accordance with **EM-**

SOP-102, *Installation of Groundwater Monitoring Wells and Piezometers*, Rev. 3, February 3, 2004.

2.6 Waste Management

Wastes generated during this injection program were managed per BNL's Waste Management Policy/Procedures and BNL's Waste Management Plan for Investigation-Derived Waste (12/11/2002). Prior to the start of the fieldwork, the EM team reviewed and subsequently followed the BNL SOP for handling of investigative-derived waste (BNL EM-SOP-802). Well purge water and rinse water from decontamination of field equipment are examples of waste that are expected to be generated during the fieldwork. None of this waste is hazardous.