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TECHNICAL MEMORANDUM SOURCE AREA INVESTIGATION AND NATURAL ATTENUATION EVALUATION NIROP FRIDLEY MN

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ARCADIS U.S., Inc.
430 First Avenue North
Suite 720
Minneapolis
Minnesota 55401
Tel 612.339.9434
Fax 612.336.4538

MEMO

To:
Deepa De Alwis
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Copies:
Doug Hildre
BAE US Combat Systems

From:
Brad Koons
Bryan Zinda

Date:
February 13, 2009

ARCADIS Project No.:
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Subject:
Source Area Investigation and Natural Attenuation Evaluation Technical Memo
BAE US Combat Systems North Site, Fridley, MN

This technical memorandum provides a review of historical source area investigation and a continuous evaluation of groundwater quality data to support natural attenuation as the recommended remedy for the BAE US Combat Systems corrective action Site in Fridley MN. The source area investigation review was based on previous reports submitted by a former consultant, Tetra Tech, for the site. The two main reports that were reviewed were the Site Evaluation Report (October 1998) and the RCRA Facility Investigation (June 2005). The review suggested that soil impact near the source may not be fully delineated based on the available soil data and that additional soil investigation in the source area is recommended. The natural attenuation evaluation performed by Tetra Tech has also been expanded in this memorandum by incorporating newly available groundwater data and by utilizing a statistical trend analysis program to assess plume stability and estimate plume longevity.

Source Area Characterization

Six potential source areas were identified in historical reports: AOC-UD02 former Paint Booth, AOC-UD03 former Paint shops, the Machining Area, the Pump Assembly/Hydraulic Test Area, and SWMU#6 former Paint Storage Dry Well (Figure 1). Descriptions of the activities associated with these areas of interest and chemicals used were summarized in the 1998 S/ite Evaluation Report. A brief summary of that information and investigation activities conducted in these areas is below.

AOC-UD02 former Paint Booth

AOC-UD02 former Paint Booths was located at the southeast end of the building. The semi-enclosed paint booths operated from 1941 to 1972 and were used to spray paint small parts. The booths were decommissioned in 1972 and one booth was moved to the AOC-UD03 area, and was only used for a few years. The units sat on concrete floor, and based on historical records liquids may have been discharged to the sanitary sewer, dried paint was scrapped and disposed of offsite, and paint solvents were allowed to evaporate, transferred to drums or into the drain. It was reported that methyl ethyl ketone (MEK), paint thinner, and xylene were used on rags to clean parts before painting.

TW-UD02-02 was advanced to 24 feet below ground surface (bgs) in the vicinity of AOC-UD02. Minor PIDs readings (<5 instrument units) were observed in soil that was screened from grade to 6 feet below grade and no VOCs observed in groundwater collected from this temp well above method detection limits. Therefore, AOC-UD02 was not considered a significant source area.

AOC-UD03 former Paint Shop

AOC-UD03 former paint shop was located at the on the eastern end of the building near MW-UD62S. A painting booth was used in this area for a short period of a few years. As with AOC-UD02, it was reported that MEK, paint thinner, and xylene were used on rags to clean parts before painting. The former Paint Shop area was also indicated in the historical reports as being used as the pipe department, where pipes were formed and cleaned. The pipes were cleaned with acids, alkaline cleaners, MEK and/or tricholoroethylene (TCE).

Temporary monitoring well TW-UD03-2 was advanced to 23.5 feet below grade in the paint shop area in April of 2000. Minor PID readings (<5 instrument units) were observed in soil that was screened from grade to 20 feet below grade. Elevated PID readings of 6.8 to 23 instrument units were observed from 20 to 23.5 feet below grade. A grab water sample was collected and analyzed. Tetrachloroethene (PCE), TCE, cis-1, 2 –Dichloroethene (cis-DCE), 1,1-Dichloroethane (1,1-DCA), and 1,1,1-Trichloroethane (1,1,1-TCA) in the part per million range were detected.

MW-UD62-S and MW-UD61-I were advanced on what is believed to be the eastern edge of the former paint shop. No PID readings were observed (0 instrument units) in soil screened from grade to greater than 20 feet below grade for each boring. Repeated groundwater-quality sampling from these monitoring wells has shown MW-UD62-S is heavily impacted by chlorinated solvents.

AOC-UD03 is thought to be the likely source area due to 1) high levels of groundwater contamination in this area and 2) groundwater contaminants are consistent with historical chemical usage. Because soil quality data collected in AOC-UD03 are limited to field screening observations, additional soil investigation activities will be proposed for this area. The purpose of this investigation will be to collect soil contaminant concentration data to facilitate estimation of source area boundaries in accordance with MPCA technical guidance on monitored natural attenuation remedy demonstrations. Companion data such as bulk soil density, soil porosity, and fraction organic content will also be collected as needed. ARCADIS and BAE will review historical site plans to verify the pipe department location and confirm that the paint shop was located in close proximity to monitoring wells MW-UD62S and MW-UD61I. Once these locations have been verified a soil investigation work plan will be prepared and submitted to the MPCA for review.

Machining Area

Small quantities of TCE and Stoddard Solvent were used in the portable tanks (10 to 50 gallons) for cold cleaning metal parts. The cold cleaning units were maintained by a separate crew. The crew would remove old solvent and deliver fresh solvent. Solvent was stored at several locations throughout the area, and was also used for miscellaneous cleanup of part equipment. Temporary monitoring well TW-11 was advanced in this area in January of 2004, and had no elevated PID readings throughout the boring. Groundwater concentrations were also low. Three groundwater samples were collected from TW-11 at depths of 43 feet bgs, 63 feet bgs, and 83 feet bgs. The highest groundwater TCE concentration seen was 32 ug/L at 63 feet bgs. No PCE was detected in any of the samples. The Machining Area is determined not to be a source area due to the fact that no elevated PIDs were seen in the boring, and groundwater concentrations are low.

Pump Assembly/Hydraulic Test Area

The Pump Assembly Area and Hydraulic Test Area reportedly used more solvents than the Machine Area. TCE was allegedly used to wet mop the floors in this area, and was stored in 10 to 50 gallons tanks throughout this area for cleaning of metal parts. Based on historical interviews, solvents may have been discharged to the sanitary sewer. Temporary monitoring well TW-10 was advanced in this area in January of 2004, and had no elevated PID reading throughout the boring. Groundwater concentrations were also low. Three groundwater samples were collected from TW-10 at depths of 38 feet bgs, 63 feet bgs, and 83 feet bgs. The highest groundwater TCE concentration seen was 8.9 ug/L at 83 feet bgs. PCE was detected in one sample at 83 feet bgs with a concentration of 0.16 ug/l. The Pump Assembly and Hydraulic Test Area was determined not to be a source area due to the fact that no elevated PID readings were seen and TW-10 exhibited low groundwater contaminant concentrations.

Test Tanks

The Test Tank(s) were "field constructed underground tank(s) initially used for water recycle" . The approximate dimension of the concrete tank(s) was 10 feet by 50 feet by 12 feet or approximately 40,000 gallons. The tank(s) were constructed in 1941, and haven't been used in the last 30 years. The tank(s) were emptied twice of oily water since 1980. The water in the tanks were tested and not found to contain significant concentrations of chlorinated solvents,"

Two temporary wells (TW-UD01-01-S and TW-UD01-02-S) were completed in this area in February 2000, and had no elevated PID readings throughout either boring. Groundwater concentrations were also low. TCE and 1,1,1-TCA were detected in TW-UD01-02 at concentrations of 0.7 ug/L and 4.6 ug/L. Acetone and toluene were detected in TW-UD01-01 at concentrations of 28ug/L and 0.4 ug/L. The Test Tank(s) were determined not to be a source area due to the fact that no elevated PIDs were seen in the borings, and groundwater concentrations are low.

SWMU#6 former Paint Storage Dry Well

The SWMU #6 dry well drained the paint storage area and was designed to infiltrate liquids from the former paint storage building. The dry well was not routinely used, but was designed to provide drainage in the case that a paint fire occurred. The dry well was an unlined underground unit, and leaking paint containers and paint spills may have entered the dry well. The dry well was approximately 8 feet in diameter by 14 feet deep, and was used from 1941 to 1972. The dry well was located on the east end of the property and no longer exists at the surface. It is unknown if it still exists below ground surface. The former dry well location is now on Burlington Northern Santa Fe Railroad property.

A soil boring was advanced near SWMU#6 in 2000 to assess soil quality due to the potential that chemicals stored in the former paint storage building were discharged to the drain in the building that led to the dry well. Two soil samples were collected from the SWMU#6 area, and were called SB-6-01 and SB-6-02. The soil boring location was based on measurements taken from scaled site plans showing the dry well and referencing those measurements to existing building corners. Soil sample SB-6-01 was collected from 4 to 6 feet bgs, and SB-6-02 from 22 to 24 feet bgs. The shallow soil sample (4 to 6 feet bgs) only contained a detection of naphthalene at 55 ug/kg. The deeper soil sample was collected near the water table at 22 to 24 feet bgs and contained PCE and TCE. The detected results were 81 ug/kg PCE and 110 ug/kg TCE (Table 1). No elevated PID readings were detected during the field screening.

Due to the uncertainty of the dry well location, the soil quality results from soil boring SWMU #6 may not be fully representative of soil quality at the dry well. However, the PCE and TCE concentrations at depth in this sampling location are insignificant as compared to groundwater concentrations near the former Paint Shop Area, which suggests that the dry well was not a significant source area. Because soil sampling

verified that the dry well was not a significant source, no additional soil investigation is proposed to assess SWMU #6.

Previous Natural Attenuation Evaluation

Tetra Tech evaluated groundwater data collected between 2000 and 2006 to assess the adequacy of natural attenuation as a final remedy for site groundwater (Tetra Tech, 2004; Tetra Tech, 2007). Their approach focused on two lines of evidence recommended by the US Environmental Protection Agency for natural attenuation demonstrations (USEPA, 1998):

- Analytical data showing that geochemical conditions are suitable for biodegradation and that active biodegradation has occurred as indicated by the consumption of electron acceptors and / or the production of metabolic by-products.

- Historical trends in contaminant data showing plume stabilization and / or loss of contaminant mass over time.

Results and conclusions of the previous evaluation are summarized in the following:

- Biodegradation of chlorinated compounds was evidenced by the detection of daughter products, e.g., cis-DCE, vinyl chloride (VC), 1,1-DCA, in most monitoring wells across the site.

- Natural attenuation parameters, such as dissolved oxygen, nitrate, sulfate, iron, and manganese, were evaluated for two source area wells (MW-UD-62S and MW-UD-66I). Tetra Tech concluded that geochemical conditions were moderately reducing, and is suitable for microbial anaerobic reductive dechlorination to occur.

- Historical concentrations of two source area monitoring wells, MW-UD-66I and MW-UD-62S, were plotted on graphs to demonstrate the general contaminant trends over time. The trends were inferred by visually observing the general upward or downward trend of the datasets. It was concluded that source zone concentrations are decreasing despite some scattering of elevated TCE and cis-DCE concentrations in MW-UD-62S in 2007.

- First-order decay rate and time to achieve remediation goals was calculated by fitting historical concentration data of individual monitoring wells to a first-order decay model (i.e. linear regression of the historical data). Based on data from only two sampling events (2002 and 2006) and an average first-order decay coefficient from multiple monitoring wells, Tetra Tech projected up to 37 years for reaching the target TCE concentration of 5 ug/L.

- BIOCHLOR was used to predict the future extent of contamination. This was in turn used to indirectly estimate the longevity of the dissolved plume. The modeling was performed with the following assumptions and procedures:

    - The modeling effort began by arbitrarily assuming 2006 as the 19th year since an active release last occurred.

    - The 2006 concentrations of two source wells, MW-UD-62S and MW-UD-66I, were the field-observed data used to compare against the model-predicted concentrations at these locations.

    - The field-observed concentrations and the model-predicted concentrations were matched through trial-and-error by adjusting the 0th year (the year that the last release occurred) source concentrations and biotransformation parameter inputs (e.g. first-order decay rate constants).

    - Once the source concentrations and the biotransformation parameters were calibrated, the model was iterated until concentrations below the HRLs were obtained. The year in which the HRLs were attained was the end point of natural attenuation.

  Based on this methodology, it was suggested that the dissolved plume will not last for more than 30 years from 2004 (Tetra Tech, 2004).

Available Site Data

Since the previous natural attenuation evaluation, additional data was available from two rounds of groundwater sampling (2007 and 2008). The new data was incorporated into the natural attenuation evaluation to provide a current perspective on concentration trends and the progress of natural attenuation at the site. In addition, the current evaluation was performed using a trend analysis program to generate more systematic and statistically valid results.

Site groundwater quality data were compiled from data tables presented in previous reports submitted by Tetra Tech, including the Supplemental RCRA Facility Investigation and the RCRA Corrective Measures Study submitted in April 2004 and January 2007 and groundwater quality data collected following submission of those reports. Groundwater data collected from 11 permanent monitoring wells and 5 temporary wells between February 2000 and October 2008 is included and presented on Tables 2 and 3. Only constituents with detected values are included in the data tables.

Trend Analysis using MAROS

Groundwater data trend analysis was performed using the Monitoring and Remediation Optimization System (MAROS) program developed by the Air Force Center for Environmental Excellence. The MAROS program was used to perform Mann Kendall and linear regression tests to develop statistical-based conclusions regarding constituent concentration trends.

Both Mann-Kendall and linear regression are statistical tests commonly used to evaluate groundwater plume trend. The Mann-Kendall test is a nonparametric test which has no distributional assumption and irregularly spaced measurement periods are permitted. Linear regression is a parametric test which makes assumptions on the normality of the data distribution and is more efficient when data is normally distributed. Both tests require at least 4 data points in order to obtain a test statistic (Mann-Kendall statistic or slope of the linear regression) and a confidence level of the analysis. A decision matrix based on values of the test statistic and the confidence level is used to determine the overall concentration trend. In additional to trend analysis, the "Ln Slope" values from the linear regression analysis are used to project the time frame within which the remediation goals (i.e., Health Risk Limits [HRL] developed by the Minnesota Department of Health) may be attained via natural attenuation.

The trend analyses were performed on the major constituents of concern of the site, including chlorinated ethenes and chlorinated ethanes. Groundwater data from the onsite monitoring wells listed in Table 2 was imported into the MAROS program. The program requires identification of monitoring wells as being in the source or tail region of the plume. Based on the TCE plume map developed by Tetra Tech (Figure 2), four monitoring wells (MW-UD-61I, MW-UD-62S, MW-UD-65S, and MW-UD-66I) are defined as in the source region whereas all other wells are in the tail region of the plume.

The MAROS result reports are included as Appendix A. The results suggest that concentrations of parent compounds, PCE, TCE, and 1,1,1-TCA, are generally stable or decreasing within the source region with the exception of PCE in MW-UD-65S which is probably increasing. However, it should be noted that PCE in MW-UD-65S has been below the HRL of 5 ug/L except for one sample collected in 2005 (7.6 ug/L) and that the overall potentially increasing trend may be attributed to the concentration spike slightly above the HRL in 2005. The concentration has been stable since 2005 and additional groundwater monitoring will resolve whether the increasing trend will continue or stabilize.

The analyses determined that the trend of TCE and PCE in MW-UD-62S was stable despite the concentration spikes in 2007. Similarly, parent compounds in the downgradient region and daughter products in the entire plume are showing stable or decreasing trend. The results clearly demonstrate plume stabilization and satisfy the first line of evidence for the occurrence of natural attenuation.

First-order Decay Rate and Natural Attenuation Time Frame Estimate

Groundwater quality data were fitted to a first-order model, and linear regression was used to estimate the decay rate to project the time required to achieve the remediation goals of the constituents of concern based on natural attenuation. Results of the remediation time frame projection are included in Table 4. Note that the decay rate was only calculated for datasets with at least 4 data points and that the time frame projection was only performed on constituents showing a decreasing trend based on linear regression and with the most recent concentrations above the HRL. Based on the available dataset and the current decay rates, the HRLs will generally be reached within 10 to 40 years. An exception to this is TCE in MW-UD-62S, which may take a substantially longer time (> 980 years) to achieve the HRL of 5 ug/L for TCE.

The current estimated natural attenuation time frame for TCE in MW-UD-62S is more than 25 times longer than the time frame projected by Tetra Tech previously. Three reasons may have contributed to the discrepancy between the two estimates:

- A geometric mean of decay rate constants from four monitoring wells was used to estimate the duration of natural attenuation and yielded a time frame of 37 years for TCE in MW-UD-62S. If the well-specific rate constant was used, the time frame would be twice as long as that determined from the site-wide average (Appendix B).
- Only two data points (2002 and 2006) were used in Tetra Tech's first-order decay model and time frame estimate. When all available data between 2002 and 2006 (five data points) was incorporated into the regression model, the projected time frame would increase by an order of magnitude (Appendix B).
- The 7-point linear regression model with the new data from 2007 and 2008 yielded a first-order decay rate that is one order of magnitude smaller than the 2-point and 5-point models. The resulting attenuation time frame increases accordingly (Appendix B).

This comparison demonstrates that the concentration spike in 2007 has significantly increased the first-order decay time frame. When the Nov. 2007 TCE data point was excluded, the time frame is approximately 100 years from 2000 (Appendix B). It appears that the 2007 data may have skewed the overall time frame estimate. Further groundwater monitoring will provide additional data to resolve the discrepancy in time frame estimate.

Conclusion and Recommendation

Observations of chlorinated solvent biological degradation daughter products in monitoring wells indicate that natural attenuation has been occurring at the site. Results from the trend analyses demonstrate that groundwater concentrations are largely decreasing or stable, which shows that monitored natural attenuation is a sufficient remedy for the groundwater impacts. Soil data review suggested that the current

available soil data is not adequate for source area evaluation. Soil borings will be installed at the Site to investigate source area soils. The exact number of soil borings and locations will be proposed in a Work Plan to be submitted three (3) weeks following this letter report.

Based on the soil and groundwater quality data evaluation, ARCADIS recommends the following site activities to further demonstrate that monitored natural attenuation is an appropriate remedy for the site:

- The annual groundwater monitoring should be continued to provide additional data for natural attenuation time frame estimate and trend analysis.
- Future groundwater samples will be analyzed for dissolved ethene and ethane gasses to confirm that complete anaerobic dechlorination to innocuous end products is occurring at that site.

References

Air Force Center for Environmental Excellence, Monitoring and Remediation Optimization System (MAROS) Software Version 2.2 User's Guide, March 2006.

Tetra Tech, Site Evaluation Report, United Defense, L.P., Fridley Minnesota,October 1998.

Tetra Tech, Supplemental RCRA Facility Investigation, United Defense, L.P., Fridley Minnesota, April 2004.

Tetra Tech, RCRA Facility Investigation, United Defense, L.P., Fridley Minnesota, June 2005.

Tetra Tech, RCRA Corrective Measures Study, BAE Systems, Fridley Minnesota, January 2007.

USEPA, Technical Protocol to Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, September 1998.

Table 1. Historical Soil Data from SMWU #6 - Former Point Storage Dry Well
BAE US Combat Systems, Fridley, Minnesota

Sample ID	SB-#6-01	SB-#6-02
Depth (ft bgs)	4 - 6	22 - 24
Constituent		
Tetrachloroethylene (PCE)	–	81
Trichloroethylene (TCE)	–	110
Naphthalene	55	–

Note:
ft bgs Feet below ground surface

Table 2. Historical Groundwater Data of Permanent Monitoring Wells
BAE US Combat Systems, Fridley, Minnesota

Concentration (µg/L)	Well MW-UD-58I							Well MW-UD-59I				Well MW-UD-60S			Well MW-UD-61I						
Constituent / Sampling Date	**Feb-00**	**Dec-02**	**Feb-03**	**Oct-05**	**Dec-06**	**Nov-07**	**Oct-08**	**Feb-00**	**Dec-02**	**Feb-03**	**Oct-08**	**Feb-00**	**Dec-02**	**Feb-03**	**Feb-00**	**Dec-02**	**Feb-03**	**Oct-05**	**Dec-06**	**Nov-07**	**Oct-08**
1,1,1-TRICHLOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,1,2,2-TETRACHLOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,1,2-TRICHLOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,1-DICHLOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7	–	–	–	–	–	–
1,1-DICHLOROETHENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,2-DICHLOROBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
cis-1,2-DICHLOROETHYLENE	1 5	–	–	–	–	–	–	20	17	15	14 8	–	–	–	1.8	–	–	1.2	–	–	–
ETHYLBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
NAPHTHALENE	–	–	–	–	–	–	–	2.2	–	–	–	–	–	–	–	–	–	–	–	–	–
TETRACHLOROETHYLENE(PCE)	0 76	1.2	1	–	–	–	–	–	–	–	–	–	–	–	0.67	–	–	–	–	–	–
trans-1,2-DICHLOROETHENE	–	–	–	–	–	–	–	56	54	47	36.4	–	–	–	–	–	–	–	–	–	–
TRICHLOROETHYLENE (TCE)	35	17	20	9 6	10.3	7.1	8	340	210	200	49.9	0 7	1 1	0.71	52	18	8 2	68 1	4.5	27.1	2 7
VINYL CHLORIDE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,2,4-TRIMETHYLBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ISOPROPYLBENZENE (CUMENE)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
n-BUTYLBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
n-PROPYLBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P-CYMENE (p-ISOPROPYLTOLUENE)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
XYLENE, O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
XYLENES, M&P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note:
– Data not available or below detection limit

Table 2. Historical Groundwater Data of Permanent Monitoring Wells
BAE US Combat Systems, Fridley, Minnesota

Concentration (µg/L) Constituent / Sampling Date	Well MW-UD-62S							Well MW-UD-63S			Well MW-UD-65S						Well MW-UD-66I					
	Feb-00	Dec-02	Feb-03	Oct-05	Dec-06	Nov-07	Oct-08	Feb-00	Dec-02	Feb-03	Dec-02	Feb-03	Oct-05	Dec-06	Nov-07	Oct-08	Dec-02	Feb-03	Oct-05	Dec-06	Nov-07	Oct-08
1,1,1-TRICHLOROETHANE	2100	1500	590	777	168	1050	408	–	–	–	1.7	–	8.7	3.7	1.9	1.6	66	110	37.5	20 9	15.7	7 6
1,1,2,2-TETRACHLOROETHANE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.1	–	–	–	–	–	–	–
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	–	–	–	3 3	–	–	–	–	–	–	–	–	–	–	–	–	–	1 6	1.3	–	–	–
1,1,2-TRICHLOROETHANE	–	–	–	1 2	–	–	–	–	–	–	–	–	–	–	–	–	–	1.6	–	–	–	–
1,1-DICHLOROETHANE	940	590	190	394	91.9	585	178	–	–	–	–	–	7.7	1.8	–	1.6	280	380	110	105	38.2	25.7
1,1-DICHLOROETHENE	–	54	–	18	14.9	30 9	–	–	–	–	–	–	–	–	–	–	32	50	22 1	17	12.7	11.4
1,2-DICHLOROBENZENE	–	–	–	2 8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0 76	–	–	–	–
cis-1,2-DICHLOROETHYLENE	6900	6600	1500	4530	793	6320	2630	–	–	–	1 8	–	37 9	7.3	2 3	7.2	1300	1700	462	449	151	119
ETHYLBENZENE	–	–	–	–	–	–	–	16	5.7	6 7	–	–	–	–	–	–	–	–	–	–	–	–
NAPHTHALENE	30	–	–	15.8	–	–	–	13	8.1	7.2	–	–	–	–	–	–	–	–	–	–	–	–
TETRACHLOROETHYLENE(PCE)	560	530	180	371	86	929	175	–	–	–	0.86	0.92	7 6	4	3 1	3.3	120	170	78 9	43 8	46.5	47.6
trans-1,2-DICHLOROETHENE	71	61	21	67.6	9.4	60 2	35 1	–	–	–	–	–	–	–	–	–	–	23	10.3	–	–	5.2
TRICHLOROETHYLENE (TCE)	6700	7300	2800	7350	3850	12400	3250	–	0 5	–	14	15	138	63.8	28.9	28 4	3300	4100	1540	1470	1160	998
VINYL CHLORIDE	170	190	50	66	22.6	135	49.6	–	–	–	–	–	–	–	–	–	–	3.1	0.98	–	–	–
1,2,4-TRIMETHYLBENZENE	–	–	–	–	–	–	–	75	72	82	–	–	–	–	–	–	–	–	–	–	–	–
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	–	–	–	–	–	–	–	19	18	18	–	–	–	–	–	–	–	–	–	–	–	–
ISOPROPYLBENZENE (CUMENE)	–	–	–	–	–	–	–	2 2	2 4	3.3	–	–	–	–	–	–	–	–	–	–	–	–
n-BUTYLBENZENE	–	–	–	–	–	–	–	–	–	1 7	–	–	–	–	–	–	–	–	–	–	–	–
n-PROPYLBENZENE	–	–	–	–	–	–	–	7	8	10	–	–	–	–	–	–	–	–	–	–	–	–
P-CYMENE (p-ISOPROPYLTOLUENE)	–	–	–	–	–	–	–	1 4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
XYLENE, O	–	–	–	–	–	–	–	1.6	1.9	2 2	–	–	–	–	–	–	–	–	–	–	–	–
XYLENES, M&P	–	–	–	–	–	–	–	55	13	13	–	–	–	–	–	–	–	–	–	–	–	–

Note
– Data not available or below detection limit

Table 2. Historical Groundwater Data of Permanent Monitoring Wells
BAE US Combat Systems, Fridley, Minnesota

Concentration (µg/L) Constituent / Sampling Date	Well MW-UD-67S Dec-02	Feb-03	Well MW-UD-68I Dec-02	Feb-03	Well MW-UD-69D Oct-05	Dec-06	Nov-07	Oct-08	Well USGS-9 Feb-00	Dec-02	Feb-03
1,1,1-TRICHLOROETHANE	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-TETRACHLOROETHANE	--	--	--	--	--	--	4 5	--	--	--	--
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	--	--	--	--	--	--	--	--	--	--	--
1,1,2-TRICHLOROETHANE	--	--	--	--	--	--	--	--	--	--	--
1,1-DICHLOROETHANE	--	--	1.6	1 8	--	--	--	--	7.7	10	6.8
1,1-DICHLOROETHENE	--	--	--	2 4	--	--	--	--	3.6	4.9	4.3
1,2-DICHLOROBENZENE	--	--	--	--	--	--	--	--	--	--	--
BENZENE	--	--	--	--	--	--	--	--	--	--	--
cis-1,2-DICHLOROETHYLENE	--	--	2.6	2.4	--	--	--	--	45	50	49
ETHYLBENZENE	--	--	--	--	--	--	--	--	--	--	--
NAPHTHALENE	--	--	--	--	--	--	--	--	--	--	--
TETRACHLOROETHYLENE(PCE)	--	--	2 5	0.66	9.4	6.6	4.5	3.1	--	--	--
trans-1,2-DICHLOROETHENE	--	--	--	--	--	--	--	--	110	100	150
TRICHLOROETHYLENE (TCE)	4.2	4.7	69	73	18	13.8	11.2	10 1	240	93	94
VINYL CHLORIDE	--	--	--	--	--	--	--	--	--	--	--
1,2,4-TRIMETHYLBENZENE	--	--	--	--	--	--	--	--	--	--	--
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	--	--	--	--	--	--	--	--	--	--	--
ISOPROPYLBENZENE (CUMENE)	--	--	--	--	--	--	--	--	--	--	--
n-BUTYLBENZENE	--	--	--	--	--	--	--	--	--	--	--
n-PROPYLBENZENE	--	--	--	--	--	--	--	--	--	--	--
P-CYMENE (p-ISOPROPYLTOLUENE)	--	--	--	--	--	--	--	--	--	--	--
XYLENE, O	--	--	--	--	--	--	--	--	--	--	--
XYLENES, M&P	--	--	--	--	--	--	--	--	--	--	--

Note
-- Data not available or below detection limit

Table 3. Historical Groundwater Data of Temporary Monitoring Wells
BAE US Combat Systems, Fridley, Minnesota

Concentration (µg/L)	Well TW-10			Well TW-11			Well TW-12			Well TW-13				Well TW-14			
Sampling Depth (ft bgs)	38	63	83	43	63	83	43	63	78	82	92	102	112	85	95	105	118
Constituent / Sampling Date	Jan-04	Jan-04	Jan-04	Jan-04	Jan-04	Jan-04	Jan-04	Jan-04	Jan-04	Dec-04	Dec-04	Dec-04	Dec-04	Dec-04	Dec-04	Dec-04	Dec-04
1,1-DICHLOROETHENE	–	–	–	–	–	–	–	–	0 51	–	–	–	–	–	–	–	–
ACETONE	–	15	10	6.3	6 6	–	–	20	9.9	–	–	–	–	–	–	–	–
BENZENE	–	0 16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BROMODICHLOROMETHANE	–	–	–	–	–	–	–	–	–	–	–	–	2.8	2	2 1	1 4	–
CHLOROFORM	0.23	0 27	–	–	–	–	–	0.28	–	–	6	2.4	15.1	10.4	12.7	9	3
CHLOROMETHANE	3.7	11	25	18	7.6	12	19	4 7	10	–	–	–	–	–	–	–	–
cis-1,2-DICHLOROETHYLENE	–	–	–	–	0.48	2 1	–	–	9 6	7.4	1.8	1.5	–	–	–	–	–
ETHYLBENZENE	–	–	–	–	–	0 32	–	–	–	–	–	–	–	–	–	–	–
METHYL ETHYL KETONE (2-BUTANONE)	–	2	1.5	1.3	–	–	–	1.1	0.58	–	–	–	–	–	–	–	–
t-BUTYLBENZENE	2.6	1 6	0.95	–	–	–	–	0 78	–	–	–	–	–	–	–	–	–
TETRACHLOROETHYLENE(PCE)	–	–	0.16	–	–	–	–	–	–	9	–	5.3	–	–	–	–	10 3
TETRAHYDROFURAN	–	–	0 9	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOLUENE	0 44	1.7	1.7	–	0.84	0.65	2.3	3.5	1 3	–	–	9 8	–	–	–	–	–
TRICHLOROETHYLENE (TCE)	–	4.6	8 9	4	32	1 6	1 5	1.2	130	56.3	27.4	25.3	–	2.8	1.6	7 4	10.5
XYLENES, TOTAL	1.5	1.4	1 3	0.19	1 1	1.7	0.87	0.9	0.27	–	–	–	–	–	–	–	–

Note
— Data not available or below detection limit

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Table 4. Natural Attentuation Time Fram Estimate
BAE US Combat Systems, Fridley, Minnesota

Constituent	Ln slope[a]	Most Recent Concentration (ug/L)	Date of Most Recent Concentration	HRL (ug/L)	Year to HRL	Timeframe (# of year from 2009)
Well MW-0UD-58I:						
TRICHLOROETHYLENE (TCE)	-0.00049	8	Oct 2008	5	May 2011	2.4
Well MW-UD-59I:						
TRICHLOROETHYLENE (TCE)	-0.00062	49.9	Oct 2008	5	Nov 2018	9.9
Well MW-UD-62S:						
1,1,1-TRICHLOROETHANE	-0.00048	408	Oct 2008	200	Oct 2012	3.8
1,1-DICHLOROETHANE	-0.00039	178	Oct 2008	70	Apr 2015	6.3
1,1-DICHLOROETHENE	-0.0015	30.9	Nov 2007	6	Oct 2010	1.8
cis-1,2-DICHLOROETHYLENE	-0.00024	2630	Oct 2008	70	Feb 2050	41.1
TETRACHLOROETHYLENE (PCE)	-0.0002	175	Oct 2008	5	Jun 2057	48.5
TRICHLOROETHYLENE (TCE)	-0.000018	3250	Oct 2008	5	Dec 2993	985.6
VINYL CHLORIDE	-0.00035	49.6	Oct 2008	0.2	Nov 2051	42.9
Well MW-UD-65S:						
1,1,1-TRICHLOROETHANE	-0.000098	1.6	Oct 2008	200	concentration < HRL	NA
1,1-DICHLOROETHANE	-0.0017	1.6	Oct 2008	70	concentration < HRL	NA
Well MW-UD-66I:						
1,1,1-TRICHLOROETHANE	-0.0011	7.6	Oct 2008	200	concentration < HRL	NA
1,1-DICHLOROETHANE	-0.0012	25.7	Oct 2008	70	concentration < HRL	NA
1,1-DICHLOROETHENE	-0.00061	11.4	Oct 2008	6	Aug 2011	2.6
cis-1,2-DICHLOROETHYLENE	-0.0012	119	Oct 2008	70	Dec 2009	1.0
TETRACHLOROETHYLENE (PCE)	-0.0006	47.6	Oct 2008	5	Jan 2019	10.0
trans-1,2-DICHLOROETHENE	-0.0013	5.2	Oct 2008	100	concentration < HRL	NA
TRICHLOROETHYLENE (TCE)	-0.00063	998	Oct 2008	5	Oct 2031	22.8
VINYL CHLORIDE	-0.00092	0.98	Oct 2005	0.2	Jun 2010	1.5

Notes: See Page 2.

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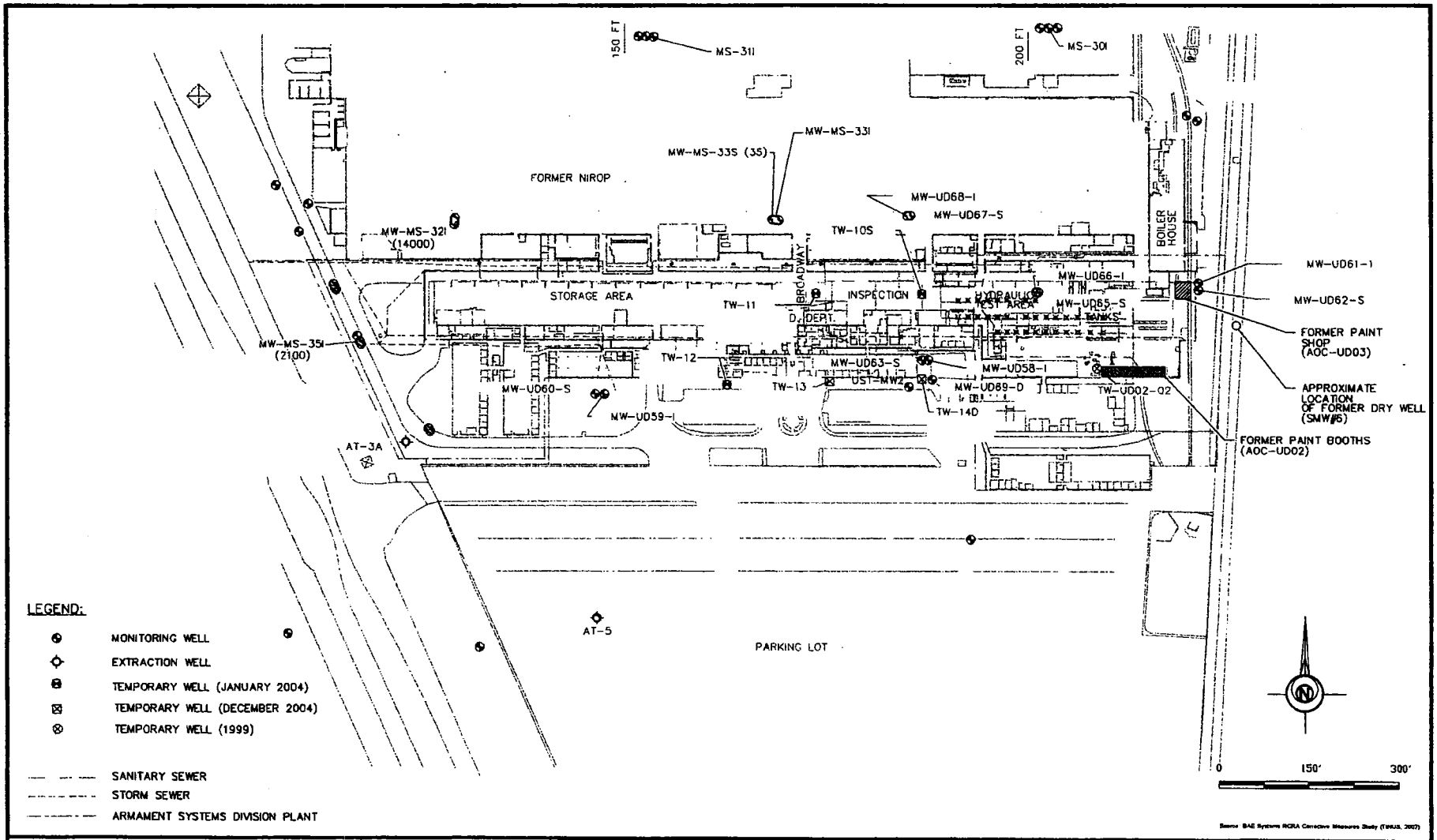
Table 4. Natural Attentuation Time Fram Estimate
BAE US Combat Systems, Fridley, Minnesota

Constituent	Ln slope[a]	Most Recent Concentration (ug/L)	Date of Most Recent Concentration	HRL (ug/L)	Year to HRL	Timeframe (# of year from 2009)
Well MW-UD-69D:						
TETRACHLOROETHYLENE (PCE)	-0.001	3.1	Oct 2008	5	concentration < HRL	NA
TRICHLOROETHYLENE (TCE)	-0.00054	10.1	Oct 2008	5	Apr 2012	3.3

Notes:
NA Not applicable.
a From MAROS linear regression output.
HRL Health Risk Limit developed by the Minnesota Department of Health.



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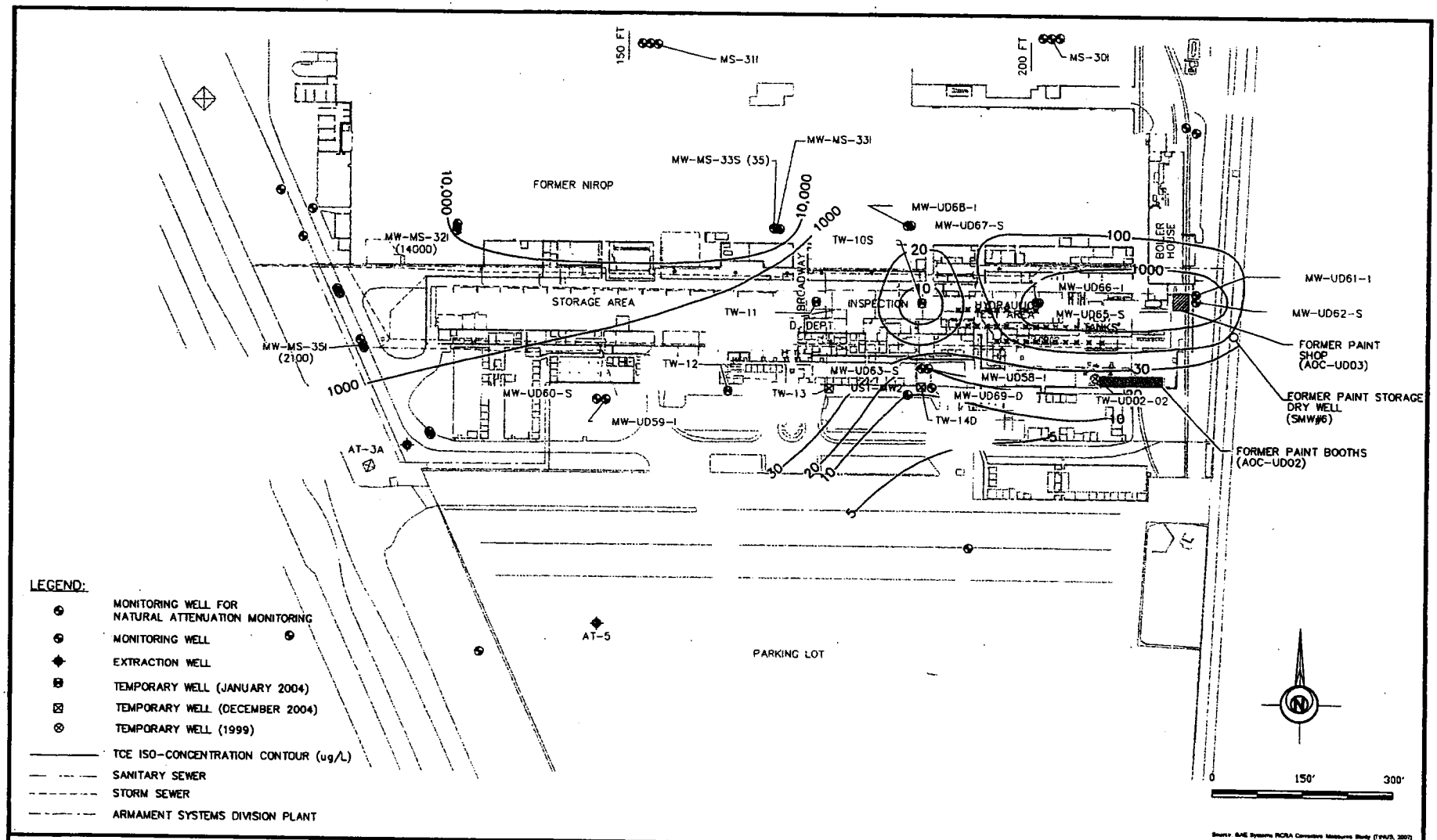
SITE LAYOUT

BAE US COMBAT SYSTEMS
FRIDLEY, MINNESOTA

DRAWN	DATE	PROJECT MANAGER	DRAWING NAME
		LEAD DESIGN PROF.	CHECKED
BAE US COMBAT SYSTEMS		PROJECT NUMBER	FIGURE NUMBER 1



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TCE ISO-CONCENTRATION CONTOUR MAP

BAE US COMBAT SYSTEMS
FRIDLEY, MINNESOTA

DRAWN	DATE	PROJECT MANAGER	DRAWING NAME
BAE US COMBAT SYSTEMS		LEAD DESIGN PROF.	CHECKED
		PROJECT NUMBER	FIGURE NUMBER 2

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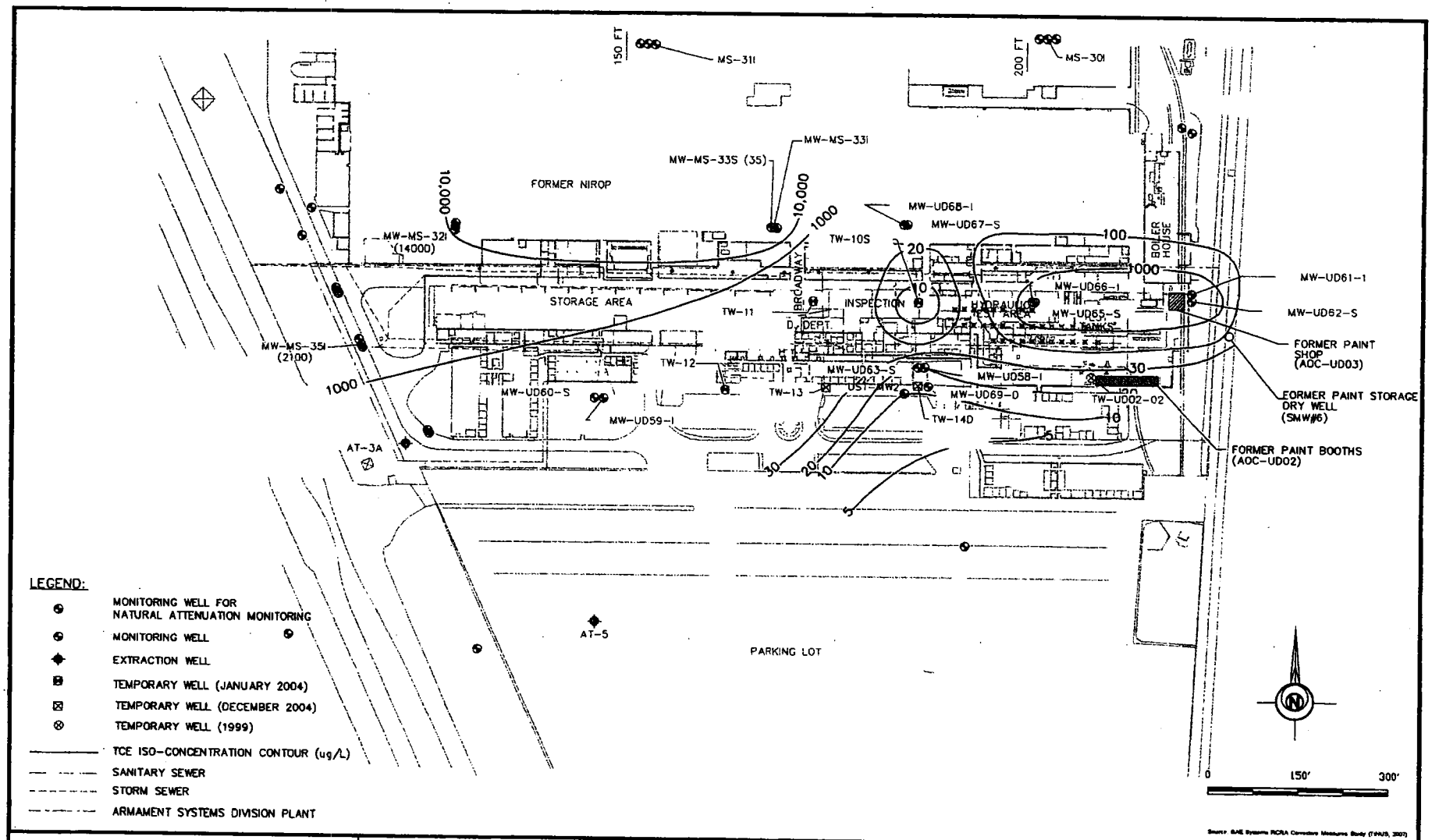
Appendix A

MAROS Result Reports



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TCE ISO-CONCENTRATION CONTOUR MAP

BAE US COMBAT SYSTEMS
FRIDLEY, MINNESOTA

DRAWN	DATE	PROJECT MANAGER	DRAWING NAME
BAE US COMBAT SYSTEMS		LEAD DESIGN PROF.	CHECKED
		PROJECT NUMBER	FIGURE NUMBER 2

MAROS Linear Regression Statistics Summary

Project: BAE System North
User Name: ARCADIS
Location: Fridley
State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
cis-1,2-DICHLOROETHYLENE									
MW-UD-65S	S	1.1E-02	7.2E-03	1.5E-02	No	2.9E-04	1.34	62.4%	NT
MW-UD-61I	S	1.0E-03	8.5E-04	6.3E-04	No	-4.2E-04	0.63	96.2%	D
MW-UD-62S	S	4.2E+00	4.5E+00	2.5E+00	No	-2.4E-04	0.61	75.8%	S
MW-UD-66I	S	7.0E-01	4.6E-01	6.5E-01	No	-1.2E-03	0.93	99.9%	D
MW-UD-68I	T	2.5E-03	2.5E-03	1.4E-04	No	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
USGS-9	T	4.8E-02	4.9E-02	2.6E-03	No	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	1.7E-02	1.6E-02	2.4E-03	No	-8.4E-05	0.14	89.7%	S
MW-UD-58I	T	8.3E-04	5.0E-04	5.8E-04	No	0.0E+00	0.00	0.0%	N/A
TETRACHLOROETHYLENE(PCE)									
MW-UD-61I	S	5.6E-04	5.0E-04	9.8E-05	No	0.0E+00	0.00	0.0%	N/A
MW-UD-62S	S	4.0E-01	3.7E-01	2.9E-01	No	-2.0E-04	0.73	72.7%	S
MW-UD-65S	S	3.3E-03	3.2E-03	2.5E-03	No	6.9E-04	0.75	94.5%	PI
MW-UD-66I	S	8.4E-02	6.3E-02	5.1E-02	No	-6.0E-04	0.61	99.7%	D
MW-UD-58I	T	7.9E-04	7.6E-04	3.1E-04	No	-2.2E-04	0.39	92.3%	PD
MW-UD-68I	T	1.6E-03	1.6E-03	1.3E-03	No	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.9E-03	5.6E-03	2.7E-03	No	-1.0E-03	0.46	99.8%	D
MW-UD-59I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
trans-1,2-DICHLOROETHENE									
MW-UD-61I	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-66I	S	9.8E-03	7.8E-03	9.7E-03	No	-1.3E-03	0.99	85.2%	S
MW-UD-65S	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-62S	S	4.6E-02	6.0E-02	2.4E-02	No	-1.9E-04	0.53	73.7%	S
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-58I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
USGS-9	T	1.2E-01	1.1E-01	2.6E-02	No	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	4.8E-02	5.1E-02	8.9E-03	No	-1.4E-04	0.18	97.8%	D
TRICHLOROETHYLENE (TCE)									
MW-UD-61I	S	2.6E-02	1.8E-02	2.5E-02	No	-5.3E-04	0.98	86.8%	S
MW-UD-66I	S	2.1E+00	1.5E+00	1.3E+00	No	-6.3E-04	0.61	100.0%	D
MW-UD-62S	S	6.2E+00	6.7E+00	3.3E+00	No	-1.8E-05	0.54	53.3%	S
MW-UD-65S	S	4.8E-02	2.9E-02	4.8E-02	No	4.2E-04	0.99	79.9%	NT
MW-UD-69D	T	1.3E-02	1.3E-02	3.5E-03	No	-5.4E-04	0.26	99.6%	D

Project: BAE System North **User Name:** ARCADIS

Location: Fridley **State:** Minnesota

Well	Source/ Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
TRICHLOROETHYLENE (TCE)									
MW-UD-67S	T	4.5E-03	4.5E-03	3.5E-04	No	0.0E+00	0.00	0.0%	N/A
MW-UD-68I	T	7.1E-02	7.1E-02	2.8E-03	No	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-58I	T	1.5E-02	1.0E-02	9.9E-03	No	-4.9E-04	0.65	100.0%	D
USGS-9	T	1.4E-01	9.4E-02	8.5E-02	No	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	2.0E-01	2.1E-01	1.2E-01	No	-6.2E-04	0.59	99.8%	D
VINYL CHLORIDE									
MW-UD-66I	S	1.3E-03	7.4E-04	1.2E-03	No	-9.2E-04	0.98	99.1%	D
MW-UD-61I	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-65S	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-62S	S	9.8E-02	6.6E-02	6.6E-02	No	-3.5E-04	0.68	87.9%	S
MW-UD-59I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-58I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Linear Regression Statistics Summary

Project: BAE System North

Location: Fridley

User Name: ARCADIS

State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence In Trend	Concentration Trend
1,1,1-TRICHLOROETHANE									
MW-UD-62S	S	9.4E-01	7.8E-01	6.7E-01	No	-4.8E-04	0.71	94.0%	PD
MW-UD-65S	S	3.5E-03	1.9E-03	3.0E-03	No	-9.8E-05	0.86	57.1%	S
MW-UD-66I	S	4.3E-02	2.9E-02	3.9E-02	No	-1.1E-03	0.90	99.9%	D
MW-UD-61I	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-58I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
1,1-DICHLOROETHANE									
MW-UD-61I	S	9.0E-04	5.0E-04	6.9E-04	No	0.0E+00	0.00	0.0%	N/A
MW-UD-62S	S	4.2E-01	3.9E-01	3.0E-01	No	-3.9E-04	0.71	89.2%	S
MW-UD-65S	S	2.9E-03	1.7E-03	3.3E-03	No	-1.7E-03	1.12	86.2%	NT
MW-UD-66I	S	1.6E-01	1.1E-01	1.4E-01	No	-1.2E-03	0.91	99.9%	D
MW-UD-58I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-68I	T	1.7E-03	1.7E-03	1.4E-04	No	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
USGS-9	T	8.2E-03	7.7E-03	1.7E-03	No	0.0E+00	0.00	0.0%	N/A
1,1-DICHLOROETHENE									
MW-UD-66I	S	2.4E-02	2.0E-02	1.5E-02	No	-6.1E-04	0.61	99.9%	D
MW-UD-65S	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-62S	S	2.4E-02	1.8E-02	2.0E-02	No	-1.5E-03	0.85	90.2%	PD
MW-UD-61I	S	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
USGS-9	T	4.3E-03	4.3E-03	6.5E-04	No	0.0E+00	0.00	0.0%	N/A
MW-UD-59I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-60S	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-68I	T	2.4E-03	2.4E-03	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
MW-UD-69D	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A
MW-UD-58I	T	5.0E-04	5.0E-04	0.0E+00	Yes	0.0E+00	0.00	0.0%	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: BAE System North
User Name: ARCADIS
Location: Fridley
State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
cis-1,2-DICHLOROETHYLENE								
MW-UD-62S	S	7	7	0.61	-9	88.1%	No	S
MW-UD-61I	S	4	2	0.63	-5	89.6%	No	S
MW-UD-65S	S	5	5	1.34	0	40.8%	No	NT
MW-UD-66I	S	6	6	0.93	-13	99.2%	No	D
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
USGS-9	T	3	3	0.00	0	0.0%	No	N/A
MW-UD-58I	T	3	1	0.00	0	0.0%	No	N/A
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-59I	T	4	4	0.14	-6	95.8%	No	D
MW-UD-68I	T	2	2	0.00	0	0.0%	No	N/A
TETRACHLOROETHYLENE(PCE)								
MW-UD-62S	S	7	7	0.73	-7	80.9%	No	S
MW-UD-61I	S	3	1	0.00	0	0.0%	No	N/A
MW-UD-65S	S	6	6	0.75	5	76.5%	No	NT
MW-UD-66I	S	6	6	0.61	-7	86.4%	No	S
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-59I	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-68I	T	2	2	0.00	0	0.0%	No	N/A
MW-UD-69D	T	4	4	0.46	-6	95.8%	No	D
MW-UD-58I	T	5	3	0.39	-5	82.1%	No	S
trans-1,2-DICHLOROETHENE								
MW-UD-62S	S	7	7	0.53	-9	88.1%	No	S
MW-UD-61I	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-65S	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-66I	S	4	3	0.99	-4	83.3%	No	S
MW-UD-59I	T	4	4	0.18	-6	95.8%	No	D
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-58I	T	2	0	0.00	0	0.0%	Yes	N/A
USGS-9	T	3	3	0.00	0	0.0%	No	N/A
TRICHLOROETHYLENE (TCE)								
MW-UD-66I	S	6	6	0.61	-13	99.2%	No	D
MW-UD-62S	S	7	7	0.54	1	50.0%	No	NT
MW-UD-65S	S	6	6	0.99	3	64.0%	No	NT

Project: BAE System North

User Name: ARCADIS

Location: Fridley

State: Minnesota

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
TRICHLOROETHYLENE (TCE)								
MW-UD-61I	S	7	7	0.98	-9	88.1%	No	S
MW-UD-69D	T	4	4	0.26	-6	95.8%	No	D
MW-UD-58I	T	7	7	0.65	-15	98.5%	No	D
MW-UD-68I	T	2	2	0.00	0	0.0%	No	N/A
MW-UD-67S	T	2	2	0.00	0	0.0%	No	N/A
MW-UD-59I	T	4	4	0.59	-6	95.8%	No	D
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
USGS-9	T	3	3	0.00	0	0.0%	No	N/A
VINYL CHLORIDE								
MW-UD-65S	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-62S	S	7	7	0.68	-9	88.1%	No	S
MW-UD-66I	S	4	2	0.98	-5	89.6%	No	S
MW-UD-61I	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-58I	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-59I	T	1	0	0.00	0	0.0%	Yes	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project: BAE System North
User Name: ARCADIS
Location: Fridley
State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence In Trend	All Samples "ND" ?	Concentration Trend
1,1,1-TRICHLOROETHANE								
MW-UD-62S	S	7	7	0.71	-11	93.2%	No	PD
MW-UD-61I	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-65S	S	5	5	0.86	-4	75.8%	No	S
MW-UD-66I	S	6	6	0.90	-13	99.2%	No	D
MW-UD-59I	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-58I	T	2	0	0.00	0	0.0%	Yes	N/A
1,1-DICHLOROETHANE								
MW-UD-61I	S	3	1	0.00	0	0.0%	No	N/A
MW-UD-62S	S	7	7	0.71	-11	93.2%	No	PD
MW-UD-65S	S	4	3	1.12	-4	83.3%	No	NT
MW-UD-66I	S	6	6	0.91	-13	99.2%	No	D
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-58I	T	2	0	0.00	0	0.0%	Yes	N/A
USGS-9	T	3	3	0.00	0	0.0%	No	N/A
MW-UD-59I	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-68I	T	2	2	0.00	0	0.0%	No	N/A
1,1-DICHLOROETHENE								
MW-UD-65S	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-61I	S	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-62S	S	5	4	0.85	-6	88.3%	No	S
MW-UD-66I	S	6	6	0.61	-13	99.2%	No	D
MW-UD-68I	T	1	1	0.00	0	0.0%	No	N/A
MW-UD-69D	T	2	0	0.00	0	0.0%	Yes	N/A
MW-UD-59I	T	1	0	0.00	0	0.0%	Yes	N/A
MW-UD-58I	T	2	0	0.00	0	0.0%	Yes	N/A
USGS-9	T	3	3	0.00	0	0.0%	No	N/A
MW-UD-60S	T	1	0	0.00	0	0.0%	Yes	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: BAE System North
User Name: ARCADIS
Location: Fridley
State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
cis-1,2-DICHLOROETHYLENE								
MW-UD-58I	T	3	1	8.3E-04	5.0E-04	No	N/A	N/A
MW-UD-59I	T	4	4	1.7E-02	1.6E-02	No	D	S
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	4	2	1.0E-03	8.5E-04	No	S	D
MW-UD-62S	S	7	7	4.2E+00	4.5E+00	No	S	S
MW-UD-65S	S	5	5	1.1E-02	7.2E-03	No	NT	NT
MW-UD-66I	S	6	6	7.0E-01	4.6E-01	No	D	D
MW-UD-68I	T	2	2	2.5E-03	2.5E-03	No	N/A	N/A
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
USGS-9	T	3	3	4.8E-02	4.9E-02	No	N/A	N/A
TETRACHLOROETHYLENE(PCE)								
MW-UD-58I	T	5	3	7.9E-04	7.6E-04	No	S	PD
MW-UD-59I	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	3	1	5.6E-04	5.0E-04	No	N/A	N/A
MW-UD-62S	S	7	7	4.0E-01	3.7E-01	No	S	S
MW-UD-65S	S	6	6	3.3E-03	3.2E-03	No	NT	PI
MW-UD-66I	S	6	6	8.4E-02	6.3E-02	No	S	D
MW-UD-68I	T	2	2	1.6E-03	1.6E-03	No	N/A	N/A
MW-UD-69D	T	4	4	5.9E-03	5.6E-03	No	D	D
trans-1,2-DICHLOROETHENE								
MW-UD-58I	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-59I	T	4	4	4.8E-02	5.1E-02	No	D	D
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-62S	S	7	7	4.6E-02	6.0E-02	No	S	S
MW-UD-65S	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-66I	S	4	3	9.8E-03	7.8E-03	No	S	S
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
USGS-9	T	3	3	1.2E-01	1.1E-01	No	N/A	N/A
TRICHLOROETHYLENE (TCE)								
MW-UD-58I	T	7	7	1.5E-02	1.0E-02	No	D	D

MAROS Statistical Trend Analysis Summary

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
TRICHLOROETHYLENE (TCE)								
MW-UD-59I	T	4	4	2.0E-01	2.1E-01	No	D	D
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	7	7	2.6E-02	1.8E-02	No	S	S
MW-UD-62S	S	7	7	6.2E+00	6.7E+00	No	NT	S
MW-UD-65S	S	6	6	4.8E-02	2.9E-02	No	NT	NT
MW-UD-66I	S	6	6	2.1E+00	1.5E+00	No	D	D
MW-UD-67S	T	2	2	4.5E-03	4.5E-03	No	N/A	N/A
MW-UD-68I	T	2	2	7.1E-02	7.1E-02	No	N/A	N/A
MW-UD-69D	T	4	4	1.3E-02	1.3E-02	No	D	D
USGS-9	T	3	3	1.4E-01	9.4E-02	No	N/A	N/A
VINYL CHLORIDE								
MW-UD-58I	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-59I	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-62S	S	7	7	9.8E-02	6.6E-02	No	S	S
MW-UD-65S	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-66I	S	4	2	1.3E-03	7.4E-04	No	S	D
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: BAE System North
User Name: ARCADIS
Location: Fridley
State: Minnesota

Time Period: 2/1/2000 to 10/1/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
1,1,1-TRICHLOROETHANE								
MW-UD-58I	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-59I	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-62S	S	7	7	9.4E-01	7.8E-01	No	PD	PD
MW-UD-65S	S	5	5	3.5E-03	1.9E-03	No	S	S
MW-UD-66I	S	6	6	4.3E-02	2.9E-02	No	D	D
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
1,1-DICHLOROETHANE								
MW-UD-58I	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-59I	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	3	1	9.0E-04	5.0E-04	No	N/A	N/A
MW-UD-62S	S	7	7	4.2E-01	3.9E-01	No	PD	S
MW-UD-65S	S	4	3	2.9E-03	1.7E-03	No	NT	NT
MW-UD-66I	S	6	6	1.6E-01	1.1E-01	No	D	D
MW-UD-68I	T	2	2	1.7E-03	1.7E-03	No	N/A	N/A
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
USGS-9	T	3	3	8.2E-03	7.7E-03	No	N/A	N/A
1,1-DICHLOROETHENE								
MW-UD-58I	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-59I	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-60S	T	1	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-61I	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-62S	S	5	4	2.4E-02	1.8E-02	No	S	PD
MW-UD-65S	S	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
MW-UD-66I	S	6	6	2.4E-02	2.0E-02	No	D	D
MW-UD-68I	T	1	1	2.4E-03	2.4E-03	No	N/A	N/A
MW-UD-69D	T	2	0	5.0E-04	5.0E-04	Yes	N/A	N/A
USGS-9	T	3	3	4.3E-03	4.3E-03	No	N/A	N/A

MAROS Statistical Trend Analysis Summary

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
1,1-DICHLOROETHENE								

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

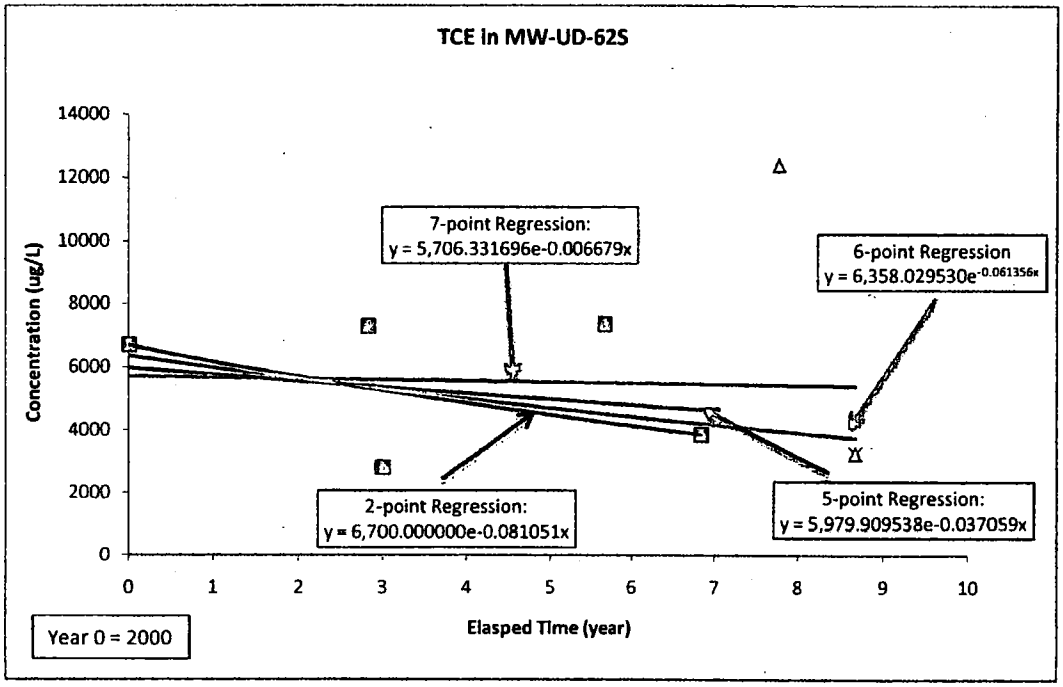
The Number of Samples and Number of Detects shown above are post-consolidation values.

ARCADIS

Appendix B

Natural Attenuation Time Frame Estimate from Different Datasets

Attachment B Natural Attenuation Time Frame Estimate from Different Datasets



	1st-order Rate Constant (1/yr)	Initial concentration (ug/L)	Date of Initial Concentration	Time to HRL (yr)	Note
Geometric Mean	-0.18	3,850	Feb 2000	36.9	A geometric mean of 1st-order rate constants from four well; 2 data points were used for each rate constant estimate (Tetra Tech, 2007).
2-Point Regression	-0.081	3,850	Feb 2000	82.1	2 data points between 2000 and 2006 were used to calculate the 1st-order decay rate (Tetra Tech, 2007).
5-Point Regression	-0.037	3,850	Feb 2000	179.6	5 data points between 2000 and 2006 were used to calculate the 1st-order decay rate.
6-Point Regression	-0.061	3,850	Feb 2000	108.3	6 data points between 2000 and 2008 (omitting the Nov. 07 data) were used to calculate the 1st-order decay rate.
7-Point Regression	-0.0067	3,250	Oct 2008	969.8	7 data points between 2000 and 2008 were used to calculate the 1st-order decay rate.

Note:
HRL: Health Risk Limit developed by the Minnesota Department of Health