

## MEMORANDUM

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From: Mindy Vanderford, GSI Environmental, Inc.

Date: 06-February-2009

RE: Review of Interim Groundwater Monitoring Plan  
BNSF Former Tie Treating Plant  
Somers, Montana

The BNSF Somers Former Tie Treating Site encompasses approximately 80 acres near Flathead Lake, just outside of the town of Somers in northwestern Montana. The Site was operated as a railroad tie and wood treatment facility by Burlington Northern Railroad and its predecessors between 1901 and 1986. During the period of plant operation soil and shallow groundwater became affected by constituents associated with wood preservation, including creosote and zinc compounds.

The Somers Site was proposed for inclusion on the National Priorities List on the basis of "potential negative effects on Flathead Lake and the water supply for the town of Somers". However, the Site was removed from the proposal process as remediation could be addressed under Subtitle C corrective action. Remedial activities are currently performed by the potentially responsible parties (PRPs) under the regulatory oversight of Montana Department of Environmental Quality (MDEQ) and USEPA Region 8.

USEPA and MDEQ have requested GSI Environmental under contract to EMS to review the current groundwater Interim Monitoring Plan (IMP) and provide recommendations on its ability to achieve monitoring objectives in the short-term. USEPA/MDEQ have requested a formal analysis of the monitoring network using the Monitoring and Remediation Optimization System (MAROS) software; however, the current network has insufficient data to perform many of the statistical analyses contained in the software.

The statistical algorithms in MAROS require data from a minimum of four sampling events and six well locations with detected concentrations. Data from less than four sampling events have been collected since termination of the groundwater treatment system (GWTS). The current monitoring network has approximately eight monitoring locations, and a high number of non-detect results within that network. Additionally, a comprehensive Site database has not been made available to perform statistical analyses. Therefore, a qualitative analysis has been performed to recommend possible improvements to the monitoring network, as well as data management and analysis procedures going forward. To this end, the following tasks have been performed:

- ◆ Qualitatively evaluate the ability of the groundwater monitoring network to achieve stated goals and objectives.
- ◆ Evaluate the appropriateness of statistical methods proposed to demonstrate plume stability and protectiveness of the remedy.

- ◆ Evaluate the spatial distribution of wells with respect to groundwater flow direction, potential receptors, and points of compliance at the proposed boundary of the technical impracticability (TI) zone or institutional control.
- ◆ Recommend new locations that may be needed to achieve monitoring goals.
- ◆ Identify redundant locations that could be removed from the monitoring program.
- ◆ Recommend improvements to Site data management.

Sources reviewed for the following memorandum are listed in the References section at the end of the document.

## **Site Background**

Historical features of the Somers Site include a retort building, housing the wood treating equipment, three large insulated creosote product storage tanks, wastewater impoundments and one sanitary lagoon. Immediately south of the retort building, a lagoon (referred to as CERCLA lagoon) received process waste waters up until 1971. The lagoon, overflowed to a ditch that discharged to a swampy area south of the facility immediately adjacent to Flathead Lake. Flathead Lake is located downgradient to the east/southeast of the Site approximately 1300 feet from the former facility. A municipal supply well for the city of Somers is completed in bedrock approximately 1300 feet west of the facility.

Shallow geology at the Somers Site is characterized by interbedded sediments resulting from different depositional environments, including glacial and fluvial processes. The stratigraphy underlying the Site includes an upper unit, composed of fill up to 10 feet below ground surface (bgs). The fill is underlain by a unit consisting of sandy silt and silty sand that ranges in thickness from 0 to 25 feet, decreasing in thickness towards the lake. The upper portion of the unit is a sandy silt that grades downward into a silty sand with well-sorted, and largely discontinuous sand lenses present. The degree of hydraulic connection between the sand lenses may vary across the Site, creating a complex subsurface environment. Underlying the sandy silt layer is a 60- to 70-foot-thick finer-grained unit primarily composed of silt with some fine-grained sands and clays. Thin, intermittent, sand lenses are present to depths of approximately 45 feet bgs. The fine-grained unit is underlain by Precambrian bedrock and fractured bedrock at approximately 100 ft bgs, which slopes to the east.

Two aquifers are considered to be present at the Site: a surficial aquifer in the low-permeability, heterogeneous silt and a lower, bedrock aquifer. The current monitoring network review is limited to the surficial aquifer. Groundwater flow in the surficial aquifer is generally to the east from the CERCLA lagoon toward the lake, although flow can range to northeasterly in the area of the land treatment unit (LTU). During the period of operation of the pump and treat system, a potentiometric depression was created in the area of the CERCLA lagoon. Based on the Site conceptual model described in the Technical Impracticability Evaluation (RETEC, 2003) and subsequent Request to Modify Groundwater Treatment Systems (ENSR/AECOM, 2004), the Site is characterized by low-permeability sediments with variable hydraulic conductivity in the range of less than 1 to 7 ft/day ( $\sim 5.7E-3$  to  $3.5E-4$  cm/s) and a seepage velocity of approximately 0.1 ft/day (porosity of 0.2, hydraulic gradient of 0.002) (see Table 2).

## Regulatory Status

Remedial investigation (RI) activities commenced in 1984. A Record of Decision (ROD) for the Site was completed in 1989, specifying remedies for soil and groundwater. The soil remedy included excavation and treatment of soils in an on-Site land treatment unit (LTU) installed in 1991. The LTU is a 14-acre, lined facility north of the former plant and CERCLA lagoon. Soil excavation included both unsaturated and saturated soils in the swampy area and in and around the CERCLA lagoon. Excavation at the CERCLA lagoon removed dense-non-aqueous phase liquid (DNAPL)-affected soils and free-phase creosote. The LTU is currently in a 30-year post-closure care period after reaching final closure in November 2002. The monitoring network for the LTU is listed in Table 1.

Subsurface sediments continue to be affected by residual DNAPL most likely present in ganglia or discontinuous smaller pockets within the soil. Creosote constituents, largely phenols and polycyclic aromatic hydrocarbons (PAH), are poorly soluble, hydrophobic compounds, prone to slow desorption kinetics in affected environments (Alexander, 2000; Fu, Kan et al. 1994; Kan, Fu et al. 1997; Xia and Pignatello 2001; Chen, Lakshmanan et al. 2004).

The groundwater remedy specified in the ROD included installation of a pump and treat system to hydraulically contain impacted groundwater, remove creosote contamination and stimulate *in-situ* biological treatment of dissolved contaminants. The remedy included a requirement for groundwater monitoring to collect data in support of a determination of remedial efficacy. The GWTS was built in 1992 with start up occurring in 1994. The system included two arrays of recovery and injection wells, one in the CERCLA lagoon and the second south of the lagoon, designed to stimulate *in-situ* biodegradation. Above-ground treatment included removal of oil, solids and iron with secondary treatment to remove dissolved organic constituents for subsequent re-injection or surface discharge. (ENSR/AECOM, 2008a)

The Flathead City-County Health Department submitted a Petition for Controlled Groundwater Area (institutional control) with the Montana Department of Natural Resources Conservation (DNRC) in June, 2002. The petition proposed that DNRC designate a controlled groundwater area consisting of approximately 67 acres, in order to prevent groundwater withdrawals that could potentially cause contaminant migration or exposure of receptors to groundwater that exceeded drinking water standards for PAH compounds and zinc. The purpose of the petition was to close the alluvial aquifer to appropriation of groundwater until the groundwater is restored to regulatory standards. The Controlled Groundwater Area was designated in May, 2003 and prohibits drilling into and extracting water from the alluvial aquifer in the region of the Somers Site with the exception of wells required for monitoring and remedial action.

A Technical Impracticability (TI) evaluation of the restoration potential of the existing GWTS remedy was submitted to EPA/MDEQ in 2001 (RETEC, 2003). A formal Request to Modify the Groundwater Treatment System was submitted in 2004 (ENSR/AECOM, 2004), proposing a change in remedial strategy and a waiver of the applicable or relevant and appropriate requirements (ARARs) for groundwater at the Site. Under CERCLA, all remedies are required to be protective of human health and the environment and to attain the ARARs pertaining to the selected remedy. The TI evaluation was prepared to demonstrate that the groundwater ARARs could not be

achieved in a reasonable time-frame and that portions of the Site (see Appendix A) should be released from having to achieve these standards.

The TI evaluation and Request to Modify the Groundwater Treatment System included modeling results and qualitative evaluations (i.e. aquifer permeability, DNAPL characteristics, aquifer water production) to identify barriers to aquifer restoration specific to portions of the Somers Site. The report identified the specific area of the surficial aquifer where meeting ARARs in a reasonable timeframe was proposed to be impracticable. The proposed TI zone extends from just southeast of the LTU, including the CERCLA lagoon, the area between monitoring wells S-88-1 to S-85-6A/B and beyond, south to S-84-16 and east/northeast to the area between S-88-3 and S-91-2.

The TI evaluation was approved by EPA in April, 2003. The Final Interim Monitoring Plan (ENSR/AECOM, 2008) was submitted to the Agencies in February 2008, outlining a groundwater monitoring program and analysis plan that would be implemented over a two-year period during which the GWTS would be shut off. The purpose of the two-year interim monitoring period is to ascertain the "stability and containment of the dissolved creosote constituent plume" through quarterly monitoring. The following report reviews the IMP and its ability to support the stated goal.

### **Interim Monitoring Program**

As part of the Request to Modify the Groundwater Treatment System, an interim monitoring period of two years was proposed to evaluate the effects of the shut-down of the GWTS. Details of the proposed monitoring program and accompanying statistical analyses are provided in the Final Groundwater Treatment System Interim Monitoring Plan (ENSR/AECOM, 2008b). Monitoring locations, rationale for the monitoring locations, parameters monitored and estimated monitoring frequencies for wells at the Site are presented in Table 1.

According to the agreed plan for the interim monitoring period and Site regulatory requirements, the objectives of the monitoring program are to:

- ◆ Demonstrate plume stability following GWTS shut down;
- ◆ Confirm containment of Site constituents of concern (COCs);
- ◆ Monitor natural attenuation (NA) parameters to confirm on-going attenuation of Site COCs;
- ◆ Measure creosote accumulation in the former CERCLA lagoon area; demonstrate an effective means by which accumulated creosote may be removed from wells.
- ◆ Demonstrate steady state and protective conditions based on a statistical evaluations of groundwater monitoring data;
- ◆ Ensure safety of the public drinking water through continued sampling of the municipal well.

## **Efficacy of the Network at Achieving Objectives**

### *Demonstrate Plume Stability and Protective Conditions*

Plume stability is a concept often referred to and seldom explicitly defined. Site managers may find a challenge in demonstrating plume stability after the termination of the GWTS as dissolved concentrations within the plume will most likely rebound to a certain extent. The extent of rebound will be mediated by: 1) the rate of slow desorption of aged constituents from sediments, 2) the rate of intrinsic biodegradation and 3) hydrogeology. As the first two of these processes are extremely slow in the case of creosote contamination, the time-frame of rebound could be on the order of 10 or more years. The interim monitoring period of two years is most likely not long enough to gage the extent of concentration rebound or provide a meaningful trend (or meaningful lack of trend) for long-term decision making.

In order to make a rough estimate the rate and extent of rebound and the influence of desorption hysteresis on dissolved phase concentrations, the Dual-Equilibrium Desorption and Transport Model (DED) tool (GSI, 2006) was used to evaluate Site data. The DED Model is a screening level tool designed to simulate the effect of slow desorption on dissolved phase concentrations of organic compounds and provide decision support for setting realistic time-frames to achieve remediation goals. The tool is designed after Chen et al., 2004. The DED-Transport tool solves for constituent concentrations in 1-dimension and simulates advection, dispersion, first-order degradation, and linear as well as dual-equilibrium desorption assumptions in the downgradient direction of groundwater flow. The model assumes simplified initial and boundary conditions, and therefore provides an approximation of expected concentrations.

Input parameters estimated for the model are shown in Table 2. Because of subsurface heterogeneity at the Site, high and low hydraulic conductivities (K) were estimated from Site reports for the model runs. Likewise, high and low biodegradation rates ( $\lambda$ ) were used to determine the sensitivity of the output to input parameters. Preliminary results for model runs for high K and low  $\lambda$  (Case 1), high K and high  $\lambda$  (Case 2), low K and low  $\lambda$  (Case 3), and low K and high  $\lambda$  (Case 4) are shown on Table 3 for both linear and DED assumptions. Simulations were run for the compound naphthalene, one of the more mobile and biodegradable constituents of creosote.

The model output includes two graphs for each case. The Breakthrough Curves (Figures 1a, 2a, 3a, 4a) illustrate estimated concentrations at a point 900 feet downgradient from the source area over time for each of the input conditions (roughly the distance to the proposed TI boundary). The Concentration vs. Distance graphs (Figures 1b, 2b, 3b, 4b) estimate concentrations along the direction of groundwater flow at 10 years after 2007. The input plume maximum concentration and location of maximum concentration ( $C_{max}$  and  $X_{max}$  respectively) are 18 mg/L at source well S-88-1 (data from 2/28/2007), 150 feet downgradient from the lagoon. For all graphs, estimated concentrations assuming both linear desorption and dual-equilibrium desorption are shown.

For the case where biodegradation is low and hydraulic conductivity is high (Case 1), the model shows the concentration rising in a fairly linear fashion over the time-frame, arriving at about 0.03 mg/L near the proposed TI boundary in 10 years. Under high

conductivity conditions where no biodegradation occurs, the model indicates that there may be an exceedance of the regulatory screening level in approximately 12 years. Using these inputs, linear and DED assumptions produce similar results.

For cases where lower hydraulic conductivities were used, concentrations did not exceed the screening level at the proposed TI boundary for over 100 years (maximum time modeled). Scenarios where higher biodegradation rates were assumed, slow desorption (DED assumption) had more impact on the distribution of concentrations and the final concentration at the 900 ft point. For these model runs, concentrations did not reach high levels, but also did not attenuate as rapidly as under linear desorption assumptions.

The purpose of presenting the four scenarios is to demonstrate the sensitivity of dissolved concentrations in the plume to the initial conditions of hydraulic conductivity and biodegradation. The actual extent of concentration rebound may be higher or lower than shown, given the highly generalized input parameters and complex hydrogeology. The rate of biodegradation after shut-down of the treatment system, designed in part, to stimulate biodegradation, is particularly important to the extent of concentration rebound. Based on the DED tool prediction, trends for wells in the plume stability network, particularly those in the mid-plume region, are likely to show increasing or probably increasing (significance at the 10% level) trends in the short to medium term.

A potential complication with using Mann-Kendall test to evaluate trends at individual wells in the two-year time-frame is that the slow rate of change and the amount of scatter or variance in the data may produce a 'no trend' result when the trend is actually increasing (or decreasing) very slowly. Trend evaluation on only four data points is possible, but the result often has very low statistical power, limiting confidence in the results. Also, under the scenarios explored, an increasing trend at some locations does not necessarily indicate there will be exceedances of regulatory limits at downgradient locations. So, individual well trend analysis alone may not be the best metric for assessing overall plume stability or the protectiveness of the remedy during the interim period.

#### *Mann-Kendall Test for Trend*

As stated in the IMP, the primary means of demonstrating plume stability at the Somers Site is through statistical trend analysis at individual well locations using a Mann-Kendall test for trend. Statistical tests for seasonality at the well locations will also be used, and the Mann-Kendall test qualified accordingly. Presumably, the distribution of trends within the plume originating near the CERCLA lagoon will be plotted, compared with potentiometric surface data and NA parameters and used to support a conclusion of plume-wide stability.

The stated method of performing the Mann-Kendall test for trend is reasonable, but could be enhanced by using the method used in the MAROS software (Aziz, 2003) or a similar approach. The test for trend in the MAROS software includes a calculation of the coefficient of variation (COV) within the data, which can be significant given the sample dataset provided (see Table 4, COV above 1 is considered high variance).

The Mann-Kendall test in MAROS defines 'stability' explicitly as having a non-increasing trend and low COV. Datasets with high COV and a positive S statistic are identified as

having 'no trend' with high data variability. Typically, the Mann-Kendall method (Gilbert, 1987) tests for the presence or absence of trends, with the null hypothesis being 'no trend'. With sufficient data, the null hypothesis can be rejected, but using the traditional method, there is no conclusion of 'stability' in the trend. Datasets with a large percentage of non-detects (30% or greater) and significant data scatter are more likely to return 'no trend' Mann-Kendall results. Distinguishing 'no trend' from 'stable trend' can be helpful given a dataset with high variability and a larger percentage of non-detect results.

Another advantage to the Mann-Kendall as performed in MAROS is that decreasing trends are defined explicitly. Also, 'probably increasing' and 'probably decreasing' trends are identified for datasets at the 10% level of significance. By identifying potential trends at the 90% confidence level, early indications of future trends may be identified. For all locations, trend reporting should include the S statistic, COV and significance (confidence) as well as the detection frequency of the constituent. Careful review of these summary statistics will reduce the chance of identifying false trends (both increasing and decreasing). Example summary statistics for naphthalene from the Somers Site database are shown on Table 2.

Based on data provided, analytical results for the Somers Site have a fairly high number of non-detect results and significant scatter in the data. Statistical interpretation of data with a high percentage of non-detects and scatter can be enhanced by using the ProUCL software sponsored by USEPA (USEPA, 2007). The ProUCL software can be used to compute summary statistics and identify distributions for datasets with high rates of non-detects as well as internally censored (several detection limits) data.

The ProUCL software may also be used to evaluate a 95% upper confidence limit (UCL) on analytical data and evaluate datasets with large numbers of non-detect results for true outliers. Calculating a 95% UCL for priority constituents at the plume stability monitoring locations will indicate when a concentration is outside of the expected high range based on previous analytical data. A 95% UCL can be used to set an acceptable high rebound concentration, exceedances of which would indicate a contingent remedy should be considered. Setting the 95% UCL using concentration data collected before or in the early period of GWTS operation may indicate a possible upper value for concentration rebound.

#### *Confirming Containment of Site COCs and Measuring Natural Attenuation Parameters*

While the requirement to achieve ARARs within the proposed TI boundary may be waived at some point, groundwater concentrations outside of the proposed TI boundary must meet regulatory standards. In order to confirm that protective concentrations are met at regulatory boundaries, point of compliance (POC) wells should be monitored at the downgradient boundaries. As long as concentrations at the POC wells are below the regulatory limits, the plume is contained. For the proposed plume-stability network, S-84-16 performs the delineation function on the southern border of the TI, and S-85-6a and b are close to the eastern border. S-84-15 and S-91-2 are approximately 300 feet outside of the proposed TI zone. Therefore, the north/northeastern boundary of the proposed TI does not currently have a monitoring location to confirm compliance. While groundwater flow in the area is largely easterly, an apparent northeasterly gradient exists in potentiometric maps prior to GWTS start-up.

Within the plume, attenuation monitoring points (AMPs) or sentry wells should be established. AMPs would be locations within the migration pathway of COCs that are used to verify that the ARARs will not be exceeded at the regulatory or institutional control boundaries. Attenuation action levels (AALs) are maximum concentrations that can occur at an AMP without signaling a possible future exceedance of regulatory limits at the proposed boundary. That is, the AAL is the maximum concentration that is still protective of downgradient receptors in a given flow regime. Confirmed exceedance of an AAL usually triggers initiation of a contingent remedy.

AALs can be calculated from modeling or empirical data or may be the 95% UCL on anticipated rebound at the location. AALs could be developed for S-88-1, S-88-3 and S-85-a and b, and used alongside NA parameters to make the case for control of the plume in the absence of the GWTS. Demonstration of concentrations below AALs and on-going conditions favorable to biodegradation may be a more effective end-point than trend analysis when concentration rebound is a possibility.

NA parameters are collected at a number of locations where COCs are not analyzed. In order to demonstrate the effect of NA, periodic analysis of COCs in the NA network may strengthen the lines of evidence for containment of the plume via biodegradation. Consider sampling the NA wells for TPAH at the end of the two-year interim period and before each five year review during the long-term care phase.

While the request to modify the GWTS was submitted on the basis that the GWTS could not *remediate* affected groundwater in a reasonable time-frame, no determination of the efficacy of the GWTS at *controlling* the plume was made. In order to permanently terminate groundwater pumping at the Site, the capacity of natural processes to control the spread of the plume within the proposed TI boundary must be demonstrated.

Control of the spread of the plume will be demonstrated by showing that the rate of desorption of constituents is matched by attenuation processes such as biodegradation, dispersion, dilution, or adsorption. To this end, the USEPA has identified three potential lines of evidence to demonstrate NA (USEPA, 1999). In the case of the Somers Site, the primary line of evidence should include concentration vs. time graphs of analytical data accompanying the Mann-Kendall trend statistics described above. A second line of evidence would be hydrogeologic and geochemical data that support constituent destruction rather than transport (e.g. confirmation of low hydraulic conductivity along with NA parameters). Hydrogeologic, geochemical and analytical data must integrate with the Site conceptual model to provide a demonstration of low uncertainty and high predictability of concentrations at the Site. Graphical presentation of Mann-Kendall results, geochemical results and hydrogeologic results could support the second line of evidence.

The third line of evidence includes results from microcosm studies which may directly demonstrate NA processes. Performance of laboratory studies on Somers sediments is most likely unnecessary; however, an investigation of literature on the subject of desorption versus biodegradation and a quantitative estimation of how these processes may be influencing dissolved concentrations at the Somers Site may provide greater confidence in the ability of natural processes to control the plume at this Site.



## Recommendations

- ◆ *Prepare and maintain a comprehensive Site database with analytical results and sampling location information.* The database provided for the monitoring network review did not contain data for TPAH or CPAH that are the basis for evaluating the achievement of monitoring objectives and remedial goals. A comprehensive database would include geographic coordinates and well screened intervals for current and historical monitoring locations as well as ARARs or other regulatory screening levels applicable to the Site and geographic information system files showing institutional boundaries. An updated database should be made available to Site decision-makers after every sampling event.
- ◆ *Establish point of compliance (POC) monitoring locations.* Install a monitoring location between S-91-2 and S-85-6b to monitor the proposed boundary of the T1 zone on the northeast side, addressing the monitoring objective of demonstrating containment of the plume.
- ◆ *Designate AMP wells within the plume and calculate AALs,* which would be maximum concentration levels that would be still protective at the regulatory boundaries.
- ◆ *Identify data points that are statistical outliers and expand the statistical analysis to include 95% upper confidence level for priority constituents at plume stability monitoring locations.* Consider finding a 95% UCL on expected rebound concentrations using historic or modeling data. Summary statistics for data sets with >30% non-detect results should be analyzed using Kaplan-Meier method using ProUCL software.
- ◆ *Expand the reporting of Mann-Kendall test statistics.* Include the detection frequency and other summary statistics in the monitoring report. Add concentration vs. time graphs for key locations (AMPs above). Plot Mann-Kendall trends on the Site map to demonstrate trends spatially; consider layering geochemical data (DO, ORP) on the map to link trends with geochemical processes.
- ◆ *Estimate slow desorption and biodegradation capacity based on a thorough literature review and published models of the physical processes.* Due to the age of the Site, PAH constituents in the subsurface are most likely highly sorbed, or 'aged', in sediments (Alexander, 2000). Aged constituents desorb very slowly under most environmental conditions. The concentration at which the plume will "stabilize" will reflect the desorption rate from affected sediments as well as the Site-specific biotransformation rate and hydrogeology. More effort should be made to quantitatively assess the physical process of slow desorption at the Site and its implication for long-term management.
- ◆ *Establish monitoring objectives for long-term demonstration of remedial protectiveness and identify triggers for implementation of contingent remedies to control the plume.*
- ◆ *Re-evaluate the monitoring program at the end of the interim monitoring period.*

## REFERENCES

- Alexander, M. (2000). "Aging, bioavailability, and overestimation of risk from environmental pollutants". Environmental Science and Technology **34**(20): 4259-4265.
- Aziz, J. A., C. J. Newell, M. Ling, H. S. Rifai and J. R. Gonzales (2003). "MAROS: A Decision Support System for Optimizing Monitoring Plans." Ground Water **41**(3): 355-367.
- Chen, W., K. Lakshmanan, A. T. Kan and M. B. Tomson (2004). "A Program for Evaluating Dual-Equilibrium Desorption Effects on Remediation." Ground Water **42**(4): 620-624.
- ENSR/AECOM. (2008a). Phase I Groundwater Remedy Annual CERCLA Report April through December 2007; BNSF Former Tie Treating Plant Somers, Montana. April 2008.
- ENSR/AECOM. (2008b). FINAL Groundwater Treatment System Interim Monitoring Plan BNSF Former Tie Treatment Plant Somers, Montana. February, 2008
- ENSR/AECOM. (2004). Request to Modify Groundwater Treatment System former Somers Tie Treating Plant, Somers, Montana, Final. April, 2004.
- Fu, G., A. T. Kan and M. B. Tomson (1994). "Adsorption and desorption hysteresis of polycyclic aromatic hydrocarbons in surface sediment." Environmental Toxicology and Chemistry **13**(10): 1559-1567.
- Gilbert, R. O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY, ISBN 0-442-23050-8.
- GSI. (2006). Dual-Equilibrium Desorption and Transport Model. Prepared for Savannah River National Laboratory and USDOE. 2006. [www.gsi-net.com](http://www.gsi-net.com).
- Kan, A. T., G. Fu, M. A. Hunter and M. B. Tomson (1997). "Irreversible adsorption of naphthalene and tetrachlorobiphenyl to Lula and surrogate sediments." Environmental Science and Technology **31**(8): 2176-2185.
- RETEC, (2003). Technical Impracticability Evaluation for Groundwater Restoration, Former Somers Tie Treating Plant Somers, Montana. February, 2003.
- Somers\_IMP Well Historic Database. Accessed November 2008.
- USEPA. (1999). Use of Monitoring Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Directive No. 9200.4-17P. April, 1999.
- USEPA, Region 8 (2001) Five-Year Review Report for the Burlington Northern Somers Site. September, 2001.
- USEPA, (2007). ProUCL Version 4.0. Software. April 2007
- Xia, G. and J. J. Pignatello (2001). "Detailed sorption isotherms of polar and apolar compounds in a high-organic soil." Environmental Science and Technology **35**(1): 84-94.

**TABLE 1  
INTERIM GROUNDWATER MONITORING NETWORK  
Somers Tie Treating Plant, Somers Montana**

<b>Well Name</b>	<b>Purpose</b>	<b>Constituents</b>	<b>Current Statistical Analysis</b>	<b>Recommended Additional Statistical Analysis</b>	<b>Current Frequency</b>
<b>Plume Stability Network</b>					
S-84-15	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH	Mann-Kendall	95% UCL	Quarterly
S-84-16	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH	Mann-Kendall	95% UCL	Quarterly
S-88-3	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH NA parameters Creosote accumulation	Mann-Kendall, geochemical NA	95% UCL	Quarterly
S-85-6A	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH NA parameters	Mann-Kendall, geochemical NA	95% UCL	Quarterly
S85-6B	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH NA parameters	Mann-Kendall, geochemical NA	95% UCL	Quarterly
S-91-2	Plume Stability/Downgradient	Phenols/PAH's/TPAH/CPAH	Mann-Kendall	95% UCL	Quarterly
S-88-2	Source area well -- not explicitly in plume stability network	Creosote accumulation, PAH	unknown	Mann Kendall, 95% UCL	Quarterly
S-3R*	LTU well/Background	Phenols/PAH's/TPAH/CPAH	Detection monitoring		Quarterly
S-4 *	Plume Stability/Background	Phenols/PAH's/TPAH/CPAH	Detection monitoring		Quarterly
<b>Natural Attenuation Network</b>					
S-85-7	Upgradient NA well	NA parameters	Geochemical NA		Quarterly
S-85-8a	Upgradient NA well	NA parameters	Geochemical NA		Quarterly
S-85-8b	Upgradient NA well	NA parameters	Geochemical NA		Quarterly
S-93-2S	Residual Creosote Source Area NA	NA parameters	Geochemical NA		Quarterly
S-93-2D	Residual Creosote Source Area NA	NA parameters	Geochemical NA		Quarterly
S-88-1	Residual Creosote Source Area NA	NA parameters, Creosote accumulation	Geochemical NA	Add biennial TPAH analyses	Quarterly
S-93-5S	Residual Creosote Source Area NA	NA parameters, Creosote accumulation	Geochemical NA		Quarterly

See Notes End of Table

**TABLE 1  
INTERIM GROUNDWATER MONITORING NETWORK  
Somers Tie Treating Plant, Somers Montana**

<b>Well Name</b>	<b>Purpose</b>	<b>Constituents</b>	<b>Current Statistical Analysis</b>	<b>Recommended Additional Statistical Analysis</b>	<b>Current Frequency</b>
<b>Land Treatment Unit Area</b>					
S-85-5A	LTU and Northeast TI area	Phenols/PAH's/TPAH/CPAH, Zinc	Detection monitoring	95% UCL	Quarterly
S-85-5B	LTU and Northeast TI area	Phenols/PAH's/TPAH/CPAH, Zinc	Detection monitoring	95% UCL	Quarterly
S-5R	LTU	Phenols/PAH's/TPAH/CPAH, Zinc	Detection monitoring		Variable decreasing frequency
S-93-7	LTU	Phenols/PAH's/TPAH/CPAH Zinc	Detection monitoring		
S-6*	LTU	Phenols/PAH's/TPAH/CPAH, Zinc	Detection monitoring		
<b>Other</b>					
S-84-10	Swamp		Detection monitoring		Variable decreasing frequency
S-91-4	Swamp		Detection monitoring		
TW-1	Municipal Well	PAH/TPAH/CPAH	Detection monitoring	95% UCL below MCL	Quarterly

**Notes:**

1. Data from ENSR/AECOM, 2008 Intermim Monitoring Plan (IMP) and 2nd Quarter Report July 2008. and from site database EPA November 2008.
2. \* = well was dry during 2nd quarter sampling 2008.
3. LTU = Land Treatment Unit; UCL = Upper Confidence Limit; NA = Natural Attenuation
4. NA parameters include nitrate, sulfate, iron, methane and dissolved oxygen/ORP.
5. Discrpancies between the IMP and Quarterly Monitoring Report may exist, and have not been resolved here.

Issue Date: 02-March-2009

**TABLE 2  
INPUT PARAMETERS DESORPTION MODEL  
Somers Tie Treating Plant, Somers Montana**

PARAMETER	VALUE	UNITS	SOURCE
Hydraulic Conductivity	5.00E-03 5.00E-04	cm/s cm/s	TI Evaluation (RETEC, 2003) estimates vary between 5.7E-3 to 3.5E-4
Effective Porosity	0.2	--	TI Evaluation (RETEC, 2003)
Hydraulic Gradient	0.002	--	TI Evaluation (RETEC, 2003)
Soil Bulk Density	1.7	g/cc	Estimated from soil type
Fraction Organic Carbon	0.0001	--	Estimated from soil type
Estimated Plume Length	1,000	Feet	Estimated maximum extent of plume past S-85-6a/b
COC Octanol-Water Partition Coefficient	1.48E+03	--	From TCEQ TRRP program physical constants for Naphthalene
COC Aqueous Solubility	3.14E+01	mg/L	
Simulation Distance	900	Feet	Estimated distance to proposed TI boundary
Simulation Time	10	Year	
1st-Order Decay Rate	0.02 0.9	Year <sup>-1</sup> Year <sup>-1</sup>	GeoTrans report (2008) (estimated from site data) Howard, 1991 estimate of naphthalene half-life
Inflow Concentration	0	mg/L	Upgradient of plume
Distance at Max Concentration	150	Feet	Source area downgradient from CERCLA Lagoon
Maximum Concentration	18	mg/L	Naphthalene concentration at S-88-on 12/28/2007
Minimum Concentration	0.005	mg/L	Representative detection limit
Regulatory Screening Levels Naphthalene	0.62	mg/L	ARAR from ROD (USEPA, 1989)

**Notes:**

1. RETEC, 2003 = Technical Impracticability Evaluation for Groundwater Restoration
2. GeoTrans (2008) = Memorandum Review Related to Discontinuing Active Remediation
3. Howard, 1991 = Handbook of Environmental Degradation Rates
4. Other data taken from Somers Site data, references in main report.

**TABLE 3  
DESORPTION MODEL RESULTS  
ESTIMATED DOWNGRAIDENT CONCENTRATIONS  
Somers Tie Treating Plant, Somers Montana**

INPUT PARAMETERS	Linear Assumption [mg/L]	DED Assumption [mg/L]
Case 1: High hydraulic conductivity; low biodegradation rate	0.28	0.28
Case 2: High hydraulic conductivity; high biodegradation rate	0.002	0.0037
Case 3: Low hydraulic conductivity; low biodegradation rate	0.013	0.012
Case 4: Low hydraulic conductivity; high biodegradation rate	1.60E-06	0.00196

**Notes:**

1. High and low hydraulic conductivity and biodegradation rates are shown on Table 2.
2. Estimated concentrations shown are for a location 900 feet downgradient of the source area 10 years from 2007.
3. See Figures for graphical results.

**TABLE 4**  
**SAMPLE SUMMARY STATISTICS 1995 - 2008**  
**Somers Tie Treating Plant, Somers Montana**

Well Name	Constituent	Percent Detection	Coefficient of Variation	Mann-Kendall (S) Statistic	Confidence in Trend	Mann-Kendall Trend	Average Concentration [mg/L]
S-3	Naphthalene	20%	1.91	4	75.8%	NT	2.72E-04
S-4	Naphthalene	0%	--	--	--	ND	--
S-5R	Naphthalene	0%	--	--	--	ND	--
S-6	Naphthalene	53%	1.37	-79	99.7%	D	1.76E-01
S-84-16	Naphthalene	20%	2.98	31	83.3%	NT	2.50E-04
S-85-5A	Naphthalene	25%	2.57	-39	82.5%	NT	5.16E-04
S-85-5B	Naphthalene	10%	0.56	23	76.0%	NT	4.80E-05
S-85-6A	Naphthalene	5%	0.16	17	69.6%	NT	4.15E-05
S-85-6B	Naphthalene	23%	2.15	7	56.6%	NT	1.67E-04
S-85-7	Naphthalene	9%	0.03	8	70.3%	NT	4.04E-05
S-85-8A	Naphthalene	25%	3.15	8	68.1%	NT	5.18E-04
S-85-8B	Naphthalene	17%	2.28	1	50.0%	NT	1.34E-04
S-88-1	Naphthalene	100%	0.71	56	88.6%	NT	<b>9.38E+00</b>
S-88-2	Naphthalene	69%	3.24	-261	99.9%	D	4.18E-01
S-88-3	Naphthalene	84%	1.61	-411	100.0%	D	7.08E-02
S-91-2	Naphthalene	30%	1.88	-100	98.1%	D	6.95E-04
S-93-2D	Naphthalene	75%	6.17	-240	99.8%	D	<b>1.15E+01</b>
S-93-2S	Naphthalene	95%	0.72	83	100.0%	I	<b>1.39E+00</b>
S-93-7	Naphthalene	0%	--	--	--	ND	--

## Notes:

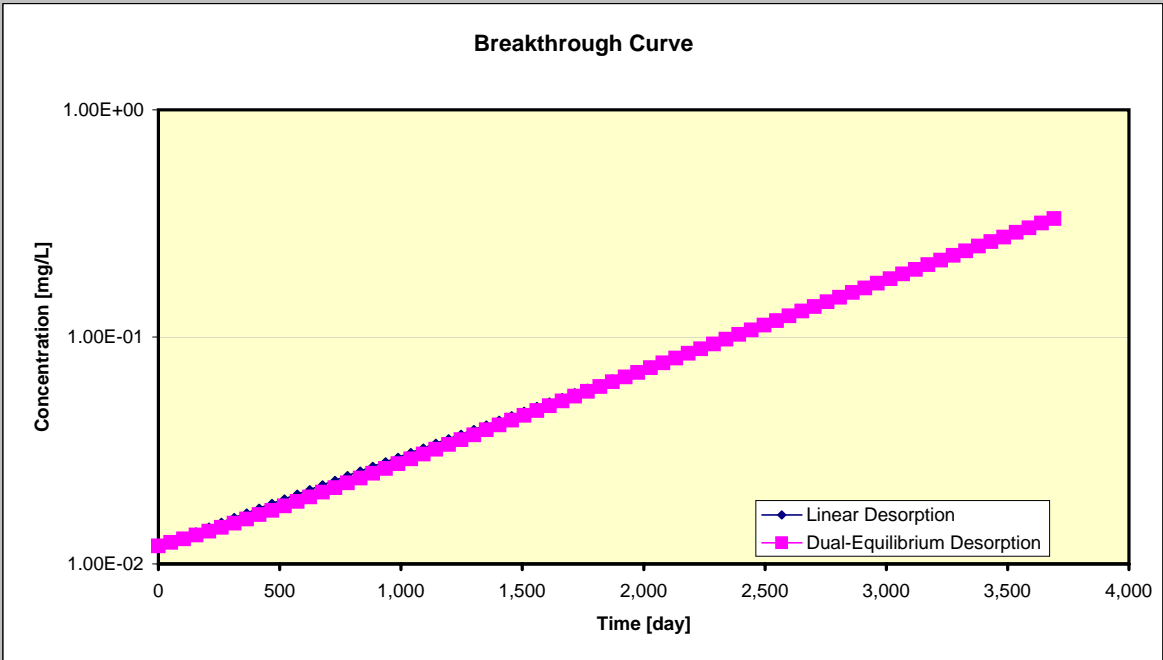
- Percent detection = (Number of Detections/Number of Samples) \*100
- Coefficient of variation = Standard deviation/Sample mean.
- Mann-Kendall S statistic explained in Aziz, 2003.
- Confidence in trend = 100\* (1 - probability of accepting the null hypothesis for S and the number of samples).
- Average concentrations March 1995 - January 2008. Numbers in bold indicate average concentrations exceeding the screening level for naphthalene (0.62 mg/L).
- Mann Kendall trends NT = No Trend; ND = Non-detect; D = Decreasing; I = Increasing. Trends are for the March 1995 - January 2008.

DED-Transport Model  
Concentration vs. Time

**DISSOLVED CONCENTRATION OVER TIME**  
**DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

High hydraulic conductivity and low biodegradation assumption

Concentration vs. Time at Distance =  feet



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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[Return to Input Screen](#)

Figure 1a: Concentration vs. Time for Naphthalene, 900 ft downgradient of CERCLA Lagoon; Linear and DED desorption assumptions.

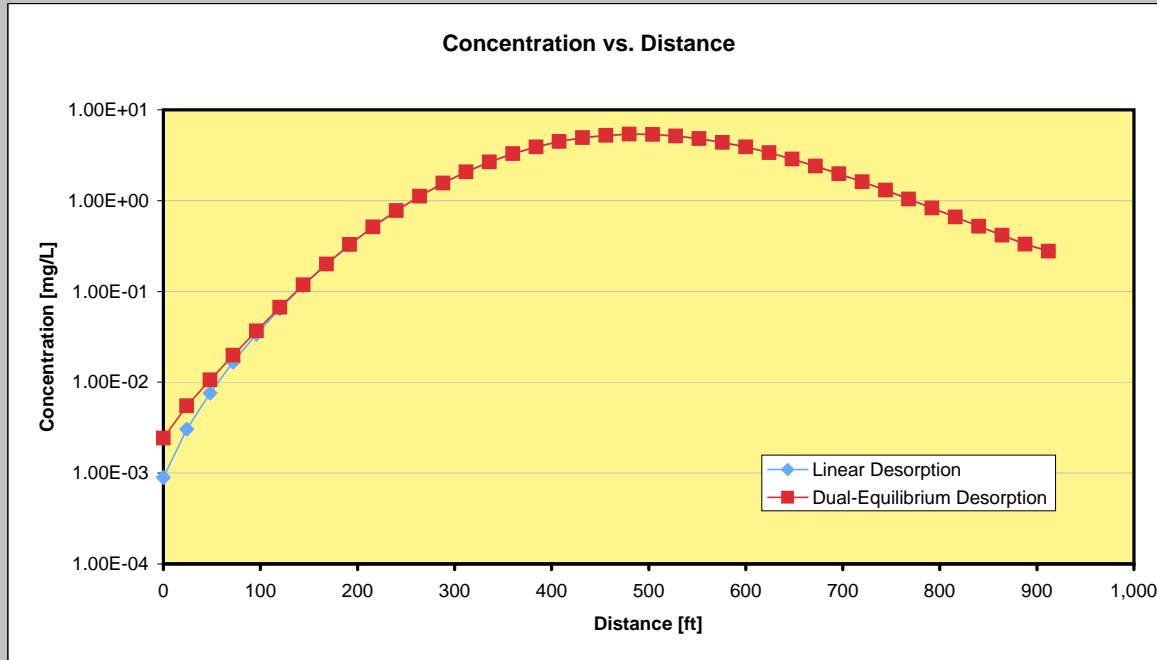


DED-Transport Model  
Concentration vs. Distance

**DISSOLVED CONCENTRATION DOWNGRADE  
DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

High hydraulic conductivity; low biodegradation rates

Concentration vs. Distance at Time =  years



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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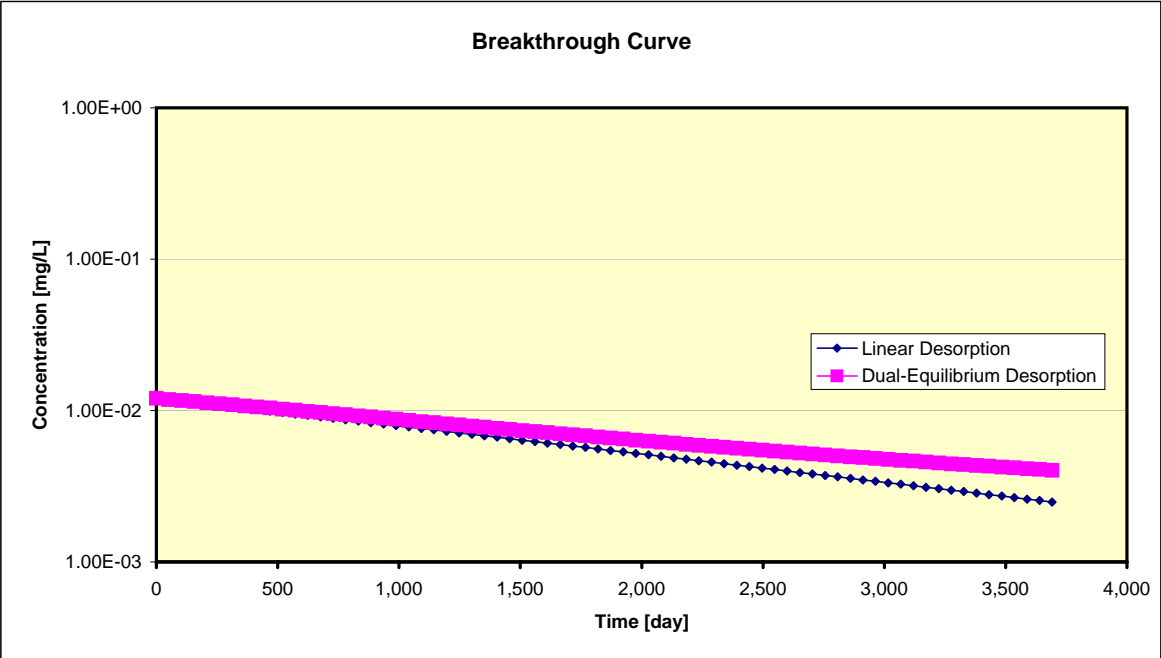
Figure 1b: Concentration vs. Distance for Naphthalene, Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Time

**DISSOLVED CONCENTRATION OVER TIME**  
**DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

High hydraulic conductivity and high biodegradation assumption

Concentration vs. Time at Distance =  feet



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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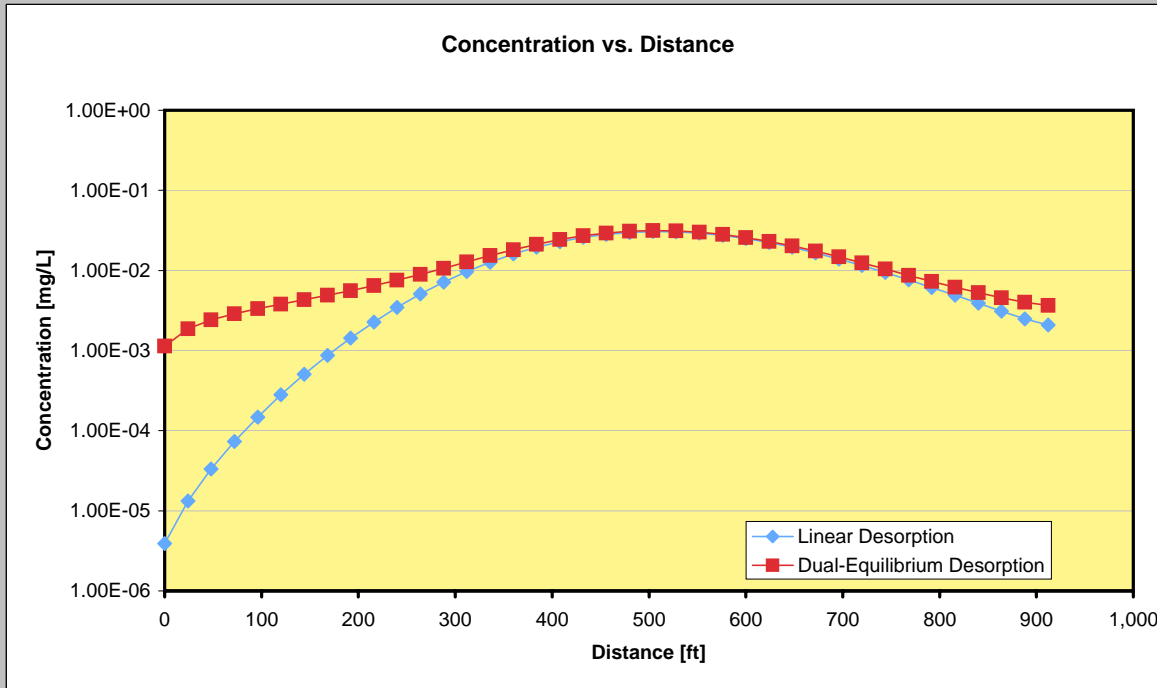
Figure 2a: Concentration vs. Time for Naphthalene, 900 ft downgradient of CERCLA Lagoon; Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Distance

**DISSOLVED CONCENTRATION DOWNGRADIENT  
DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

High hydraulic conductivity; high biodegradation rates

Concentration vs. Distance at Time =  years



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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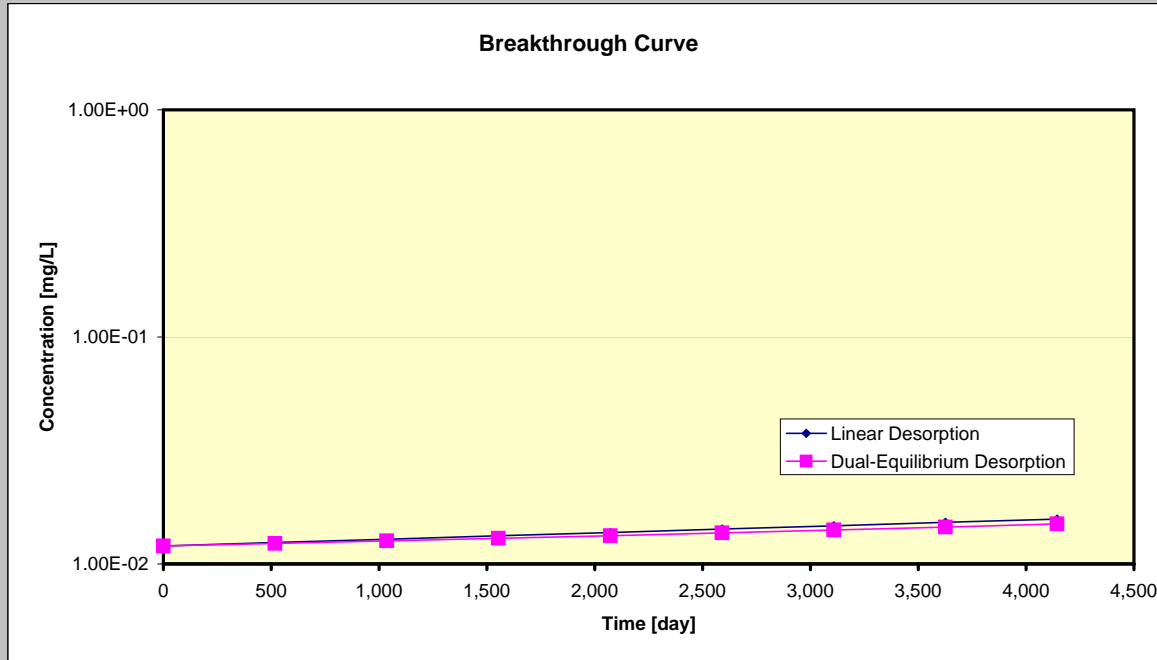
Figure 2b: Concentration vs. Distance for Naphthalene, Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Time

**DISSOLVED CONCENTRATION OVER TIME**  
**DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

Low hydraulic conductivity and low biodegradation assumption

Concentration vs. Time at Distance =  feet



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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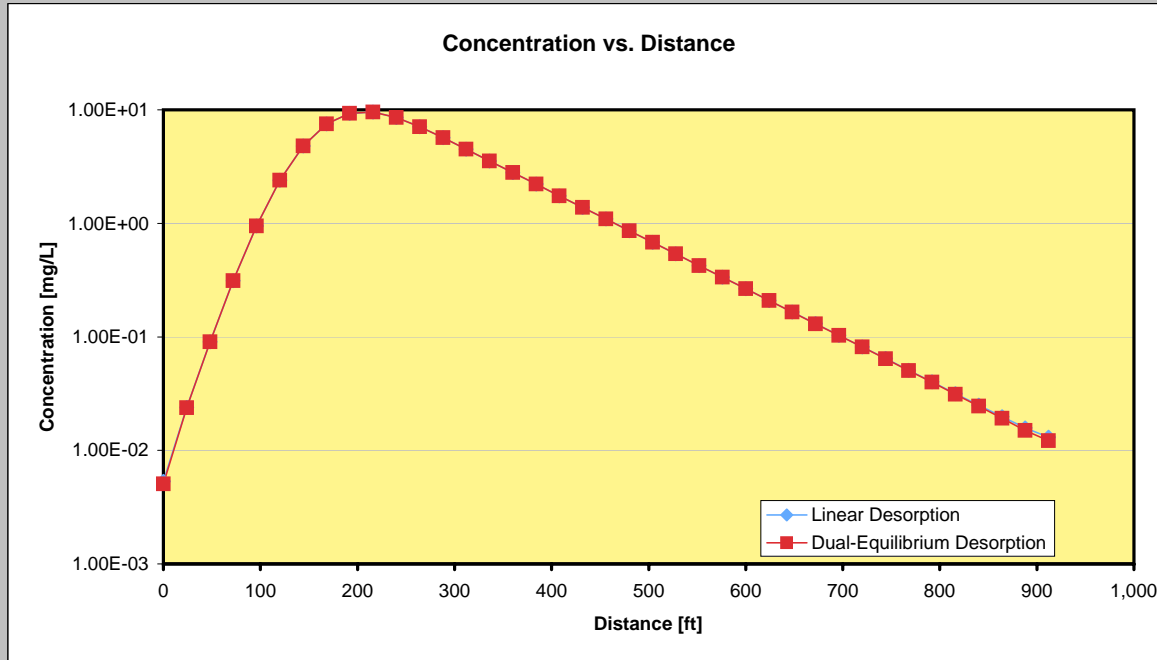
Figure 3a: Concentration vs. Time for Naphthalene, 900 ft downgradient of CERCLA Lagoon; Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Distance

**DISSOLVED CONCENTRATION DOWNGRADIENT  
DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

Low hydraulic conductivity; low biodegradation rates

Concentration vs. Distance at Time =  years



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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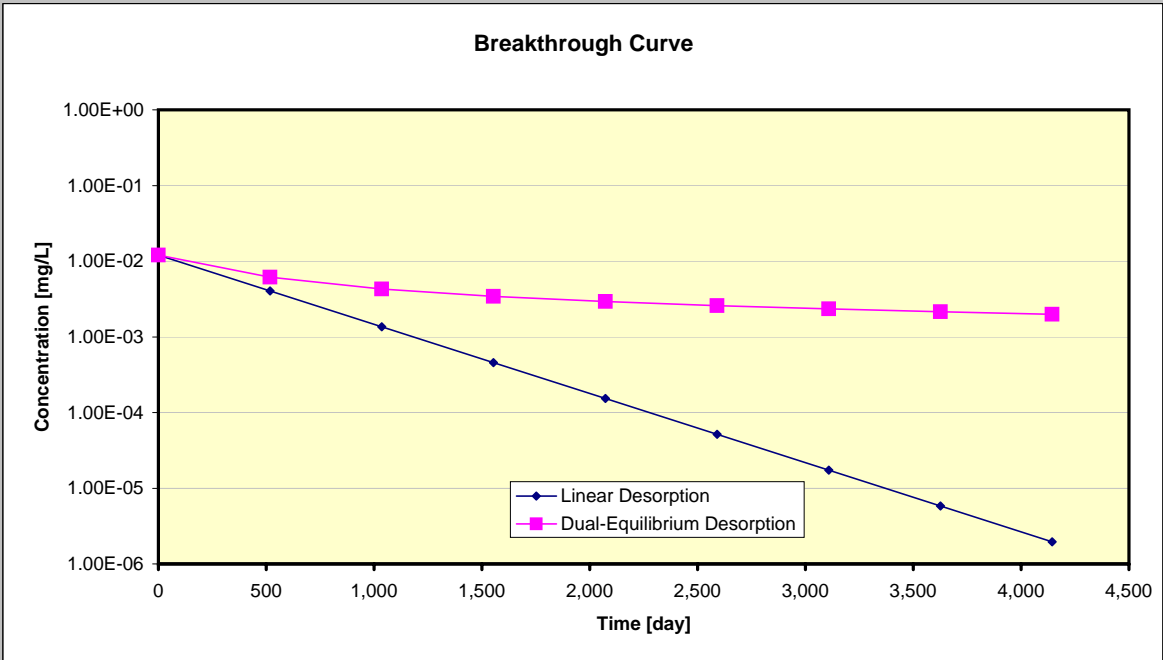
Figure 3b: Concentration vs. Distance for Naphthalene, Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Time

**DISSOLVED CONCENTRATION OVER TIME**  
**DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

*Low hydraulic conductivity and high biodegradation assumption*

Concentration vs. Time at Distance =  feet



Input Parameters

COC   
 Kow   
 Solubility  mg/L  
 C max  mg/L

Final Concentration:  
 DED Assumption:  mg/L  
 Linear Assumption:  mg/L

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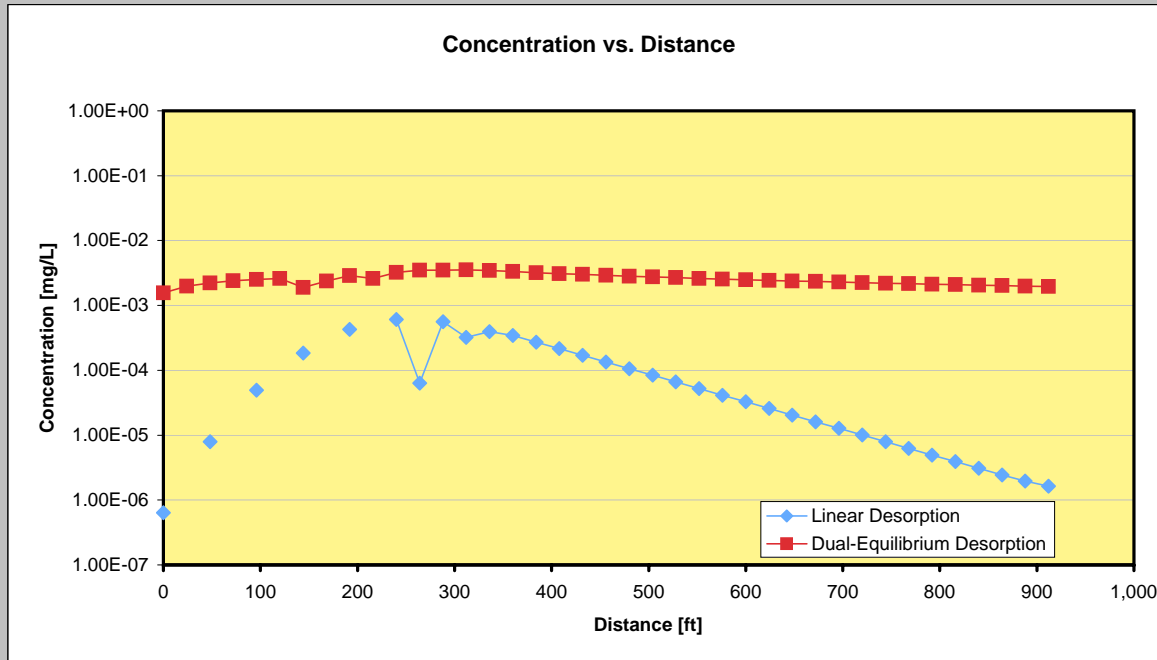
Figure 4a: Concentration vs. Time for Naphthalene, 900 ft downgradient of CERCLA Lagoon; Linear and DED desorption assumptions.

DED-Transport Model  
Concentration vs. Distance

**DISSOLVED CONCENTRATION DOWNGRADIENT  
DUAL-EQUILIBRIUM AND LINEAR DESORPTION ASSUMPTIONS**

Low hydraulic conductivity; high biodegradation rates

Concentration vs. Distance at Time =  years



Input Parameters

COC   
Kow   
Solubility  mg/L  
C max  mg/L

Final Concentration:  
DED Assumption:  mg/L  
Linear Assumption:  mg/L

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Figure 4b: Concentration vs. Distance for Naphthalene Linear and DED desorption assumptions.

02-March, 2009

## **Review of Interim Groundwater Monitoring Plan**

BNSF Former Tie Treating Plant  
Somers, Montana

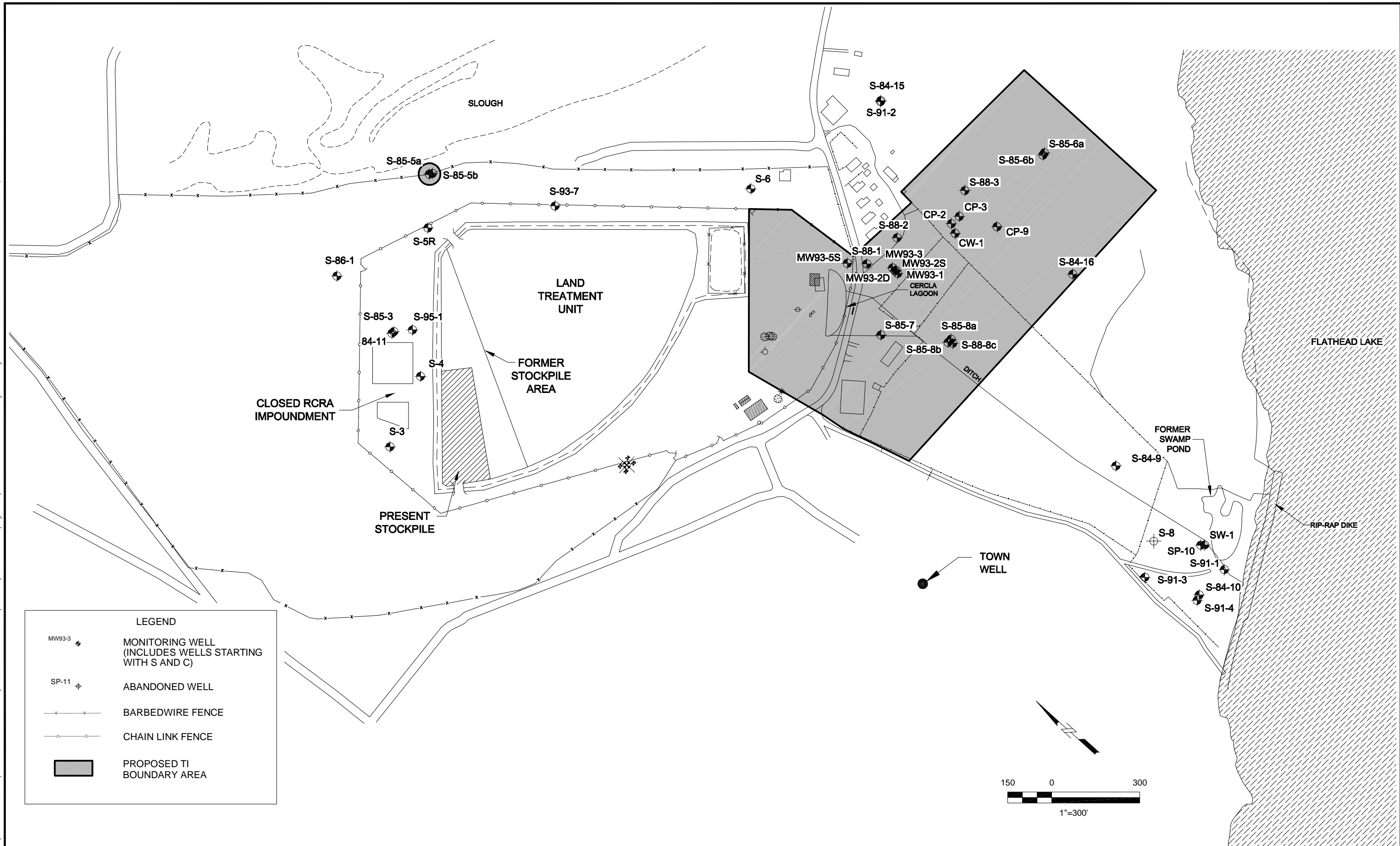
### **Appendix A**

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Appendix A      Map of proposed TI boundary and well network (RETEC, 2003; Fig 5.1)



File: F:\PROJECTS\BNSF RAILWAY\01140\_176 Somers\Golden Files\_2006\01860\TI Nov2002\Figures\SOM-TIE-5-1.DWG Layout: Layout1 User: mawilliamson Plotted: Jul 23, 2008 - 7:24am Xref's:



Technical Impracticability Evaluation for Groundwater Restoration BNSF, Somers, Montana (BN080-01860-240)		<b>PROPOSED TI BOUNDARY</b>
DATE: 02/07/03	DRWN: RLL / E.S.S.	<b>FIGURE 5-1</b>

02-March, 2009

## **Review of Interim Groundwater Monitoring Plan**

BNSF Former Tie Treating Plant  
Somers, Montana

### **Appendix B**

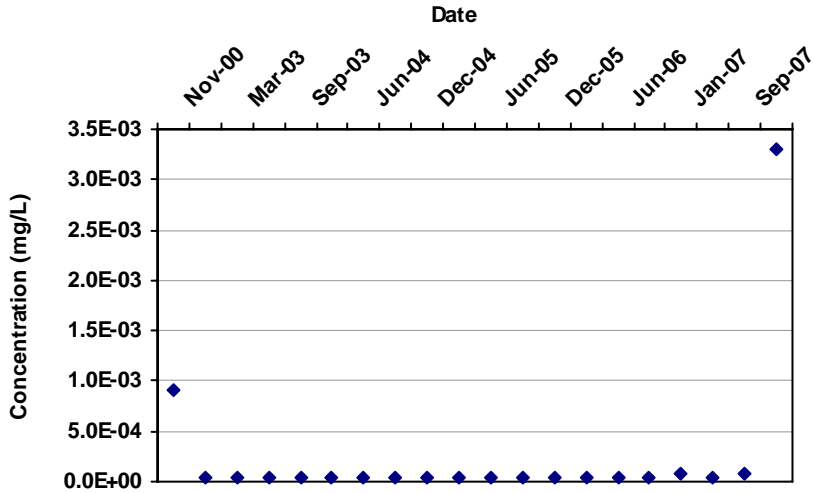
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Appendix B      Example Mann Kendall Reports with Concentration vs. Time Plots

# MAROS Mann-Kendall Statistics Summary

Well: S-84-16  
 Well Type: T  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

31

Confidence in Trend:

83.3%

Coefficient of Variation:

2.98

Mann Kendall Concentration Trend:  
(See Note)

NT

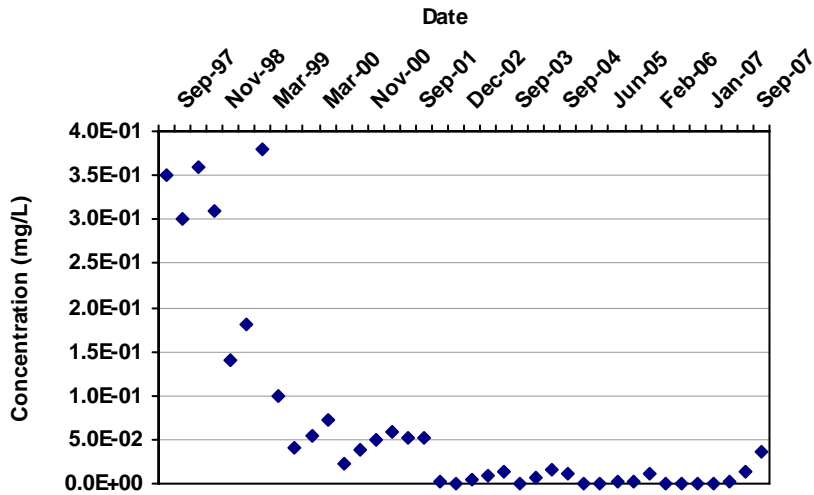
## Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-84-16	T	11/29/2000	Naphthalene	9.0E-04		1	1
S-84-16	T	12/1/2002	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	3/3/2003	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	6/2/2003	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	9/2/2003	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	3/22/2004	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	6/4/2004	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	9/1/2004	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	12/1/2004	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	2/28/2005	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	6/1/2005	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	8/31/2005	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	12/1/2005	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	3/1/2006	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	6/1/2006	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	9/1/2006	Naphthalene	4.0E-05	ND	1	0
S-84-16	T	1/3/2007	Naphthalene	7.5E-05		2	1
S-84-16	T	6/4/2007	Naphthalene	4.0E-05	ND	2	0
S-84-16	T	9/6/2007	Naphthalene	7.5E-05		2	1
S-84-16	T	1/8/2008	Naphthalene	3.3E-03		1	1

# MAROS Mann-Kendall Statistics Summary

Well: S-88-3  
 Well Type: S  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

-411

Confidence in Trend:

100.0%

Coefficient of Variation:

1.61

Mann Kendall Concentration Trend: (See Note)

D

## Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-88-3	S	9/3/1997	Naphthalene	3.5E-01		1	1
S-88-3	S	10/29/1997	Naphthalene	3.0E-01		1	1
S-88-3	S	9/2/1998	Naphthalene	3.6E-01		1	1
S-88-3	S	11/30/1998	Naphthalene	3.1E-01		1	1
S-88-3	S	3/1/1999	Naphthalene	1.4E-01		1	1
S-88-3	S	3/6/1999	Naphthalene	1.8E-01		1	1
S-88-3	S	3/7/1999	Naphthalene	3.8E-01		1	1
S-88-3	S	6/1/1999	Naphthalene	1.0E-01		1	1
S-88-3	S	12/1/1999	Naphthalene	4.0E-02		1	1
S-88-3	S	3/2/2000	Naphthalene	5.4E-02		1	1
S-88-3	S	6/1/2000	Naphthalene	7.2E-02		1	1
S-88-3	S	9/3/2000	Naphthalene	2.2E-02		1	1
S-88-3	S	11/29/2000	Naphthalene	3.8E-02		1	1
S-88-3	S	3/21/2001	Naphthalene	5.0E-02		1	1
S-88-3	S	5/31/2001	Naphthalene	5.8E-02		1	1
S-88-3	S	9/11/2001	Naphthalene	5.1E-02		2	2
S-88-3	S	12/2/2001	Naphthalene	5.2E-02		2	2
S-88-3	S	9/23/2002	Naphthalene	2.6E-03		1	1
S-88-3	S	12/1/2002	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	3/3/2003	Naphthalene	3.5E-03		1	1
S-88-3	S	6/2/2003	Naphthalene	8.4E-03		1	1
S-88-3	S	9/2/2003	Naphthalene	1.5E-02		1	1

# MAROS Mann-Kendall Statistics Summary

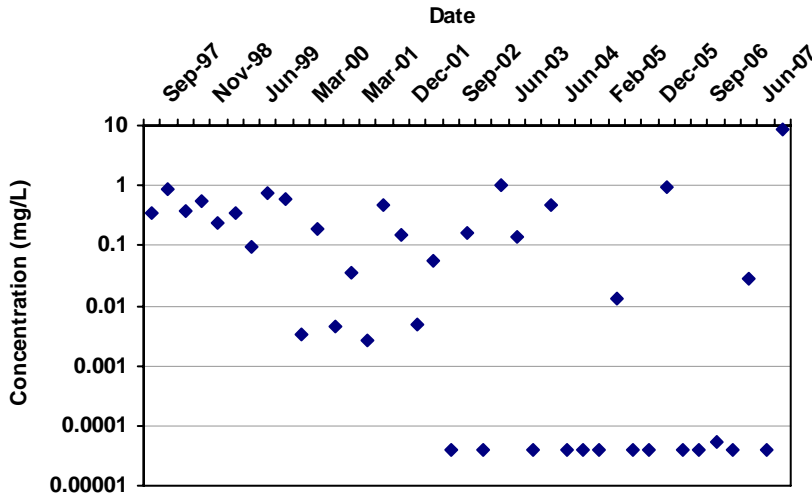
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-88-3	S	3/23/2004	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	6/4/2004	Naphthalene	6.2E-03		1	1
S-88-3	S	9/1/2004	Naphthalene	1.5E-02		1	1
S-88-3	S	12/1/2004	Naphthalene	1.1E-02		1	1
S-88-3	S	2/28/2005	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	6/1/2005	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	8/31/2005	Naphthalene	3.3E-03		1	1
S-88-3	S	12/1/2005	Naphthalene	3.3E-03		1	1
S-88-3	S	2/28/2006	Naphthalene	1.1E-02		1	1
S-88-3	S	6/1/2006	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	9/1/2006	Naphthalene	4.0E-05	ND	1	0
S-88-3	S	1/3/2007	Naphthalene	7.2E-04		2	1
S-88-3	S	2/28/2007	Naphthalene	7.7E-04		2	1
S-88-3	S	6/4/2007	Naphthalene	2.8E-03		2	1
S-88-3	S	9/6/2007	Naphthalene	1.3E-02		2	2
S-88-3	S	1/8/2008	Naphthalene	3.7E-02		1	1

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); ND = Non-detect

# MAROS Mann-Kendall Statistics Summary

Well: S-88-2  
 Well Type: S  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

-261

Confidence in Trend:

99.9%

Coefficient of Variation:

3.24

Mann Kendall Concentration Trend:  
(See Note)

D

## Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-88-2	S	9/3/1997	Naphthalene	3.6E-01		1	1
S-88-2	S	10/30/1997	Naphthalene	8.9E-01		1	1
S-88-2	S	9/2/1998	Naphthalene	3.7E-01		1	1
S-88-2	S	11/30/1998	Naphthalene	5.7E-01		1	1
S-88-2	S	3/1/1999	Naphthalene	2.4E-01		1	1
S-88-2	S	3/6/1999	Naphthalene	3.4E-01		2	2
S-88-2	S	6/1/1999	Naphthalene	9.2E-02		1	1
S-88-2	S	9/2/1999	Naphthalene	7.6E-01		1	1
S-88-2	S	12/1/1999	Naphthalene	5.8E-01		1	1
S-88-2	S	3/2/2000	Naphthalene	3.2E-03		1	1
S-88-2	S	6/1/2000	Naphthalene	1.9E-01		1	1
S-88-2	S	11/29/2000	Naphthalene	4.6E-03		1	1
S-88-2	S	3/22/2001	Naphthalene	3.5E-02		1	1
S-88-2	S	5/31/2001	Naphthalene	2.6E-03		1	1
S-88-2	S	9/11/2001	Naphthalene	4.7E-01		2	2
S-88-2	S	12/2/2001	Naphthalene	1.5E-01		2	2
S-88-2	S	3/5/2002	Naphthalene	4.7E-03		1	1
S-88-2	S	6/2/2002	Naphthalene	5.4E-02		1	1
S-88-2	S	9/23/2002	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	12/1/2002	Naphthalene	1.6E-01		1	1
S-88-2	S	3/3/2003	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	6/2/2003	Naphthalene	9.8E-01		1	1

# MAROS Mann-Kendall Statistics Summary

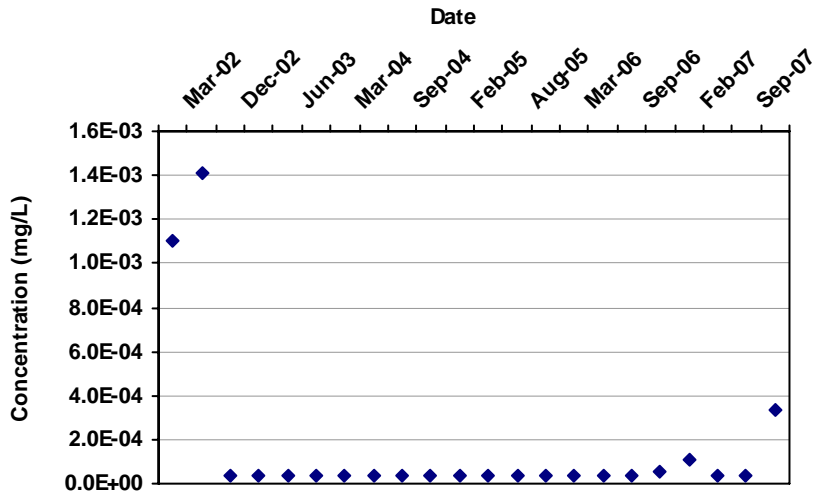
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-88-2	S	9/2/2003	Naphthalene	1.4E-01		1	1
S-88-2	S	3/23/2004	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	6/4/2004	Naphthalene	4.6E-01		1	1
S-88-2	S	9/2/2004	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	12/1/2004	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	2/28/2005	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	6/1/2005	Naphthalene	1.3E-02		2	1
S-88-2	S	9/1/2005	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	12/1/2005	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	2/28/2006	Naphthalene	9.3E-01		1	1
S-88-2	S	6/1/2006	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	9/1/2006	Naphthalene	4.0E-05	ND	1	0
S-88-2	S	1/3/2007	Naphthalene	5.3E-05		2	1
S-88-2	S	2/28/2007	Naphthalene	4.0E-05	ND	2	0
S-88-2	S	6/4/2007	Naphthalene	2.8E-02		2	1
S-88-2	S	9/6/2007	Naphthalene	4.0E-05	ND	2	0
S-88-2	S	1/8/2008	Naphthalene	8.5E+00		1	1

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); ND = Non-detect

# MAROS Mann-Kendall Statistics Summary

Well: S-85-6B  
 Well Type: S  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

7

Confidence in Trend:

56.6%

Coefficient of Variation:

2.15

Mann Kendall Concentration Trend: (See Note)

NT

## Data Table:

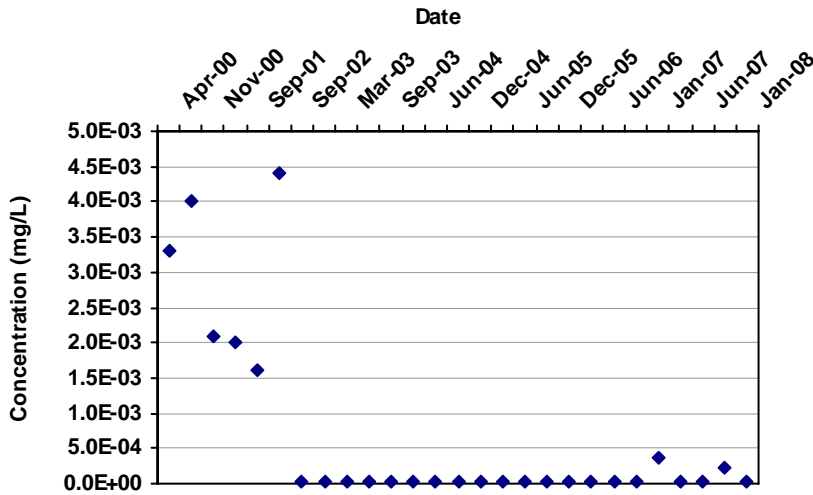
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-85-6B	S	3/5/2002	Naphthalene	1.1E-03		1	1
S-85-6B	S	9/24/2002	Naphthalene	1.4E-03		1	1
S-85-6B	S	12/1/2002	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	3/3/2003	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	6/2/2003	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	9/2/2003	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	3/22/2004	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	6/4/2004	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	9/1/2004	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	12/1/2004	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	2/28/2005	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	6/1/2005	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	8/31/2005	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	12/1/2005	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	3/2/2006	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	6/1/2006	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	9/1/2006	Naphthalene	4.0E-05	ND	1	0
S-85-6B	S	1/3/2007	Naphthalene	5.3E-05		2	1
S-85-6B	S	2/28/2007	Naphthalene	1.1E-04		2	1
S-85-6B	S	6/4/2007	Naphthalene	4.0E-05	ND	2	0
S-85-6B	S	9/6/2007	Naphthalene	4.0E-05	ND	2	0
S-85-6B	S	1/8/2008	Naphthalene	3.3E-04		1	1



# MAROS Mann-Kendall Statistics Summary

Well: S-91-2  
 Well Type: T  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

-100

Confidence in Trend:

98.1%

Coefficient of Variation:

1.88

Mann Kendall Concentration Trend: (See Note)

D

## Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-91-2	T	4/17/2000	Naphthalene	3.3E-03		1	1
S-91-2	T	9/3/2000	Naphthalene	4.0E-03		1	1
S-91-2	T	11/29/2000	Naphthalene	2.1E-03		1	1
S-91-2	T	3/21/2001	Naphthalene	2.0E-03		1	1
S-91-2	T	9/11/2001	Naphthalene	1.6E-03		2	2
S-91-2	T	12/2/2001	Naphthalene	4.4E-03		1	1
S-91-2	T	9/23/2002	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	12/1/2002	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	3/3/2003	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	6/2/2003	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	9/1/2003	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	3/23/2004	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	6/4/2004	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	9/2/2004	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	12/1/2004	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	2/28/2005	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	6/1/2005	Naphthalene	4.0E-05	ND	2	0
S-91-2	T	9/1/2005	Naphthalene	4.0E-05	ND	2	0
S-91-2	T	12/1/2005	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	2/28/2006	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	6/1/2006	Naphthalene	4.0E-05	ND	1	0
S-91-2	T	9/1/2006	Naphthalene	4.0E-05	ND	1	0

# MAROS Mann-Kendall Statistics Summary

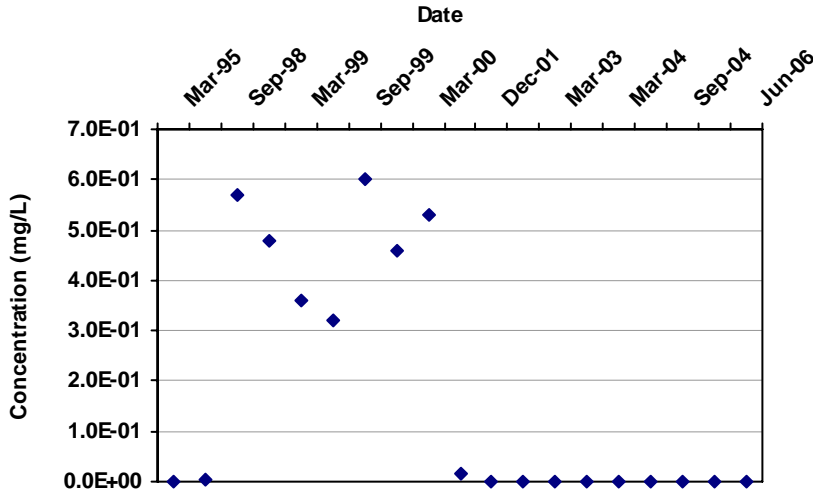
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-91-2	T	1/3/2007	Naphthalene	3.7E-04		2	1
S-91-2	T	2/28/2007	Naphthalene	4.0E-05	ND	2	0
S-91-2	T	6/4/2007	Naphthalene	4.0E-05	ND	2	0
S-91-2	T	9/6/2007	Naphthalene	2.3E-04		2	1
S-91-2	T	1/7/2008	Naphthalene	4.0E-05	ND	1	0

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); ND = Non-detect

# MAROS Mann-Kendall Statistics Summary

Well: S-6  
 Well Type: T  
 COC: Naphthalene

Time Period: 3/31/1995 to 1/8/2008  
 Consolidation Period: No Time Consolidation  
 Consolidation Type: Median  
 Duplicate Consolidation: Average  
 ND Values: Specified Detection Limit  
 J Flag Values : Actual Value



Mann Kendall S Statistic:

-79

Confidence in Trend:

99.7%

Coefficient of Variation:

1.37

Mann Kendall Concentration Trend: (See Note)

D

## Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
S-6	T	3/31/1995	Naphthalene	4.0E-05	ND	1	0
S-6	T	3/5/1998	Naphthalene	3.3E-03		1	1
S-6	T	9/2/1998	Naphthalene	5.7E-01		1	1
S-6	T	11/30/1998	Naphthalene	4.8E-01		1	1
S-6	T	3/1/1999	Naphthalene	3.6E-01		1	1
S-6	T	6/1/1999	Naphthalene	3.2E-01		1	1
S-6	T	9/1/1999	Naphthalene	6.0E-01		1	1
S-6	T	12/1/1999	Naphthalene	4.6E-01		1	1
S-6	T	3/1/2000	Naphthalene	5.3E-01		1	1
S-6	T	9/4/2000	Naphthalene	1.7E-02		2	2
S-6	T	12/2/2001	Naphthalene	1.1E-03		1	1
S-6	T	12/2/2002	Naphthalene	4.0E-05	ND	1	0
S-6	T	3/2/2003	Naphthalene	4.0E-05	ND	1	0
S-6	T	6/1/2003	Naphthalene	4.0E-05	ND	1	0
S-6	T	3/22/2004	Naphthalene	4.0E-05	ND	1	0
S-6	T	6/3/2004	Naphthalene	4.0E-05	ND	1	0
S-6	T	9/1/2004	Naphthalene	4.0E-05	ND	1	0
S-6	T	6/1/2005	Naphthalene	4.0E-05	ND	1	0
S-6	T	6/1/2006	Naphthalene	4.0E-05	ND	1	0

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); ND = Non-detect