Solid Waste and
Emergency Response
(5203P)

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EXECUTIVE SUMMARY

This report reviews and provides recommendations for improving a groundwater monitoring network for the Delatte Metals Superfund site. The Delatte Metals site consists of former battery recycling facilities located just outside of Ponchatoula, Louisiana. Substantial remedial work has been accomplished at the site, including removal of thousands of yards of contaminated soil, decommissioning of buildings and tanks, the installation of a bio-barrier to treat contaminated groundwater in the highest of the three water-bearing zones, and institutional controls to secure the site from inappropriate use. The site was deleted from the NPL in August 2005.

The primary goal of optimizing the groundwater monitoring strategy at the Delatte Metals site is to create a dataset that fully supports site management decisions while minimizing the time and expense associated with collecting and interpreting data. The recommendations contained in this report are intended to further develop understanding of the site conceptual model and management objectives and to support the development of a comprehensive management strategy for the future, within the context of CERCLA and the NCP.

The current groundwater monitoring network has been evaluated using a formal qualitative approach as well as statistical tools found in the Monitoring and Remediation Optimization System (MAROS) software. Recommendations are made for groundwater sampling frequency and location based on current hydrogeologic conditions and pending data needs. The monitoring program was evaluated using analytical data collected from January 2004─following installation of the remedy in the First Water Bearing Zone (FWBZ)─to August 2008. Historical data collected in support of the remedial investigation (RI) (TetraTech 2000b) were considered as part of the qualitative analysis to identify historical sources and maximum concentrations. This report outlines recommendations based on a formal evaluation, but final determination of any sampling locations and frequencies are to be decided by the overseeing regulatory agencies.

Project Goals and Objectives

The goal of the groundwater long-term monitoring optimization (LTMO) process is to review the current monitoring program and provide recommendations for improving the efficiency and accuracy of the network in supporting site management decisions and confirming achievement of Remedial Action Objectives (RAOs). Specifically, the LTMO process provides information on the completeness of site characterization, stability of the plume, sufficiency and redundancy of monitoring locations and an appropriate sampling frequency. The end product of the LTMO process at the Delatte site is a recommendation for specific sampling locations, frequencies, and analytes as well as data management practices that address site management needs.

Based on the site history and overall goals of the Superfund program, the following expanded monitoring objectives are recommended to support future site management decisions. Some of these suggested objectives have already been recommended in other site documents, such as the Five Year Review and Quarterly Operation and Maintenance Reports, and are reinforced here:

- Delineate the extent of groundwater affected above primary EPA Maximum Contaminant Levels (MCLs) in all three groundwater units and groundwater affected above ecological risk standards (EPA Water Quality Criteria) in the FWBZ.
- Delineate the extent of the FWBZ north of Tributary 1 and south of Tributary 2.
- Monitor concentrations of contaminants over time in the affected groundwater units.
- Monitor possible exposure pathways such as groundwater discharge to surface-water bodies, wetlands, and lower groundwater units.
- Monitor the boundaries of the institutional control (IC) to ensure that concentrations do not exceed regulatory limits in offsite locations.
- Monitor groundwater in historical source areas to confirm progress toward unrestricted property use.
- Monitor locations that may indicate an impending exceedance of regulatory levels at compliance or exposure points.

Groundwater Monitoring Recommendations

The following recommendations are made based on the results of both a qualitative review and statistical analysis of the current monitoring network. Detailed results of the analyses are presented in Sections 2.0 and 3.0. Recommendations contained in this report are designed to address program monitoring goals and objectives and to help answer outstanding questions on the management of the site. The recommendations are intended to help clarify the site conceptual model and enhance data management to demonstrate the accomplishment of site goals.

- *Applicable or relevant and appropriate requirements (ARARs) for groundwater in each hydrogeologic zone should be defined or clarified and made available to site stakeholders.* For each medium where contaminants are left in place, protective concentrations should be specified. Protective concentrations are calculated based on the site-specific transport mechanisms associated with complete or potentially complete exposure pathways. Additionally, regulatory standards applicable to Class 2 and 3 groundwaters outside of the institutional control should be clarified. While current site groundwater concentrations probably do not present excess risk, without clear ARARs, regulatory screening levels and remedial goals, the appropriateness of the analyte list, sampling locations and analytical methods for groundwater monitoring cannot be evaluated. Without unambiguous remedial goals, the efficacy of the remedy cannot be determined. Without specific risk-based standards, attainment of RAOs cannot be demonstrated.

- *No new monitoring locations are recommended for the second and third water-bearing zones (SWBZ and TWBZ).* No data gaps were found in the characterization of the SWBZ and TWBZ (with the exception of detection limits and analyte list mentioned below). No wells in the SWBZ or TWBZ are recommended for removal from the program at this time. Reduce the frequency of groundwater sampling in the SWBZ and TWBZ to semiannual.

- *Four new groundwater monitoring locations are recommended to delineate affected groundwater in the northern FWBZ outside the current extent of the network.* New locations are needed to evaluate the performance of the remedy, serve as point-of-compliance wells, monitor plume stability, and assess concentrations discharging to surface water. A fifth groundwater monitoring location is recommended for the upgradient source area defined by Geoprobe locations DD-27 and DE-27 from the RI. Monitoring in this area would help demonstrate the extent of source attenuation since demolition and soil remediation activities and to assess possible migration of residual contaminants toward the surface-water discharge points.

- *Continue quarterly sampling frequency for existing and new monitoring locations in the FWBZ, as well as surface water.* Quarterly sampling is recommended for 2 to 3 years, using consistently low laboratory reporting limits and the expanded analyte list, until a dataset with sufficient statistical power has been developed to address site monitoring objectives. Consider re-evaluating the monitoring network in 2 – 3 years for possible further reductions in both the number of locations and frequency of sampling

- *Maintain a site-wide electronic analytical database with a complete set of historical and current analytical data for all constituents.* Historical groundwater characterization data, including samples collected by Geoprobe, should be readily accessible to compare with current data. Also, supplemental data such as the piezometer samples taken to evaluate remedy performance should be available to compare with data from permanent monitoring wells and predicted concentrations in the area. The database should include detection limits, sample location coordinates, sampling methods, and other details that would streamline interpretation of site data.

- *Collect additional data on surface- water concentrations and perform calculations to determine the effect of dilution on groundwater discharge to surface water in order to develop protective concentration levels for the FWBZ.* The 2007 five-year review recommends a program to sample surface water and an expanded investigation of groundwater/surface-water interface. These data will provide important information on impacts of affected groundwater discharge to surface water. Groundwater discharge to surface water is a potentially complete exposure pathway for which ARARs and remedial goals have not been fully developed. Protective concentrations for FWBZ groundwater discharging to surface water may be calculated by estimating surface water flow in the water bodies to quantify the effect of dilution. A resulting theoretical impact to the surface water could then be compared to protective surface water standards calculated in the Human Health Risk Assessment (HHRA) (TetraTech 2000c) and in the Baseline Ecological Risk Assessment (BERA). Groundwater should be sampled near the discharge to Tributaries 1 and 2 and Selsers Creek using the expanded analyte list to demonstrate that discharged concentrations are below protective levels.

- *Expand the analyte list to include all constituents historically found above maximum contaminant levels (MCLs) in the FWBZ and those identified in the BERA (TetraTech, 2000a) as contaminants of concern (COCs) for ecological receptors.* An expanded analytical list will help clarify the remedial goals and ARARs for each groundwater zone and confirm the results of the remedial action Historical groundwater data indicate the presence of metals exceeding conservative screening levels that currently are not included as laboratory analytes. These contaminants include aluminum, antimony, beryllium, cadmium, copper, selenium and zinc in addition to acidity, lead, arsenic, manganese, thallium, and nickel (see Table 1).

- *Establish analytical laboratory reporting limits significantly lower than conservative screening levels.* As stated in the first five-year review (EPA 2007), collected data are of insufficient resolution to reliably determine concentration trends for some contaminants. For detection monitoring, high reporting limits mask the presence of low concentrations of constituents, limiting the ability of the sampling program to achieve the stated goals. Variable reporting limits introduce artificial patterns into the data analysis for samples with low concentrations. Data quality objectives for reporting limits and detection limits should be clarified and communicated to contracting laboratories.

1.0 INTRODUCTION

The Delatte Metals Superfund site (DM site) is a former National Priorities Listed (NPL) site located just outside of Ponchatoula, Louisiana. The site is located in a rural section of Tangipahoa Parish, with surrounding agricultural, light industrial and undeveloped land. The current site encompasses the former Delatte Metals, Inc. facility and the adjacent abandoned North Ponchatoula Battery Company (NPBC) facility. The combined properties cover approximately 18.9 acres. The total area of concern, including offsite wetlands, tributaries, Selsers Creek, Cypress Swamp, residences and undeveloped land, is approximately 56.8 acres.

Groundwater at the DM site is affected by elevated concentrations of metals and low pH as a result of historical battery recycling activities. The DM site has undergone extensive remediation but there are currently several questions outstanding relating to future site management for which groundwater monitoring data are required. The purpose of the following long-term monitoring optimization (LTMO) is to review the current groundwater monitoring program and provide recommendations to improve the effectiveness, accuracy, and efficiency of the program a to support site management decisions.

In order to recommend an optimized network that addresses monitoring objectives, spatial and analytical data from the DM site were analyzed using a series of quantitative and qualitative methods. A quantitative statistical evaluation of site data was conducted using tools in the MAROS software. The qualitative evaluation included a review of site characterization, assumptions, sources, hydrogeologic conditions, well construction and placement relative to potential receptors and site boundaries. Both quantitative statistical and qualitative evaluations were combined using a 'lines of evidence' approach to recommend an updated set of monitoring objectives and a final groundwater monitoring strategy. Tasks performed during the analysis of the monitoring network include:

- Review site documents to identify key components of the site conceptual model and the regulatory framework and to determine future needs for and use of site groundwater data.

- Evaluate well locations and screened intervals within the context of the hydrogeologic regime to determine if the site is well characterized.

- Determine if data are of sufficient quality and quantity to address management decisions.

- Evaluate overall "plume stability" through concentration trend and moment analysis.

- Evaluate individual well concentration trends over time for analytes of concern.

- Recommend sampling locations based on an analysis of spatial uncertainty and hydrogeologic factors.

- Recommend sampling frequency based on both qualitative and quantitative statistical analysis results.

A discussion of the background and regulatory context for the DM site is provided below. Section 2.0 contains the qualitative evaluation of the monitoring network. The results of the quantitative, statistical analysis of groundwater data are provided in Section 3.0. Summary conclusions and recommendations are presented in Section 4.0. A list of reports, site documents and data reviewed for the analysis are included in Section 5.0.

1.1 SITE BACKGROUND AND REGULATORY HISTORY

Battery recycling and smelting operations began at Delatte Metals, Inc. during the 1960s and continued until approximately 1992. The adjacent NPBC operated between the 1960s and 1981. Site operations included demolition of spent lead-acid batteries to recover lead plates, which were subsequently smelted to produce lead ingots. At the Delatte facility, the process involved sawing off the tops of batteries, removing the lead plates, and dumping the battery-acid into a sump. Until the 1980s battery acid was pumped into an unlined pond on the north side of the property (between Tributaries 1 and 2 see Figure 1). The empty battery casings were processed onsite and either stored as battery chips or recycled as plastic. Rinse water from the battery chip operation was stored in a settling pond where the recoverable solids (mainly lead sulfate and lead oxide) were transported to the smelter for lead recycling. At the NPBC, the process was similar, but battery acid was dumped into two unlined neutralization ponds.

The NPBC facility closed in 1981 for failing to meet state and federal environmental regulations. The company had been cited several times for hazardous waste discharges during the 1970s and was denied a permit to discharge wastes to Selsers Creek. The company was declared bankrupt in 1985. Throughout the 1980s, the Delatte facility worked to close out the acid neutralization pond and was cited for various deficiencies in environmental management. In the early 1990s, groundwater wells were installed and various waste characterization activities were conducted to comply with Louisiana Department of Environmental Quality (LDEQ) requirements. In June 1992, Delatte ceased all smelting activities, but maintained limited operations as a scrap dealer.

By 1996, the LDEQ requested that EPA Region 6 consider the Delatte and NPBC sites as one site. In July 1998, the combined Delatte/NPBC site was proposed for inclusion on the NPL, and time-critical removal actions were initiated. The site was formally placed on the NPL in January 1999.

An RI report with detailed site characterization was issued for the DM site in 2000 (TetraTech 2000b). The RI included extensive soil, sediment, groundwater, surface water, and biota sampling. Human health and ecological risk assessments ((TetraTech 2000c; TetraTech 2000a)) were also completed in 2000. A record of decision (ROD) (EPA 2000) was signed in September 2000 that selected the following remedies:

- Immobilization of contaminants to address the source of contamination
- Offsite disposal of immobilized wastes
- Permeable treatment walls to attempt to neutralize acidity and restrict transport of contaminants in the FWBZ groundwater
- ICs, including deed notices, to limit access to the site and prohibit use of water in the FWBZ and SWBZ within the IC boundaries
- Groundwater monitoring to ensure protectiveness of the chosen remedy

A Final Remedial Design Report was completed in January 2001 (TetraTech 2001). The remedial action (RA) was initiated in November 2002 and completed in September 2003. The major components of the RA included excavation, immobilization, and transport of principal threat wastes offsite and the installation of a permeable reactive barrier (PRB) in the FWBZ to neutralize acid and retard metals in the upper groundwater zone. The DM site was de-listed from the NPL in August 2005. A Five-Year Review (EPA 2007) was issued in 2007.

1.2 GEOLOGY, HYDROGEOLOGY AND CONCEPTUAL SITE MODEL

The DM site is located in a topographically flat area, with ground surface elevations that range between 5 and 15 feet above mean sea level. The site slopes west toward Selsers Creek (see Figure 1) which flows to the south. A cypress swamp is located southwest of the site across Weinberger Road and drains to Selsers Creek which also receives runoff from the site via ditches and tributaries (TetraTech 2000b).

The area includes a mix of commercial, industrial, agricultural, and residential properties with wetland areas to the south, southwest and due east. Residential property is located south and north/northwest of the facility, while the site is bounded on the south by Weinberger Road. Selsers Creek is west of the site, with residences on the west bank of the creek. Tributaries to Selsers Creek run just north of the PRB and south of the northern waste pile and acid pit area (see Figure 1).

Three distinct shallow water-bearing zones have been encountered beneath the site:

- The FWBZ extends from ground surface to a maximum of 28 ft below ground surface (bgs) but is generally found between 5 and 15 ft bgs. The FWBZ is thought to be hydraulically connected to Selsers Creek as well as the tributaries feeding Selsers Creek. The measured thickness of the FWBZ ranges from 2 to 18 feet. This zone is discontinuous across the site and is typically unconfined or semi-confined. The zone is thought to pinch out just south of MW-06 and somewhere north of Tributary 1, although the full extent of the FWBZ has not been fully delineated (based on documents reviewed). Saturated conditions exist east and southeast of MW-06, but the unit disappears or becomes unsaturated toward the south (see Appendix C, Figure 5). The FWBZ is overlain by a sandy/silty clay, and a clay unit is encountered underneath the transmissive zone.

Groundwater flow in the FWBZ is generally to the north/northwest, but may be influenced locally by discontinuities. According to the Louisiana Risk Evaluation/Corrective Action Program (RECAP), analysis of hydrology and water quality, the FWBZ is considered Class 3B (a source of a moderate quantity of water, with a total dissolved solids concentration greater than 10,000 mg/L). Under RECAP, Class 3 waters are divided into those discharging into potential drinking water sources (DW) and those that do not discharge into potential drinking water bodies (NDW). Louisiana RECAP screening levels for Class 3 waters (GW3) are listed on Table 1.

- The SWBZ is generally between 15 and 40 ft bgs and consists of layers of silt, silty clay, clayey sand, silty sand, or sand. The SWBZ appears to be confined and relatively continuous across the site, with the possible exception of one location on the north side of the property. The RECAP classification of the SWBZ is 2C, and it is not anticipated to be a water supply. The FWBZ does not overlie the SWBZ at the south of the site near Weinberger Road. Current IC's on the Delatte and NPBC property prevent use of FWBZ and SWBZ groundwater.

- The TWBZ is between 58 and 62 ft bgs, extending to a maximum depth of 100 ft bgs. This zone appears to be confined and continuous across the site. The TWBZ has historically been exploited for agricultural and domestic water supplies in the area (EPA 2000b) and is a RECAP Class 1B aquifer. The TWBZ is considered to be in the regional shallow aquifer (TetraTech 2001). Because it is considered a potential source of drinking water, MCLs are relevant water quality goals.

1.3 REMEDIAL DESIGN

The RAOs for the DM site as stated in the ROD include: 1) treat or remove the principal threat wastes; 2) reduce or eliminate the direct contact threats associated with contaminated soil; and 3) minimize or eliminate contaminant migration to ground water and surface waters to levels that ensure beneficial reuse of these resources.

The primary components of the RA relative to affected groundwater included solidification/stabilization or removal of contaminated soils (which were considered primary sources), installation of a series of PRB walls to neutralize acidic water in the FWBZ prior to discharge to the surface or lower units and groundwater monitoring of the three water-bearing zones to ensure the protectiveness of the remedies.

The PRB is a passive treatment system consisting of three segments (see Figures 1-5) in the northern area of the property. The PRB was constructed in a trench approximately 15 feet bgs and was composed of composted manure and limestone. The purpose of the PRB is to neutralize the acidic conditions of the groundwater and to precipitate lead dissolved in groundwater through geochemical interaction with the wall components. The PRB was installed in May of 2003. A performance review of the PRB was conducted by the EPA's Applied Research and Technical Support Branch using data collected between the years of 2004 and 2006. The performance review was included in the Five-Year Review (EPA 2007).

2.0 QUALITATIVE EVALUATION

The purpose of a qualitative evaluation of the monitoring network is to review the accumulated data and fundamental assumptions underlying the conceptual site model and determine if there are any outstanding data gaps that need to be addressed by modifying the monitoring program. Qualitative evaluations include evaluating historical characterization of source areas, hydrogeology, analyte list, data quality and quantity, delineation of affected media, and locations of potential receptors relative to overall site monitoring goals.

2.1 SITE CHARACTERIZATION

The DM site was extensively characterized during the RI in 1999 with results summarized in the RI document (TetraTech 2000b). The RI identifies historical sources of groundwater contaminants based on site operational history and surface soil sampling. Likely contributors to groundwater contamination include the former acid pond, slag pile and former battery chip pile in the north of the property, slag piles, on the NPBC site and the former slag pile to the south of the site.

DM geology and hydrology were investigated using Geoprobe sampling and installation of groundwater monitoring wells in addition to sampling local water supply wells screened in the TWBZ. The groundwater monitoring network is illustrated on Figure 1. Geologic cross-sections, well boring logs, and potentiometric surface maps are included in the RI report. The RI was fairly comprehensive with regard to characterizing the three groundwater units, and no significant data gaps were found in the characterization of the SWBZ and TWBZ. However, the extent of the FWBZ was not well delineated north of Tributary 1 and south of Tributary 2.

Figure 5 in Appendix C is reproduced from the ROD and indicates that the FWBZ pinches out to the north and south of the acid neutralization pond area. However, the location of the Geoprobe samples, shown on Figure 7 from the RI, along with the boring logs and cross-sections, indicate that there was insufficient data to locate the extent of the FWBZ with these data alone. No other data sources for delineation of the unit are mentioned in the RI. Additional data may be necessary to delineate the extent of affected groundwater in the FWBZ.

Delineation of the saturated extent of the FWBZ will provide data to estimate the extent and magnitude of affected groundwater and the probable discharge points to surface water and lower groundwater units. Hydrogeologic and analytical delineation of the FWBZ will help estimate the total dissolved mass of contaminants in the FWBZ to document the fate of contaminants over time and progress toward restoring the aquifer. If the FWBZ does end north of BA-9, with affected groundwater meeting a fine-grained zone, continued monitoring of the SWBZ well BA-09A and surface water in Tributary 1 is required to determine if contaminated groundwater is impacting these bodies.

As discussed in the ROD, primary source areas for contaminant migration to groundwater include the former acid neutralization ponds in the north of the site, affected soils, and various slag piles dispersed across the site. The ROD does not address the possibility of persistent secondary source areas that may contribute to groundwater contamination after removal of affected soils. The assumptions about soil-based source areas were used to develop remedial approaches and should be carefully reviewed using recent data. For example, one location where data indicate a continuing residual source of arsenic is located in the FWBZ north of the PRB, just outside of the extent of the former acid neutralization ponds. Another area that may be a continuing source of contaminants to groundwater is located east of the current FWBZ network on the NPBC property.

One purpose of LTMO is to examine the assumptions about sources put forth in the ROD and determine if these assumptions are still supported by the data. Several key assumptions articulated in the ROD and included in the conceptual site model should be reviewed with continued data collection. These assumptions include: 1) concentrations of contaminants in groundwater will attenuate when affected surface soils are removed; 2) all COCs are co-located; 3) the major FWBZ source area is inside the PRB; and 4) lead is the primary COC. Groundwater data should be collected to support a quantitative review of these assumptions.

Key Point: The saturated extent of the FWBZ should be confirmed by geologic sampling north of Tributary 1 and south of Tributary 2. Key assumptions of site source areas and fate processes should be reviewed using the full dataset.

2.2 DATA QUALITY AND QUANTITY

A groundwater analytical dataset for the DM site was supplied by EPA Region 6. Data supplied include results for arsenic, lead, manganese, nickel, and thallium at active monitoring locations from 2004 through 2008. Data collected in support of the RI and data collected from piezometers to evaluate the PRB were not available in electronic format for review. Consequently, formal evaluation of the monitoring network was based on the short list of constituents monitored in established wells from 2004 to 2008. Sampling results from the RI and piezometers were reviewed based on the data summaries and conclusions provided in site reports. Groundwater monitoring locations included in the evaluation are listed in Tables 2, 9, and 15 (corresponding with the three groundwater units) and shown on Figure 1.

Chemical analytical data were collected quarterly between January 2004 and August 2008. The density of data is sufficient to perform most statistical analyses of interest including trend evaluations. However, as noted in the first five-year review, laboratory detection limits for many samples were above conservative screening levels. High and variable detection limits introduce false trends into the data and make interpretation of site processes and data trends difficult.

Historical data from the RI, HHRA, and BERA indicate the presence of a number of metal contaminants in groundwater above preliminary screening levels for the relevant regulatory programs (see Table 1). The process by which metals were screened and prioritized or eliminated from further consideration is not made clear in the main text of the ROD and appears inconsistent with recommendations in the risk assessments. An

ARAR for lead in groundwater is stated in the ROD, but it is unclear if the ARAR for lead applies to all site groundwater or just selected zones. No discussions of arsenic, (identified as a major contaminant in the HHRA see Appendix C Table 11.1), pH, nickel, thallium, or manganese are included in the body of the ROD. ARARs for some contaminants may have been intended by way of inclusion in the text of memoranda from Region 6 risk assessors attached as appendices to the ROD (reproduced in Appendix C of this report). Other detected site contaminants are not mentioned at all.

The current analyte list for groundwater sampling (arsenic, lead, manganese, nickel, thallium, and pH) was developed in the site Operation and Maintenance (O&M) Manual (EPA 2004) based on an interpretation of the HHRA. The relationship between decisions articulated in the ROD and the O&M procedures are not clear. CERCLA mandates MCLs as ARARs and remedial goals for potential drinking water sources such as the TWBZ. However, the TWBZ is not monitored for antimony, beryllium, cadmium, chromium, or selenium, which exist in upper groundwater zones above primary MCLs and have the potential to migrate to the TWBZ (see Table 1).

A review of the HHRA indicates that arsenic and bis(2-ethylhexyl)phthalate in groundwater pose the greatest cumulative excess risk for cancer, and arsenic, thallium, manganese, and nickel exceed risk levels for non-cancer endpoints for groundwater ingestion and dermal contact. However, it is unclear if this assessment was conducted by finding the 95% upper confidence limit (UCL) of concentrations aggregated for all groundwater zones or just for TWBZ concentrations. Additional data would be needed to assess the appropriateness of the 95% UCL. No specific calculations on transport of high concentrations from upper zones to the TWBZ are included in the HHRA. The influence of pH on metal mobility was not considered. Excess risk from lead is calculated on a site-specific, cumulative basis using the IEUBK model.

In a memorandum from David Riley dated 4/26/2000 and included in the ROD as an appendix, MCLs are identified as Preliminary Remediation Goals (PRGs) for groundwater based on human health while Region 6 medium-specific screening levels (MSSLs) are identified for contaminants with no MCLs. The memorandum does not specify or distinguish between groundwater zones or areas within the IC versus areas outside of the IC. Based on the HHRA, MCLs and MSSLs are also protective for human dermal exposures resulting from FWBZ groundwater discharge to surface water. However, it is unclear if the HHRA standards and contaminants are considered official COCs with ARARs or cleanup goals for groundwater in the FWBZ and SWBZ. Decision documents do not mention modeling or calculations on how concentrations may attenuate as FWBZ and SWBZ contaminants migrate to the TWBZ or surface water. No protective concentrations are identified for FWBZ or SWBZ, so, technically, contaminants in these zones have no cleanup goals and may exist at any magnitude without triggering contingent action.

Groundwater contaminants for which human-health goals are recommended by Region 6 risk assessors include the inorganic constituents arsenic at 50 μg/L, lead at 15 μg/L, manganese at 1700 μg/L, nickel at 100 μg/L, and thallium at 2 μg/L (pH is not included). A short list of organic compounds is also included in the memorandum on human health standards for groundwater (EPA 2000). The organic compounds listed were not detected frequently and are highly hydrophobic and unlikely to be transported in groundwater; however, there is no clear explanation why they are not included in the analyte list for groundwater monitoring.

Since publication of the ROD, the MCL for arsenic has dropped from 50 µg/L to 10 µg/L, and the MCL for nickel was rescinded in 1994. The RECAP standard for arsenic for a class 3 drinking water (DW) source (FWBZ) groundwater is 50 µg/L. The RECAP standard for class 3 DW for nickel is 670 µg/L, and the MSSL is 730 µg/L. Site ARARs for groundwater were reviewed in the first five year review, and 10 µg/L arsenic and 730 µ/L nickel were identified as appropriate screening levels. However, it is unclear where these values apply because the groundwater zones and areal boundaries are not specified. Additional data have not been collected to delineate site groundwater to the new screening levels and data quality objectives to reduce detection limits below the new screening level for arsenic were not developed for the data reviewed. Also, it is unclear if more conservative screening levels or cleanup standards apply to groundwater outside of the IC boundary.

The results of the BERA indicate a number of metals in FWBZ groundwater may potentially impact ecological receptors in surface water. The BERA identified aluminum, arsenic, cadmium, copper, lead, selenium, and zinc as significant COCs for wildlife receptors exposed to groundwater discharging to surface water. Risk drivers for benthic invertebrates include aluminum, antimony, arsenic, and copper. For amphibians and fish, aluminum, cadmium, copper, lead, selenium, and zinc pose a potential risk. Additionally, the risk from aluminum is exacerbated by low pH. The BERA identified groundwater discharging to surface water as one of the affected media candidates for remediation.

In the BERA, water quality criteria (WQC) promulgated by EPA modified for water hardness are identified as likely ARARs for groundwater in the FWBZ (see Appendix C in this report or Table 3-3 in the BERA). However, in Appendix D of the ROD, where ecological PRGs are discussed, the groundwater to surface-water exposure pathway is not considered in the conceptual model, or in the development of protective standards, and no explanation is provided as to how this pathway was screened. The memorandum from Susan Roddy (dated 4/26/2000 and reproduced in Appendix C) included in the ROD indicates there are no remediation goals based on ecological risk for groundwater, even though excess risk was identified in the BERA. An explanation of how the groundwater discharge to surface-water pathway was eliminated from consideration and is not provided in the ROD, RI, or in the extensive communication between risk assessors included as an appendix to the BERA.

Future groundwater sampling, which includes a full set of site-related analytes with EPA MCLs as well as those contaminants identified in the BERA, would provide more comprehensive understanding of the site conditions. Groundwater concentrations should be delineated horizontally and vertically to the more conservative standards, and data should be collected with detection limits below these standards (e.g. 10 µg/L for arsenic and 100 µg/L for nickel). Groundwater data will contribute to a comprehensive review of ARARs and PRGs and a final determination of protective concentrations for the FWBZ and SWBZ. A supporting document that includes a clear explanation of how each contaminant found in each groundwater zone above background or conservative screening levels was screened from future consideration for each exposure pathway would clarify appropriate remedial goals and data quality objectives for the sampling program.

Key Points:

- Current data are insufficient, both in terms of quality (detection limits) and quantity (analyte list), to evaluate the status of site groundwater.

- Contaminants with complete exposure pathways have been left in place in the FWBZ and SWBZ without defined ARARS, remedial goals or protective concentrations. Because there are no numerical groundwater standards for the FWBZ and SWBZ against which to judge the efficacy of the remedy, the success or failure of the remedy currently cannot be evaluated.

- Additional data should be collected to perform a comprehensive review of ARARs and PRGs as well as potential exposure pathways.

2.3 MONITORING OBJECTIVES AND LOCATIONS

The location and frequency of groundwater monitoring points are determined by the site monitoring goals and objectives. Current groundwater monitoring objectives for the DM site include monitoring groundwater downgradient of the PRB for pH and metals and monitoring the TWBZ for increasing metals concentrations. However, no decision points related to monitoring results are articulated in site decision documents, so it is unclear how monitoring data from the FWBZ and SWBZ are to be used.

Based on the site history and overall goals of the Superfund program, the following expanded monitoring objectives are recommended to more directly address the tasks of documenting protectiveness of the remedies, accuracy of assumptions articulated in the ROD and progress toward “beneficial reuse” of the resources:

- Delineate the extent of groundwater affected above primary MCL in all three groundwater units and groundwater affected above ecological risk standards (EPA Water Quality Criteria) in the FWBZ.

- Delineate the extent of the FWBZ north of Tributary 1 and south of Tributary 2.

- Monitor concentrations of contaminants over time in the affected groundwater units.

- Monitor possible exposure pathways, such as groundwater discharge to surface-water bodies, wetlands, and lower groundwater units.

- Monitor the boundaries of the IC to ensure that concentrations do not exceed regulatory limits in offsite locations.

- Monitor groundwater in historical source areas to confirm progress toward unrestricted property use.

- Monitor locations that may indicate an impending exceedance of regulatory levels at compliance or exposure points.

2.3.1 Plume Delineation and Point-of-Compliance Wells

Delineation of affected groundwater is an important concept, as it defines the extent of impact from site activities. Most monitoring programs establish point-of-compliance (POC) locations where numerical standards must be met. Concentrations at POC locations cannot exceed the protective concentrations identified for the medium. If standards at POC wells are exceeded, installation of a contingent remedy is triggered to treat or control contaminant migration. Many times the POCs are located at property or IC boundaries or immediately upgradient of potential points of exposure, such as domestic wells and surface-water discharges.

In order to designate POC locations, protective concentrations must be known. TWBZ monitoring wells can be POC locations with MCLs and MSSLs as the concentration limit (as MCLs are mandated by CERCLA for this unit, but not expressly listed in the ROD). FWBZ POC wells would include locations near potential discharge to surface water and areas where downward transport through the fine-grained zone is most likely. Regulated concentration limits for FWBZ POC wells would be concentrations that are protective for human and ecological receptors after discharge to surface water and lower geologic units.

The FWBZ plume is not delineated to the north of the PRB for arsenic, to the west for manganese, or northeast of DW-03 for several metals. Delineation involves sampling groundwater downgradient until concentrations below conservative screening levels or at background levels are found. While Selsers Creek is most likely a flow boundary for the FWBZ, it is unclear if Tributaries 1 and 2 perform a similar function to the north and south. It also is unclear how far north groundwater exceeds MCLs for arsenic. The area downgradient of well BA-9 contains residences and is outside of the current IC, and there may be no regulatory restriction on drilling into this unit. It is not clear if more conservative screening levels apply outside of the IC. BA-9 has increasing concentration trends for arsenic and lead (see Section 3.0 and Figure 2).

The plume north of DW-03 is not delineated. The FWBZ in this area exceeds MCLs and MSSLs for arsenic, manganese, and lead, and groundwater is outside the eastern edge of the PRB, so it is untreated. Tributary 1 may not be a sufficient barrier to northward groundwater flow, so at least one additional monitoring location is required to delineate groundwater north of DW-03.

Increasing concentration trends at MW-02 indicate groundwater may be bypassing the western PRB to the south. The performance review of the PRB indicated that groundwater may be mounding behind the PRB and that hydraulic gradients vary, which may divert water around the PRB. The overall conclusion in 2006 was that the majority of groundwater was being treated by the PRB, even with hydraulic mounding. Hydraulic conditions should be evaluated annually to confirm that a substantial amount of groundwater is not bypassing the PRB.

In order to evaluate potential bypassing of the PRB, an additional monitoring location is recommended for the area between MW-02 and Selsers Creek (see Figure 5). Another new well is recommended outside of the PRB to the west which would form a line from MW-01 south to Tributary 2, to evaluate PRB performance, short-circuiting of groundwater, and possible discharge of affected groundwater to Selsers Creek. The new wells would constitute POC wells for discharge of contaminants to surface water. Piezometers installed outside the western arm of the PRB should be assessed to determine if they can provide routine monitoring data (quarterly) on groundwater passing through the PRB toward Selsers Creek. Inclusion of data collected from piezometers would enhance the understanding of the site conditions and could usefully be added to the comprehensive site database for review with data from monitoring wells.

2.3.2 Historical Source Areas

Based on historical data, an area of high lead and manganese concentrations in the FWBZ exists to the southeast of the current network near historical Geoprobe locations DD-27 and DE-27 (1390 µg/L and 1170 µg/L lead respectively see Figure 5 in Appendix C). No recent data are available for this area, so predicting possible downgradient impacts due to lead mobilization is difficult. An additional well is recommended for this area to monitor the historical source. Data from the new location would be used to determine if lead is attenuating or has the potential to migrate into the northern monitoring network. Hydrogeologic data from this area would help to confirm groundwater flow direction.

2.3.3 Surface Water

Based on site hydrogeologic data and cross-sections (TetraTech 2000b) groundwater in the FWBZ has the potential to discharge to surface water. Several reports including the Five-Year Review have recommended additional surface-water monitoring of Selsers Creek and Tributaries 1 and 2 (EPA 2007 and several quarterly O&M reports), and a surface-water monitoring program is anticipated to be added to the current site monitoring program in the near future. RECAP provides guidelines for evaluating the impact of discharge of Class 3 groundwater on surface water (LDEQ 2003).

Surface-water monitoring of Tributary 2 immediately south of MW-02, between MW-01 and DW-01 on Tributary 1 and along Selsers Creek west of the PRB, would provide information on fate of groundwater contaminants and possible discharge of affected groundwater to points of human and ecological exposure. Monitoring along Tributary 2 may indicate if groundwater from the area of MW-06 is impacting the surface. Surface-water monitoring should be conducted on the same schedule as groundwater monitoring in order to provide a comparable dataset. Surface and groundwater data should be included in a site database in order to facilitate analysis of potential migration of constituents.

Further investigation of the groundwater to surface-water interface has been proposed in addition to surface-water monitoring. As part of the expanded investigation, the recommend-ation is to calculate contaminant flux to surface water and the effect of dilution on final concentrations. In order to perform these calculations, data from the discharge points for the FWBZ should be collected from wells installed near the streams, piezometers, or temporary borings. Also, data on water flow in the tributaries and Selsers Creek at high and low stage should be collected. Actual and modeled surface-water concentrations may be compared with risk-based values from both the HHRA and BERA. The result of these calculations will be the designation of protective concentrations (groundwater concentrations that do not cause surface-water exceedances of WQC and neutral pH under low-flow conditions) for the FWBZ. Protective concentrations would be remedial goals for the FWBZ. With appropriate remedial goals, the efficacy and protectiveness of the remedy can be demonstrated.

2.3.4 PRB Monitoring

PRB efficacy should be evaluated annually due to documented variability in results of general PRB efficacy (Johnson, Thoms et al. 2008). In order to evaluate the efficacy of the PRB, all piezometers associated with PRB should be sampled for hydrogeologic parameters as well as the complete analyte list, including pH, using conservative detection limits. Piezometer data should be interpreted alongside data from permanent monitoring wells and discrepancies in trends and exceedances should be addressed.

Key Points: Four new monitoring locations are recommended for the FWBZ to delineate affected groundwater in the northern and western areas of the property. One new well is recommended to monitor a historical FWBZ lead and manganese source area to the east. Surface-water monitoring and an estimate of discharge dilution by surface water are recommended. Incorporation of some PRB piezometers into routine monitoring is recommended, and an annual comprehensive sampling of piezometers is recommended to document function of the remedy.

3.0 QUANTITATIVE EVALUATION

Data from 26 monitoring wells at depths corresponding to the FWBZ, SWBZ, and TWBZ were included in the quantitative network analysis for the DM site. Results for the statistical analyses are presented below, organized by groundwater zone.

3.1 FWBZ

A summary of FWBZ wells is presented in Table 2 with aquifer specific input parameters for the MAROS software presented in Table 3. Monitoring data for the metals arsenic, lead, manganese, nickel and thallium between 2004 and 2008 were screened to determine the priority COCs for the monitoring network using metrics for toxicity, prevalence and mobility. Screening levels for DM site groundwater contaminants used in the quantitative analysis are: arsenic 10 µg/L, lead 15 µg/L, manganese 1,700 µg/L, nickel 730 µg/L, and thallium 2 µg/L. Based on the results, lead, manganese, arsenic, and thallium are all priority constituents in the FWBZ. Arsenic is the constituent that exceeds its screening limit by the highest amount across the FWBZ and is a priority for toxicity. Manganese exceeds its screening level at the most locations across the unit. Lead is the most mobile of the constituents investigated. Most recent nickel concentrations in the FWBZ are below the current screening level, so nickel does not appear as a priority COC. Out of 180 samples collected from 2004 to 2008 in the FWBZ, only four thallium analyses show concentrations above the screening level of 2 µg/L. Thallium does not consistently exceed standards in the FWBZ. Detailed results of the screening process are located in Appendix B.

3.1.1 Plume Stability

Concentration Trends

Individual well concentration trends using the Mann-Kendall method are summarized in the table below and in Tables 4 and 5 along with summary statistics for FWBZ wells. For the metal constituents, concentration trends were evaluated for data collected between 2004 and 2008. Average concentrations calculated for arsenic, manganese, lead, and nickel were normalized by the screening levels and plotted on Figures 2 and 3. Results of the individual well Mann-Kendall trends for select metals are also illustrated on Figures 2 (for arsenic and lead) and 3 (for manganese and nickel). A summary of trend results as well as select, detailed, Mann-Kendall reports are located in Appendix B.

Trends for pH were found for the full period (2004 - 2008) and for 2006 - 2008. The trends for 2006 - 2008 were determined because data for several wells indicated a change in direction of the trend after 2006. Table 4 summarizes pH data for the FWBZ, including the average and minimum pH 2004 - 2008 for each well. For most of the locations, between 2004 and 2008 pH was increasing, stable or showed no trend. However, trend analysis 2006 to 2008 indicates decreasing or probably decreasing trends at most locations. Plots of pH vs. time are provided in Appendix B, along with the results of the Mann-Kendall trend analysis for each location.

Based on the plots, pH values appear to have gone up through 2005, peaking in 2006 and dropping after that. The performance review of the PRB was conducted in 2006. Minimum pH values were found in 2008 for locations MW-01 and BA-9 and in 2007 for MW-06 outside of the PRB. The data indicate the need for continued evaluation of PRB function or the possibility of sources outside of the PRB.

Number and percentage of total wells in each trend category

FWBZ Metal	Total Wells	Number and Percentage of Wells for Each Trend Category				
		Non Detect	PD, D	S	I, PI	No Trend
Arsenic	9	0	1 (11%)	0	2 (22%)	6 (67%)
Lead	9	0	1 (11%)	0	5 (56%)	3 (33%)
Manganese	9	0	4 (44%)	2 (22%)	2 (22%)	1 (11%)
Nickel	9	0	4 (44%)	1 (11%)	3 (33%)	1 (11%)

Note: Decreasing trend (D), Probably Decreasing trend (PD), Stable (S), Probably Increasing trend (PI), and Increasing trend (I).

Summary statistics and Mann-Kendall results for arsenic indicate elevated concentrations in the FWBZ outside of the PRB with a “hot spot” at DW-01. Based on the distribution of concentrations, a residual source area for arsenic may exist north of the PRB and south of Tributary 1. Concentration trends for individual wells indicate an increasing arsenic trend at BA-9. BA-9 is outside of the PRB, outside of the IC and downgradient of both DW-01 and Tributary 1. A strongly decreasing arsenic trend is seen at BA-3, inside the PRB.

The BA-9 analytical data are problematic in that between May 2004 and June 2006, arsenic was not detected. During this time, reporting limits for arsenic were 15 and 50 μg/L, with the exception of October 2005, where a reporting limit of 1 μg/L resulted in a detection of 1.3 μg/L. The increasing trend is probably an accurate assessment, but the reporting limits may mask the progress of increasing concentrations. A probably-increasing arsenic trend is found at MW-02, but concentrations are largely below the screening level at this location and the trend may result from an outlier datum. Most locations in the FWBZ showed variable arsenic concentrations that may be accounted for by low concentrations with changes in reporting limits.

Manganese is present above regulatory levels across the unit, with higher concentrations found at DW-02 (see Figure 3). Unlike arsenic, manganese-affected groundwater may be migrating to the southwest, with increasing concentration trends seen at MW-02 and MW-06. Decreasing manganese concentrations in groundwater were found at DW-02 and outside of the PRB at DW-01, BA-9 and DW-03 (east of the PRB). Detection limits for manganese are acceptably below the screening levels, so trends do not have to be qualified for this constituent.

Overall, concentrations of lead in the FWBZ are below the screening level, with exceedances found at BA-03 inside the PRB and DW-03 east of the PRB (see Figure 2).

However, five locations show increasing concentration trends, including BA-03 and DW-02 inside the PRB and BA-9 and DW-03 outside the PRB. As with the arsenic dataset, some reporting limits are above the screening level. Reporting limits of 125 μg/L were recorded in 2004 (action level = 15 μg/L). Because of this, non-detect values from 2004 may exaggerate trends in the data.

Both DW-03 and BA-9 show spikes in lead concentrations between June 2006 and March 2008. The increase in lead concentrations may be transient, but further monitoring is required to confirm this observation. Based on historical data, an area of high lead and manganese concentrations exists to the southeast of the current FWBZ network. With the current dataset, it is difficult to assess if lead from this area is impacting downgradient locations.

The distribution of nickel in the FWBZ resembles that of manganese, with increasing trends toward the southwest (see Figure 3), but concentrations are largely below screening levels across the unit. Well DW-02, with the highest historical nickel concentrations shows decreasing concentrations trends. Most wells in the FWBZ have less than a 30% detection frequency for thallium, which means that trend estimation is not appropriate at these locations. MW-02 is the only location that routinely exceeds screening levels for thallium, and shows no trend. Thallium is detected at BA-3 and shows an increasing trend.

Moments

Moment analysis is used to estimate the stability of groundwater plumes. Stable plumes require less monitoring effort. Moment analysis methods were used to estimate the total dissolved mass (zeroth moment), center of mass (first moment) and distribution of mass (second moment) for priority constituents in the FWBZ. The Mann-Kendall trends of the moments were determined for data between 2004 and 2008 using annually consolidated data. Annual averages for each COC and well combination were used in order to reduce the impact of scatter in the data. Estimates of the zeroth and first moments for arsenic, manganese, and lead in the FWBZ are shown in Table 6. First moments (center of mass) over time for arsenic and lead are illustrated on Figure 2 and for manganese and nickel on Figure 3.

Total dissolved mass trends indicate that, within the network, the concentration of arsenic, nickel, and manganese are mostly stable, but concentrations for lead are increasing. An increasing total mass for lead may indicate that lead is dissolving from secondary sources or entering the network from locations outside of the current network. Part of the increasing trend result may be an artifact of very high reporting limits in 2004. More data are required to confirm trends.

First moments indicate the change in the center of mass of the plume over time. For arsenic and lead in the FWBZ, the centers of mass are largely stable (see Figure 2) indicating that individual wells with increasing or decreasing concentrations are not changing enough to influence the overall distribution of mass in the network. This result indicates that the plumes are not changing rapidly or expanding within the current network and are relatively stable. However, the arsenic plume is not delineated to the north, so the expansion of the plume cannot be fully evaluated.

Second moments indicate the pattern of dilution and dispersion of mass as it moves from the center of the plume to the edges. No clear trend in second moments was found for FWBZ. For manganese, second moments show more mass is moving to the edges of the plume relative to the center. However, results for arsenic and lead indicate a fairly stable distribution of mass relative to the edges of the network.

3.1.2 Well Redundancy and Sufficiency

The spatial redundancy and sufficiency analysis included a qualitative evaluation of well locations (see Section 2.0) as well as statistical analysis. Spatial redundancy and sufficiency statistics include calculations of SF, AR, and CR to rank the importance of the well and evaluate uncertainty in the network (see Appendix A for discussion).

Because the monitoring network in the FWBZ is relatively small and each well currently performs an essential monitoring function, removal of wells from the network was not considered at this time. Preliminary results do indicate that the number of wells could be reduced in the future, after a larger, more statistically significant dataset has been collected and the plume is well delineated.

The graphical well sufficiency analyses for the FWBZ are illustrated in Appendix B. MAROS uses the Delaunay triangulation and SF calculations to identify areas within the monitoring network with high concentration uncertainties. Graphical results illustrate polygons created by the triangulation method and indicate areas of high uncertainty with a red "L" or an "E" in the center of the triangle. For FWBZ, no areas of high concentration uncertainty were found within the current network for the constituents analyzed. No new monitoring locations are recommended for areas within the current network, upgradient of the PRB. However, new locations recommended outside of the current network are discussed in Section 2.0.

3.1.3 Sampling Frequency

Table 7 summarizes the select results of the MAROS preliminary sampling frequency recommendation (result for the priority COC at each location). The Modified Cost-Effective Sampling (MCES) method evaluates overall (2004 - 2008) and recent (2006 - 2008) temporal trends and rates of concentration change, and recommends an optimized sampling frequency based on comparing the rates of concentration change.

The rate of change of priority metal concentrations for FWBZ wells is very low, but many locations show a high degree of variance in the data—in part due to variability in the reporting limits. While several wells in the FWBZ have preliminary recommendations for semiannual, annual, to biennial (every two years) sampling, the current recommendation is to maintain quarterly sampling. MAROS recommended quarterly monitoring for BA-3, DW-03, MW-01, and MW-02 based on rate of change and trend results. Quarterly monitoring has already provided a good dataset; however, high variance and detection limits for the data limit the power of the dataset to address site management decisions.

The results and recommendations for the FWBZ are summarized in Table 8. Once additional data are collected (2 -3 years), both spatially and temporally, the monitoring network can be re-evaluated to see if a reduction in monitoring effort is appropriate.

3.2 SWBZ

A summary of SWBZ wells is presented in Table 9 with aquifer specific input parameters for the MAROS software presented in Table 10. The primary goal of the monitoring network in the SWBZ is to determine if contaminants from upper strata are impacting lower units and to demonstrate continued attenuation of contaminants in the SWBZ. Monitoring data for the SWBZ were screened to determine SWBZ plume-wide priority COCs. Acidic groundwater is absent from the SWBZ, so pH was not assessed.

Thallium is the only constituent in the SWBZ overall plume found above screening levels. Lead exceeds screening levels at one location, only (BC-17). However, this is largely due to intermittent outlier concentrations, such as 94 µg/L in March 2004 at BC-25 followed by 15 quarters of non-detect results. Thallium was detected sporadically at high concentrations relative to its very low screening level in SWBZ wells, with no particular pattern. Consequently, thallium exceedances may be outliers associated with sampling rather than actual exceedances. Lead exceeds screening levels at one location, only (BC-17). Detailed results of the screening are located in Appendix B.

3.2.1 Plume Stability

Concentration Trends

Individual well concentration trends using the Mann-Kendall method for SWBZ wells are summarized in the table below and in Table 11. Results of the individual well Mann-Kendall trends for select metals are also illustrated on Figure 4 (for lead and manganese). A summary of trend results and select, detailed Mann-Kendall reports are in Appendix B.

Number and percentage of total wells in each trend category.

SWBZ Metal	Total Wells	Number and Percentage of Wells for Each Trend Category				
		Non Detect	PD, D	S	I, PI	No Trend
Arsenic	13	0	4 (31%)	1 (7%)	1 (7%)	7 (54%)
Lead	13	0	1 (7%)	0	5 (38%)	7 (54%)
Manganese	13	0	5 (38%)	3 (23%)	2 (15%)	3 (23%)
Nickel	13	0	1 (7%)	2 (15%)	2 (15%)	8 (62%)
Thallium	13	1 (7%)	0	0	0	12 (93%)

Note: Decreasing trend (D), Probably Decreasing trend (PD), Stable (S), Probably Increasing trend (PI), and Increasing trend (I).

Lead concentrations exceed screening levels only at location BC-17, which has a probably decreasing concentration trend. Some locations with concentrations below screening levels and intermittent detections indicate increasing concentration trends (MW-04, BA-09A, BC-25, BC-19, and BC-07); however, this may be an artifact of varying reporting limits. Additional data with lower, consistent reporting limits are required to confirm the concentration trends.

Manganese concentrations exceed screening levels at BA-05, in the north of the site, with probably increasing concentrations found at BA-01 and MW-03. This area of manganese-affected groundwater may be related to manganese in FWBZ near MW-06. Continued monitoring and conceptual model development in this area is recommended.

Data for thallium in the SWBZ indicate sporadic detections, with occasional high concentrations. Detection frequencies for thallium are extremely low (below 30%), so trend analysis for this dataset is not appropriate. Thallium detection frequencies for the SWBZ are shown in Table 11. Thallium detections may be an artifact of particulates in aqueous samples, and very few dissolved metal sample results with sufficiently low reporting limits are available to evaluate suspended vs. dissolved thallium in the SWBZ. Detection monitoring should continue for thallium in the SWBZ.

Moments

Table 12 lists the results of the estimates and trends for the zeroth and first moments. Trends for both manganese and lead show stable to no trend for both dissolved mass and center of mass indicating fairly stable plumes despite some increasing trends at some individual locations. The annual center of mass for both manganese and lead are illustrated on Figure 4.

Second moments for the SWBZ, which indicate the dispersion of the plume from the center to the edges, also show largely stable trends. The trend for manganese shows lower concentrations on the edge relative to the center. Stable results for the moment analyses support the conclusion that monitoring frequency may be reduced without loss of information.

3.2.2 Well Redundancy and Sufficiency

Analysis of spatial redundancy in the SWBZ indicates that locations DW-04, MW-03, and BA-01 may provide redundant information for the priority COCs. However, as wells within the current network perform detection monitoring and function to assess possible impacts to the SWBZ from historically affected soils, no wells are recommended for removal from the program at this time. Preliminary results do indicate that the number of wells could be reduced in the future, after a larger, more statistically significant dataset (with more consistent reporting limits) has been collected.

The graphical well sufficiency analyses for the SWBZ are illustrated in Appendix B. For SWBZ, no areas of high concentration uncertainty were found for the constituents analyzed. No new monitoring locations are recommended for areas within the current SWBZ network.

The SWBZ is well delineated to both the west and the north. While lead concentrations appear to be increasing to the west of BC-17, all wells are currently below screening levels and BC-17 has a decreasing concentration trend. While high manganese concentrations at MW-03 and BC-25 are of concern, no new delineation wells are recommended for the area west of MW-03, as drilling through the affected FWBZ is not recommended. Continued monitoring of manganese in the area of MW-03 and BC-25 is recommended, particularly in relation to increasing manganese trends at FWBZ well MW-06. The site conceptual model should be reviewed to explain high manganese concentrations in the MW-06, MW-03, and BA-01 groundwater locations relative to potential surface source areas.

3.2.3 Sampling Frequency

Table 13 summarizes the select results of the MAROS preliminary sampling frequency recommendation (result for the priority COC at each location). For most location and COC combinations in the SWBZ, a much-reduced sampling frequency resulted based on the rate of concentration change and the trend. Most locations have a preliminary recommendation for annual to biennial monitoring. Overall, a semiannual monitoring frequency has been recommended considering qualitative factors. Semiannual monitoring will provide a statistically significant dataset to evaluate the variance in the data in the near term and to monitor lead and manganese concentrations on the western edge of the network.

A summary of the results and recommendations for the SWBZ are listed in Table 14. Once additional data are collected (2 -3 years), both spatially from new locations and temporally, the monitoring network can be re-evaluated to determine if a reduction in monitoring effort is appropriate.

3.3 TWBZ

A summary of TWBZ wells is presented in Table 15. As only four monitoring wells are present in this groundwater unit, the MAROS software could not be used to evaluate spatial uncertainty, moments or sampling frequency (spatial analyses have a six well with detected concentrations minimum requirement). The TWBZ network serves a detection monitoring function to alert regulators if constituents are impacting this unit from upper zones.

Summary statistics and Mann-Kendall trends for metals are shown in Table 16. Summary results for the Mann-Kendall trend analysis and individual well trends for the TWBZ are located in Appendix B. None of the metals evaluated exceeded regulatory screening levels routinely. Some high concentrations were recorded for site constituents, but these results are somewhat intermittent and may be related to external sources of variability in the data. A summary of the results and recommendations for the SWBZ are listed in Table 17.

Mann-Kendall trends for arsenic were decreasing for all wells; however, reporting limits for arsenic in 2008 were up to 20 µg/L, twice the MCL. Arsenic0 concentrations are most likely stable at very low levels, but the changing reporting limits complicate data interpretation.

Some lead concentrations may appear to be increasing in the TWBZ. For location BA-01A, the average detected concentration is approximately 1.7 µg/L for 12 samples with reporting limits 0.5 to 0.1 µg/L. However, seven analyses in the early part of the record with higher reporting limits (2 to 10 µg/L) had non-detect results. Consequently, the trend reflects the sampling artifact of changing reporting limits rather than actual concentrations. As concentrations are quite low in the TWBZ, the data should be interpreted carefully with regard to the reporting limits.

4.0 FINDINGS AND RECOMMENDATIONS

Qualitative and quantitative methods have been used to evaluate the ability of the DM site groundwater monitoring network to address critical site management issues. The following findings and recommendations have been developed based on the results of this evaluation.

The most significant finding of the review of the groundwater monitoring program is that the current data are insufficient, both in terms of quality (detection limits are too high) and quantity (analyte list is not comprehensive) to evaluate the status of site groundwater. The root of this problem is the ambiguity of the ROD in addressing site ARARs and relevant remedial goals. Additional data should be collected to perform a comprehensive review of ARARs and establish PRGs for all affected media as well as potential exposure pathways. ARARs should be stated clearly so that an appropriate analyte list, detection limits, and points of compliance can be established for the site. While current site groundwater concentrations probably do not present excess risk, without clear ARARs and remedial goals, the appropriateness of the analyte list, sampling locations and analytical methods for groundwater monitoring cannot be evaluated. A clear statement of relevant numerical standards would help define the monitoring rationale and anticipated data use for each affected groundwater zone.

- *Finding:* A significant amount of data have been collected during the RI and subsequent remedy implementation and monitoring phases of site management. Due to the large amount and complexity of the data, finding critical information about the site is challenging. Site data should be organized so that stakeholders reviewing the site have access to explanatory information without investing a lot of time and effort.

- *Recommendation:* Maintain a site-wide analytical database with a complete set of historical and current analytical data for all constituents. Historical groundwater characterization data, including samples collected by Geoprobe, should be readily accessible to compare with current data. Also, supplemental data such as the piezometer samples taken to evaluate the remedy should be available to compare with data from permanent monitoring wells and predicted concentrations in the area. The database should include detection limits, sample location coordinates, sampling methods and other details that would streamline interpretation of site data. If the site contractor has already developed a comprehensive database (as referenced in the Remedial Investigation Report (TetraTech 2000b), the database should be made available to reviewers.

- *Finding:* The ROD does not explain why contaminants that were identified as posing potential risk to ecological and human receptors in risk assessments were screened from development of ARARs. Site decision documents do not clearly indicate why or how contaminants with MCLs found at high concentrations in the FWBZ should be monitored for transport to the TWBZ. The HHRA does not present sufficient information to eliminate transport of antimony, beryllium, cadmium, chromium, and selenium to the TWBZ. It is unclear why lead was considered the only site COC. Clarification of site ARARs and unambiguous designation of cleanup goals are essential to development of an appropriate monitoring program.

- *Recommendation:* Expand the analyte list to include all constituents identified in the BERA as COCs for ecological receptors including aluminum, antimony, cadmium, copper, selenium, and zinc in addition to acidity, lead, arsenic, manganese, thallium, and nickel. Historical groundwater data indicate the presence of metals exceeding conservative screening levels that are currently not included as laboratory analytes (see Table 1) and were not clearly screened in the ROD. Contaminants left in place in the FWBZ and SWBZ, subject to transport along complete exposure pathways do not currently have remedial goals. No decision points or contingent remedies have been designated should concentrations exceed MCLs and MSSLs in the TWBZ or if surface-water concentrations exceed WQC. There are currently no standards to determine if the remedy is loosing efficacy prior to an unacceptable impact on surface or drinking water sources. Additional data are required to determine if ARARs for additional metals recommended in the BERA should be included in the program.

- *Finding:* Collected data are of insufficient quality to reliably determine concentration trends for some contaminants.

- *Recommendation:* Establish analytical laboratory reporting limits significantly lower than conservative screening levels. This recommendation was also made in the recent five-year review. For detection monitoring, high reporting limits mask the presence of low concentrations of constituents, limiting the ability of the sampling program to achieve the stated goals. In the five-year review, it was reported that contaminant concentrations in the TWBZ were increasing, but this appears to be an artifact of poor data quality. Variable reporting limits introduce artificial patterns into the data analysis for samples with low concentrations. Update the data quality objectives for reporting limits and detection limits to reflect the change in screening level for arsenic (from 50 μg/L to 10 μg/L) and communicate this to contracting laboratories.

- *Finding:* The saturated extent of the FWBZ has not been delineated, and the contaminant plume in the FWBZ has not been delineated to relevant screening levels. Trend analysis indicates increasing concentrations at downgradient locations outside of the IC. What appear to be historical source areas are not being monitored. Overall, initial site assumptions articulated in the ROD should be reviewed using the best quality data.

- *Recommendation:* Install four new groundwater monitoring locations to delineate affected groundwater in the northern FWBZ outside the current extent of the network. New locations are required to evaluate the performance of the remedy, function as point of compliance wells, monitor plume stability and assess possible discharge to surface water. A fifth groundwater monitoring location is recommended for the upgradient source area defined by Geoprobe locations DD-27 and DE-27 from the RI. This area should be evaluated to determine the extent of source attenuation since the initial characterization and possible migration of residual contaminants toward the surface-water discharge points.

- *Finding:* Site documents do not contain a calculation of the effect of dilution on discharge of affected groundwater to surface water. Dilution effects may impact the review of ARARs for the FWBZ, and may actually increase the estimate of the maximum concentration that is still protective of potential surface-water receptors. Proposed surface-water sampling should be included in the overall assessment of the impact of groundwater discharge.

- *Recommendation:* Collect additional surface-water analytical data and data to determine the effect of dilution on groundwater discharge to surface water. Groundwater discharge to surface water is a potentially complete exposure pathway for which ARARs and remedial goals were not clearly developed. Protective concentrations for FWBZ groundwater discharging to surface water should be calculated. As part of these efforts, surface-water flow in the water bodies should be estimated and the effect of dilution on final concentrations should be quantified. Resulting theoretical impact to the surface water should be compared to protective surface-water standards calculated in the HHRA and in the BERA. Groundwater should be sampled near the discharge to Tributaries 1 and 2 and Selsers Creek, using the expanded analyte list.

- *Finding:* While some FWBZ monitoring locations may not need to be sampled quarterly, several locations show changing concentrations that should be monitored quarterly.

- *Recommendation:* Continue quarterly sampling for existing and new monitoring locations in the FWBZ, as well as surface water. Quarterly sampling should be conducted for 2 to 3 years, using consistently low laboratory reporting limits and the expanded analyte list until a dataset with sufficient statistical power has been developed to address site monitoring objectives listed below. Consider re-evaluating the monitoring network in 2 to 3 years. Reductions in both the number of locations and frequency of sampling may be possible in the future.

- *Finding:* The SWBZ and TWBZ are fairly well delineated and have a sufficient number of locations to achieve monitoring objectives associated with detection monitoring. The sampling frequency of SWBZ and TWBZ monitoring wells can be reduced without loss of information.

- *Recommendation:* No new monitoring locations are recommended for the SWBZ and TWBZ. No wells in the SWBZ and TWBZ are recommended for removal from the program at this time. Continue sampling residential water wells in the TWBZ at the current frequency. The frequency of sampling site monitoring wells in the SWBZ and TWBZ can be reduced to semiannual. TWBZ wells should be designated as POC locations.

- The following monitoring objectives are recommended to more directly address future site management decisions. Monitoring objectives define why, where, and how often data should be collected. Well-articulated monitoring objectives help determine the type of data analyses that will support site management decisions. For these reasons, expanded monitoring objectives should be included in site decision documents.

- Delineate the extent of groundwater affected above primary MCL in all three groundwater units and groundwater affected above ecological risk standards (EPA WQC) in the FWBZ.

- Delineate the extent of the FWBZ north of Tributary 1 and south of Tributary 2.

- Monitor concentrations of contaminants over time in the affected groundwater units.

- Monitor possible exposure pathways such as groundwater discharge to surface-water bodies, wetlands, and lower groundwater units.

- Monitor the boundaries of the IC to ensure that concentrations do not exceed regulatory limits in offsite locations.

- Monitor groundwater in historical source areas to confirm progress toward unrestricted property use.

- Monitor locations that may indicate an impending exceedance of regulatory levels at compliance or exposure points.

5.0 REFERENCES

AFCEE (2004). Monitoring and Remediation Optimization System (MAROS) 2.2 Software Users Guide. Air Force Center for Environmental Excellence. http://www.gsi-net.com/software/MAROS_V2_1Manual.pdf

AFCEE (1997). Air Force Center for Environmental Excellence, AFCEE Long-Term Monitoring Optimization Guide, http://www.afcee.brooks.af.mil.

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.

Gilbert, R. O. (1987). Statistical Methods for Environmental Pollution Monitoring. New York. Van Norstrand Reinhold.

Johnson, R. L., R. B. Thoms, O. Johnson and T. Krug (2008). "Field Evidence for Flow Reduction through a Zero-Valent Iron Permeable Reactive Barrier." Ground Water Monitoring & Remediation **28**(3): 47-55.

LDEQ (2003). Appendix H: Methods for the Development, Identification, and Application of Screening Standards and MO-1, MO-2, and MO-3 RECAP Standards. Louisiana Department of Environmental Quality. Louisiana Risk Evaluation/Corrective Action Program (RECAP).

Ridley, M.N., Johnson, V. M and Tuckfield, R. C. (1995). Cost-Effective Sampling of Ground Water Monitoring Wells. HAZMACON. San Jose, California.

Riley, D. (2000) Memorandum on Recommended Remediation Goals for Delatte Metals Site. April 26, 2000. Included in Appendix B of Record of Decision (EPA, 2000).

TetraTech (2000a).*Baseline Ecological Risk Assessment.* US Environmental Protection Agency Region 6. March 16, 2000

TetraTech (2000b).*Delatte Metal Remedial Investigation Report.* Prepared for US Environmental Protection Agency Region 6. January 2000

TetraTech (2000c).*Delatte Metals Human Health Risk Assessment.* US Environmental Protection Agency Region 6. March 3, 2000

TetraTech (2001).*Delatte Metals Final Design Report Ponchatoula, Louisiana.* Prepared for US Environmental Protection Agency Region 6. January, 2001

EPA (1992). Methods for Evaluating the Attainment of Cleanup Standards: Volume 2 Ground Water. Washington, D.C., United States Environmental Protection Agency Office of Policy Planning and Evaluation.

EPA (2000b). Record of Decision Delatte Metals Superfund Site Ponchatoula/Tangipahoa Parish, Louisiana. Dallas, TX, EPA Region 6.

EPA (2001).*Comprehensive Five-Year Review Guidance.* EPA 540-R-01-007. US Environmental Protection Agency Office of Emergency and Remedial Response.

EPA (2004). Operation and Maintenance Manual Delatte Metals Superfund Site Ponchatoula, Tangipahoa Parish, Louisiana. Dallas, TX, Prepared for EPA Region 6 by Tetra Tech EM Inc.

EPA (2004). Remedial Action Report Delatte Metals Superfund Site, Ponchatoula, Tangipahoa Parish, Louisiana EPA ID No. LAD052510344. Dallas, TX, Prepared for USEP Region 6 A by Tetra Tech EM, Inc.

EPA (2007). Five-Year Review Report Delatte Metals Superfund Site, Ponchatoula, Tangipahoa Parish, Louisiana. Dallas, TX, EPA Region 6.

TABLES

TABLE 1
GROUNDWATER SCREENING CONCENTRATIONS AND CRITERIA

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Priority Pollutant Metals	Maximum FWBZ Concentration 2004 - 2008 [ug/L]	Maximum Concentration from Remedial Investigation [ug/L]	USEPA Primary or Secondary MCLs [ug/L]	USEPA Region 6 MSSL [ug/L]	USEPA Water Quality Criteria [ug/L]	Water Quality Criteria (Adjusted for Site-Specific Hardness)	RECAP GW 3 DW [ug/L]	RECAP GW 3 NDW [ug/L]	Identified as COPC in HH Risk Assessment	Identified as COPC in Ecological Risk Assessment	Recommended Analytes for Future Groundwater Monitoring	Apparent Relevant Criteria for FWBZ [ug/L]	Type of Cleanup Standard
Aluminum		4,160,000	50* - 200*	37,000	87	87				X	X	87	Ecological
Antimony		350	6	15			6	262					
Arsenic	1,410	1,480	10	0.05	150	150	50	50	X	X	X	10	Human Health
Barium		1,500	2,000	2,600			2,000	45,000					
Beryllium		169	4	73			4	300					
Cadmium		4,740	5	18	2.2	0.9	10	10		X	X	0.9	Ecological
Chromium VI		500	100	180	11	11	50	1,900					
Cobalt		300		2,200			2,000	39,000					
Copper		791	1300	1,400	9	2.94	1,000	1,300		X	X	2.9	Ecological
Lead	490	2,320	15	15	2.5	0.57	50	50	X	X	X	0.6	Ecological
Manganese	59,600	77,100	50*	1,700					X		X	1,700	Human Health
Mercury		0.24	2	4	0.77		2	2					
Nickel	3,560	6,100		730	52	16.63	670	13,000	X		X	100	Human Health
Selenium		62	50	180	5		50	50		X	X	5	Ecological
Silver		30	100*	180		0.4	130	540					
Thallium	235	123	2	3			2	2	X		X	2	Human Health
Vanadium		3,610		260			230	4,500					
Zinc		11,200	5000*	11,000	120	38.14	5,000	8,000		X	X	38.1	Ecological

Notes:

1. Maximum concentrations of priority pollutant metals in FWBZ groundwater from USEPA Region 6 data received 12/2008. Maximum groundwater concentrations from Remedial Investigation Report (USEPA, 2000a).
2. USEPA Secondary MCLs are designated with *.
3. USEPA Region 6 MSSL = Medium Specific Screening Levels from 1999 were used as preliminary groundwater screening levels used in RI Report. Screening values for groundwater with human receptors.
4. USEPA Water Quality Critera identified as Applicable Relevant or Appropriate Requirements (ARARs) for groundwater discharging to surface water for ecological receptors at Delatte Metals from the Baseline Ecological Risk Assessment (BERA) (TetraTech, 2000). The adjusted values for hardness were determined by TetraTech in the ERA.
6. RECAP = Louisiana DEQ Risk Evaluation Corrective Action Program standards. GW3 = Values for Class 3A groundwater; DW = groundwater discharging to a drinking water source. NDW = groundwater does not discharge to a drinking water source.
7. Blank cells indicate no values available from databases or literature.
8. Ecological standards for groundwater are WQC for surface water, as no dilution calculations have been performed.

TABLE 2
FIRST WATER-BEARING ZONE MONITORING WELL NETWORK SUMMARY

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Well Name	Hydrologic Zone	Screened Interval [ft bgs]	Source or Tail (for MAROS)	Minimum Sample Date	Maximum Sample Date	Number of Samples (2004-2008)	Current Sampling Frequency	Priority Constituent	Well Description
First Water-Bearing Zone									
BA-3	1	3.0 to 13.0	S	1/1/2004	8/8/2008	20	Quarterly (+)	Lead	Monitors area upgradient from treatment wall former acid pond.
BA-9	1	7.5 to 17.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic/ Manganese	Monitors outside wall north/northeast of main waste area. Monitors efficacy of treatment.
DW-01	1	8.5 to 18.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors outside wall north of waste pits and acid pond.
DW-02	1	5.5 to 10.5	S	1/1/2004	8/8/2008	20	Quarterly (+)	Thallium	Monitors area within treatment wall upgradient of former waste piles and acid pond.
DW-03	1	5.5 to 15.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Lead	Monitors area east of former acid pond near tributary.
MW-01	1	13.0 to 28.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors area outside treatment wall near Selsers Creek. Monitors efficacy of treatment wall.
MW-02	1	5.0 to 10.0	S	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Delineates affected groundwater southwest of waste pits; monitors possible discharge to Selsers Creek (~100 ft).
MW-06	1	9.0 to 14.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Delineates affected groundwater south of main waste area and west of developed areas. Most upgradient point in FWBZ.
PW-04	1	7.0 to 17.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Delineates affected groundwater in easternmost area of FWBZ.
BC-31	1	5.5 to 15.5	T	No data					Abandoned
MW-7	1	NA	T	No data					Abandoned

Notes:

1. Wells listed are in current monitoring program. Data from USEPA Region 6, Nov. 2008. Well locations illustrated on Figure 1.
2. Groundwater zones are based on the depth of the well screened interval. The First-Water Bearing Zone (FWBZ) extends from the surface to approximately 25 ft bgs.
3. Priority constituent at each location was determined by dividing the maximum metals concentrations by the associated MCL or MSSL screening value.
   The metal with maximum ratio of concentration to screening level is the priority constituent.

TABLE 3
FIRST WATER-BEARING ZONE
AQUIFER INPUT PARAMETERS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Parameter	Value	Units
Hydraulic conductivity, average (K)	15.85	ft/day
Hydraulic gradient i	0.03	ft/ft
Porosity n	0.35	
Seepage velocity	511	ft/yr
Depth	5 -15	ft bgs
RECAP Classification	3B	
Plume Length	900	ft
Plume Width	900	ft
Distance to Receptors (Selsers Creek)	100	ft
GWFluctuations	No	--
SourceTreatment	Permeable reactive barrier/excavation	--
Contaminant Type	Metals	--
NAPLPresent	No	--
Groundwater flow direction (N/NW)	100	degrees
Source Location near Well	DW-02	--
Source X-Coordinate	3571555	ft
Source Y-Coordinate	700994.9	ft
Coordinate System	NAD 83 SP Louisiana South	
Plume Thickness	10	Feet
Priority Constituent	**Screening Levels**	
Arsenic	10	ug/L
Lead	15	ug/L
Manganese	1700	ug/L
Nickel	730	ug/L
Thallium	2	ug/L
pH	6-9	units

Notes:
1. Aquifer data from RI (TetraTech, 2000), Five-Year Review (USEPA,2007), and O&M Reports (SEMS, 2008a, SEMS, 2007).
2. Multiple source areas may exists, DW-02 was chosen as a source due to the presence of historic high concentrations.
3. A wide range of transmissivites are present in the aquifer, and groundwater velocity calculations result in a range, with values shown being the best estimate.
4. Screening levels are based on screening levels from the Five-Year Review.
5. No data for other site COCs were available.

TABLE 4
FIRST WATER-BEARING ZONE pH SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Average pH	Minimum pH	Date of Minimum pH	Mann-Kendall Trend 2004 - 2008	Mann-Kendall Trend 2006 - 2008
pH					
BA-3	4.8	3.3	1/1/2004	S	D
BA-9	3.7	3.2	8/8/2008	I	NT
DW-01	4.7	3.4	5/1/2004	I	NT
DW-02	3.3	2.3	7/1/2004	PI	D
DW-03	4.2	3.0	7/1/2004	NT	D
MW-01	3.8	3.2	8/8/2008	S	D
MW-02	3.5	2.9	1/1/2004	NT	PD
MW-06	4.1	3.5	12/1/2007	NT	PD
PW-04	4.1	3.1	7/1/2004	NT	PD

Notes

1. Screening level MSSL pH = 6 - 9.
2. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; NT = No Trend.
3. The average and minimum pH were calculated for all pH data 2004 - 2008. The sample date of the minimum pH value is shown.
4. Mann-Kendall trends for pH were found for samples 2004 - 2008 and for samples collected 2006 - 2008.
5. Well Names in **Bold** are outside of PRB.

TABLE 5
FIRST WATER-BEARING ZONE WELL TREND SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Number of Samples	Number of Detects	Percent Detection	Maximum Result [mg/L]	Max Result Above Standard?	Average Result [mg/L]	Average Result Above Standard?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
Arsenic										
BA-3	20	19	95%	**0.0412**	**Yes**	**0.0167**	**Yes**	D	D	D
BA-9	20	12	60%	**0.0388**	**Yes**	**0.0142**	**Yes**	I	I	I
DW-01	20	20	100%	**1.41**	**Yes**	**0.2292**	**Yes**	NT	NT	NT
DW-02	20	16	80%	**0.235**	**Yes**	**0.0784**	**Yes**	NT	NT	NT
DW-03	20	18	90%	**0.0906**	**Yes**	**0.0332**	**Yes**	NT	NT	NT
MW-01	20	17	85%	**0.468**	**Yes**	**0.0961**	**Yes**	NT	NT	NT
MW-02	20	13	65%	**0.0282**	**Yes**	0.0034	No	PI	PI	PI
MW-06	20	10	50%	**0.0101**	**Yes**	0.0026	No	NT	NT	NT
PW-04	20	14	70%	**0.0112**	**Yes**	0.0034	No	NT	NT	NT
Lead										
BA-3	20	15	75%	**0.49**	**Yes**	**0.1424**	**Yes**	I	I	I
BA-9	20	12	60%	0.0026	No	0.0007	No	I	I	I
DW-01	20	13	65%	**0.0535**	**Yes**	0.0053	No	NT	NT	NT
DW-02	20	12	60%	**0.0397**	**Yes**	0.0079	No	I	I	I
DW-03	20	18	90%	**0.349**	**Yes**	**0.0530**	**Yes**	I	I	I
MW-01	20	14	70%	**0.0549**	**Yes**	0.0081	No	NT	NT	NT
MW-02	20	18	90%	0.0146	No	0.0085	No	PD	S	S
MW-06	20	14	70%	0.0103	No	0.0016	No	PI	NT	PI
PW-04	20	14	70%	0.00285	No	0.0012	No	NT	PI	PI
Manganese										
BA-3	20	20	100%	**3.76**	**Yes**	**2.3**	**Yes**	NT	NT	NT
BA-9	20	20	100%	**7.48**	**Yes**	**4.7**	**Yes**	D	D	D
DW-01	20	20	100%	**11.2**	**Yes**	**5.0**	**Yes**	D	D	D
DW-02	20	20	100%	**59.6**	**Yes**	**24.7**	**Yes**	D	D	D
DW-03	20	20	100%	**11.3**	**Yes**	**3.4**	**Yes**	D	D	D
MW-01	20	20	100%	**12.8**	**Yes**	**8.7**	**Yes**	S	S	S
MW-02	20	20	100%	**4.0**	**Yes**	1.7	No	I	I	I
MW-06	20	20	100%	**4.3**	**Yes**	**2.2**	**Yes**	I	I	I
PW-04	20	20	100%	**3.9**	**Yes**	1.6	No	S	S	S
Nickel										
BA-3	20	18	90%	0.177	No	0.0744	No	I	I	I
BA-9	20	20	100%	0.52	No	0.2987	No	D	D	D
DW-01	20	20	100%	0.358	No	0.0936	No	D	D	D
DW-02	20	20	100%	**3.56**	**Yes**	**1.3042**	**Yes**	D	D	D
DW-03	20	20	100%	0.45	No	0.1313	No	D	D	D
MW-01	20	20	100%	**0.735**	**Yes**	0.4496	No	S	D	PD
MW-02	20	19	95%	0.429	No	0.1134	No	I	I	I
MW-06	20	17	85%	0.0513	No	0.0197	No	I	I	I
PW-04	20	18	90%	0.102	No	0.0392	No	NT	NT	NT

Notes

1. Trends were evaluated for data collected between 2004 and 2008.
2. Number of Samples is the number of quarterly samples for the compound at this location.
   Number of Detects is the number of times the compound has been detected for data at this location.
3. Maximum Result is the maximum concentration for the COC analyzed between 2004 and 2008.
4. Screening level Arsenic = 0.010mg/L; Lead = 0.015 mg/L; Manganese = 1.7 mg/L;
   Nickel = 0.730 mg/L; Thallium = 0.002 mg/L. Concentrations above screening levels are shown in **Bold.**
5. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; INT = Intermittent detections <30% detection frequency.
6. Mann-Kendall trend results are illustrated on Figures 2 and 3.
7. Thallium is not detected with high frequency plume-wide, and is not present above screening levels at most locations.

TABLE 5
FIRST WATER-BEARING ZONE WELL TREND SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Number of Samples	Number of Detects	Percent Detection	Maximum Result [mg/L]	Max Result Above Standard?	Average Result [mg/L]	Average Result Above Standard?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
Thallium										
BA-3	20	10	50%	**0.00267**	**Yes**	0.0007	No	I	I	I
BA-9	20	2	10%	0.000922	No	0.0002	No	INT	INT	INT
DW-01	20	4	20%	0.00105	No	0.0002	No	INT	INT	INT
DW-02	20	1	5%	**0.235**	**Yes**	**0.0118**	**Yes**	INT	INT	INT
DW-03	20	2	10%	**0.011**	**Yes**	0.0007	No	INT	INT	INT
MW-01	20	0	0%	ND	No	ND	No	ND	ND	ND
MW-02	20	13	65%	0.00159	No	0.0006	No	NT	NT	NT
MW-06	20	5	25%	0.00124	No	0.0002	No	INT	INT	INT
PW-04	20	1	5%	**0.0022**	**Yes**	0.0002	No	INT	INT	INT

WellName	Arsenic Exceeds	Arsenic Trend	Lead Exceeds	Lead Trend	Manganese Exceeds	Manganese Trend	Nickel Exceeds	Nickel Trend	Thallium Exceeds	Thallium Trend
BA-3	**Yes**	**D**	**Yes**	**I**	**Yes**	**NT**	No	I	No	I
BA-9	**Yes**	**I**	No	I	**Yes**	**D**	No	D	No	NT
DW-01	**Yes**	**NT**	No	NT	**Yes**	**D**	No	D	No	NT
DW-02	**Yes**	**NT**	No	I	**Yes**	**D**	**Yes**	**D**	**Yes**	**NT**
DW-03	**Yes**	**NT**	**Yes**	**I**	**Yes**	**D**	No	D	No	NT
MW-01	**Yes**	**NT**	No	NT	**Yes**	**S**	No	S	No	ND
MW-02*	No	PI	No	PD	No	I	No	I	No	NT
MW-06	No	NT	No	PI	**Yes**	**I**	No	I	No	I
PW-04	No	NT	No	NT	No	S	No	NT	No	NT

Notes:

1. MW-02* data for arsenic appear to have an outlier data point controlling trend. Thallium data have a number of outliers.
2. DW-02 increasing trend for lead appears to be some scattered concentrations above ND 2005 - 2007, concentrations may be trending back down.
3. MW-06 PI trend for lead appears to be controlled by two outlier data points
4. Locations and COCs with average concentrations above screening levels are shown in Bold.

TABLE 6
FIRST WATER-BEARING ZONE
MOMENT ESTIMATES AND TRENDS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Zone	Effective Sample Event Date	Estimate of Dissolved Mass [Kg]	Distance of Center of Mass from Source [ft]
Arsenic	2004	0.81	312
	2005	0.15	356
	2006	0.11	294
	2007	0.38	266
	2008	0.50	266
	Trend	**S**	**S**
Manganese	2004	125.47	223
	2005	69.49	254
	2006	91.91	258
	2007	76.58	277
	2008	65.11	269
	Trend	**S**	**I**
Lead	2004	0.01	321
	2005	0.02	277
	2006	0.08	333
	2007	0.25	327
	2008	0.12	295
	Trend	**I**	**S**

Notes:
1. Input parameters for the moment analysis are listed in Table 2.
2. Moments are based on annually consolidated concentrations.
3. Estimated mass is the total dissolved mass of the total metal within the network indicated.
5. Trends are Mann Kendall trends on the moments, S=Stable, I = Increasing.
6. First moments are illustrated on Figure 2.

TABLE 7
FIRST WATER-BEARING ZONE MCES SAMPLING FREQUENCY ANALYSIS RESULTS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Well Name	Priority Constituent	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2006-2008)	Frequency Based on Recent Data (2006-2008)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2004 - 2008)	Frequency Based on Overall Data (2004 - 2008)	MAROS Recommended Frequency	Current Sampling Frequency
FWBZ									
BA-3	Lead	-7.06E-05	S	Annual	2.29E-04	I	Quarterly	Quarterly	Quarterly
BA-9	Arsenic	3.87E-05	I	Quarterly	1.31E-05	I	Annual	Quarterly	Quarterly
DW-01	Arsenic	2.44E-05	NT	SemiAnnual	-1.75E-04	NT	Annual	SemiAnnual	Quarterly
DW-02	Thallium	-3.25E-39	S	Annual	-3.44E-05	NT	Annual	Biennial	Quarterly
DW-03	Lead	2.04E-04	PI	Quarterly	7.15E-05	I	Quarterly	Quarterly	Quarterly
MW-01	Arsenic	5.70E-05	NT	Quarterly	-7.13E-05	NT	Annual	Quarterly	Quarterly
MW-02	Manganese	4.73E-04	NT	Annual	1.40E-03	I	Quarterly	Quarterly	Quarterly
MW-06	Manganese	-1.72E-03	S	Annual	1.09E-03	I	SemiAnnual	SemiAnnual	Quarterly
PW-04	Manganese	1.31E-03	I	SemiAnnual	-2.04E-04	S	Annual	SemiAnnual	Quarterly

Notes:

1. Concentration rate of change is from linear regression calculations. 'Recent' concentration rate of change and MK trends are calculated from data collected 2006 - 2008.
2. MK trend = Mann Kendall trend. D = Decreasing, PD = Probably Decreasing, S = Stable, PI = Probably Increasing, I = Increasing; NT = No Trend.
3. Recent data frequency is the estimated sample frequency based on the recent trend.
4. Overall rate of change and MK trend are for the full data set (2004-2008) for each well. The overall result is the estimated sample frequncy based on the full data record.
6. MAROS Recommended Frequency is the final frequency from the MAROS calculations based on both recent and overall trends.
7. Current frequency is the approximate sampling frequency currently implemented.
8. The final recommended sampling frequency is based on a combination of qualitative and statistical evaluations.
9. Results for the priority constituent (based on risk ratio) are shown.

TABLE 8
FIRST WATER-BEARING ZONE FINAL RECOMMENDED MONITORING NETWORK

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

	Lines of Evidence					
WellName	**Exceedances**	**Mann Kendall Trends**	**Preliminary MAROS Frequency**	**Monitoring Rationale**	**Recommendation After Qualitative Review**	**Final Recommended Frequency**
FWBZ						
BA-3	As, Pb, Mn	Increasing for Pb and Ni, Decreasing for As.	Quarterly for Pb	Monitors area of affected groundwater before it enters PRB	Retain to evaluate PRB efficacy and source depletion	Quarterly
BA-9	As, Mn,	Increasing for As and Pb; Decreasing for Mn and Ni	Quarterly for As	Monitor area downgradient from PRB, area of arsenic	Retain to evaluate PRB efficacy and to delineate plume to north	Quarterly
DW-01	As, Mn	No trend for As and Pb, decreasing for Mn and Ni	Semi-annual for As	Monitors immediately downgradient from PRB to north between PRB and Tributrary 2	Retain to monitor efficacy of RPB and area of arsenic-affected groundwater north of PRB	Quarterly
DW-02	As, Mn, Ni and Tl	No trend for As, increasing trend for Pb, decreasing for Mn and Ni	Biennial for thallium	Monitors upgradient of PRB, higher concentration area	Retain to evaluate source area	Quarterly
DW-03	As, Pb, Mn	Increasing trend for Pb, no trend for As, decreasing for Mn	Quarterly for Pb	Monitors eastern end of PRB and any groundwater that may be escaping the PRB	Retain to monitor possible discharge to Tributary 1 and to delineate plume to NE	Quarterly
MW-01	As, Mn	No trend for As and Pb, stable for Ni and Mn	Quarterly for As	Monitors area outside of PRB, between the PRB and Selsers Creek	Retain to monitor possible discharge to Selsers Creek and efficacy of PRB	Quarterly
MW-02	None	Increasing for Mn and Ni	Quarterly for Mn	Monitors area south of PRB for groundwater going around PRB	Retain to monitor possible exposure route to Selsers Creek/Tributary 2	Quarterly
MW-06	Mn	Increasing for Mn	Semi-annual for Mn	Monitors most upgradient area of groundwaterr, south of Tributary 1	Retain to monitor source area of Mn	Quarterly
PW-04	None	Stable for Mn	Semi-annual for Mn	Monitors eastern most edge of FWBZ	Retain to delineate plume to east	Quarterly
Additional Locations						
Groundwater wells -- 4 monitoring wells outside of the PRB along possible exposure routes to delineate the plumes and monitor efficacy of PRB						
Groundwater -- 1 well (or temporary sampling location) southeast of main FWBZ network.						
Surface water monitoring locations along Tributaries 1 and 2						
Surface water monitoring locations on Selsers Creek, east of PRB						

Notes:
1. Exceedances indicate metals where the average concentration 2004 - 2008 are above the regulatory screening level. pH is below standards at all locations.
2. Mann-Kendall trends 2004 - 2008 are referenced. See Table 5 for details.
3. The Preliminary MAROS frequency is the MAROS generated recommended sampling frequency for the constituent indicated.
4. Final Recommendation based on statistical as well as qualitative evaluation.

TABLE 9
SECOND WATER-BEARING ZONE MONITORING WELL NETWORK SUMMARY

LONG-TERM MONITORING OPTIMIZATION
DELATTE METALS SUPERFUND SITE
PONCHATOULA, LOUISIANA

Well Name	Hydrologic Zone	Screened Interval [ft bgs]	Source or Tail (for MAROS)	Minimum Sample Date	Maximum Sample Date	Number of Samples (2004-2008)	Current Sampling Frequency	Priority Constituent	Well Description
Second Water-Bearing Zone									
BA-01	2	15.5 to 25.5	S	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Monitors area upgradient of treatment wall toward main developed area.
BA-05	2	8.0 to 18.0	S	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Monitors inside treatment wall in center of area of waste piles. Source area for manganese
BA-09A	2	31.5 to 41.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors area outside of treatment wall, north of site.
BC-03	2	17.5 to 27.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors area east of Delatte site, near historic residence.
BC-07	2	8.0 to 18.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors western side of main developed area.
BC-17	2	17.5 to 27.5	S	1/1/2004	8/8/2008	20	Quarterly (+)	Lead	Monitors high concentration area near former slag pile.
BC-19	2	12.0 to 22.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Delineates area west of former slag pile and former battery chip pile at Delatte.
BC-21R	2	12.0 to 17.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Monitors area of former battery chip waste pile.
BC-25	2	21.5 to 31.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Lead	Delineates plume on western edge of Mn-Pb
DW-04	2	27.5 to 37.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Thallium	Monitors western fence-line near center of site, near developed area.
MW-03	2	17.0 to 27.0	T	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Monitors fence-line of Delatte, Mn plume moving N/NW
MW-04	2	13.5 to 23.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	None	Northern delineation point for SWBZ near residences.
MW-A	2	16.5 to 26.5	T	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors inside treatment wall in center of area of waste piles.
BC-01	2	16.0 to 26.0	T	Limited Data (3 samples in 2004)				--	Closed
BC-11	2	18.0 to 28.0	T	Limited Data (3 samples in 2004)				--	Closed
BC-27	2	17.5 to 27.5	T	Limited Data (3 samples in 2004)				--	Closed
MW-5	2	14.5 to 19.5	T	Limited Data (3 samples in 2004)				--	Closed

Notes:

1. Wells listed are in current monitoring program. Data from USEPA Region 6, Nov. 2008. Well locations illustrated on Figure 1.
2. Groundwater zones are based on the depth of the well screened interval. The Second-Water Bearing Zone (SWBZ) extends from approximately 20 ft bgs to 40 ft bgs.
3. Priority constituent at each location was determined by dividing the maximum metals concentrations by the associated regulatory screening value.
   The metal with maximum ratio of concentration to screening level is the priority constituent.

TABLE 10
SECOND WATER-BEARING ZONE
AQUIFER INPUT PARAMETERS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Parameter	Value	Units
Hydraulic conductivity, average (K)	0.53	ft/day
Hydraulic gradient i	0.01	ft/ft
Porosity n	0.5	
Seepage velocity	3.9	ft/yr
Depth	20 -40	ft bgs
RECAP Classification	2C	
Plume Length	1500	ft
Plume Width	600	ft
Distance to Receptors (Selsers Creek)	160	ft
GWFluctuations	No	--
SourceTreatment	Excavation of surface piles	--
Contaminant Type	Metals	--
NAPLPresent	No	--
Groundwater flow direction (W/NW)	180	degrees
Source Location near Well	BC-17	--
Source X-Coordinate	3571685.22	ft
Source Y-Coordinate	700232.77	ft
Coordinate System	NAD 83 SP Louisiana South	
Plume Thickness	10	Feet
Priority Constituent	**Cleanup Goals**	
Arsenic	10	ug/L
Lead	15	ug/L
Manganese	1700	ug/L
Nickel	730	ug/L
Thallium	2	ug/L
pH	6-9	units

Notes:
1. Aquifer data from RI (TetraTech, 2000), Five-Year Review (USEPA,2007), and O&M Reports (SEMS, 2008a, SEMS, 2007).
2. Multiple source areas may exists, BC-17 was chosen as a source due to the presence of historic high concentrations.
3. A wide range of transmissivites are present in the aquifer, and groundwater velocity calculations result in a range, with values shown being the best estimate.
4. Screening levels are based on screening levels in the Five-Year Review.
5. No data for other site COCs were available.

TABLE 11
SECOND WATER-BEARING ZONE WELL TREND SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Number of Samples	Number of Detects	Percent Detection	Maximum Result [ug/L]	Max Result Above Standard?	Average Result [ug/L]	Average Result Above Standard?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
Arsenic										
BA-01	20	15	75%	**13**	**Yes**	3.20	No	NT	NT	NT
BA-05	20	16	80%	**18.7**	**Yes**	4.21	No	NT	NT	NT
BA-09A	20	17	85%	**11.2**	**Yes**	3.30	No	NT	NT	NT
BC-03	20	16	80%	**14.3**	**Yes**	3.31	No	PD	PD	PD
BC-07	20	15	75%	**14.3**	**Yes**	3.06	No	D	D	D
BC-17	20	17	85%	**11.2**	**Yes**	4.95	No	S	S	S
BC-19	20	16	80%	**13.6**	**Yes**	2.97	No	NT	PD	S
BC-21R	20	14	70%	9.5	No	1.83	No	NT	NT	NT
BC-25	20	14	70%	**11.7**	**Yes**	2.19	No	NT	NT	NT
DW-04	20	15	75%	**12.5**	**Yes**	2.68	No	PD	D	D
MW-03	20	13	65%	**12.6**	**Yes**	2.14	No	D	D	D
MW-04	20	12	60%	9.9	No	1.55	No	PI	NT	PI
MW-A	20	15	75%	**18.8**	**Yes**	2.36	No	NT	NT	NT
Lead										
BA-01	20	13	65%	**17.3**	**Yes**	1.90	No	NT	NT	NT
BA-05	20	13	65%	6.8	No	1.11	No	NT	NT	NT
BA-09A	20	12	60%	0.857	No	0.38	No	I	I	I
BC-03	20	15	75%	3.2	No	1.31	No	NT	PI	PI
BC-07	20	13	65%	2.5	No	0.68	No	I	I	I
BC-17	20	20	100%	**469**	**Yes**	**147.15**	**Yes**	PD	S	S
BC-19	20	15	75%	2.7	No	0.64	No	I	PI	PI
BC-21R	20	11	55%	2.4	No	0.56	No	NT	NT	NT
BC-25	20	11	55%	2.3	No	0.52	No	I	I	I
DW-04	20	14	70%	9.9	No	3.12	No	NT	NT	NT
MW-03	20	12	60%	4.8	No	1.11	No	NT	I	PI
MW-04	20	14	70%	5.34	No	0.83	No	PI	PI	PI
MW-A	20	12	60%	4	No	0.84	No	NT	NT	NT
Manganese										
BA-01	20	20	100%	1460	No	875.6	No	PI	NT	PI
BA-05	20	20	100%	**31,400**	**Yes**	**12,952**	**Yes**	D	D	D
BA-09A	20	20	100%	98.7	No	47.6	No	PD	D	D
BC-03	20	20	100%	119	No	34.9	No	D	D	D
BC-07	20	20	100%	189	No	86.7	No	S	NT	S
BC-17	20	20	100%	1680	No	515.6	No	D	S	PD
BC-19	20	18	90%	147	No	30.8	No	NT	NT	NT
BC-21R	20	18	90%	182	No	61.5	No	NT	NT	NT
BC-25	20	20	100%	770	No	269.3	No	D	PD	D
DW-04	20	20	100%	87	No	56.8	No	S	I	PI
MW-03	20	20	100%	1480	No	920.1	No	PI	NT	PI
MW-04	20	19	95%	67.8	No	14.0	No	NT	NT	NT
MW-A	20	17	85%	19.4	No	7.8	No	S	NT	S
Thallium										
BA-01	20	1	5%	1.7	No	0.18	No	NT	PD	ND*
BA-05	20	2	10%	1.64	No	0.23	No	NT	NT	INT
BA-09A	20	1	5%	0.833	No	0.14	No	NT	NT	ND*
BC-03	20	1	5%	0.904	No	0.14	No	NT	PI	ND*
BC-07	20	2	10%	0.682	No	0.15	No	NT	I	INT
BC-17	20	5	25%	**14.5**	**Yes**	1.22	No	NT	PD	INT
BC-19	20	3	15%	**21.1**	**Yes**	1.54	No	NT	D	INT
BC-21R	20	2	10%	1.7	No	0.20	No	NT	NT	INT
BC-25	20	2	10%	**94**	**Yes**	**4.82**	**Yes**	NT	NT	INT
DW-04	20	3	15%	**25.5**	**Yes**	1.42	No	NT	NT	INT
MW-03	20	1	5%	0.499	No	0.12	No	NT	PI	ND*
MW-04	20	1	5%	0.868	No	0.14	No	NT	NT	ND*
MW-A	20	0	0%	ND	No	ND	No	ND	ND	ND

Notes

1. Trends were evaluated for data collected between 2004 and 2008.
2. Number of Samples is the number of quarterly samples for the compound at this location.
   Number of Detects is the number of times the compound has been detected for data at this location.
3. Maximum Result is the maximum concentration for the COC analyzed between 2004 and 2008.
4. Screening levels from Five-Year Review; Arsenic = 0.010mg/L; Lead = 0.015 mg/L; Manganese = 1.7 mg/L;
   Nickel = 0.73 mg/L; Thallium = 0.002 mg/L.
5. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; ND* = Non-detect except for one trace value; INT = Intermittent detection <30% detection frequency..
6. Mann-Kendall trend results are illustrated on Figure 4.
7. Nickel concentrations did not exceed screening levels in the SWBZ.

TABLE 11
SECOND WATER-BEARING ZONE WELL TREND SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Arsenic Exceeds	Arsenic Trend	Lead Exceeds	Lead Trend	Manganese Exceeds	Manganese Trend	Thallium Exceeds	Thallium Trend
BA-01	No	NT	No	NT	No	PI	No	ND*
BA-05	No	NT	No	NT	**Yes**	**D**	No	INT
BA-09A	No	NT	No	I	No	PD	No	ND*
BC-03	No	PD	No	NT	No	D	No	ND*
BC-07	No	D	No	I	No	S	No	INT
BC-17	No	S	**Yes**	**PD**	No	D	No	INT
BC-19	No	NT	No	I	No	NT	No	INT
BC-21R	No	NT	No	NT	No	NT	No	INT
BC-25	No	NT	No	I	No	D	**Yes**	**INT**
DW-04	No	PD	No	NT	No	S	No	INT
MW-03	No	D	No	NT	No	PI	No	ND*
MW-04	No	PI	No	PI	No	NT	No	ND*
MW-A	No	NT	No	NT	No	S	No	ND

TABLE 12
SECOND WATER-BEARING ZONE
MOMENT ESTIMATES AND TRENDS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

COC	Effective Sample Event Date	Estimate of Dissolved Mass [Kg]	Distance of Center of Mass from Source [ft]
Manganese	2004	11.50	522
	2005	9.15	498
	2006	7.66	521
	2007	9.56	578
	2008	9.44	576
	Trend	**NT**	**NT**
Lead	2004	0.09	128
	2005	0.10	79
	2006	0.14	60
	2007	0.23	104
	2008	0.11	129
	Trend	**S**	**NT**

Notes:
1. Input parameters for the moment analysis are listed in Table 9.
2. Moments are based on all wells sampled during the year indicated.
   Sampling data were averaged over the year to determine consolidated value.
3. Estimated mass is the total dissolved mass of the total metal within the network indicated.
4. Trends are Mann Kendall trends on the moments, S=Stable, NT = No Trend.
5. First moments are illustrated on Figure 4.

TABLE 13
SECOND WATER-BEARING ZONE MCES SAMPLING FREQUENCY ANALYSIS RESULTS

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Well Name	Priority Constituent	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2006-2008)	Frequency Based on Recent Data (2006-2008)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2004 - 2008)	Frequency Based on Overall Data (2004 - 2008)	MAROS Recommended Frequency	Current Sampling Frequency
SWBZ									
BA-01	Manganese	6.65E-04	PI	Annual	1.62E-04	PI	Annual	Annual	Quarterly
BA-05	Manganese	-1.08E-03	S	Annual	-7.64E-03	D	Annual	Annual	Quarterly
BA-09A	Manganese	5.47E-06	NT	Annual	-1.66E-05	PD	Annual	Biennial	Quarterly
BC-03	Manganese	-5.49E-06	S	Annual	-2.32E-05	D	Annual	Biennial	Quarterly
BC-07	Manganese	7.28E-06	NT	Annual	-1.47E-06	S	Annual	Biennial	Quarterly
BC-17	Lead	-1.39E-04	NT	Annual	-6.62E-05	PD	Annual	Annual	Quarterly
BC-19	Manganese	1.61E-05	NT	Annual	-4.42E-06	NT	Annual	Biennial	Quarterly
BC-21R	Manganese	4.01E-05	NT	Annual	2.05E-05	NT	Annual	Biennial	Quarterly
BC-25	Thallium	1.36E-07	NT	Annual	-1.27E-05	NT	Annual	Biennial	Quarterly
DW-04	Manganese	-3.36E-05	D	Annual	-7.08E-07	S	Annual	Biennial	Quarterly
MW-03	Manganese	-1.19E-04	S	Annual	1.58E-04	PI	Annual	Annual	Quarterly
MW-04	Manganese	1.52E-05	NT	Annual	9.24E-07	NT	Annual	Biennial	Quarterly
MW-A	Manganese	1.38E-06	NT	Annual	-5.52E-07	S	Annual	Biennial	Quarterly

Notes:
1. Concentration rate of change is from linear regression calculations. 'Recent' concentration rate of change and MK trends are calculated from data collected 2006 - 2008.
2. MK trend = Mann Kendall trend. D = Decreasing, PD = Probably Decreasing, S = Stable, PI = Probably Increasing, I = Increasing; NT = No Trend.
3. Recent data frequency is the estimated sample frequency based on the recent trend.
4. Overall rate of change and MK trend are for the full data set (2004-2008) for each well. The overall result is the estimated sample frequncy based on the full data record.
6. MAROS Recommended Frequency is the final frequency from the MAROS calculations based on both recent and overall trends.
7. Current frequency is the approximate sampling frequency currently implemented.
8. The final recommended sampling frequency is based on a combination of qualitative and statistical evaluations.
9. Results for the priority constituent (based on risk ratio) are shown.

TABLE 14
SECOND WATER-BEARING ZONE FINAL RECOMMENDED MONITORING NETWORK

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Well Name	Lines of Evidence					
	Exceedances	Mann Kendall Trends	Preliminary MAROS Frequency	Monitoring Rationale	Recommendation After Qualitative Review	Final Recommended Frequency
SWBZ						
BA-01	(None)	Probably increasing trend for Mn	Annual for Mn	Monitors Mn affected groundwater in northern area of SWBZ plume.	Retain to evaluate Mn concentrations	Semiannual
BA-05	Mn	Decreasing trend for Mn	Annual for Mn	Monitors area of highest Mn concentration in SWBZ	Retain to evaluate Mn source concentrations	Semiannual
BA-09A	(None)		Biennial for Mn	Monitors northernmost area of SWBZ (with the exception of MW-05, for which there is no data).	Retain to delineate plume to north.	Semiannual
BC-03	(None)		Biennial for Mn	Monitors southernmost area of the SWBZ	Retain to delineate plume to south.	Semiannual
BC-07	(None)		Biennial for Mn	Delineates southwestern edge of plume	Retain to delineate plume to the southwest.	Semiannual
BC-17	Pb	Decreasing trend for Mn, probably decreasing trend for Pb	Annual for Pb	Monitors area of highest Pb concentration and high Mn concentration in the SWBZ	Retain to monitor source area	Semiannual
BC-19	(None)		Biennial for Mn	Monitors and delineates area downgradient from BC-17 source area	Retain to delineate plume to west and monitor possible expansion of plume.	Semiannual
BC-21R	(None)		Biennial for Mn	Monitors low concentration area between southern and northern property areas.	Retain to monitor southern area of MN affected groundwater and northern limit of Pb affected groundwater.	Semiannual
BC-25	Tl	No trend for Tl	Biennial for Tl	Monitors western edge of high Mn and Tl concentrations.	Retain to delineate plume to west.	Semiannual
DW-04	(None)		Biennial for Mn	Delineates southwestern edge of Pb plume, south of former furnace building.	Retain to delineate Pb plume in southwest.	Semiannual
MW-03	(None)	Probably increasing trend for Mn	Annual for Mn	Monitors area of high Mn concentration	Retain to monitor area of high and possibly increasing MN	Semiannual
MW-04	(None)		Biennial for Mn	Monitors northeast corner of SWBZ	Retain to delineate plume to the northeast.	Semiannual
MW-A	(None)		Biennial for Mn	Delineates northern Mn plume to the west.	Retain to delineate Mn plume to the west.	Semiannual

Notes:
1. Exceedances indicate metals where the average concentration 2004 - 2008 are above the regulatory screening level.
2. Mann-Kendall trends 2004 - 2008 are referenced. See Table 11 for details.
3. The Preliminary MAROS frequency is the MAROS generated recommended sampling frequency for the constituent indicated.
4. Final Recommendation based on statistical as well as qualitative evaluation.

TABLE 15
THIRD WATER-BEARING ZONE MONITORING WELL NETWORK SUMMARY

LONG-TERM MONITORING OPTIMIZATION
DELATTE METALS SUPERFUND SITE
PONCHATOULA, LOUISIANA

Well Name	Hydrologic Zone	Screened Interval [ft bgs]	Source or Tail (for MAROS)	Minimum Sample Date	Maximum Sample Date	Number of Samples (2004-2008)	Current Sampling Frequency	Priority Constituent	Well Description
Third Water-Bearing Zone									
BA-01A	3	35.5 to 45.5	--	1/1/2004	8/8/2008	20	Quarterly (+)	Manganese	Monitors area under Mn plume, northern area of Site
BA-03A	3	89.5 to 99.5	--	1/1/2004	8/8/2008	20	Quarterly (+)	Thallium	Monitors western edge of Site
BA-05A	3	36.0 to 39.5	--	1/1/2004	8/8/2008	20	Quarterly (+)	Arsenic	Monitors northern end of Delatte Site
BB-01	3	85.5 to 95.5	--	1/1/2004	8/8/2008	20	Quarterly (+)	Lead	Monitors southern end of Delatte Site

Notes:

1. Wells listed are in current monitoring program. Data from USEPA Region 6, Nov. 2008. Well locations illustrated on Figure 1.
2. Groundwater zones are based on the depth of the well screened interval. The Third-Water Bearing Zone (TWBZ) from 58 to 100 ft bgs.
3. Priority constituent at each location was determined by dividing the maximum metals concentrations by the associated regulatory screening value.

TABLE 16
THIRD WATER-BEARING ZONE WELL TREND SUMMARY RESULTS: 2004-2008

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

WellName	Number of Samples	Number of Detects	Percent Detection	Maximum Result [ug/L]	Max Result Above Standard?	Average Result [ug/L]	Average Result Above Standard?	Mann-Kendall Trend	Linear Regression Trend
Arsenic									
BA-01A	20	16	80%	**16.8**	**Yes**	6.47	No	D	S
BA-03A	20	17	85%	**11.3**	**Yes**	2.91	No	D	S
BA-05A	20	17	85%	**11.3**	**Yes**	3.35	No	D	S
BB-01	20	17	85%	**18.7**	**Yes**	6.62	No	D	S
Lead									
BA-01A	20	12	60%	4.9	No	1.06	No	I	I
BA-03A	20	17	85%	14.6	No	5.53	No	S	PI
BA-05A	20	11	55%	6.6	No	2.05	No	NT	I
BB-01	20	17	85%	**15.2**	**Yes**	8.59	No	NT	PI
Manganese									
BA-01A	20	20	100%	1370	No	91.9	No	D	NT
BA-03A	20	20	100%	68.2	No	38.6	No	D	D
BA-05A	20	20	100%	54.4	No	31.9	No	NT	NT
BB-01	20	18	90%	13.8	No	5.8	No	NT	PI
Nickel									
BA-01A	20	16	80%	22	No	2.49	No	NT	NT
BA-03A	20	16	80%	5.2	No	1.89	No	S	S
BA-05A	20	16	80%	50.1	No	3.56	No	NT	NT
BB-01	20	17	85%	3.7	No	1.91	No	S	NT
Thallium									
BA-01A	20	2	10%	0.489	No	0.12	No	INT	INT
BA-03A	20	3	15%	**2.2**	**Yes**	0.34	No	INT	INT
BA-05A	20	0	0%	ND	No	ND	No	ND	ND
BB-01	20	0	0%	ND	No	ND	No	ND	ND

WellName	Arsenic Exceeds	Arsenic Trend	Lead Exceeds	Lead Trend	Manganese Exceeds	Manganese Trend	Thallium Exceeds	Thallium Trend
BA-01	No	D	No	I	No	D	No	INT
BA-05	No	D	No	S	No	D	No	INT
BA-09A	No	D	No	NT	No	NT	No	ND
BC-03	No	D	No	NT	No	NT	No	ND

Notes
1. Trends were evaluated for data collected between 2004 and 2008.
2. Number of Samples is the number of quarterly samples for the compound at this location.
   Number of Detects is the number of times the compound has been detected for data at this location.
3. Maximum Result is the maximum concentration for the COC analyzed between 2004 and 2008.
4. Screening levels Arsenic = 0.010 mg/L; Lead = 0.015 mg/L; Manganese = 1.7 mg/L;
   Nickel = 0.730 mg/L; Thallium = 0.002 mg/L.
5. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; INT = Intermittent detection <30% detection frequency.

TABLE 17
THIRD WATER-BEARING ZONE FINAL RECOMMENDED MONITORING NETWORK

LONG-TERM MONITORING OPTIMIZATION
Delatte Metals, Ponchatoula, Louisiana

Well Name	Lines of Evidence					
	Exceedances	Mann Kendall Trends	Preliminary MAROS Frequency	Monitoring Rationale	Recommendation After Qualitative Review	Final Recommended Frequency
TWBZ						
BA-01A	(None)	Probably increasing trend for Mn	--	Monitors area under Mn plume, northern area of Site	Retain to evaluate Mn concentrations in north	Semiannual
BA-03A	(None)	Decreasing trend for Mn	--	Monitors western edge of Site	Retain to western edge of TWBZ	Semiannual
BA-05A	(None)	Increasing trend for Pb	--	Monitors northern end of Delatte Site	Rretain to delineate plume to north.	Semiannual
BB-01	(None)	Decreasing trend for Mn	--	Monitors southern end of Delatte Site	Retain to delineate plume to south.	Semiannual

Notes:
1. Exceedances indicate metals where the average concentration 2004 - 2008 are above the regulatory screening level.
2. Mann-Kendall trends 2004 - 2008 are referenced. See Table 16 for details.
3. The Preliminary MAROS frequency was not evaluated for the TWBZ, due to the limited number of locations.
4. Final Recommendation based on statistical as well as qualitative evaluation.

FIGURES

LEGEND

Monitoring Well Locations

- First Water-Bearing Zone
- Second Water-Bearing Zone
- Third Water-Bearing Zone
- Closed or abandoned well

- PRB Wall
- Delatte Boundary (approx.)
- Approximate extent of FGWBZ

Scale (ft)

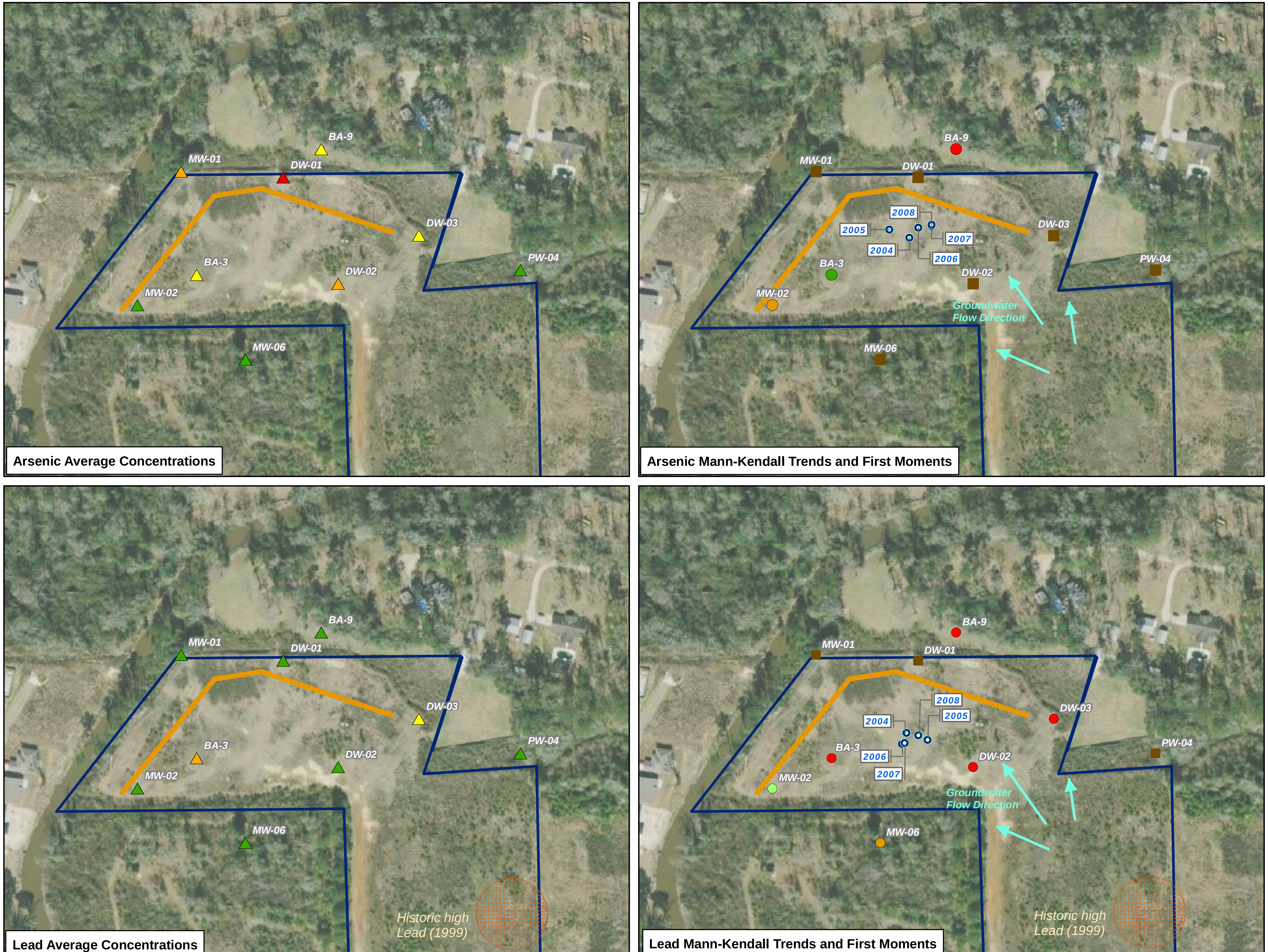
0 90 180

GROUNDWATER MONITORING LOCATIONS

Delatte Metals Site

Ponchatoula, Louisiana

Coord sys:	WGS 84 UTM 15N	Issued:	14-SEPT-2009
Drawn By:	MV/cdm	Revised:	
Ck'd By:	MV	Map ID:	
Appv'd By:	MV		**Figure 1**



N

LEGEND

- PRB Wall
- Delatte Boundary (approx.)
- First Moments (Center of Mass)

Ratio of Average Concentration to Screening Level

- 0 - 1.0
- 1.0 - 5.0
- 5.0 - 10
- 10 - 100

Mann-Kendall Trends

- Increasing
- Probably Increasing
- Stable
- Probably Decreasing
- Decreasing
- No Trend

Notes:

1) Mann-Kendall trends 2004 - 2008.
2) Historic area of high lead concentrations from 1999 RI data - geoprobe DD-27 and DE-27.
3) General groundwater flow direction from potentiometric map 3rd quarter 2008.

Scale (ft)

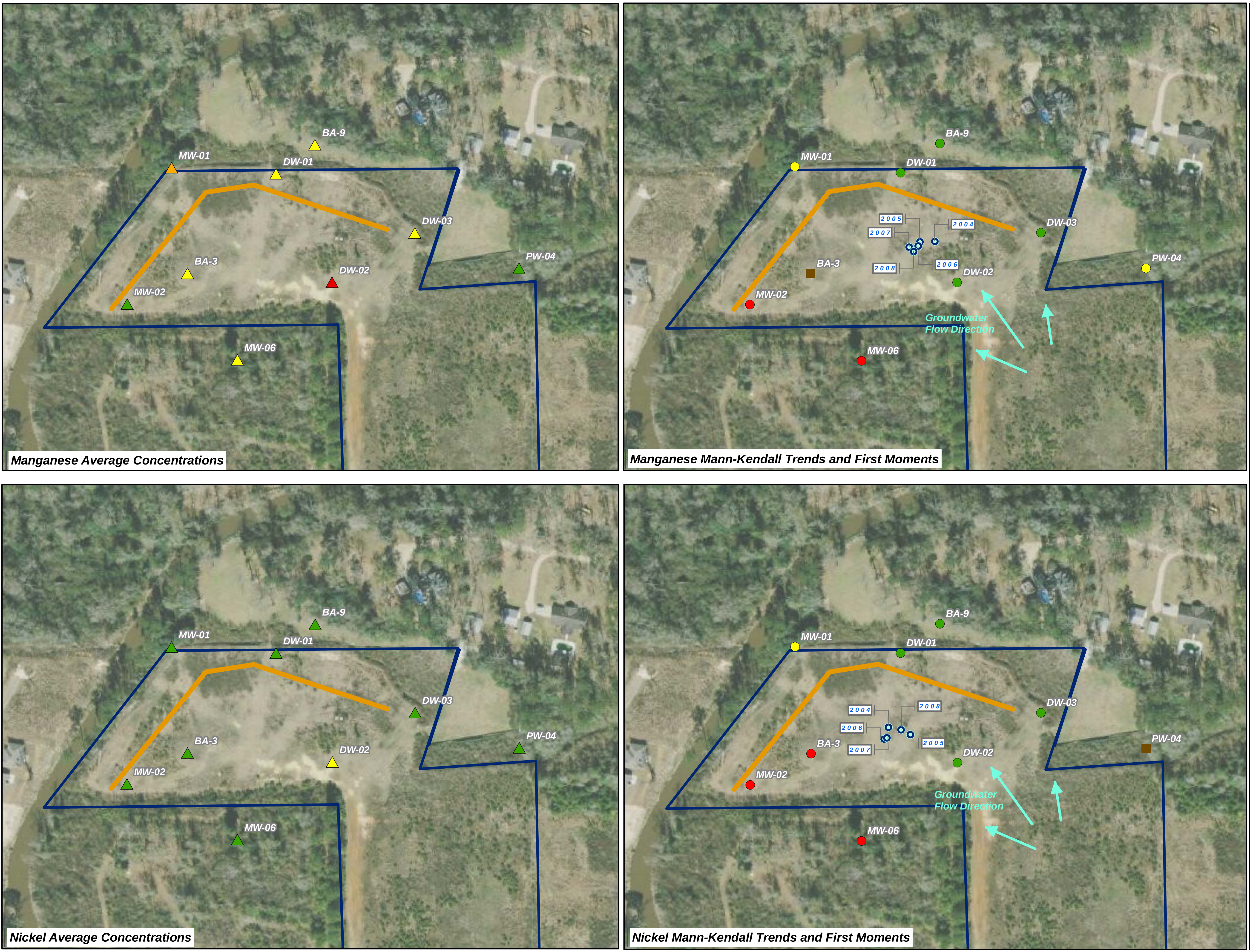
0 100 200

FWBZ MANN-KENDALL TRENDS AND FIRST MOMENTS ARSENIC AND LEAD

Delatte Metals Site

Ponchatoula, Louisiana

Coord sys:	WGS 84 UTM 15N	Issued:	14-SEPT-2009
Drawn By:	MV/cdm	Revised:	
Ck'd By:	MV	Map ID:	
Appv'd By:	MV		Figure 2



N

Legend

PRB Wall

Delatte Boundary (approx.)

First Moments (Center of Mass)

Ratio of Average Concentration to Screening Level

- 0 - 1.0
- 1.0 - 5.0
- 5.0 - 10
- 10 - 100

Mann-Kendall Trends

- Increasing
- Probably Increasing
- Stable
- Probably Decreasing
- Decreasing
- No Trend

Notes:

1) Mann-Kendall trends 2004 - 2008.

2) General groundwater flow direction from potentiometric map 3rd quarter 2008.

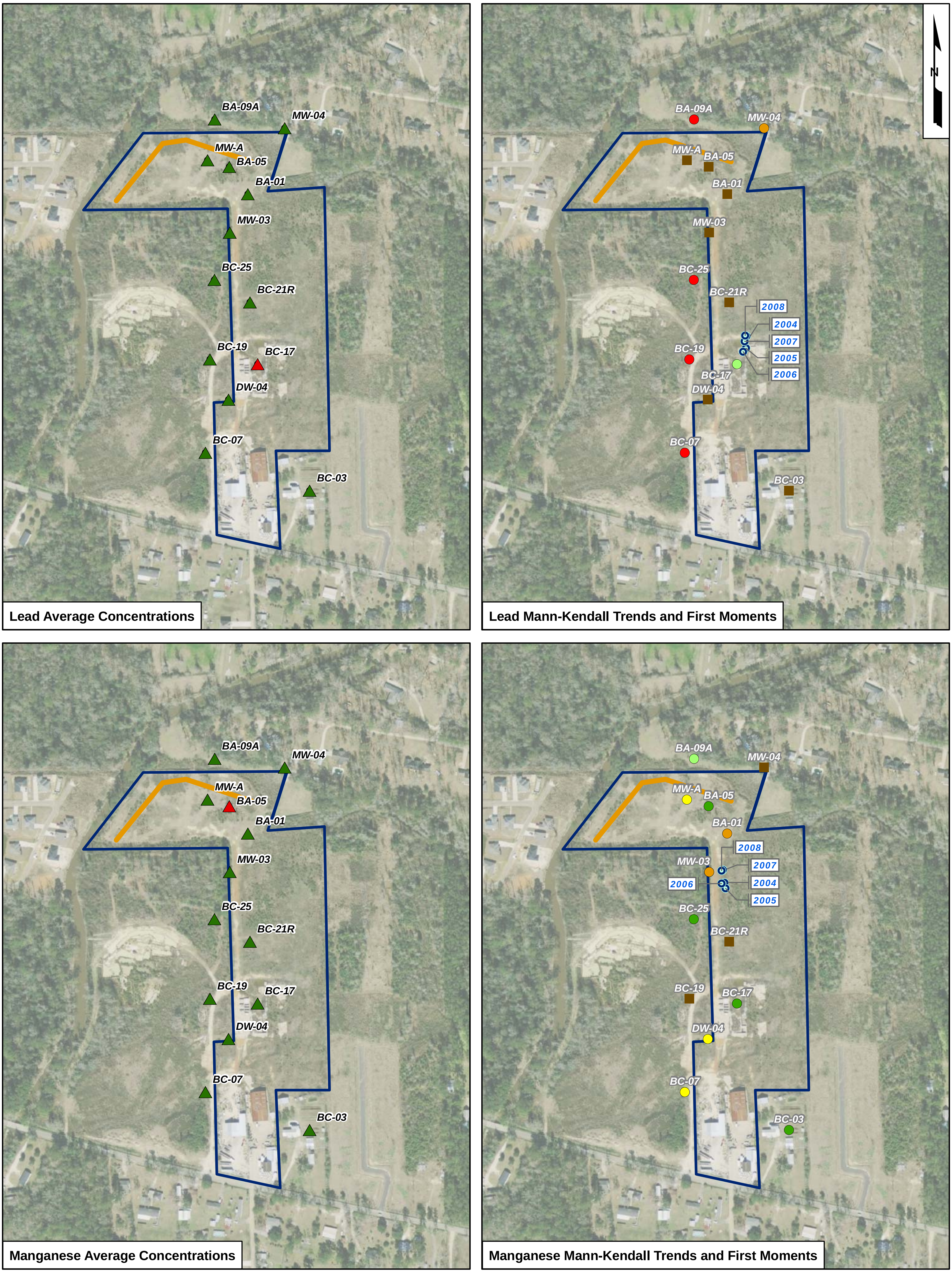
Scale (ft)
0 100 200

FWBZ MANN-KENDALL TRENDS AND FIRST MOMENTS MANGANESE AND NICKEL

Delatte Metals Site

Ponchatoula, Louisiana

Coord sys: WGS 84 UTM 15N		Issued: 14-SEPT-2009	
Drawn By: MV		Revised:	
Ckd By: MV		Map ID:	
Appv'd By:		Figure 3	



LEGEND

PRB Wall
Delatte Boundary (approx.)
First Moments (Center of Mass)

Ratio of Average Concentration to Screening Level

- 0 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0

Mann-Kendall Trends

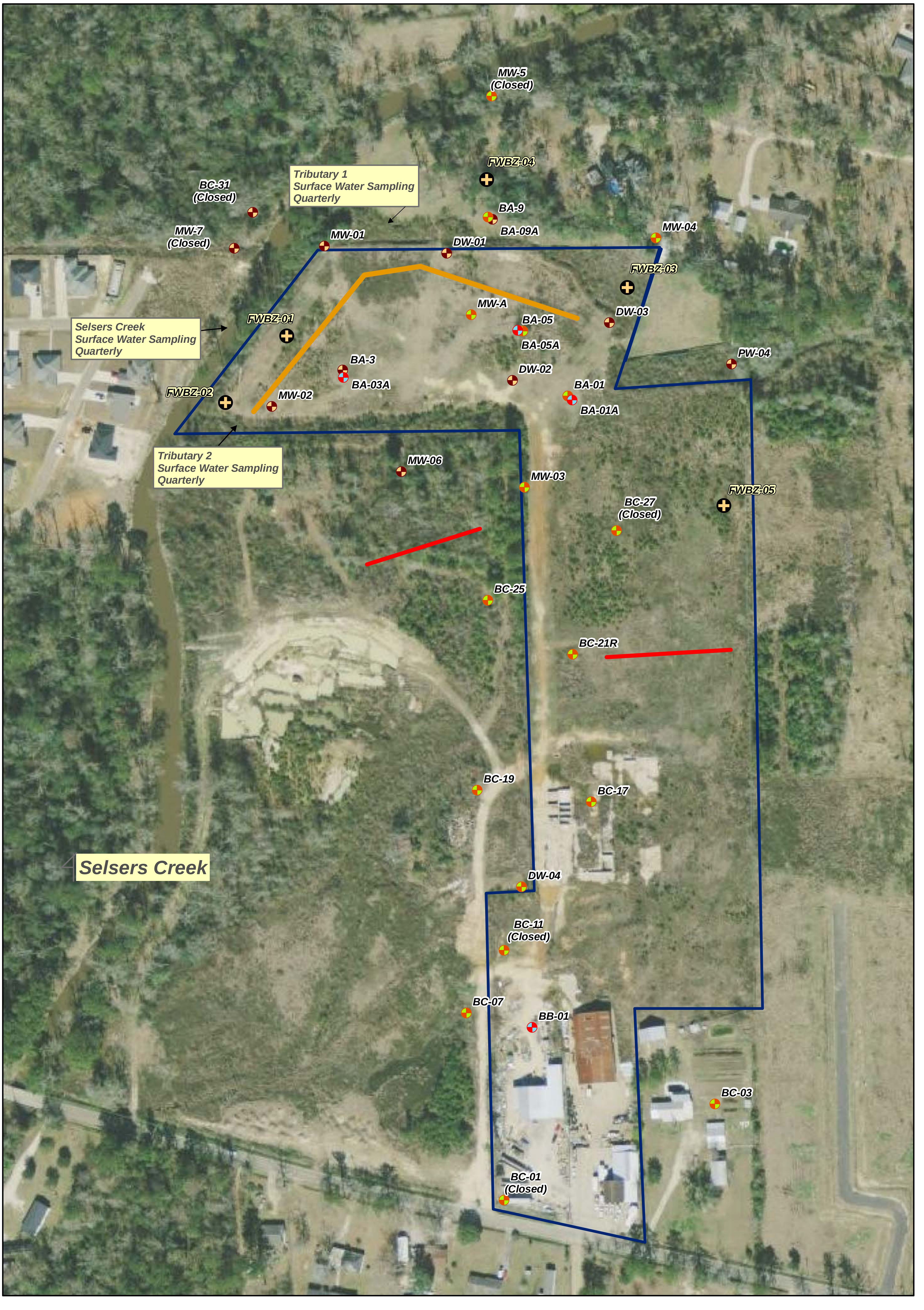
- Increasing
- Probably Increasing
- Stable
- Probably Decreasing
- Decreasing
- No Trend

Scale (ft)
0 200 400

SWBZ MANN-KENDALL TRENDS AND FIRST MOMENTS LEAD AND MANGANESE

Delatte Metals Site
Ponchatoula, Louisiana

Coord sys: WGS 84 UTM 15N		Issued: 14-SEPT-2009	
Drawn By: MV/cdm		Revised:	
Ck'd By: MV		Map ID:	
Appv'd By: MV		**Figure 4**	



Legend

Monitoring Well Locations

- Proposed New Locations
- FWBZ Quarterly
- SWBZ Semiannual
- TWBZ Semiannual

- Approximate Southern extent of FWBZ
- PRB Wall
- Delatte Boundary (approx.)

N

Scale (ft)
0 100 200

DELATTE RECOMMENDED MONITORING LOCATIONS

Delatte Metals Site
Ponchatoula, Louisiana

Coord sys:	WGS 84 UTM 15N	Issued:	14-SEPT-2009
Drawn By:	MV	Revised:	
Ckd By:	MV	Map ID:	
Appv'd By:			Figure 5

APPENDIX A:
MAROS 2.2 Methodology

APPENDIX A
MAROS 2.2 METHODOLOGY

Contents

MAROS METHODOLOGY

MAROS is a collection of tools in one software package that is used in an explanatory, non-linear but linked fashion to review and increase the efficiency of groundwater monitoring networks. The tool includes models, statistics, heuristic rules, and empirical relationships to assist the user in optimizing a groundwater monitoring network system. The final optimized network maintains adequate delineation while providing information on plume dynamics over time. Results generated from the software tool can be used to develop *lines of evidence*, which, in combination with expert opinion, can be used to inform regulatory decisions for safe and economical long-term monitoring of groundwater plumes. For a more detailed description of the structure of the software and further utilities, refer to the MAROS 2.2 Manual (AFCEE, 2003; http://www.gsi-net.com/en/software/free-software/maros.html) and Aziz et al., 2003.

1.0 MAROS Conceptual Model

In MAROS 2.2, two levels of analysis are used for optimizing long-term monitoring plans: 1) an overview statistical evaluation based on temporal trend analyses and plume stability information; and 2) a more detailed statistical optimization based on spatial and temporal redundancy and sufficiency identification methods (see Figures A.1 and A.2 for further details). In general, the MAROS method applies to 2-D aquifers that have relatively simple site hydrogeology. However, for a multi-aquifer (3-D) system, the user has the option to apply the statistical analysis layer-by-layer.

The overview statistics or interpretive trend analyses assess the general monitoring system category by considering *individual well concentration trends*, *overall plume stability*, and qualitative factors such as seepage velocity, remedial systems, and the location of potential receptors. The method relies on temporal trend analysis to assess plume stability, which is then used to determine the general monitoring system category. The monitoring system category is evaluated separately for both source and tail regions.

Source zone monitoring wells could include areas with non-aqueous phase liquids (NAPLs), contaminated vadose zone soils, and areas where aqueous-phase releases have been introduced into ground water. Alternately, a source zone could be an area upgradient of a remedy such as a pump and treat (P&T) system or barrier wall. The source zone generally contains locations with historical high groundwater concentrations of the COCs.

The tail zone is usually the area downgradient of the contaminant source zone or major remedial system. Although this classification is a simplification of the plume conceptual model, this broadness makes the user aware on an individual well basis that the concentration trend results can have a different interpretation depending on the well location in and around the plume. The location and type of the individual wells allows further interpretation of the trend results, depending on what type of well is being analyzed (e.g., remediation well, leading plume edge well, or source monitoring well). General recommendations for the monitoring network frequency and density are suggested based on heuristic rules applied to the source and tail trend results.

The detailed sampling optimization modules consist of well redundancy and well sufficiency analyses using the Delaunay method, a sampling frequency analysis using the Modified Cost Effective Sampling (MCES) method. For plumes very close to the cleanup standards, a data sufficiency analysis including statistical power analysis can be used to identify statistically 'clean' locations. The well redundancy analysis is designed to eliminate monitoring locations that do not contribute unique data to the program. The sampling frequency module is designed to suggest an optimal frequency of sampling based on the rate of change of constituent concentrations. The data sufficiency analysis uses simple statistical methods to assess the sampling record to determine if groundwater concentrations are statistically below target levels and if the current monitoring network and record is sufficient to evaluate concentrations at downgradient locations.

2.0 Data Management

In MAROS, groundwater monitoring data can be imported from simple database-format Microsoft® Excel spreadsheets, Microsoft Access tables, previously created MAROS database archive files, or entered manually. Monitoring data interpretation in MAROS is based on historical analytical data from a consistent set of wells over a series of sampling events. The analytical data is composed of the well name, coordinate location, constituent, result, detection limit and associated data qualifiers. Statistical validity of the concentration trend analysis requires constraints on the minimum data input of at least four wells (ASTM 1998) in which COCs have been detected. Individual sampling locations need to include data from at least six most-recent sampling events. To ensure a meaningful comparison of COC concentrations over time and space, both data quality and data quantity need to be considered. Prior to statistical analysis, the user can consolidate irregularly sampled data or smooth data that might result from seasonal fluctuations or a change in site conditions. Because MAROS is a later-stage analytical tool designed for long-term planning after site investigation and remedial system installation, impacts of seasonal variation in the water unit are treated on a broad scale, as they relate to multi-year trends.

Imported ground water monitoring data and the site-specific information entered in the *Site Details* input screens can be archived and exported as MAROS archive files. These archive files can be appended as new monitoring data becomes available, resulting in a dynamic long-term monitoring database that reflects the changing conditions at the site (i.e. biodegradation, compliance attainment, completion of remediation phase, etc.). For wells with a limited monitoring history, addition of information as it becomes available can change the frequency or redundancy recommendations made by MAROS.

The type of data required to run MAROS is shown in Table 1 below.

TABLE 1: Data Input for MAROS

Data Input	Format	Details
Sample Dates	MM/DD/YYYY	Sampling event dates can be consolidated in the
Well Names	Text format	Well names must be spelled consistently
Analyte Name	Text format	Analyte names must conform to MAROS input standards outlined shown in MAROS_ConstituentList.xls
Result	Number format; null cell for non-detect results	
Detection Limit	Number format	Detection limits must be included for all samples. Missing detection limits can be estimated.
Data Flag	ND or TR	Flag non-detect results with "ND". Identification of trace values (J flag) data is optional.
X and Y Coordinates	Geographical coordinates in number format; units are feet.	Coordinates can be in State Plane feet or in a site specific coordinate system. Values must be in units of feet.
Seepage velocity	Number in units of feet per year	Estimated value for formation
Plume length and width	Number in units of feet	Estimated value from plume maps
Distance to receptors	Number >0	Estimated distance from source/tail to surface water, property boundaries or drinking water wells that represent potential points of exposure.
Groundwater flow direction	Number between 1 and 359	Predominant groundwater flow direction with due east being 0 and moving counter-clockwise, north 90, west 180 and south 270.
Porosity	Number <1	Total porosity estimate for soil type
Source Coordinates	Geographic coordinates in number format; units are feet	An estimate of the coordinates of the most likely source area
Saturated Thickness	Number >1	An estimate of plume thickness, either plume-wide or at each well location.

3.0 Site Details

Information needed for the MAROS analysis includes site-specific parameters such as seepage velocity and current plume length and width. Information on the location of potential receptors relative to the source and tail regions of the plume is entered at this point. Part of the trend analysis methodology applied in MAROS focuses on where the monitoring well is located, therefore the user needs to divide site wells into two different zones: the source zone or the tail zone. Although this classification is a simplification of the well function, this broadness makes the user aware on an individual well basis that the concentration trend results can have a different interpretation depending on the well location in and around the plume. It is up to the user to make further interpretation of the trend results, depending on what type of well is being analyzed (e.g., remediation well, leading plume edge well, or monitoring well). The Site Details section of MAROS contains a preliminary map of well locations to confirm well coordinates.

4.0 Constituent Selection

A database with multiple COCs can be entered into the MAROS software. MAROS allows the analysis of up to 5 COCs concurrently and users can pick COCs from a list of compounds existing in the monitoring data. MAROS runs separate optimizations for each compound. For sites with a single source, the suggested strategy is to choose one to three priority COCs for the optimization. If, for example, the site contains multiple chlorinated volatile organic compounds (VOCs), the standard sample chemical analysis will evaluate all VOCs, so the sample locations and frequency should based on the concentration trends of the most prevalent, toxic or mobile compounds. If different chemical classes are present, such as metals and chlorinated VOCs, choose and evaluate the priority constituent in each chemical class.

MAROS includes a short module that provides recommendations on prioritizing COCs based on toxicity, prevalence, and mobility of the compound. The toxicity ranking is determined by examining a representative concentration for each compound for the entire site. The representative concentration is then compared to the screening level (PRG or MCL) for that compound and the COCs are ranked according to the representative concentrations' percent exceedance of the screening level. The evaluation of prevalence is performed by determining a representative concentration for each well location and evaluating the total number of wells with exceedances (values above screening levels) compared to the total number of wells. Compounds found over screening levels are ranked for mobility based on Kd (sorption partition coefficient). The MAROS COC assessment provides the relative ranking of each COC, but the user must choose which COCs are included in the analysis.

5.0 Data Consolidation

Typically, raw data from long-term monitoring networks have been measured irregularly in time or contain many non-detects, trace level results, and duplicate results. Therefore, before the data can be further analyzed, raw data are filtered, consolidated, transformed, and possibly smoothed to allow for a consistent dataset meeting the minimum data requirements for statistical analysis mentioned previously.

MAROS allows users to specify the period of interest in which data will be consolidated (i.e., monthly, bi-monthly, quarterly, semi-annual, yearly, or a biennial basis). In computing the representative value when consolidating, one of four statistics can be used: median, geometric mean, mean, and maximum. Non-detects can be transformed to one half the reporting or method detection limit (DL), the DL, or a fraction of the DL. Trace level results can be represented by their actual values, one half of the DL, the DL, or a fraction of their actual values. Duplicates are reduced in MAROS by one of three ways: assigning the average, maximum, or first value. The reduced data for each COC and each well can be viewed as a time series in a graphical form on a linear or semi-log plot generated by the software.

6.0 Overview Statistics: Plume Trend Analysis

Within the MAROS software, analyses of historical data provide support for a conclusion about plume stability (e.g., increasing plume, etc.). Plume stability results are assessed from time-series concentration data with the application of three statistical tools: Mann-Kendall Trend analysis, linear regression trend analysis and moment analysis. Mann-Kendall and Linear Regression methods are used to estimate the concentration trend for individual well and COC combinations based on the statistical trend analysis of concentrations versus time. These trend analyses are then consolidated to give the user a general stability estimate for source, tail and plume-wide areas as well as a preliminary recommendation for monitoring frequency and well density (see Figures 1 through 3 for further step-by-step details). The Overview Statistics are designed to allow site personnel to develop a better understanding of the plume behavior over time and understand how the individual well concentration trends are spatially distributed within the plume. The Overview step allows the user to gain information that will support a more informed decision in the next level of detailed statistical optimization analysis.

6.1 Mann-Kendall Analysis

The Mann-Kendall test is a statistical procedure that is well suited for analyzing trends in groundwater data. The Mann-Kendall test is a non-parametric test for zero slope of the first-order regression of time-ordered concentration data versus time. The advantage of the Mann-Kendall test is that no assumptions as to the statistical distribution of the data (e.g. normal, lognormal, etc.) are required, and it can be used with data sets that include irregular sampling intervals and missing data. The Mann-Kendall test is designed for analyzing a single groundwater constituent, multiple constituents are analyzed separately.

The Mann-Kendall test for trend, relies on three statistical metrics. The first metric, the S statistic, is based on the sum of the differences between data in sequential order. An S with a positive value may indicate an increase in concentrations over time and negative values indicate possible decreases. The strength of the trend is proportional to the magnitude of the S statistic (i.e., a large value indicates a strong trend). The confidence in the trend is determined by performing a hypothesis test to determine the probability of accepting the null hypothesis (no trend). The S statistic and the sample size, n, are found in a Kendall probability table such as the one reported in Hollander and Wolfe (1973). The Confidence in the Trend is found by subtracting the probability of no trend

(ρ) from 1. For low values of ρ (<0.05), confidence in the trend is high (>90%) or (ρ < 0.01) very high (>95%).

The concentration trend is determined for each well and each COC based on results of the S statistic, the confidence in the trend, and the coefficient of variation (COV). The coefficient of variation (COV) is calculated from the standard deviation divided by the mean for the dataset. The decision matrix for the Mann-Kendall evaluation is shown in Table 2 below. A Mann-Kendall statistic that is greater than 0 combined with a confidence of greater than 95% is categorized as an Increasing trend while a Mann-Kendall statistic of less than 0 with a confidence between 90% and 95% is defined as a probably Increasing trend, and so on.

Depending on statistical indicators, the concentration trend is classified into six categories:

- Decreasing (D),
- Probably Decreasing (PD),
- Stable (S),
- No Trend (NT),
- Probably Increasing (PI)
- Increasing (I)
- Non-detect (ND)
- Insufficient data (N/A).

Wells where the compound is not detected are labeled "ND" for the COC evaluated. These trend estimates are then analyzed to identify the source and tail region overall stability category (see Figure 2 for further details).

TABLE 2
Mann-Kendall Analysis Decision Matrix (Aziz, et. al., 2003)

Mann-Kendall Statistic	**Confidence in the Trend**	**Concentration Trend**
S > 0	> 95%	Increasing
S > 0	90 - 95%	Probably Increasing
S > 0	< 90%	No Trend
$S \leq 0$	< 90% and COV $\geq$ 1	No Trend
$S \leq 0$	< 90% and COV < 1	Stable
S < 0	90 - 95%	Probably Decreasing
S < 0	> 95%	Decreasing
S = 0	0	Non-detect

6.2 Linear Regression Analysis

Linear Regression is a parametric statistical procedure that is typically used for analyzing trends in data over time for datasets that have a normal or lognormal distribution. The objective of linear regression analysis is to find the trend in the dat through the estimation of the log-slope as well as placing confidence limits on the log-slope of the trend. The Linear Regression analysis in MAROS is performed on Ln(concentration) versus time. The regression model assumes that for a fixed value of x (sample date) the expected value of y (ln(concentration)) can be found by evaluating a linear function. The method of least squares is used to obtain the estimate of the linear function.

In order to test the confidence in the regression trend, confidence limits are placed on the slope of the regression line. A t-test is used to find the confidence interval for the slope by dividing the slope by the standard error of the slope. The results of the t-test along with the degrees of freedom (n-2) are used to find the confidence in the trend from a t-distribution table. The coefficient of variation, defined as the standard deviation divided by the average, is used as a secondary measure of scatter to distinguish between “Stable” or “No Trend” conditions for negative slopes. The resulting confidence in the trend, slope of the regression through the data and variance are used to determine a final trend based on the decision matrix shown on Table 3.

Using this type of analysis, a higher degree of scatter simply corresponds to a wider confidence interval about the average log-slope. Assuming the sign (i.e., positive or negative) of the estimated log-slope is correct, a level of confidence that the slope is not zero can be easily determined. Thus, despite a poor goodness of fit, the overall trend in the data may still be ascertained, where low levels of confidence correspond to “Stable” or “No Trend” conditions (depending on the degree of scatter) and higher levels of confidence indicate the stronger likelihood of a trend. Depending on statistical indicators, the concentration trend is classified into six categories:

- Decreasing (D),
- Probably Decreasing (PD),
- Stable (S),
- No Trend (NT),
- Probably Increasing (PI)
- Increasing (I).

TABLE 3
Linear Regression Analysis Decision Matrix (Aziz, et. al., 2003)

Confidence in the Trend	**Log-slope**	
	Positive	**Negative**
< 90%	No Trend	COV < 1 Stable COV > 1 No Trend
90 - 95%	Probably Increasing	Probably Decreasing
> 95%	Increasing	Decreasing

6.3 Moment Analysis

The role of moment analysis in MAROS is to provide a relative estimate of plume stability and condition within the context of results from other MAROS modules. The moment analysis algorithms in MAROS are simple approximations of complex calculations and are meant to estimate changes in total mass, center of mass and spread of mass within the network over time. The Moment Analysis module is sensitive to the number and arrangement of wells in each sampling event, so, changes in the number and identity of wells during monitoring events, and the parameters chosen for data consolidation can cause changes in the estimated moments.

The analysis of moments can be summarized as:

- Zeroth Moment: An estimate of the total dissolved mass of the constituent within the network for each sample event;
- First Moment: An estimate of the center of mass for each sample event;
- Second Moment: An estimate of the spread of the plume around the center of mass for each sample event.

Moments are calculated using the method of Delaunay Triangulation. The software constructs triangles between all of the wells in the network and estimates the total mass within each triangle using the Saturated Thickness value input as the depth of the plume. To determine the zeroth moment, the mass within each of the triangles is summed to give a plume-wide value. To find the center of mass, or first moment, the center of each triangle is determined and multiplied by the mass within the triangle, which is then normalized by the total mass in the plume. The second moment is an estimate of the relative distribution of mass between the center of the plume and the edges of the plume. Estimates are made of the relative distribution of mass in the direction of groundwater flow (X) and orthogonal to groundwater flow (Y) for each sample event.

Once moments are calculated for each sample event, the Mann-Kendall trend test is applied to determine if the results show increasing, stable or decreasing trends. When considering the results of the zeroth moment trend, the following factors could effect the calculation and interpretation of the plume mass over time: 1) change in the spatial distribution of the wells sampled historically 2) different wells sampled within the well network over time (addition and subtraction of wells within the network). 3) delineation of the plume as mass outside of the network is not included in the estimate.

The first moment estimates the center of mass, coordinates (Xc and Yc) for each sample event and COC and the distance of these coordinates from the source. If the center of mass is farther from the source, then there is an increasing trend. The changing center of mass indicates the relative distribution of mass between the source and tail over time and an increasing trend does not necessarily signal and expanding plume. An increasing center of mass is often found where significant source reduction has occurred. No appreciable movement or a stable trend in the center of mass would indicate plume stability. However, changes in the first moment over time do not necessarily completely characterize the changes in the concentration distribution (and the mass) over time. Therefore, in order to fully characterize the plume the First Moment trend should be compared to the zeroth moment trend (mass change over time).

The second moment indicates the spread of the contaminant about the center of mass (Sxx and Syy), or the distance of contamination from the center of mass for a particular COC and sample event. An increasing trend in the second moment indicates that there is less mass in the center of the plume relative to the edge. This is often seen in cases where diffusion is occurring or when a remedial system may be removing mass from the center of the plume. A decreasing trend may indicate that mass destructive processes are active on the edge of the plume.

6.4 Overall Plume Analysis

General recommendations for the monitoring network sampling frequency and density are provided by MAROS after the trend and moment analysis modules. Monitoring network improvements are suggested based on heuristic rules applied to the source and tail trend results as well as qualitative factors such as seepage velocity and distance to potential receptors.

Individual well trend results are consolidated and weighted by the MAROS software according to user input, and the direction and strength of contaminant concentration trends in the source zone and tail zone for each COC are determined. The software suggests a general, preliminary optimization plan for the current monitoring. The flow chart detailing how the trend analysis results and other site-specific parameters are used to form a general sampling frequency and well density recommendation is shown in Figure 2.

For example, a generic plan for a shrinking petroleum hydrocarbon plume (BTEX) in a slow hydrogeologic environment (silt) with no nearby receptors would entail minimal, low frequency sampling of just a few indicators. On the other hand, the generic plan for a chlorinated solvent plume in a fast hydrogeologic environment that is expanding but has very erratic concentrations over time would entail more extensive, higher frequency sampling. The preliminary plan is based on a heuristically derived algorithm for assessing future sampling duration, location and density that takes into consideration plume stability. For a detailed description of the heuristic rules used in the MAROS software, refer to the MAROS 2.2Manual (AFCEE, 2003).

7.0 Detailed Statistics: Optimization Analysis

Although the overall plume analysis shows a general recommendation for sampling frequency and sampling density, a more detailed analysis is also available with the MAROS software in order to allow for further refinements on a well-by-well basis. The MAROS Detailed Statistics allows for a quantitative analysis for spatial and temporal optimization of the well network. The MAROS Detailed Statistics results should be evaluated considering the results of the Overview Statistics as well as other qualitative features such as site monitoring objectives and the frequency of site decision making.

The Detailed Statistics sampling optimization in MAROS consists of four parts:

- Well redundancy analysis using the Delaunay method
- Well sufficiency analysis using the Delaunay method
- Sampling frequency determination using the Modified Cost Effective Sampling method
- Data sufficiency analysis using statistical power analysis.

The well redundancy analysis using the Delaunay method identifies and eliminates redundant locations from the monitoring network. The well sufficiency analysis can determine the areas where new sampling locations might be needed. The Modified CES method determines the optimal sampling frequency for a sampling location based on the direction, magnitude, and uncertainty in its concentration trend. The data sufficiency analysis examines the risk-based site cleanup status and power and expected sample size associated with the cleanup status evaluation.

7.1 Well Redundancy Analysis – Delaunay Method

The well redundancy analysis using the Delaunay method is designed to select the minimum number of sampling locations based on the spatial analysis of the relative importance of each sampling location in the monitoring network. The approach allows elimination of sampling locations that have little impact on the historical characterization of the contaminant plume. An extended method for evaluating well sufficiency based on the Delaunay method is used for recommending new sampling locations in areas with high concentration uncertainty. Details about the Delaunay method can be found in Appendix A.2 of the MAROS Manual (AFCEE, 2003).

The sampling location modules use the Delaunay triangulation method employed during the moment analysis. The method determines the significance of each sampling location relative to the overall monitoring network with respect to characterizing concentration within the plume. The Delaunay method calculates the area within the network and the average concentration of the plume using data from multiple monitoring wells. A slope factor (SF) is calculated for each well by assessing how accurately concentration at the well can be estimated from concentrations at neighboring wells.

The sampling location optimization process is performed in a stepwise fashion. Step one involves assessing the SF; if a well has a small SF (little significance to the network), the well may be removed from the monitoring network. Locations with a SF = 0.3 or less are candidates for removal. Step two involves evaluating the information loss of removing a well from the network. Information loss is measured by evaluating and Area Ratio and a Concentration Ratio, which is the plume-wide area or concentration after removal of the well normalized by the original values. If one well has a small SF, it may or may not be eliminated depending on whether the information loss in terms of area or average concentration estimates is significant. If the information loss is not significant, the well can be eliminated from the monitoring network and the process of optimization continues with fewer wells. However if the well information loss is significant then the optimization terminates. This sampling optimization process allows the user to assess “redundant” wells that will not incur significant information loss on a constituent-by-constituent basis for individual sampling events.

7.2 Well Sufficiency Analysis – Delaunay Method

The well sufficiency analysis, using the Delaunay method, is designed to recommend new sampling locations in areas *within* the existing monitoring network where there is a high level of uncertainty in contaminant concentration. Details about the well sufficiency analysis can be found in Appendix A.2 of the MAROS Manual (AFCEE, 2003).

In many cases, new sampling locations need to be added to the existing network to enhance the spatial characterization of the plume. If the MAROS algorithm calculates a high level of uncertainty in predicting the constituent concentration at nodes for a particular Delaunay triangle, a new sampling location is recommended for that area. The SF values obtained from the redundancy evaluation described above are used to calculate the concentration estimation error for each triangle. The estimated concentration uncertainty value, based on the calculated SF for each area is then classified into four levels: Small, Moderate, Large, or Extremely large (S, M, L, E). Therefore, the triangular areas with the estimated SF value at the Extremely large or Large level can be candidate regions for new sampling locations.

The results from the Delaunay method and the method for determining new sampling locations are derived solely from the spatial configuration of the monitoring network and the spatial pattern of the contaminant plume. No parameters such as the hydrogeologic conditions or regulatory factors are considered in the analysis. Therefore, professional judgment and regulatory considerations must be used to make final decisions.

7.3 Sampling Frequency Determination - Modified CES Method

The Modified CES method optimizes sampling frequency for each sampling location based on the magnitude, direction, and uncertainty of its concentration trend derived from its recent and historical monitoring records. The Modified Cost Effective Sampling (MCES) estimates a conservative lowest-frequency sampling schedule for a given groundwater monitoring location that still provides needed information for regulatory and remedial decision-making. The MCES method was developed on the basis of the Cost Effective Sampling (CES) method developed by Ridley et al (1995). Details about the MCES method can be found in Appendix A.9 of the MAROS Manual (AFCEE, 2003).

In order to estimate the least frequent sampling schedule for a monitoring location that still provides enough information for regulatory and remedial decision-making, MCES employs three steps to determine the sampling frequency. The first step involves analyzing frequency based on recent trends. A preliminary location sampling frequency (PLSF) is developed based on the rate of change of well concentrations calculated by linear regression along with the Mann-Kendall trend analysis of the most recent monitoring data (see Figure 3). The variability within the sequential sampling data is accounted for by the Mann-Kendall analysis. The rate of change vs. trend result matrix categorizes wells as requiring annual, semi-annual or quarterly sampling. The PLSF is then reevaluated and adjusted based on overall trends. If the long-term history of change is significantly greater than the recent trend, the frequency may be reduced by one level.

The final step in the analysis involves reducing frequency based on risk, site-specific conditions, regulatory requirements or other external issues. Since not all compounds in the target being assessed are equally harmful, frequency is reduced by one level if recent maximum concentration for a compound of high risk is less than 1/2 of the Maximum Concentration Limit (MCL). The result of applying this method is a suggested sampling frequency based on recent sampling data trends and overall sampling data trends and expert judgment.

The final sampling frequency determined from the MCES method can be Quarterly, Semiannual, Annual, or Biennial. Users can further reduce the sampling frequency to, for example, once every three years, if the trend estimated from Biennial data (i.e., data drawn once every two years from the original data) is the same as that estimated from the original data.

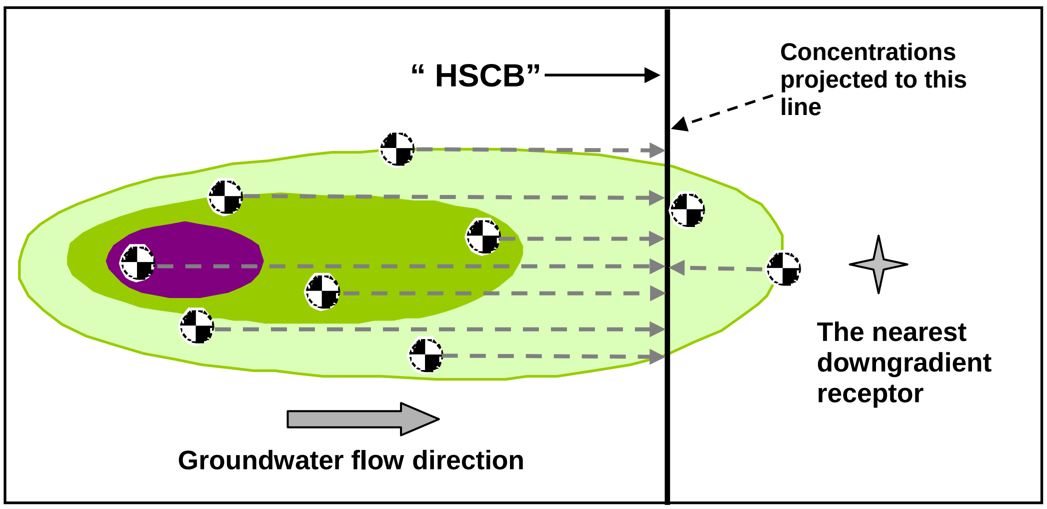
7.4 Data Sufficiency Analysis – Power Analysis

The MAROS Data Sufficiency module employs simple statistical methods to evaluate whether the collected data are adequate both in quantity and in quality for revealing changes in constituent concentrations. The first section of the module evaluates individual well concentrations to determine if they are statistically below a target screening level. The second section includes a simple calculation for estimating projected groundwater concentrations at a specified point downgradient of the plume. A statistical Power analysis is then applied to the projected concentrations to determine if the downgradient concentrations are statistically below the cleanup standard. If the number of projected concentrations is below the level to provide statistical significance, then the number of sample events required to statistically confirm concentrations below standards is estimated from the Power analysis.

Before testing the cleanup status for individual wells, the stability or trend of the contaminant plume should be evaluated. Only after the plume has reached stability or is reliably diminishing can we conduct a test to examine the cleanup status of wells. Applying the analysis to wells in an expanding plume may cause incorrect conclusions and is less meaningful.

Statistical power analysis is a technique for interpreting the results of statistical tests. The Power of a statistical test is a measure of the ability of the test to detect an effect given that the effect actually exists. The method provides additional information about a statistical test: 1) the power of the statistical test, i.e., the probability of finding a difference in the variable of interest when a difference truly exists; and 2) the expected sample size of a future sampling plan given the minimum detectable difference it is supposed to detect. For example, if the mean concentration is lower than the cleanup goal but a statistical test cannot prove this, the power and expected sample size can tell the reason and how many more samples are needed to result in a significant test. The additional samples can be obtained by a longer period of sampling or an increased sampling frequency. Details about the data sufficiency analysis can be found in Appendix A.6 of the MAROS Manual (AFCEE, 2003).

When applying the MAROS power analysis method, a hypothetical statistical compliance boundary (HSCB) is assigned to be a line perpendicular to the groundwater flow direction (see figure below). Monitoring well concentrations are projected onto the HSCB using the distance from each well to the compliance boundary along with a decay coefficient. The projected concentrations from each well and each sampling event are then used in the risk-based power analysis. Since there may be more than one sampling event selected by the user, the risk-based power analysis results are given on an event-by-event basis. This power analysis can then indicate if target are statistically achieved at the HSCB. For instance, at a site where the historical monitoring record is short with few wells, the HSCB would be distant; whereas, at a site with longer duration of sampling with many wells, the HSCB would be close. Ultimately, at a site the goal would be to have the HSCB coincide with or be within the actual compliance boundary (typically the site property line).



In order to perform a risk-based cleanup status evaluation for the whole site, a strategy was developed as follows.

- Estimate concentration versus distance decay coefficient from plume centerline wells.
- Extrapolate concentration versus distance for each well using this decay coefficient.
- Comparing the extrapolated concentrations with the compliance concentration using power analysis.

Results from this analysis can be *Attained* or *Not Attained*, providing a statistical interpretation of whether the cleanup goal has been met on the site-scale from the risk-based point of view. The results as a function of time can be used to evaluate if the monitoring system has enough power at each step in the sampling record to indicate certainty of compliance by the plume location and condition relative to the compliance boundary. For example, if results are *Not Attained* at early sampling events but are *Attained* in recent sampling events, it indicates that the recent sampling record provides a powerful enough result to indicate compliance of the plume relative to the location of the receptor or compliance boundary.

CITED REFERENCES

AFCEE 2003. Monitoring and Remediation Optimization System (MAROS) 2.1 Software Users Guide. Air Force Center for Environmental Excellence. http://www.gsi-net.com/software/MAROS_V2_1Manual.pdf

AFCEE. 1997. Air Force Center for Environmental Excellence, AFCEE Long-Term Monitoring Optimization Guide, http://www.afcee.brooks.af.mil.

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.

Gilbert, R. O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY, ISBN 0-442-23050-8.

Hollander, M. and Wolfe, D. A. (1973). Nonparametric Statistical Methods, Wiley, New York, NY.

Ridley, M.N. et al., 1995. Cost-Effective Sampling of Groundwater Monitoring Wells, the Regents of UC/LLNL, Lawrence Livermore National Laboratory.

U.S. Environmental Protection Agency, 1992. Methods for Evaluating the Attainment of Cleanup Standards Volume 2: Ground Water.

Weight, W. D. and J. L. Sonderegger (2001). Manual of Applied Field Hydrogeology. New York, NY, McGraw-Hill.

MAROS: Decision Support Tool

MAROS is a collection of tools in one software package that is used in an explanatory, non-linear fashion. The tool includes models, geostatistics, heuristic rules, and empirical relationships to assist the user in optimizing a groundwater monitoring network system while maintaining adequate delineation of the plume as well as knowledge of the plume state over time. Different users utilize the tool in different ways and interpret the results from a different viewpoint.

↓

Overview Statistics

What it is: Simple, qualitative and quantitative plume information can be gained through evaluation of monitoring network historical data trends both spatially and temporally. The MAROS Overview Statistics are the foundation the user needs to make informed optimization decisions at the site.

What it does: The Overview Statistics are designed to allow site personnel to develop a better understanding of the plume behavior over time and understand how the individual well concentration trends are spatially distributed within the plume. This step allows the user to gain information that will support a more informed decision to be made in the next level of optimization analysis.

What are the tools: Overview Statistics includes two analytical tools:

1) **Trend Analysis:** includes Mann-Kendall and Linear Regression statistics for individual wells and results in general heuristically-derived monitoring categories with a suggested sampling density and monitoring frequency.

2) **Moment Analysis:** includes dissolved mass estimation (0^{th} Moment), center of mass (1^{st} Moment), and plume spread (2^{nd} Moment) over time. Trends of these moments show the user another piece of information about the plume stability over time.

What is the product: A first-cut blueprint for a future long-term monitoring program that is intended to be a foundation for more detailed statistical analysis.

↓

Detailed Statistics

What it is: The MAROS Detailed Statistics allows for a quantitative analysis for spatial and temporal optimization of the well network on a well-by-well basis.

What it does: The results from the Overview Statistics should be considered along side the MAROS optimization recommendations gained from the Detailed Statistical Analysis. The MAROS Detailed Statistics results should be reassessed in view of site knowledge and regulatory requirements as well as the Overview Statistics.

What are the tools: Detailed Statistics includes four analytical tools:

1) **Sampling Frequency Optimization:** uses the Modified CES method to establish a recommended future sampling frequency.

2) **Well Redundancy Analysis:** uses the Delaunay Method to evaluate if any wells within the monitoring network are redundant and can be eliminated without any significant loss of plume information.

3) **Well Sufficiency Analysis:** uses the Delaunay Method to evaluate areas where new wells are recommended within the monitoring network due to high levels of concentration uncertainty.

4) **Data Sufficiency Analysis:** uses Power Analysis to assess if the historical monitoring data record has sufficient power to accurately reflect the location of the plume relative to the nearest receptor or compliance point.

What is the product: List of wells to remove from the monitoring program, locations where monitoring wells may need to be added, recommended frequency of sampling for each well, analysis if the overall system is statistically powerful to monitor the plume.

Figure 1. MAROS Decision Support Tool Flow Chart

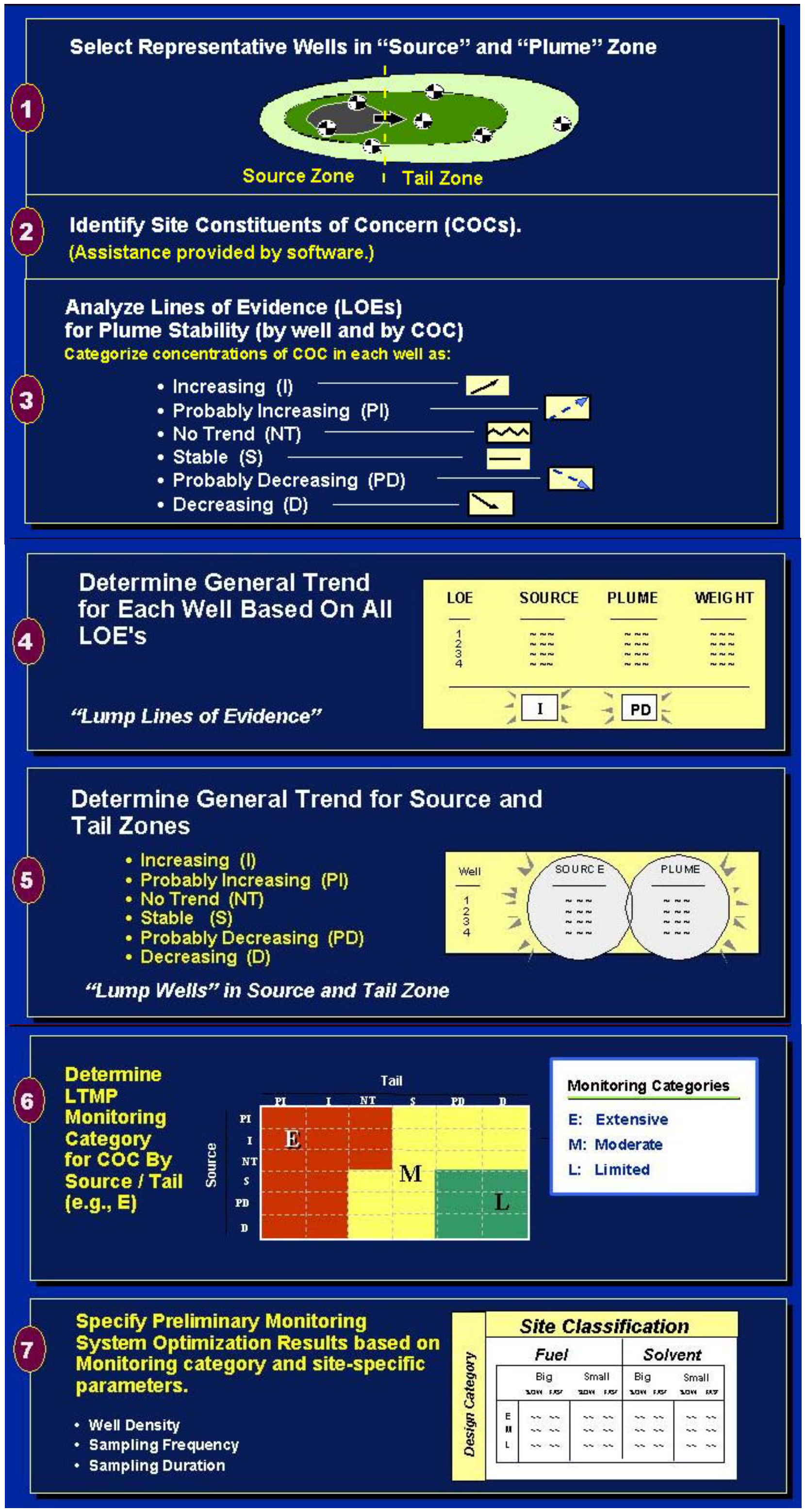


Figure 2:
MAROS Overview Statistics Trend Analysis Methodology

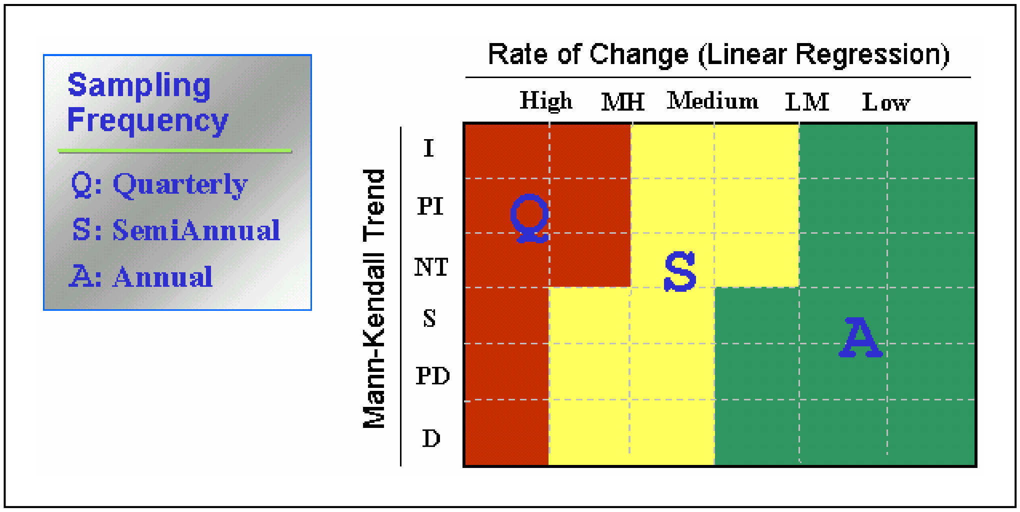


Figure 3. Decision Matrix for Determining Provisional Frequency (*Figure A.3.1 of the MAROS Manual (AFCEE 2003*)

APPENDIX B:
MAROS REPORTS

First Water-Bearing Zone

COC Assessment

pH Trend Reports

Metals Trend Reports

Well Sufficiency Spatial Analysis Results

Second Water-Bearing Zone

COC Assessment

Metals Trend Reports

Well Sufficiency Spatial Analysis Results

Third Water-Bearing Zone

Metals Trend Report

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

First Water-Bearing Zone
COC Assessment

MAROS COC Assessment

Project: Delatte **User Name:** MV

Location: Ponchatoula **State:** Louisiana

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
ARSENIC	5.6E-02	1.0E-02	455.6%
MANGANESE	6.0E+00	1.7E+00	255.7%
THALLIUM	7.0E-03	2.0E-03	248.7%
LEAD	3.2E-02	1.5E-02	111.1%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
MANGANESE	MET	9	7	77.8%	9
ARSENIC	MET	9	6	66.7%	9
THALLIUM	MET	9	5	55.6%	8
LEAD	MET	9	4	44.4%	9

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
THALLIUM	
LEAD	10
ARSENIC	25
MANGANESE	50.1

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

ARSENIC

LEAD

MANGANESE

NICKEL

THALLIUM

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

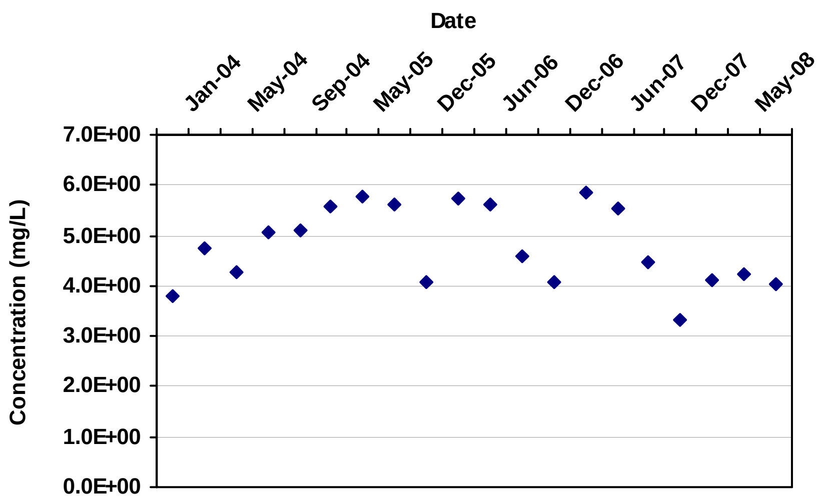
MAROS Reports

First Water-Bearing Zone
pH Trend Reports

MAROS Mann-Kendall Statistics Summary

Well: BA-3
Well Type: S
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: -23

Confidence in Trend: 76.0%

Coefficient of Variation: 0.16

Mann Kendall Concentration Trend: (See Note) S

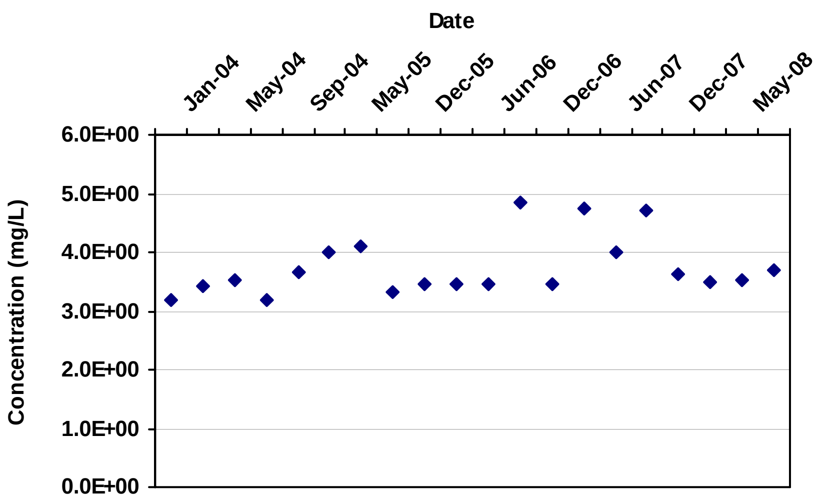
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-3	S	1/1/2004	pH	3.8E+00		1	1
BA-3	S	3/1/2004	pH	4.7E+00		1	1
BA-3	S	5/1/2004	pH	4.3E+00		1	1
BA-3	S	7/1/2004	pH	5.1E+00		1	1
BA-3	S	9/1/2004	pH	5.1E+00		1	1
BA-3	S	3/1/2005	pH	5.6E+00		1	1
BA-3	S	5/1/2005	pH	5.8E+00		1	1
BA-3	S	10/1/2005	pH	5.6E+00		1	1
BA-3	S	12/1/2005	pH	4.1E+00		1	1
BA-3	S	3/1/2006	pH	5.7E+00		1	1
BA-3	S	6/1/2006	pH	5.6E+00		1	1
BA-3	S	9/1/2006	pH	4.6E+00		1	1
BA-3	S	12/1/2006	pH	4.1E+00		1	1
BA-3	S	3/1/2007	pH	5.9E+00		1	1
BA-3	S	6/1/2007	pH	5.5E+00		1	1
BA-3	S	9/1/2007	pH	4.5E+00		1	1
BA-3	S	12/1/2007	pH	3.3E+00		1	1
BA-3	S	3/8/2008	pH	4.1E+00		1	1
BA-3	S	5/8/2008	pH	4.2E+00		1	1
BA-3	S	8/8/2008	pH	4.0E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-9
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 58

Confidence in Trend: 96.8%

Coefficient of Variation: 0.14

Mann Kendall Concentration Trend: (See Note) I

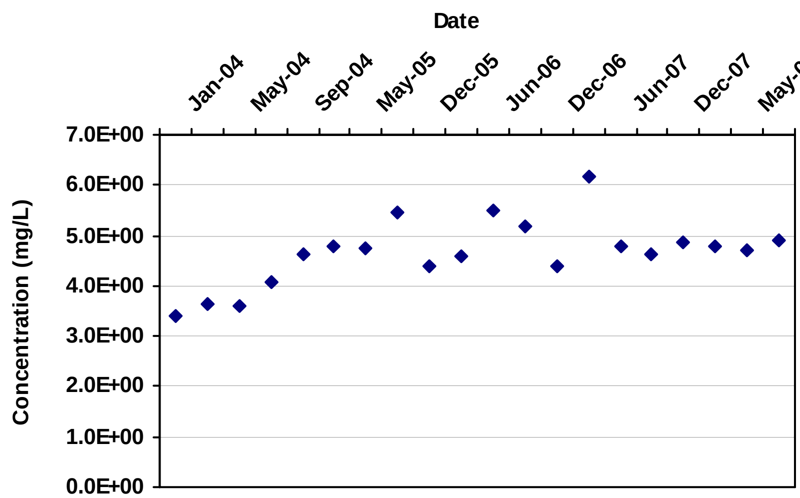
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-9	T	1/1/2004	pH	3.2E+00		1	1
BA-9	T	3/1/2004	pH	3.4E+00		1	1
BA-9	T	5/1/2004	pH	3.5E+00		1	1
BA-9	T	7/1/2004	pH	3.2E+00		1	1
BA-9	T	9/1/2004	pH	3.7E+00		1	1
BA-9	T	3/1/2005	pH	4.0E+00		1	1
BA-9	T	5/1/2005	pH	4.1E+00		1	1
BA-9	T	10/1/2005	pH	3.3E+00		1	1
BA-9	T	12/1/2005	pH	3.5E+00		1	1
BA-9	T	3/1/2006	pH	3.5E+00		1	1
BA-9	T	6/1/2006	pH	3.5E+00		1	1
BA-9	T	9/1/2006	pH	4.9E+00		1	1
BA-9	T	12/1/2006	pH	3.5E+00		1	1
BA-9	T	3/1/2007	pH	4.8E+00		1	1
BA-9	T	6/1/2007	pH	4.0E+00		1	1
BA-9	T	9/1/2007	pH	4.7E+00		1	1
BA-9	T	12/1/2007	pH	3.6E+00		1	1
BA-9	T	3/8/2008	pH	3.5E+00		1	1
BA-9	T	5/8/2008	pH	3.5E+00		1	1
BA-9	T	8/8/2008	pH	3.7E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: DW-01
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 82

Confidence in Trend: 99.6%

Coefficient of Variation: 0.14

Mann Kendall Concentration Trend: (See Note) I

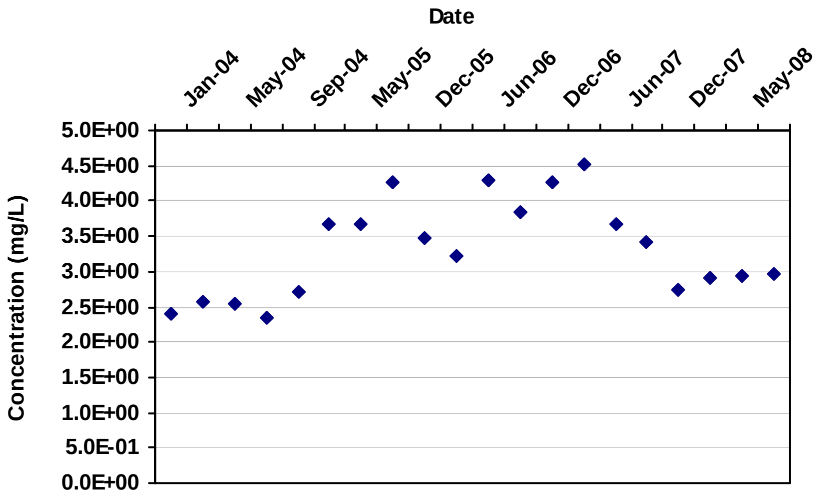
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-01	T	1/1/2004	pH	3.4E+00		1	1
DW-01	T	3/1/2004	pH	3.6E+00		1	1
DW-01	T	5/1/2004	pH	3.6E+00		1	1
DW-01	T	7/1/2004	pH	4.1E+00		1	1
DW-01	T	9/1/2004	pH	4.6E+00		1	1
DW-01	T	3/1/2005	pH	4.8E+00		1	1
DW-01	T	5/1/2005	pH	4.8E+00		1	1
DW-01	T	10/1/2005	pH	5.5E+00		1	1
DW-01	T	12/1/2005	pH	4.4E+00		1	1
DW-01	T	3/1/2006	pH	4.6E+00		1	1
DW-01	T	6/1/2006	pH	5.5E+00		1	1
DW-01	T	9/1/2006	pH	5.2E+00		1	1
DW-01	T	12/1/2006	pH	4.4E+00		1	1
DW-01	T	3/1/2007	pH	6.2E+00		1	1
DW-01	T	6/1/2007	pH	4.8E+00		1	1
DW-01	T	9/1/2007	pH	4.6E+00		1	1
DW-01	T	12/1/2007	pH	4.8E+00		1	1
DW-01	T	3/8/2008	pH	4.8E+00		1	1
DW-01	T	5/8/2008	pH	4.7E+00		1	1
DW-01	T	8/8/2008	pH	4.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: DW-02
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 42

Confidence in Trend: 90.7%

Coefficient of Variation: 0.21

Mann Kendall Concentration Trend: (See Note) PI

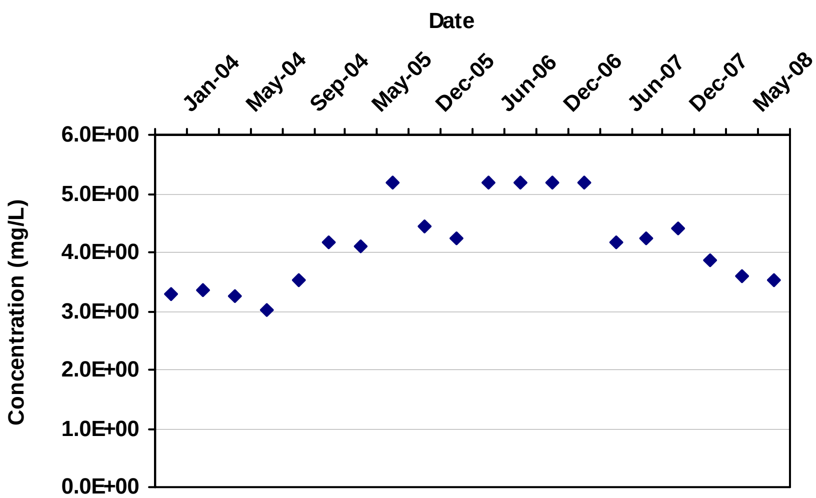
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-02	T	1/1/2004	pH	2.4E+00		1	1
DW-02	T	3/1/2004	pH	2.6E+00		1	1
DW-02	T	5/1/2004	pH	2.5E+00		1	1
DW-02	T	7/1/2004	pH	2.3E+00		1	1
DW-02	T	9/1/2004	pH	2.7E+00		1	1
DW-02	T	3/1/2005	pH	3.7E+00		1	1
DW-02	T	5/1/2005	pH	3.7E+00		1	1
DW-02	T	10/1/2005	pH	4.3E+00		1	1
DW-02	T	12/1/2005	pH	3.5E+00		1	1
DW-02	T	3/1/2006	pH	3.2E+00		1	1
DW-02	T	6/1/2006	pH	4.3E+00		1	1
DW-02	T	9/1/2006	pH	3.8E+00		1	1
DW-02	T	12/1/2006	pH	4.3E+00		1	1
DW-02	T	3/1/2007	pH	4.5E+00		1	1
DW-02	T	6/1/2007	pH	3.7E+00		1	1
DW-02	T	9/1/2007	pH	3.4E+00		1	1
DW-02	T	12/1/2007	pH	2.8E+00		1	1
DW-02	T	3/8/2008	pH	2.9E+00		1	1
DW-02	T	5/8/2008	pH	2.9E+00		1	1
DW-02	T	8/8/2008	pH	3.0E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: DW-03
Well Type: S
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 39

Confidence in Trend: 89.0%

Coefficient of Variation: 0.18

Mann Kendall Concentration Trend: (See Note) NT

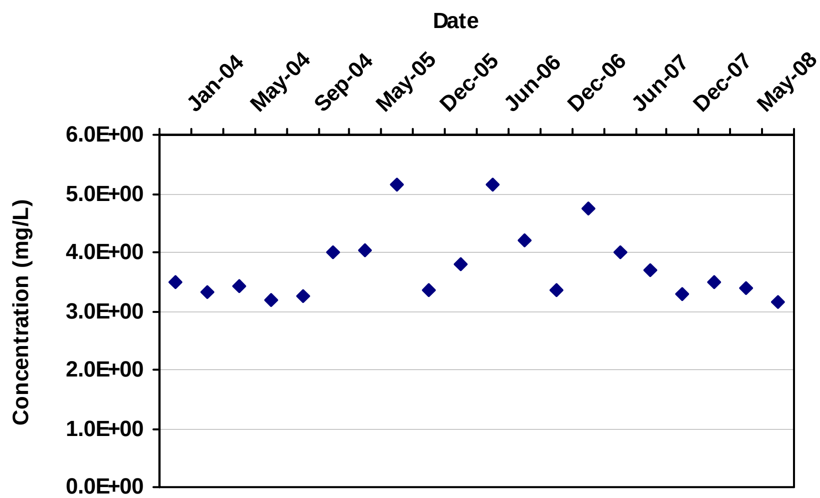
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-03	S	1/1/2004	pH	3.3E+00		1	1
DW-03	S	3/1/2004	pH	3.3E+00		1	1
DW-03	S	5/1/2004	pH	3.3E+00		1	1
DW-03	S	7/1/2004	pH	3.0E+00		1	1
DW-03	S	9/1/2004	pH	3.5E+00		1	1
DW-03	S	3/1/2005	pH	4.2E+00		1	1
DW-03	S	5/1/2005	pH	4.1E+00		1	1
DW-03	S	10/1/2005	pH	5.2E+00		1	1
DW-03	S	12/1/2005	pH	4.5E+00		1	1
DW-03	S	3/1/2006	pH	4.2E+00		1	1
DW-03	S	6/1/2006	pH	5.2E+00		1	1
DW-03	S	9/1/2006	pH	5.2E+00		1	1
DW-03	S	12/1/2006	pH	5.2E+00		1	1
DW-03	S	3/1/2007	pH	5.2E+00		1	1
DW-03	S	6/1/2007	pH	4.2E+00		1	1
DW-03	S	9/1/2007	pH	4.2E+00		1	1
DW-03	S	12/1/2007	pH	4.4E+00		1	1
DW-03	S	3/8/2008	pH	3.9E+00		1	1
DW-03	S	5/8/2008	pH	3.6E+00		1	1
DW-03	S	8/8/2008	pH	3.5E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-01
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: -4

Confidence in Trend: 53.8%

Coefficient of Variation: 0.16

Mann Kendall Concentration Trend: (See Note) S

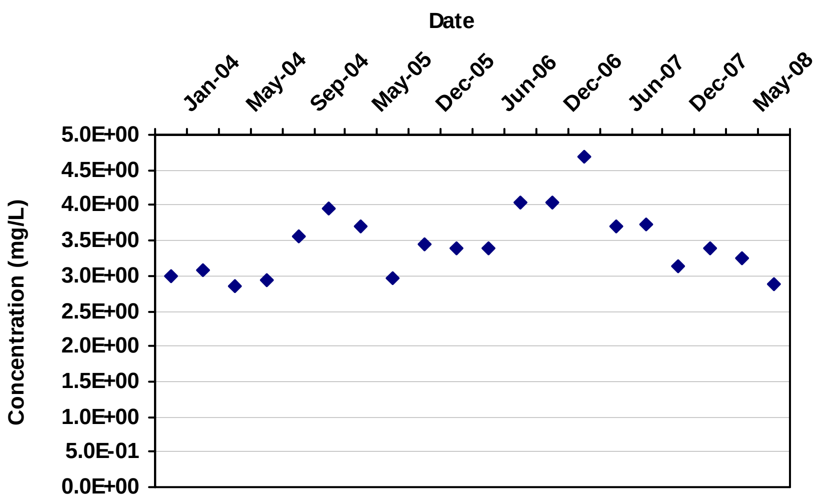
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-01	T	1/1/2004	pH	3.5E+00		1	1
MW-01	T	3/1/2004	pH	3.3E+00		1	1
MW-01	T	5/1/2004	pH	3.4E+00		1	1
MW-01	T	7/1/2004	pH	3.2E+00		1	1
MW-01	T	9/1/2004	pH	3.3E+00		1	1
MW-01	T	3/1/2005	pH	4.0E+00		1	1
MW-01	T	5/1/2005	pH	4.0E+00		1	1
MW-01	T	10/1/2005	pH	5.1E+00		1	1
MW-01	T	12/1/2005	pH	3.3E+00		1	1
MW-01	T	3/1/2006	pH	3.8E+00		1	1
MW-01	T	6/1/2006	pH	5.2E+00		1	1
MW-01	T	9/1/2006	pH	4.2E+00		1	1
MW-01	T	12/1/2006	pH	3.3E+00		1	1
MW-01	T	3/1/2007	pH	4.7E+00		1	1
MW-01	T	6/1/2007	pH	4.0E+00		1	1
MW-01	T	9/1/2007	pH	3.7E+00		1	1
MW-01	T	12/1/2007	pH	3.3E+00		1	1
MW-01	T	3/8/2008	pH	3.5E+00		1	1
MW-01	T	5/8/2008	pH	3.4E+00		1	1
MW-01	T	8/8/2008	pH	3.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-02
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 29

Confidence in Trend: 81.6%

Coefficient of Variation: 0.14

Mann Kendall Concentration Trend: (See Note) NT

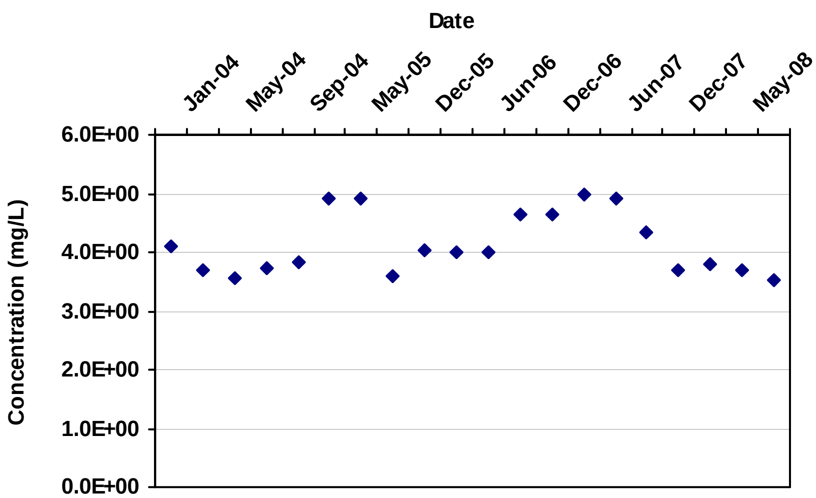
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-02	T	1/1/2004	pH	3.0E+00		1	1
MW-02	T	3/1/2004	pH	3.1E+00		1	1
MW-02	T	5/1/2004	pH	2.9E+00		1	1
MW-02	T	7/1/2004	pH	3.0E+00		1	1
MW-02	T	9/1/2004	pH	3.6E+00		1	1
MW-02	T	3/1/2005	pH	4.0E+00		1	1
MW-02	T	5/1/2005	pH	3.7E+00		1	1
MW-02	T	10/1/2005	pH	3.0E+00		1	1
MW-02	T	12/1/2005	pH	3.5E+00		1	1
MW-02	T	3/1/2006	pH	3.4E+00		1	1
MW-02	T	6/1/2006	pH	3.4E+00		1	1
MW-02	T	9/1/2006	pH	4.0E+00		1	1
MW-02	T	12/1/2006	pH	4.0E+00		1	1
MW-02	T	3/1/2007	pH	4.7E+00		1	1
MW-02	T	6/1/2007	pH	3.7E+00		1	1
MW-02	T	9/1/2007	pH	3.7E+00		1	1
MW-02	T	12/1/2007	pH	3.1E+00		1	1
MW-02	T	3/8/2008	pH	3.4E+00		1	1
MW-02	T	5/8/2008	pH	3.3E+00		1	1
MW-02	T	8/8/2008	pH	2.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-06
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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: 1

Confidence in Trend: 50.0%

Coefficient of Variation: 0.13

Mann Kendall Concentration Trend: (See Note) NT

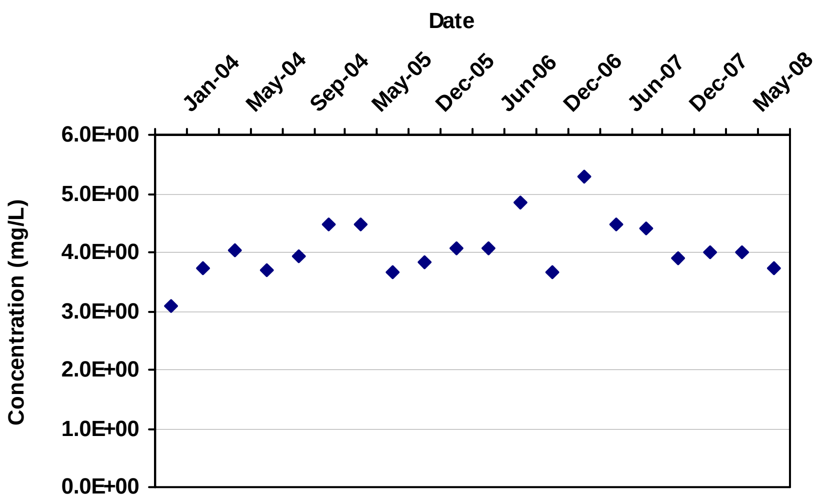
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-06	T	1/1/2004	pH	4.1E+00		1	1
MW-06	T	3/1/2004	pH	3.7E+00		1	1
MW-06	T	5/1/2004	pH	3.6E+00		1	1
MW-06	T	7/1/2004	pH	3.7E+00		1	1
MW-06	T	9/1/2004	pH	3.8E+00		1	1
MW-06	T	3/1/2005	pH	4.9E+00		1	1
MW-06	T	5/1/2005	pH	4.9E+00		1	1
MW-06	T	10/1/2005	pH	3.6E+00		1	1
MW-06	T	12/1/2005	pH	4.0E+00		1	1
MW-06	T	3/1/2006	pH	4.0E+00		1	1
MW-06	T	6/1/2006	pH	4.0E+00		1	1
MW-06	T	9/1/2006	pH	4.7E+00		1	1
MW-06	T	12/1/2006	pH	4.7E+00		1	1
MW-06	T	3/1/2007	pH	5.0E+00		1	1
MW-06	T	6/1/2007	pH	4.9E+00		1	1
MW-06	T	9/1/2007	pH	4.3E+00		1	1
MW-06	T	12/1/2007	pH	3.7E+00		1	1
MW-06	T	3/8/2008	pH	3.8E+00		1	1
MW-06	T	5/8/2008	pH	3.7E+00		1	1
MW-06	T	8/8/2008	pH	3.5E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: PW-04
Well Type: T
COC: pH

Time Period: 1/1/2004 **to** 8/8/2008
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:

0.12

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
PW-04	T	1/1/2004	pH	3.1E+00		1	1
PW-04	T	3/1/2004	pH	3.7E+00		1	1
PW-04	T	5/1/2004	pH	4.0E+00		1	1
PW-04	T	7/1/2004	pH	3.7E+00		1	1
PW-04	T	9/1/2004	pH	3.9E+00		1	1
PW-04	T	3/1/2005	pH	4.5E+00		1	1
PW-04	T	5/1/2005	pH	4.5E+00		1	1
PW-04	T	10/1/2005	pH	3.7E+00		1	1
PW-04	T	12/1/2005	pH	3.8E+00		1	1
PW-04	T	3/1/2006	pH	4.1E+00		1	1
PW-04	T	6/1/2006	pH	4.1E+00		1	1
PW-04	T	9/1/2006	pH	4.8E+00		1	1
PW-04	T	12/1/2006	pH	3.7E+00		1	1
PW-04	T	3/1/2007	pH	5.3E+00		1	1
PW-04	T	6/1/2007	pH	4.5E+00		1	1
PW-04	T	9/1/2007	pH	4.4E+00		1	1
PW-04	T	12/1/2007	pH	3.9E+00		1	1
PW-04	T	3/8/2008	pH	4.0E+00		1	1
PW-04	T	5/8/2008	pH	4.0E+00		1	1
PW-04	T	8/8/2008	pH	3.7E+00		1	1

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

First Water-Bearing Zone
Metals Trend Reports

MAROS Mann-Kendall Statistics Summary

Project: Delatte FWBZ

User Name: MV

Location: Ponchatoula

State: Louisiana

Time Period: 1/1/2004 **to** 8/8/2008

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: Specified 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
ARSENIC								
BA-3	S	20	19	0.82	-101	100.0%	No	D
BA-9	T	20	12	1.01	72	99.0%	No	I
DW-01	T	20	20	1.26	-2	51.3%	No	NT
DW-02	T	20	16	1.06	-17	69.6%	No	NT
DW-03	S	20	18	0.71	8	58.9%	No	NT
MW-01	T	20	17	1.14	-15	67.3%	No	NT
MW-02	T	20	13	1.81	47	93.2%	No	PI
MW-06	T	20	10	1.33	6	56.4%	No	NT
PW-04	T	20	14	0.94	16	68.5%	No	NT
LEAD								
BA-3	S	20	15	1.19	104	100.0%	No	I
BA-9	T	20	12	1.03	72	99.0%	No	I
DW-01	T	20	13	2.37	17	69.6%	No	NT
DW-02	T	20	12	1.35	66	98.3%	No	I
DW-03	S	20	18	1.48	61	97.5%	No	I
MW-01	T	20	14	1.81	21	74.0%	No	NT
MW-02	T	20	18	0.47	-41	90.2%	No	PD
MW-06	T	20	14	1.67	50	94.4%	No	PI
PW-04	T	20	14	0.73	37	87.7%	No	NT
MANGANESE								
BA-3	S	20	20	0.41	20	72.9%	No	NT
BA-9	T	20	20	0.36	-100	100.0%	No	D
DW-01	T	20	20	0.59	-64	98.0%	No	D
DW-02	T	20	20	0.61	-110	100.0%	No	D
DW-03	S	20	20	0.89	-86	99.8%	No	D
MW-01	T	20	20	0.29	-13	65.0%	No	S
MW-02	T	20	20	0.58	124	100.0%	No	I
MW-06	T	20	20	0.42	80	99.5%	No	I
PW-04	T	20	20	0.57	-6	56.4%	No	S
NICKEL								
BA-3	S	20	18	0.79	81	99.6%	No	I
BA-9	T	20	20	0.41	-98	99.9%	No	D
DW-01	T	20	20	0.87	-59	97.1%	No	D
DW-02	T	20	20	0.72	-97	99.9%	No	D
DW-03	S	20	20	0.87	-72	99.0%	No	D

Project: Delatte FWBZ **User Name:** MV

Location: Ponchatoula **State:** Louisiana

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
NICKEL								
MW-01	T	20	20	0.41	-10	61.3%	No	S
MW-02	T	20	19	1.00	92	99.9%	No	I
MW-06	T	20	17	0.70	93	99.9%	No	I
PW-04	T	20	18	0.67	25	78.0%	No	NT
THALLIUM								
BA-3	S	20	10	1.21	75	99.3%	No	I
BA-9	T	20	2	1.33	29	81.6%	No	NT
DW-01	T	20	4	1.24	36	87.0%	No	NT
DW-02	T	20	1	4.43	-19	71.8%	No	NT
DW-03	S	20	2	3.64	-1	50.0%	No	NT
MW-01	T	20	0	0.00	0	48.7%	Yes	ND
MW-02	T	20	13	0.80	22	75.0%	No	NT
MW-06	T	20	5	1.39	61	97.5%	No	I
PW-04	T	20	1	2.29	-19	71.8%	No	NT

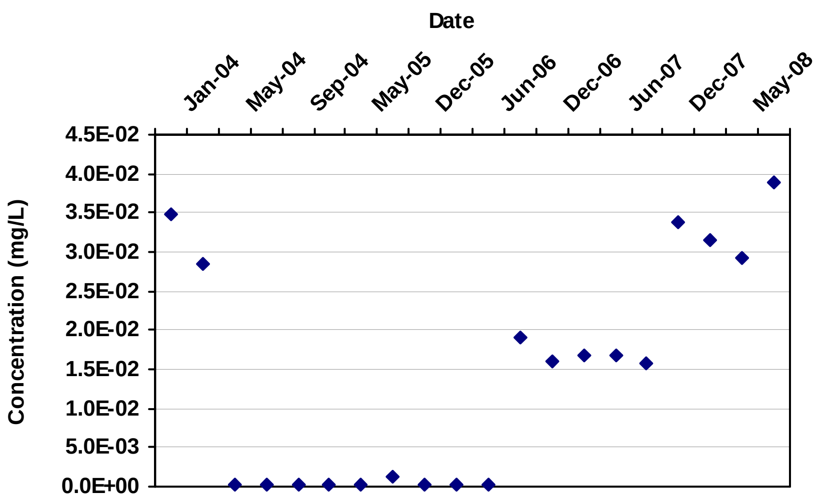
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

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

MAROS Mann-Kendall Statistics Summary

Well: BA-9
Well Type: T
COC: ARSENIC

Time Period: 1/1/2004 **to** 8/8/2008
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: 72

Confidence in Trend: 99.0%

Coefficient of Variation: 1.01

Mann Kendall Concentration Trend: (See Note) I

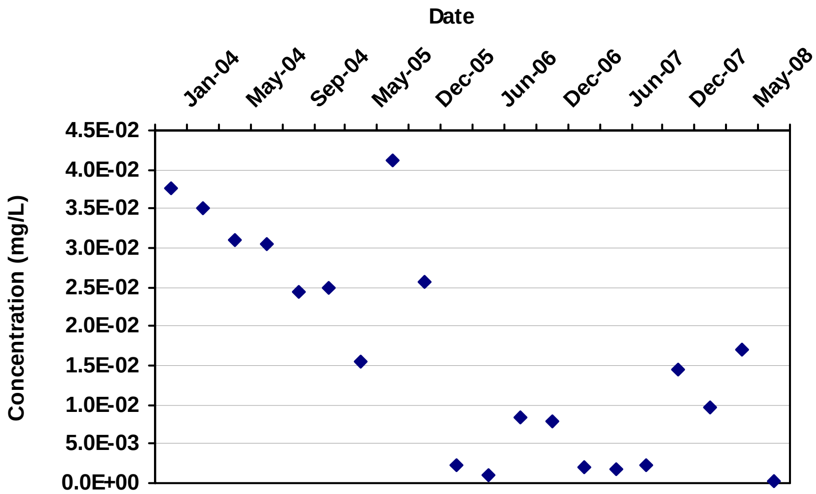
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-9	T	1/1/2004	ARSENIC	3.5E-02		1	1
BA-9	T	3/1/2004	ARSENIC	2.9E-02		1	1
BA-9	T	5/1/2004	ARSENIC	2.0E-04	ND	1	0
BA-9	T	7/1/2004	ARSENIC	2.0E-04	ND	1	0
BA-9	T	9/1/2004	ARSENIC	2.0E-04	ND	1	0
BA-9	T	3/1/2005	ARSENIC	2.0E-04	ND	1	0
BA-9	T	5/1/2005	ARSENIC	2.0E-04	ND	1	0
BA-9	T	10/1/2005	ARSENIC	1.3E-03		1	1
BA-9	T	12/1/2005	ARSENIC	2.0E-04	ND	1	0
BA-9	T	3/1/2006	ARSENIC	2.0E-04	ND	1	0
BA-9	T	6/1/2006	ARSENIC	2.0E-04	ND	1	0
BA-9	T	9/1/2006	ARSENIC	1.9E-02		1	1
BA-9	T	12/1/2006	ARSENIC	1.6E-02		1	1
BA-9	T	3/1/2007	ARSENIC	1.7E-02		1	1
BA-9	T	6/1/2007	ARSENIC	1.7E-02		1	1
BA-9	T	9/1/2007	ARSENIC	1.6E-02		1	1
BA-9	T	12/1/2007	ARSENIC	3.4E-02		1	1
BA-9	T	3/8/2008	ARSENIC	3.2E-02		1	1
BA-9	T	5/8/2008	ARSENIC	2.9E-02		1	1
BA-9	T	8/8/2008	ARSENIC	3.9E-02		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-3
Well Type: S
COC: ARSENIC

Time Period: 1/1/2004 **to** 8/8/2008
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: -101

Confidence in Trend: 100.0%

Coefficient of Variation: 0.82

Mann Kendall Concentration Trend: (See Note) D

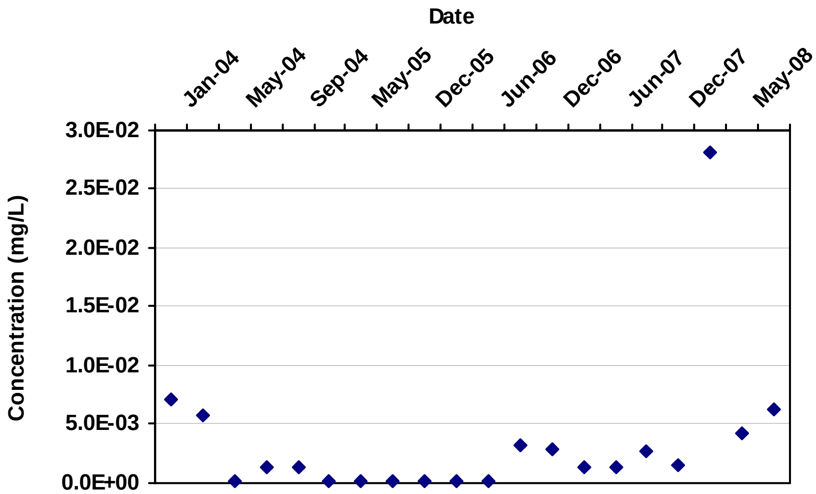
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-3	S	1/1/2004	ARSENIC	3.8E-02		1	1
BA-3	S	3/1/2004	ARSENIC	3.5E-02		1	1
BA-3	S	5/1/2004	ARSENIC	3.1E-02		1	1
BA-3	S	7/1/2004	ARSENIC	3.0E-02		1	1
BA-3	S	9/1/2004	ARSENIC	2.4E-02		1	1
BA-3	S	3/1/2005	ARSENIC	2.5E-02		1	1
BA-3	S	5/1/2005	ARSENIC	1.5E-02		1	1
BA-3	S	10/1/2005	ARSENIC	4.1E-02		1	1
BA-3	S	12/1/2005	ARSENIC	2.6E-02		1	1
BA-3	S	3/1/2006	ARSENIC	2.3E-03		1	1
BA-3	S	6/1/2006	ARSENIC	1.1E-03		1	1
BA-3	S	9/1/2006	ARSENIC	8.5E-03		1	1
BA-3	S	12/1/2006	ARSENIC	8.0E-03		1	1
BA-3	S	3/1/2007	ARSENIC	2.1E-03		1	1
BA-3	S	6/1/2007	ARSENIC	1.9E-03		1	1
BA-3	S	9/1/2007	ARSENIC	2.3E-03		1	1
BA-3	S	12/1/2007	ARSENIC	1.5E-02		1	1
BA-3	S	3/8/2008	ARSENIC	9.5E-03		1	1
BA-3	S	5/8/2008	ARSENIC	1.7E-02		1	1
BA-3	S	8/8/2008	ARSENIC	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: MW-02
Well Type: T
COC: ARSENIC

Time Period: 1/1/2004 **to** 8/8/2008
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: 47

Confidence in Trend: 93.2%

Coefficient of Variation: 1.81

Mann Kendall Concentration Trend: (See Note) PI

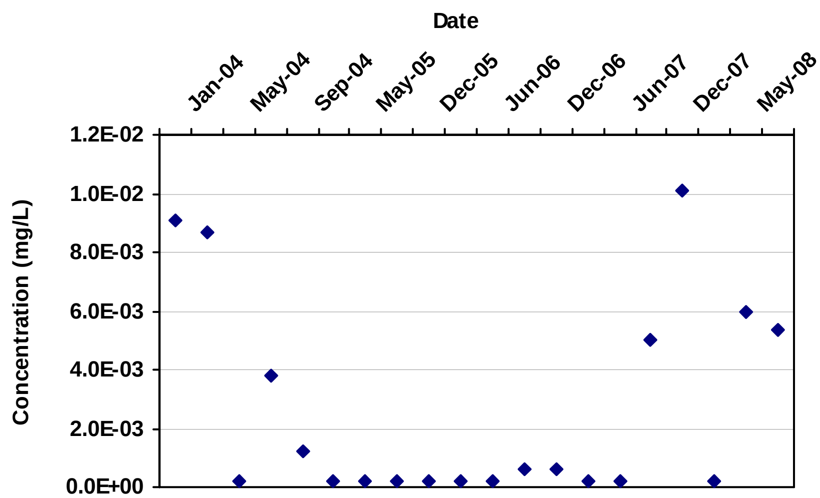
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-02	T	1/1/2004	ARSENIC	7.2E-03		1	1
MW-02	T	3/1/2004	ARSENIC	5.7E-03		1	1
MW-02	T	5/1/2004	ARSENIC	2.0E-04	ND	1	0
MW-02	T	7/1/2004	ARSENIC	1.4E-03		1	1
MW-02	T	9/1/2004	ARSENIC	1.4E-03		1	1
MW-02	T	3/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-02	T	5/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-02	T	10/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-02	T	12/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-02	T	3/1/2006	ARSENIC	2.0E-04	ND	1	0
MW-02	T	6/1/2006	ARSENIC	2.0E-04	ND	1	0
MW-02	T	9/1/2006	ARSENIC	3.2E-03		1	1
MW-02	T	12/1/2006	ARSENIC	2.8E-03		1	1
MW-02	T	3/1/2007	ARSENIC	1.4E-03		1	1
MW-02	T	6/1/2007	ARSENIC	1.4E-03		1	1
MW-02	T	9/1/2007	ARSENIC	2.7E-03		1	1
MW-02	T	12/1/2007	ARSENIC	1.5E-03		1	1
MW-02	T	3/8/2008	ARSENIC	2.8E-02		1	1
MW-02	T	5/8/2008	ARSENIC	4.2E-03		1	1
MW-02	T	8/8/2008	ARSENIC	6.2E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-06
Well Type: T
COC: ARSENIC

Time Period: 1/1/2004 **to** 8/8/2008
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: 6

Confidence in Trend: 56.4%

Coefficient of Variation: 1.33

Mann Kendall Concentration Trend: (See Note) NT

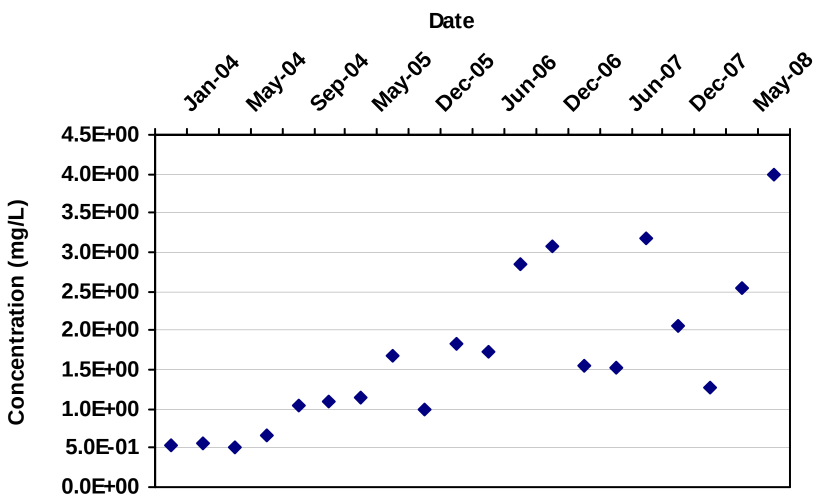
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-06	T	1/1/2004	ARSENIC	9.1E-03		1	1
MW-06	T	3/1/2004	ARSENIC	8.7E-03		1	1
MW-06	T	5/1/2004	ARSENIC	2.0E-04	ND	1	0
MW-06	T	7/1/2004	ARSENIC	3.8E-03		1	1
MW-06	T	9/1/2004	ARSENIC	1.2E-03		1	1
MW-06	T	3/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-06	T	5/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-06	T	10/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-06	T	12/1/2005	ARSENIC	2.0E-04	ND	1	0
MW-06	T	3/1/2006	ARSENIC	2.0E-04	ND	1	0
MW-06	T	6/1/2006	ARSENIC	2.0E-04	ND	1	0
MW-06	T	9/1/2006	ARSENIC	6.1E-04		1	1
MW-06	T	12/1/2006	ARSENIC	6.1E-04		1	1
MW-06	T	3/1/2007	ARSENIC	2.0E-04	ND	1	0
MW-06	T	6/1/2007	ARSENIC	2.0E-04	ND	1	0
MW-06	T	9/1/2007	ARSENIC	5.0E-03		1	1
MW-06	T	12/1/2007	ARSENIC	1.0E-02		1	1
MW-06	T	3/8/2008	ARSENIC	2.0E-04	ND	1	0
MW-06	T	5/8/2008	ARSENIC	5.9E-03		1	1
MW-06	T	8/8/2008	ARSENIC	5.3E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-02
Well Type: T
COC: MANGANESE

Time Period: to
Consolidation Period: Other
Consolidation Type: Maximum
Duplicate Consolidation: First
ND Values: Specified Detection Limit
J Flag Values : Fraction of Actual Value



Mann Kendall S Statistic: 124

Confidence in Trend: 100.0%

Coefficient of Variation: 0.58

Mann Kendall Concentration Trend: (See Note) I

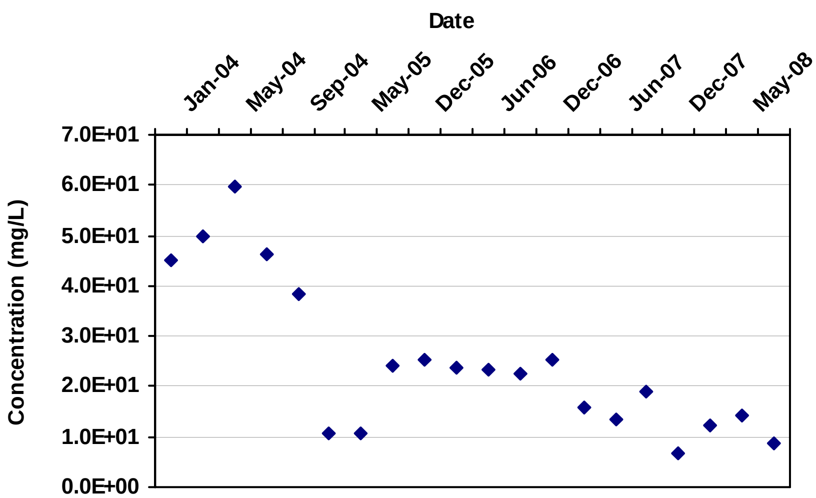
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-02	T	1/1/2004	MANGANESE	5.3E-01		1	1
MW-02	T	3/1/2004	MANGANESE	5.6E-01		1	1
MW-02	T	5/1/2004	MANGANESE	5.0E-01		1	1
MW-02	T	7/1/2004	MANGANESE	6.7E-01		1	1
MW-02	T	9/1/2004	MANGANESE	1.1E+00		1	1
MW-02	T	3/1/2005	MANGANESE	1.1E+00		1	1
MW-02	T	5/1/2005	MANGANESE	1.1E+00		1	1
MW-02	T	10/1/2005	MANGANESE	1.7E+00		1	1
MW-02	T	12/1/2005	MANGANESE	1.0E+00		1	1
MW-02	T	3/1/2006	MANGANESE	1.8E+00		1	1
MW-02	T	6/1/2006	MANGANESE	1.7E+00		1	1
MW-02	T	9/1/2006	MANGANESE	2.9E+00		1	1
MW-02	T	12/1/2006	MANGANESE	3.1E+00		1	1
MW-02	T	3/1/2007	MANGANESE	1.5E+00		1	1
MW-02	T	6/1/2007	MANGANESE	1.5E+00		1	1
MW-02	T	9/1/2007	MANGANESE	3.2E+00		1	1
MW-02	T	12/1/2007	MANGANESE	2.0E+00		1	1
MW-02	T	3/8/2008	MANGANESE	1.3E+00		1	1
MW-02	T	5/8/2008	MANGANESE	2.5E+00		1	1
MW-02	T	8/8/2008	MANGANESE	4.0E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: DW-02
Well Type: T
COC: MANGANESE

Time Period: to
Consolidation Period: Other
Consolidation Type: Maximum
Duplicate Consolidation: First
ND Values: Specified Detection Limit
J Flag Values : Fraction of Actual Value



Mann Kendall S Statistic: -110

Confidence in Trend: 100.0%

Coefficient of Variation: 0.61

Mann Kendall Concentration Trend: (See Note) D

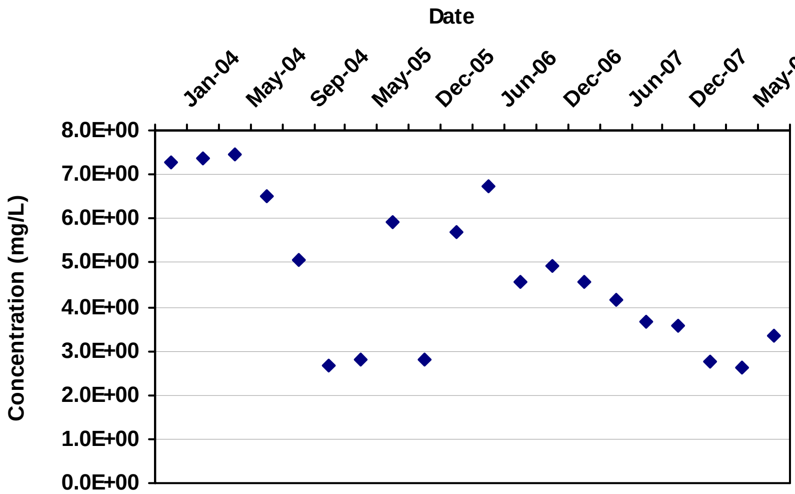
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-02	T	1/1/2004	MANGANESE	4.5E+01		1	1
DW-02	T	3/1/2004	MANGANESE	5.0E+01		1	1
DW-02	T	5/1/2004	MANGANESE	6.0E+01		1	1
DW-02	T	7/1/2004	MANGANESE	4.6E+01		1	1
DW-02	T	9/1/2004	MANGANESE	3.8E+01		1	1
DW-02	T	3/1/2005	MANGANESE	1.1E+01		1	1
DW-02	T	5/1/2005	MANGANESE	1.1E+01		1	1
DW-02	T	10/1/2005	MANGANESE	2.4E+01		1	1
DW-02	T	12/1/2005	MANGANESE	2.5E+01		1	1
DW-02	T	3/1/2006	MANGANESE	2.4E+01		1	1
DW-02	T	6/1/2006	MANGANESE	2.4E+01		1	1
DW-02	T	9/1/2006	MANGANESE	2.2E+01		1	1
DW-02	T	12/1/2006	MANGANESE	2.6E+01		1	1
DW-02	T	3/1/2007	MANGANESE	1.6E+01		1	1
DW-02	T	6/1/2007	MANGANESE	1.4E+01		1	1
DW-02	T	9/1/2007	MANGANESE	1.9E+01		1	1
DW-02	T	12/1/2007	MANGANESE	6.7E+00		1	1
DW-02	T	3/8/2008	MANGANESE	1.2E+01		1	1
DW-02	T	5/8/2008	MANGANESE	1.4E+01		1	1
DW-02	T	8/8/2008	MANGANESE	8.5E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-9
Well Type: T
COC: MANGANESE

Time Period: 1/1/2004 **to** 8/8/2008
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: 100.0%

Coefficient of Variation: 0.36

Mann Kendall Concentration Trend: (See Note) D

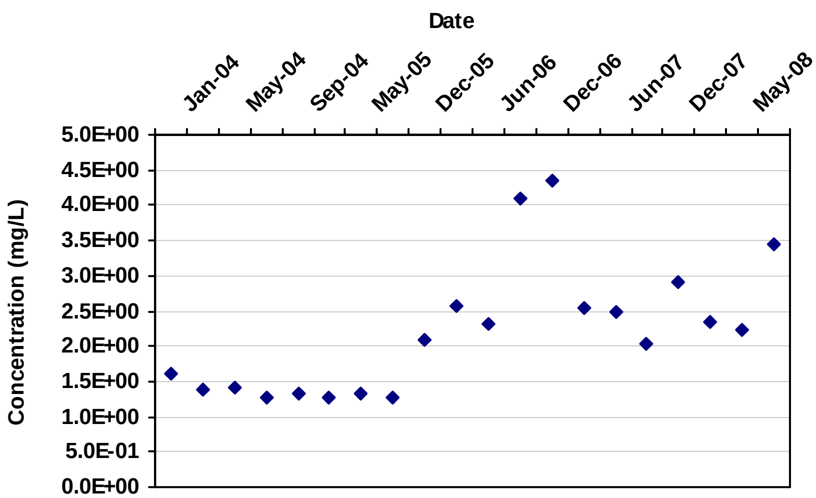
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-9	T	1/1/2004	MANGANESE	7.3E+00		1	1
BA-9	T	3/1/2004	MANGANESE	7.4E+00		1	1
BA-9	T	5/1/2004	MANGANESE	7.5E+00		1	1
BA-9	T	7/1/2004	MANGANESE	6.5E+00		1	1
BA-9	T	9/1/2004	MANGANESE	5.1E+00		1	1
BA-9	T	3/1/2005	MANGANESE	2.7E+00		1	1
BA-9	T	5/1/2005	MANGANESE	2.8E+00		1	1
BA-9	T	10/1/2005	MANGANESE	5.9E+00		1	1
BA-9	T	12/1/2005	MANGANESE	2.8E+00		1	1
BA-9	T	3/1/2006	MANGANESE	5.7E+00		1	1
BA-9	T	6/1/2006	MANGANESE	6.7E+00		1	1
BA-9	T	9/1/2006	MANGANESE	4.5E+00		1	1
BA-9	T	12/1/2006	MANGANESE	4.9E+00		1	1
BA-9	T	3/1/2007	MANGANESE	4.6E+00		1	1
BA-9	T	6/1/2007	MANGANESE	4.2E+00		1	1
BA-9	T	9/1/2007	MANGANESE	3.7E+00		1	1
BA-9	T	12/1/2007	MANGANESE	3.6E+00		1	1
BA-9	T	3/8/2008	MANGANESE	2.7E+00		1	1
BA-9	T	5/8/2008	MANGANESE	2.6E+00		1	1
BA-9	T	8/8/2008	MANGANESE	3.4E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-06
Well Type: T
COC: MANGANESE

Time Period: to
Consolidation Period: Other
Consolidation Type: Maximum
Duplicate Consolidation: First
ND Values: Specified Detection Limit
J Flag Values : Fraction of Actual Value



Mann Kendall S Statistic: 80

Confidence in Trend: 99.5%

Coefficient of Variation: 0.42

Mann Kendall Concentration Trend: (See Note) I

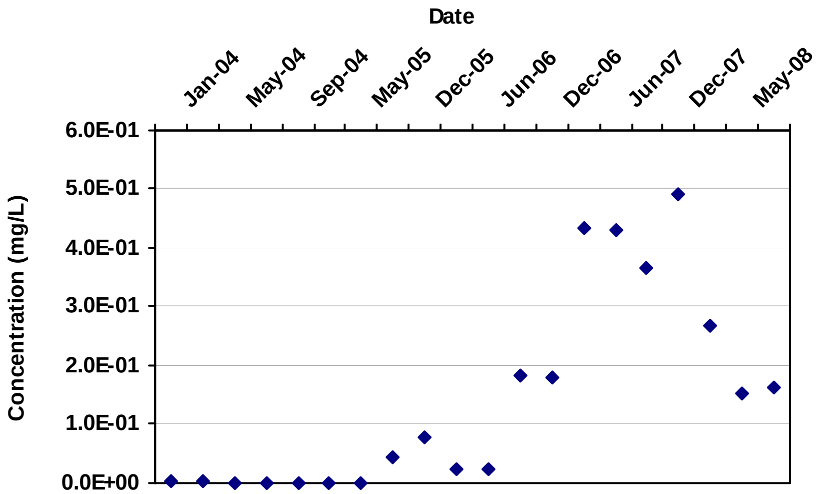
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-06	T	1/1/2004	MANGANESE	1.6E+00		1	1
MW-06	T	3/1/2004	MANGANESE	1.4E+00		1	1
MW-06	T	5/1/2004	MANGANESE	1.4E+00		1	1
MW-06	T	7/1/2004	MANGANESE	1.3E+00		1	1
MW-06	T	9/1/2004	MANGANESE	1.3E+00		1	1
MW-06	T	3/1/2005	MANGANESE	1.3E+00		1	1
MW-06	T	5/1/2005	MANGANESE	1.3E+00		1	1
MW-06	T	10/1/2005	MANGANESE	1.3E+00		1	1
MW-06	T	12/1/2005	MANGANESE	2.1E+00		1	1
MW-06	T	3/1/2006	MANGANESE	2.6E+00		1	1
MW-06	T	6/1/2006	MANGANESE	2.3E+00		1	1
MW-06	T	9/1/2006	MANGANESE	4.1E+00		1	1
MW-06	T	12/1/2006	MANGANESE	4.3E+00		1	1
MW-06	T	3/1/2007	MANGANESE	2.5E+00		1	1
MW-06	T	6/1/2007	MANGANESE	2.5E+00		1	1
MW-06	T	9/1/2007	MANGANESE	2.0E+00		1	1
MW-06	T	12/1/2007	MANGANESE	2.9E+00		1	1
MW-06	T	3/8/2008	MANGANESE	2.4E+00		1	1
MW-06	T	5/8/2008	MANGANESE	2.2E+00		1	1
MW-06	T	8/8/2008	MANGANESE	3.4E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-3
Well Type: S
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: 104

Confidence in Trend: 100.0%

Coefficient of Variation: 1.19

Mann Kendall Concentration Trend: (See Note) I

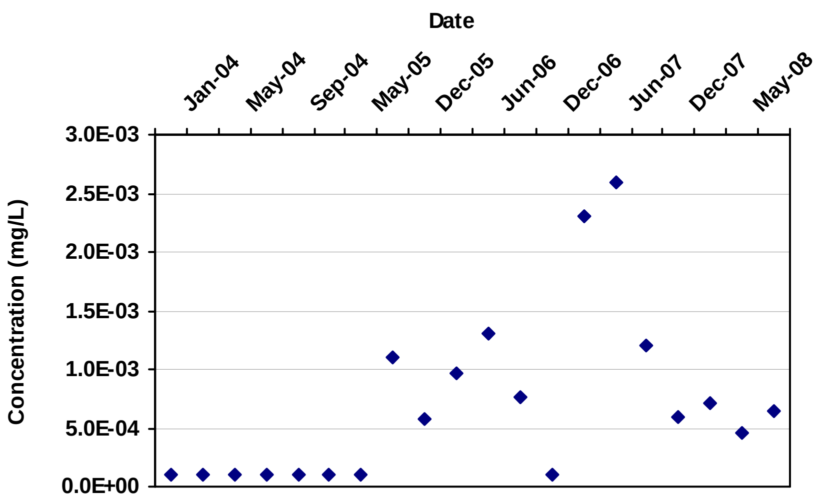
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-3	S	1/1/2004	LEAD	4.6E-03		1	1
BA-3	S	3/1/2004	LEAD	3.2E-03		1	1
BA-3	S	5/1/2004	LEAD	1.0E-04	ND	1	0
BA-3	S	7/1/2004	LEAD	1.0E-04	ND	1	0
BA-3	S	9/1/2004	LEAD	1.0E-04	ND	1	0
BA-3	S	3/1/2005	LEAD	1.0E-04	ND	1	0
BA-3	S	5/1/2005	LEAD	1.0E-04	ND	1	0
BA-3	S	10/1/2005	LEAD	4.4E-02		1	1
BA-3	S	12/1/2005	LEAD	7.8E-02		1	1
BA-3	S	3/1/2006	LEAD	2.5E-02		1	1
BA-3	S	6/1/2006	LEAD	2.4E-02		1	1
BA-3	S	9/1/2006	LEAD	1.8E-01		1	1
BA-3	S	12/1/2006	LEAD	1.8E-01		1	1
BA-3	S	3/1/2007	LEAD	4.4E-01		1	1
BA-3	S	6/1/2007	LEAD	4.3E-01		1	1
BA-3	S	9/1/2007	LEAD	3.7E-01		1	1
BA-3	S	12/1/2007	LEAD	4.9E-01		1	1
BA-3	S	3/8/2008	LEAD	2.7E-01		1	1
BA-3	S	5/8/2008	LEAD	1.5E-01		1	1
BA-3	S	8/8/2008	LEAD	1.6E-01		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-9
Well Type: T
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: 72

Confidence in Trend: 99.0%

Coefficient of Variation: 1.03

Mann Kendall Concentration Trend: (See Note) I

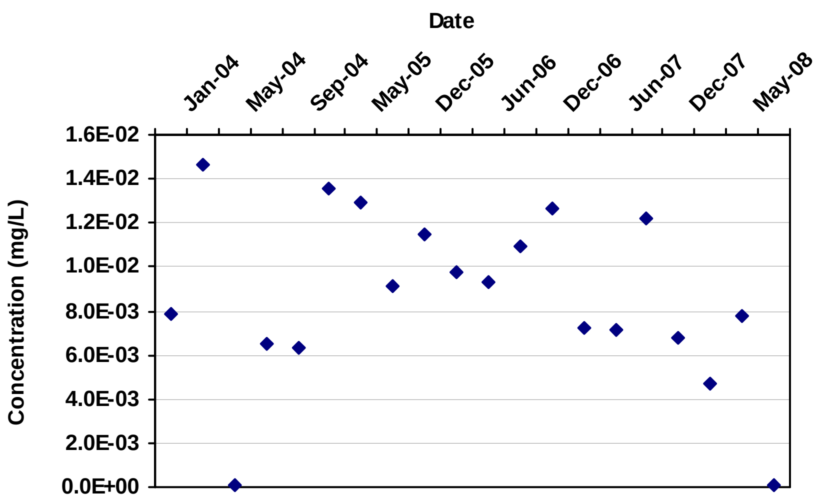
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-9	T	1/1/2004	LEAD	1.0E-04	ND	1	0
BA-9	T	3/1/2004	LEAD	1.0E-04	ND	1	0
BA-9	T	5/1/2004	LEAD	1.0E-04	ND	1	0
BA-9	T	7/1/2004	LEAD	1.0E-04	ND	1	0
BA-9	T	9/1/2004	LEAD	1.0E-04	ND	1	0
BA-9	T	3/1/2005	LEAD	1.0E-04	ND	1	0
BA-9	T	5/1/2005	LEAD	1.0E-04	ND	1	0
BA-9	T	10/1/2005	LEAD	1.1E-03		1	1
BA-9	T	12/1/2005	LEAD	5.8E-04		1	1
BA-9	T	3/1/2006	LEAD	9.7E-04		1	1
BA-9	T	6/1/2006	LEAD	1.3E-03		1	1
BA-9	T	9/1/2006	LEAD	7.7E-04		1	1
BA-9	T	12/1/2006	LEAD	1.0E-04	ND	1	0
BA-9	T	3/1/2007	LEAD	2.3E-03		1	1
BA-9	T	6/1/2007	LEAD	2.6E-03		1	1
BA-9	T	9/1/2007	LEAD	1.2E-03		1	1
BA-9	T	12/1/2007	LEAD	5.9E-04		1	1
BA-9	T	3/8/2008	LEAD	7.2E-04		1	1
BA-9	T	5/8/2008	LEAD	4.6E-04		1	1
BA-9	T	8/8/2008	LEAD	6.4E-04		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-02
Well Type: T
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: -41

Confidence in Trend: 90.2%

Coefficient of Variation: 0.47

Mann Kendall Concentration Trend: (See Note) PD

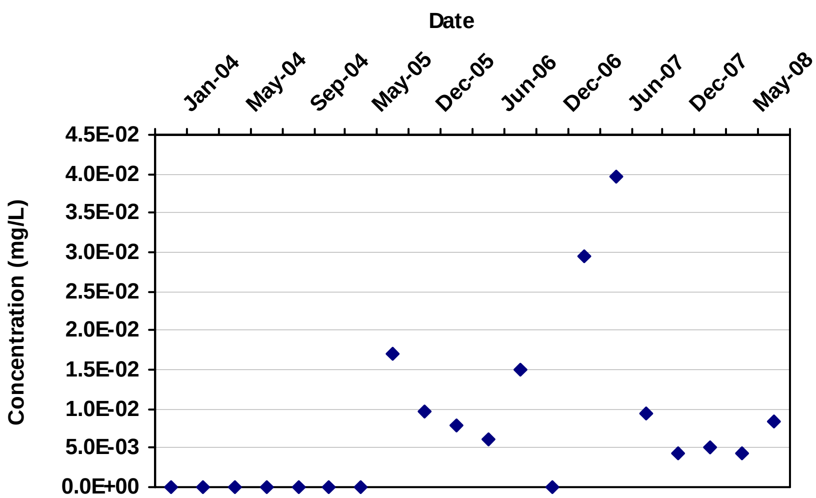
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-02	T	1/1/2004	LEAD	7.9E-03		1	1
MW-02	T	3/1/2004	LEAD	1.5E-02		1	1
MW-02	T	5/1/2004	LEAD	1.0E-04	ND	1	0
MW-02	T	7/1/2004	LEAD	6.5E-03		1	1
MW-02	T	9/1/2004	LEAD	6.3E-03		1	1
MW-02	T	3/1/2005	LEAD	1.4E-02		1	1
MW-02	T	5/1/2005	LEAD	1.3E-02		1	1
MW-02	T	10/1/2005	LEAD	9.1E-03		1	1
MW-02	T	12/1/2005	LEAD	1.2E-02		1	1
MW-02	T	3/1/2006	LEAD	9.8E-03		1	1
MW-02	T	6/1/2006	LEAD	9.3E-03		1	1
MW-02	T	9/1/2006	LEAD	1.1E-02		1	1
MW-02	T	12/1/2006	LEAD	1.3E-02		1	1
MW-02	T	3/1/2007	LEAD	7.2E-03		1	1
MW-02	T	6/1/2007	LEAD	7.1E-03		1	1
MW-02	T	9/1/2007	LEAD	1.2E-02		1	1
MW-02	T	12/1/2007	LEAD	6.7E-03		1	1
MW-02	T	3/8/2008	LEAD	4.7E-03		1	1
MW-02	T	5/8/2008	LEAD	7.8E-03		1	1
MW-02	T	8/8/2008	LEAD	1.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: DW-02
Well Type: T
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: 66

Confidence in Trend: 98.3%

Coefficient of Variation: 1.35

Mann Kendall Concentration Trend: (See Note) I

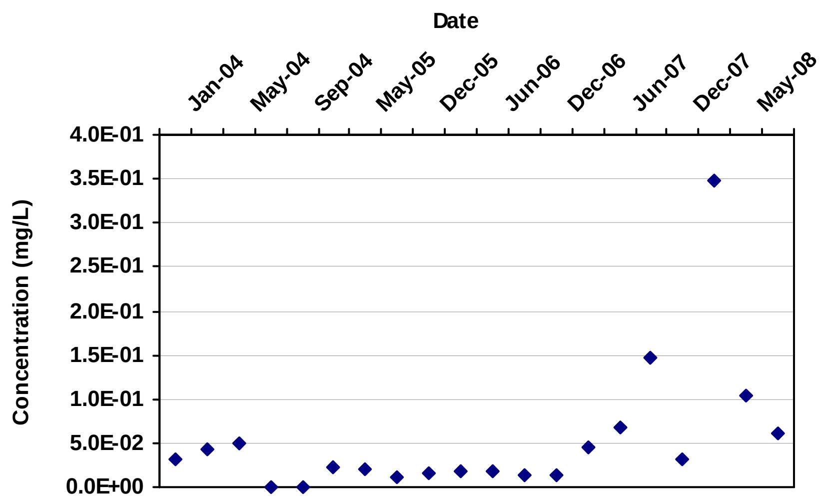
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-02	T	1/1/2004	LEAD	1.0E-04	ND	1	0
DW-02	T	3/1/2004	LEAD	1.0E-04	ND	1	0
DW-02	T	5/1/2004	LEAD	1.0E-04	ND	1	0
DW-02	T	7/1/2004	LEAD	1.0E-04	ND	1	0
DW-02	T	9/1/2004	LEAD	1.0E-04	ND	1	0
DW-02	T	3/1/2005	LEAD	1.0E-04	ND	1	0
DW-02	T	5/1/2005	LEAD	1.0E-04	ND	1	0
DW-02	T	10/1/2005	LEAD	1.7E-02		1	1
DW-02	T	12/1/2005	LEAD	9.7E-03		1	1
DW-02	T	3/1/2006	LEAD	8.0E-03		1	1
DW-02	T	6/1/2006	LEAD	6.1E-03		1	1
DW-02	T	9/1/2006	LEAD	1.5E-02		1	1
DW-02	T	12/1/2006	LEAD	1.0E-04	ND	1	0
DW-02	T	3/1/2007	LEAD	2.9E-02		1	1
DW-02	T	6/1/2007	LEAD	4.0E-02		1	1
DW-02	T	9/1/2007	LEAD	9.5E-03		1	1
DW-02	T	12/1/2007	LEAD	4.3E-03		1	1
DW-02	T	3/8/2008	LEAD	5.2E-03		1	1
DW-02	T	5/8/2008	LEAD	4.4E-03		1	1
DW-02	T	8/8/2008	LEAD	8.3E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: DW-03
Well Type: S
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: 61

Confidence in Trend: 97.5%

Coefficient of Variation: 1.48

Mann Kendall Concentration Trend: (See Note) I

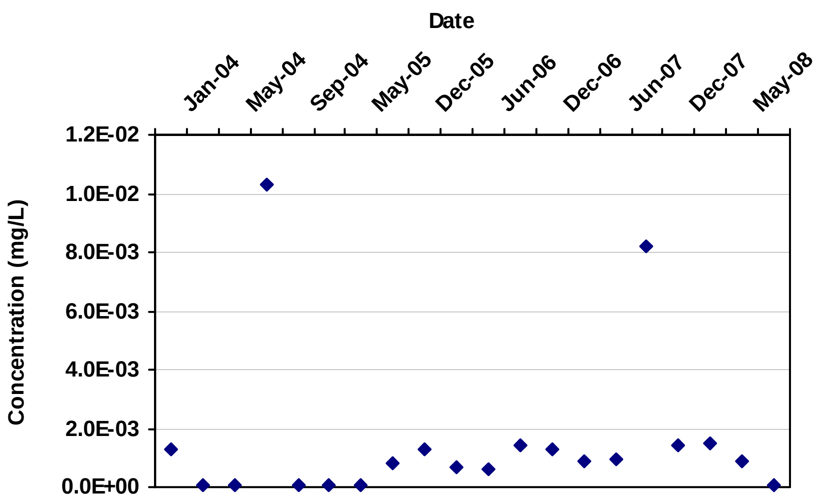
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-03	S	1/1/2004	LEAD	3.1E-02		1	1
DW-03	S	3/1/2004	LEAD	4.3E-02		1	1
DW-03	S	5/1/2004	LEAD	5.0E-02		1	1
DW-03	S	7/1/2004	LEAD	1.0E-04	ND	1	0
DW-03	S	9/1/2004	LEAD	1.0E-04	ND	1	0
DW-03	S	3/1/2005	LEAD	2.2E-02		1	1
DW-03	S	5/1/2005	LEAD	2.0E-02		1	1
DW-03	S	10/1/2005	LEAD	1.2E-02		1	1
DW-03	S	12/1/2005	LEAD	1.5E-02		1	1
DW-03	S	3/1/2006	LEAD	1.9E-02		1	1
DW-03	S	6/1/2006	LEAD	1.9E-02		1	1
DW-03	S	9/1/2006	LEAD	1.4E-02		1	1
DW-03	S	12/1/2006	LEAD	1.3E-02		1	1
DW-03	S	3/1/2007	LEAD	4.4E-02		1	1
DW-03	S	6/1/2007	LEAD	6.7E-02		1	1
DW-03	S	9/1/2007	LEAD	1.5E-01		1	1
DW-03	S	12/1/2007	LEAD	3.1E-02		1	1
DW-03	S	3/8/2008	LEAD	3.5E-01		1	1
DW-03	S	5/8/2008	LEAD	1.0E-01		1	1
DW-03	S	8/8/2008	LEAD	6.2E-02		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-06
Well Type: T
COC: LEAD

Time Period: 1/1/2004 **to** 8/8/2008
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: 50

Confidence in Trend: 94.4%

Coefficient of Variation: 1.67

Mann Kendall Concentration Trend: (See Note) PI

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-06	T	1/1/2004	LEAD	1.3E-03		1	1
MW-06	T	3/1/2004	LEAD	1.0E-04	ND	1	0
MW-06	T	5/1/2004	LEAD	1.0E-04	ND	1	0
MW-06	T	7/1/2004	LEAD	1.0E-02		1	1
MW-06	T	9/1/2004	LEAD	1.0E-04	ND	1	0
MW-06	T	3/1/2005	LEAD	1.0E-04	ND	1	0
MW-06	T	5/1/2005	LEAD	1.0E-04	ND	1	0
MW-06	T	10/1/2005	LEAD	8.1E-04		1	1
MW-06	T	12/1/2005	LEAD	1.3E-03		1	1
MW-06	T	3/1/2006	LEAD	6.8E-04		1	1
MW-06	T	6/1/2006	LEAD	6.3E-04		1	1
MW-06	T	9/1/2006	LEAD	1.4E-03		1	1
MW-06	T	12/1/2006	LEAD	1.3E-03		1	1
MW-06	T	3/1/2007	LEAD	8.6E-04		1	1
MW-06	T	6/1/2007	LEAD	9.5E-04		1	1
MW-06	T	9/1/2007	LEAD	8.2E-03		1	1
MW-06	T	12/1/2007	LEAD	1.4E-03		1	1
MW-06	T	3/8/2008	LEAD	1.5E-03		1	1
MW-06	T	5/8/2008	LEAD	9.0E-04		1	1
MW-06	T	8/8/2008	LEAD	1.0E-04	ND	1	0

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

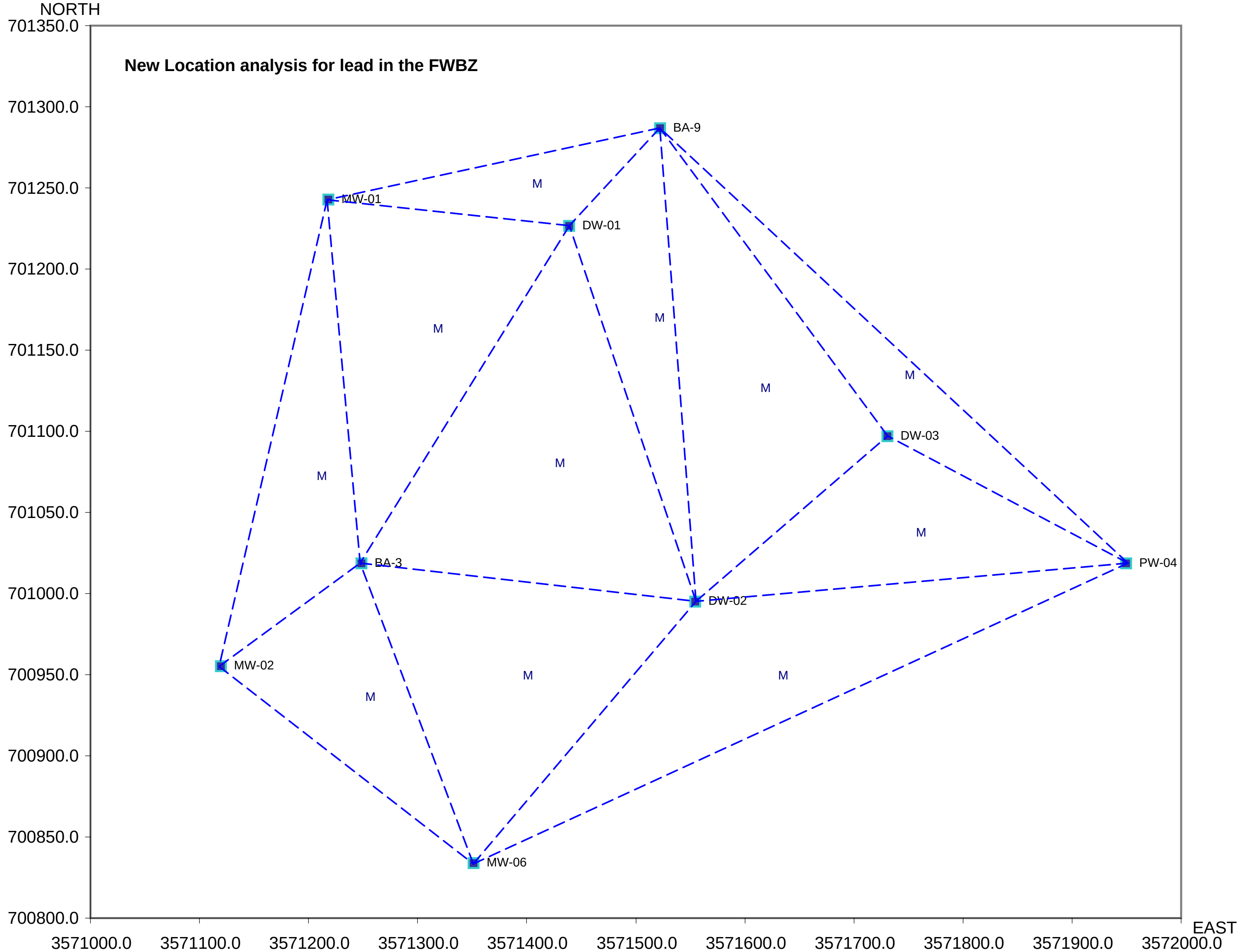
Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

First Water-Bearing Zone

Well Sufficiency Spatial Analysis Results



New Location Analysis for

LEAD

Existing Locations

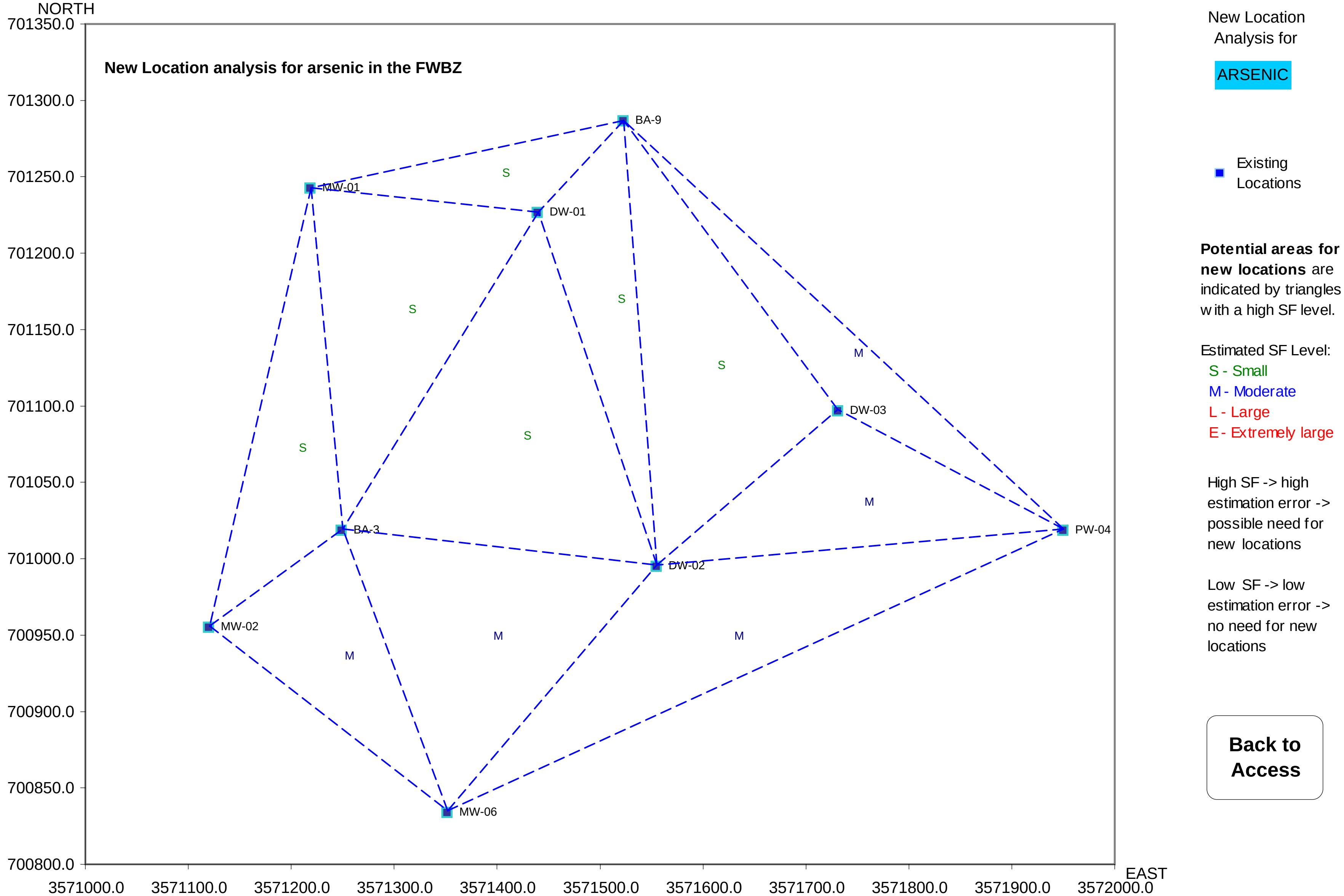
Potential areas for new locations are indicated by triangles w ith a high SF level.

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high estimation error -> possible need for new locations

Low SF -> low estimation error -> no need for new locations

Back to Access



New Location analysis for arsenic in the FWBZ
NORTH
EAST
701350.0
701300.0
701250.0
701200.0
701150.0
701100.0
701050.0
701000.0
700950.0
700900.0
700850.0
700800.0
3571000.0
3571100.0
3571200.0
3571300.0
3571400.0
3571500.0
3571600.0
3571700.0
3571800.0
3571900.0
3572000.0
BA-9
MW-01
DW-01
DW-03
PW-04
BA-3
DW-02
MW-02
MW-06
S
M
New Location Analysis for
ARSENIC
Existing Locations
Potential areas for new locations are indicated by triangles with a high SF level.
Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large
High SF -> high estimation error -> possible need for new locations
Low SF -> low estimation error -> no need for new locations
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GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

Second Water-Bearing Zone
COC Assessment

MAROS COC Assessment

Project: SWBZ **User Name:** MV

Location: Ponchatoula **State:** Louisiana

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
Thallium	2.3E-03	2.0E-03	12.9%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
Thallium	MET	13	4	30.8%	12

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
Thallium	

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

Arsenic

Lead

Manganese

Nickel

Thallium

September, 2009

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

Second Water-Bearing Zone
Metals Trend Reports

MAROS Mann-Kendall Statistics Summary

Project: Delatte SWBZ **User Name:** mv

Location: Ponchatoula **State:** Louisiana

Time Period: 1/1/2004 **to** 8/8/2008
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified 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
Arsenic								
BA-01	S	20	15	1.25	-11	62.6%	No	NT
BA-05	S	20	16	1.01	-8	58.9%	No	NT
BA-09A	T	20	17	0.89	18	70.7%	No	NT
BC-03	T	20	16	1.13	-48	93.6%	No	PD
BC-07	T	20	15	1.18	-74	99.2%	No	D
BC-17	S	20	17	0.68	-12	63.8%	No	S
BC-19	T	20	16	1.21	-26	78.9%	No	NT
BC-21R	T	20	14	1.49	-25	78.0%	No	NT
BC-25	T	20	14	1.53	-19	71.8%	No	NT
DW-04	T	20	15	1.16	-47	93.2%	No	PD
MW-03	T	20	13	1.57	-54	95.7%	No	D
MW-04	T	20	12	1.74	43	91.3%	No	PI
MW-A	T	20	15	1.84	-30	82.4%	No	NT
Lead								
BA-01	S	20	13	2.18	33	84.9%	No	NT
BA-05	S	20	13	1.60	-3	52.6%	No	NT
BA-09A	T	20	12	0.68	106	100.0%	No	I
BC-03	T	20	15	0.72	2	51.3%	No	NT
BC-07	T	20	13	1.03	70	98.8%	No	I
BC-17	S	20	20	0.99	-50	94.4%	No	PD
BC-19	T	20	15	1.07	52	95.1%	No	I
BC-21R	T	20	11	1.11	27	79.8%	No	NT
BC-25	T	20	11	1.21	71	98.9%	No	I
DW-04	T	20	14	1.03	15	67.3%	No	NT
MW-03	T	20	12	1.05	39	89.0%	No	NT
MW-04	T	20	14	1.44	43	91.3%	No	PI
MW-A	T	20	12	1.18	23	76.0%	No	NT
Manganese								
BA-01	S	20	20	0.36	48	93.6%	No	PI
BA-05	S	20	20	0.45	-106	100.0%	No	D
BA-09A	T	20	20	0.38	-48	93.6%	No	PD
BC-03	T	20	20	0.78	-68	98.6%	No	D
BC-07	T	20	20	0.50	-15	67.3%	No	S
BC-17	S	20	20	0.79	-70	98.8%	No	D
BC-19	T	20	18	1.07	-1	50.0%	No	NT
BC-21R	T	20	18	1.05	13	65.0%	No	NT

Project: Delatte SWBZ **User Name:** mv

Location: Ponchatoula **State:** Louisiana

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
Manganese								
BC-25	T	20	20	0.59	-56	96.3%	No	D
DW-04	T	20	20	0.29	-14	66.1%	No	S
MW-03	T	20	20	0.33	45	92.3%	No	PI
MW-04	T	20	19	1.16	-16	68.5%	No	NT
MW-A	T	20	17	0.70	-3	52.6%	No	S
Nickel								
BA-01	S	20	17	0.96	85	99.8%	No	I
BA-05	S	20	20	0.33	-62	97.7%	No	D
BA-09A	T	20	13	0.81	4	53.8%	No	NT
BC-03	T	20	17	0.68	44	91.8%	No	PI
BC-07	T	20	17	0.99	3	52.6%	No	NT
BC-17	S	20	16	0.76	-11	62.6%	No	S
BC-19	T	20	17	0.73	18	70.7%	No	NT
BC-21R	T	20	16	1.14	11	62.6%	No	NT
BC-25	T	20	16	0.96	-9	60.1%	No	S
DW-04	T	20	16	1.81	27	79.8%	No	NT
MW-03	T	20	17	0.70	16	68.5%	No	NT
MW-04	T	20	15	1.04	36	87.0%	No	NT
MW-A	T	20	15	2.03	26	78.9%	No	NT
Thallium								
BA-01	S	20	1	1.99	-17	69.6%	No	NT
BA-05	S	20	2	1.78	-1	50.0%	No	NT
BA-09A	T	20	1	1.20	13	65.0%	No	NT
BC-03	T	20	1	1.28	15	67.3%	No	NT
BC-07	T	20	2	1.03	29	81.6%	No	NT
BC-17	S	20	5	2.71	-19	71.8%	No	NT
BC-19	T	20	3	3.17	-24	77.0%	No	NT
BC-21R	T	20	2	1.81	-5	55.1%	No	NT
BC-25	T	20	2	4.36	-3	52.6%	No	NT
DW-04	T	20	3	4.01	8	58.9%	No	NT
MW-03	T	20	1	0.74	15	67.3%	No	NT
MW-04	T	20	1	1.24	13	65.0%	No	NT
MW-A	T	20	0	0.00	0	48.7%	Yes	ND

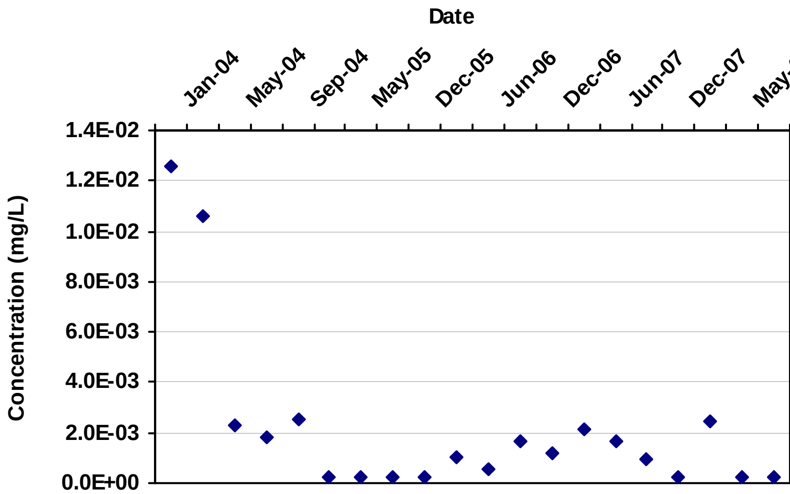
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

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

MAROS Mann-Kendall Statistics Summary

Well: MW-03
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -54

Confidence in Trend: 95.7%

Coefficient of Variation: 1.57

Mann Kendall Concentration Trend: (See Note) D

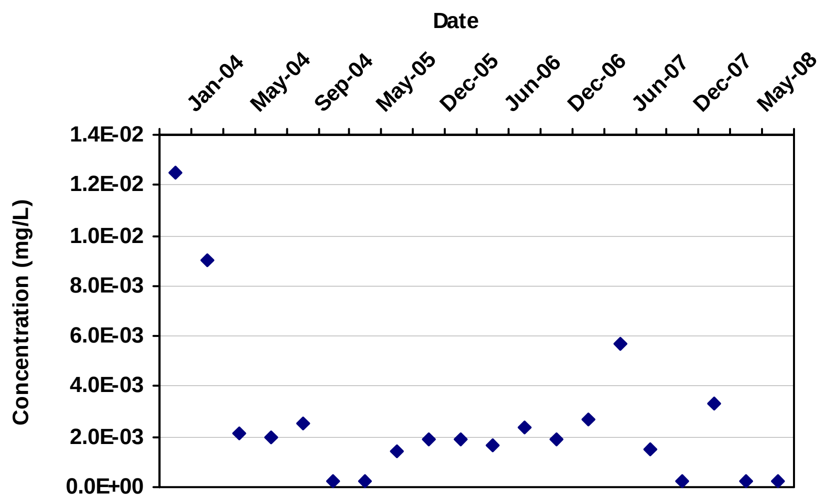
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-03	T	1/1/2004	Arsenic	1.3E-02		1	1
MW-03	T	3/1/2004	Arsenic	1.1E-02		1	1
MW-03	T	5/1/2004	Arsenic	2.3E-03		1	1
MW-03	T	7/1/2004	Arsenic	1.8E-03		1	1
MW-03	T	9/1/2004	Arsenic	2.5E-03		1	1
MW-03	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
MW-03	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
MW-03	T	10/1/2005	Arsenic	2.0E-04	ND	1	0
MW-03	T	12/1/2005	Arsenic	2.0E-04	ND	1	0
MW-03	T	3/1/2006	Arsenic	1.0E-03		1	1
MW-03	T	6/1/2006	Arsenic	5.7E-04		1	1
MW-03	T	9/1/2006	Arsenic	1.7E-03		1	1
MW-03	T	12/1/2006	Arsenic	1.2E-03		1	1
MW-03	T	3/1/2007	Arsenic	2.1E-03		1	1
MW-03	T	6/1/2007	Arsenic	1.7E-03		1	1
MW-03	T	9/1/2007	Arsenic	9.4E-04		1	1
MW-03	T	12/1/2007	Arsenic	2.0E-04	ND	1	0
MW-03	T	3/8/2008	Arsenic	2.5E-03		1	1
MW-03	T	5/8/2008	Arsenic	2.0E-04	ND	1	0
MW-03	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: DW-04
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -47

Confidence in Trend: 93.2%

Coefficient of Variation: 1.16

Mann Kendall Concentration Trend: (See Note) PD

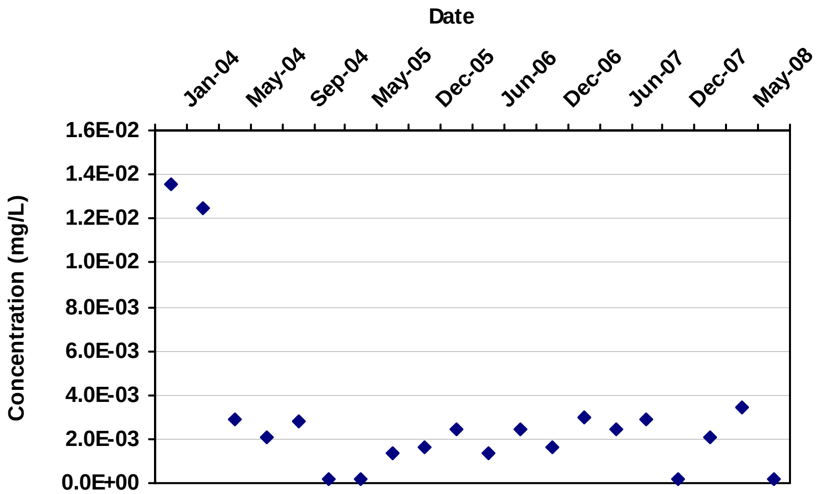
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
DW-04	T	1/1/2004	Arsenic	1.3E-02		1	1
DW-04	T	3/1/2004	Arsenic	9.0E-03		1	1
DW-04	T	5/1/2004	Arsenic	2.1E-03		1	1
DW-04	T	7/1/2004	Arsenic	2.0E-03		1	1
DW-04	T	9/1/2004	Arsenic	2.5E-03		1	1
DW-04	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
DW-04	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
DW-04	T	10/1/2005	Arsenic	1.4E-03		1	1
DW-04	T	12/1/2005	Arsenic	1.9E-03		1	1
DW-04	T	3/1/2006	Arsenic	1.9E-03		1	1
DW-04	T	6/1/2006	Arsenic	1.7E-03		1	1
DW-04	T	9/1/2006	Arsenic	2.4E-03		1	1
DW-04	T	12/1/2006	Arsenic	1.9E-03		1	1
DW-04	T	3/1/2007	Arsenic	2.7E-03		1	1
DW-04	T	6/1/2007	Arsenic	5.7E-03		1	1
DW-04	T	9/1/2007	Arsenic	1.5E-03		1	1
DW-04	T	12/1/2007	Arsenic	2.0E-04	ND	1	0
DW-04	T	3/8/2008	Arsenic	3.3E-03		1	1
DW-04	T	5/8/2008	Arsenic	2.0E-04	ND	1	0
DW-04	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BC-19
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -26

Confidence in Trend: 78.9%

Coefficient of Variation: 1.21

Mann Kendall Concentration Trend: (See Note) NT

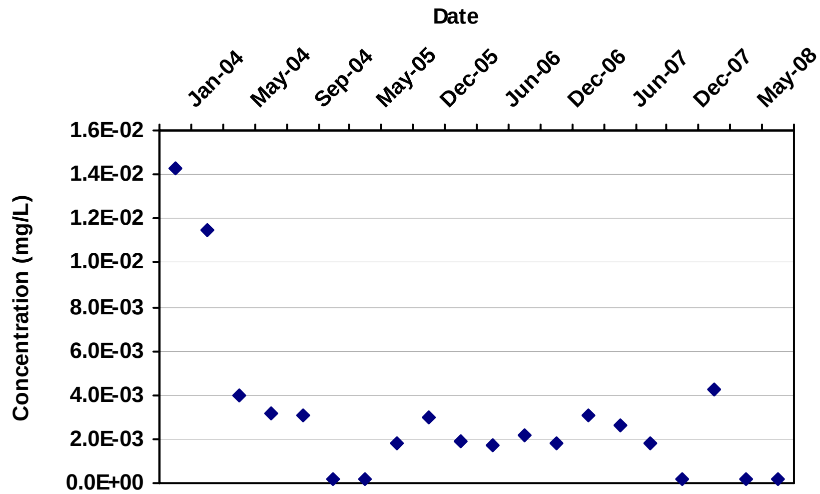
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-19	T	1/1/2004	Arsenic	1.4E-02		1	1
BC-19	T	3/1/2004	Arsenic	1.3E-02		1	1
BC-19	T	5/1/2004	Arsenic	2.9E-03		1	1
BC-19	T	7/1/2004	Arsenic	2.1E-03		1	1
BC-19	T	9/1/2004	Arsenic	2.8E-03		1	1
BC-19	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BC-19	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BC-19	T	10/1/2005	Arsenic	1.4E-03		1	1
BC-19	T	12/1/2005	Arsenic	1.6E-03		1	1
BC-19	T	3/1/2006	Arsenic	2.4E-03		1	1
BC-19	T	6/1/2006	Arsenic	1.4E-03		1	1
BC-19	T	9/1/2006	Arsenic	2.4E-03		1	1
BC-19	T	12/1/2006	Arsenic	1.6E-03		1	1
BC-19	T	3/1/2007	Arsenic	3.0E-03		1	1
BC-19	T	6/1/2007	Arsenic	2.4E-03		1	1
BC-19	T	9/1/2007	Arsenic	2.9E-03		1	1
BC-19	T	12/1/2007	Arsenic	2.0E-04	ND	1	0
BC-19	T	3/8/2008	Arsenic	2.1E-03		1	1
BC-19	T	5/8/2008	Arsenic	3.4E-03		1	1
BC-19	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BC-07
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -74

Confidence in Trend: 99.2%

Coefficient of Variation: 1.18

Mann Kendall Concentration Trend: (See Note) D

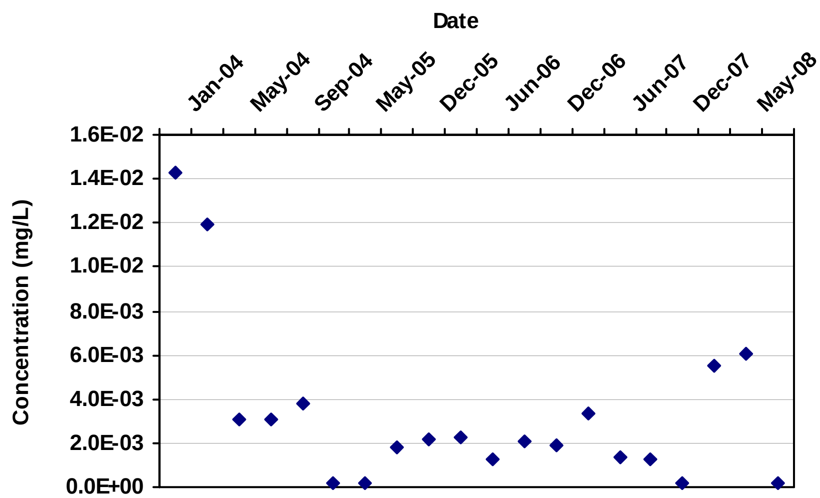
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-07	T	1/1/2004	Arsenic	1.4E-02		1	1
BC-07	T	3/1/2004	Arsenic	1.2E-02		1	1
BC-07	T	5/1/2004	Arsenic	4.0E-03		1	1
BC-07	T	7/1/2004	Arsenic	3.2E-03		1	1
BC-07	T	9/1/2004	Arsenic	3.1E-03		1	1
BC-07	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BC-07	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BC-07	T	10/1/2005	Arsenic	1.8E-03		1	1
BC-07	T	12/1/2005	Arsenic	3.0E-03		1	1
BC-07	T	3/1/2006	Arsenic	1.9E-03		1	1
BC-07	T	6/1/2006	Arsenic	1.7E-03		1	1
BC-07	T	9/1/2006	Arsenic	2.2E-03		1	1
BC-07	T	12/1/2006	Arsenic	1.8E-03		1	1
BC-07	T	3/1/2007	Arsenic	3.1E-03		1	1
BC-07	T	6/1/2007	Arsenic	2.6E-03		1	1
BC-07	T	9/1/2007	Arsenic	1.8E-03		1	1
BC-07	T	12/1/2007	Arsenic	2.0E-04	ND	1	0
BC-07	T	3/8/2008	Arsenic	4.2E-03		1	1
BC-07	T	5/8/2008	Arsenic	2.0E-04	ND	1	0
BC-07	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BC-03
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -48

Confidence in Trend: 93.6%

Coefficient of Variation: 1.13

Mann Kendall Concentration Trend: (See Note) PD

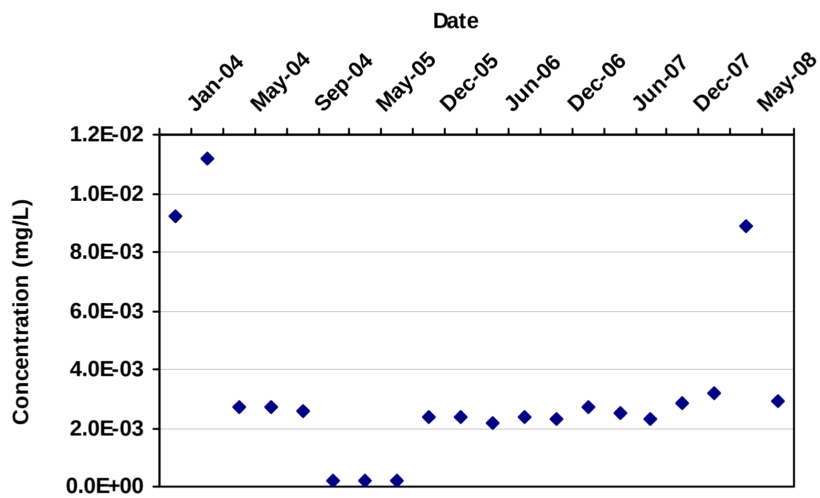
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-03	T	1/1/2004	Arsenic	1.4E-02		1	1
BC-03	T	3/1/2004	Arsenic	1.2E-02		1	1
BC-03	T	5/1/2004	Arsenic	3.1E-03		1	1
BC-03	T	7/1/2004	Arsenic	3.1E-03		1	1
BC-03	T	9/1/2004	Arsenic	3.8E-03		1	1
BC-03	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BC-03	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BC-03	T	10/1/2005	Arsenic	1.8E-03		1	1
BC-03	T	12/1/2005	Arsenic	2.2E-03		1	1
BC-03	T	3/1/2006	Arsenic	2.3E-03		1	1
BC-03	T	6/1/2006	Arsenic	1.3E-03		1	1
BC-03	T	9/1/2006	Arsenic	2.1E-03		1	1
BC-03	T	12/1/2006	Arsenic	1.9E-03		1	1
BC-03	T	3/1/2007	Arsenic	3.3E-03		1	1
BC-03	T	6/1/2007	Arsenic	1.4E-03		1	1
BC-03	T	9/1/2007	Arsenic	1.3E-03		1	1
BC-03	T	12/1/2007	Arsenic	2.0E-04	ND	1	0
BC-03	T	3/8/2008	Arsenic	5.5E-03		1	1
BC-03	T	5/8/2008	Arsenic	6.0E-03		1	1
BC-03	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BA-09A
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: 18

Confidence in Trend: 70.7%

Coefficient of Variation: 0.89

Mann Kendall Concentration Trend: (See Note) NT

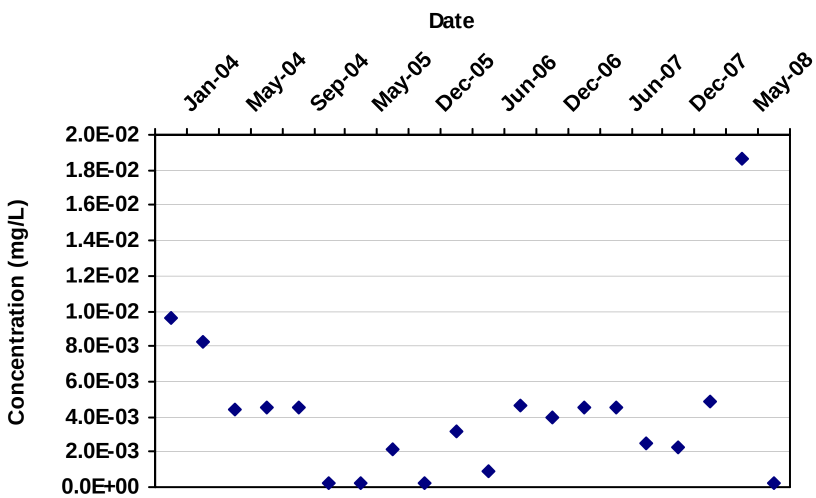
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-09A	T	1/1/2004	Arsenic	9.2E-03		1	1
BA-09A	T	3/1/2004	Arsenic	1.1E-02		1	1
BA-09A	T	5/1/2004	Arsenic	2.7E-03		1	1
BA-09A	T	7/1/2004	Arsenic	2.7E-03		1	1
BA-09A	T	9/1/2004	Arsenic	2.6E-03		1	1
BA-09A	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-09A	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-09A	T	10/1/2005	Arsenic	2.0E-04	ND	1	0
BA-09A	T	12/1/2005	Arsenic	2.4E-03		1	1
BA-09A	T	3/1/2006	Arsenic	2.4E-03		1	1
BA-09A	T	6/1/2006	Arsenic	2.2E-03		1	1
BA-09A	T	9/1/2006	Arsenic	2.4E-03		1	1
BA-09A	T	12/1/2006	Arsenic	2.3E-03		1	1
BA-09A	T	3/1/2007	Arsenic	2.7E-03		1	1
BA-09A	T	6/1/2007	Arsenic	2.5E-03		1	1
BA-09A	T	9/1/2007	Arsenic	2.3E-03		1	1
BA-09A	T	12/1/2007	Arsenic	2.8E-03		1	1
BA-09A	T	3/8/2008	Arsenic	3.2E-03		1	1
BA-09A	T	5/8/2008	Arsenic	8.9E-03		1	1
BA-09A	T	8/8/2008	Arsenic	2.9E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-05
Well Type: S
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -8

Confidence in Trend: 58.9%

Coefficient of Variation: 1.01

Mann Kendall Concentration Trend: (See Note) NT

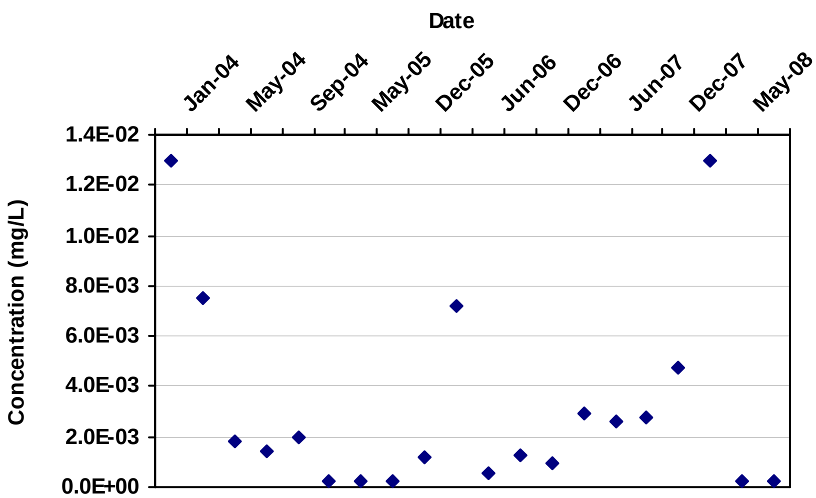
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-05	S	1/1/2004	Arsenic	9.6E-03		1	1
BA-05	S	3/1/2004	Arsenic	8.2E-03		1	1
BA-05	S	5/1/2004	Arsenic	4.4E-03		1	1
BA-05	S	7/1/2004	Arsenic	4.5E-03		1	1
BA-05	S	9/1/2004	Arsenic	4.5E-03		1	1
BA-05	S	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-05	S	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-05	S	10/1/2005	Arsenic	2.2E-03		1	1
BA-05	S	12/1/2005	Arsenic	2.0E-04	ND	1	0
BA-05	S	3/1/2006	Arsenic	3.2E-03		1	1
BA-05	S	6/1/2006	Arsenic	9.6E-04		1	1
BA-05	S	9/1/2006	Arsenic	4.6E-03		1	1
BA-05	S	12/1/2006	Arsenic	4.0E-03		1	1
BA-05	S	3/1/2007	Arsenic	4.5E-03		1	1
BA-05	S	6/1/2007	Arsenic	4.5E-03		1	1
BA-05	S	9/1/2007	Arsenic	2.5E-03		1	1
BA-05	S	12/1/2007	Arsenic	2.2E-03		1	1
BA-05	S	3/8/2008	Arsenic	4.9E-03		1	1
BA-05	S	5/8/2008	Arsenic	1.9E-02		1	1
BA-05	S	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BA-01
Well Type: S
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -11

Confidence in Trend: 62.6%

Coefficient of Variation: 1.25

Mann Kendall Concentration Trend: (See Note) NT

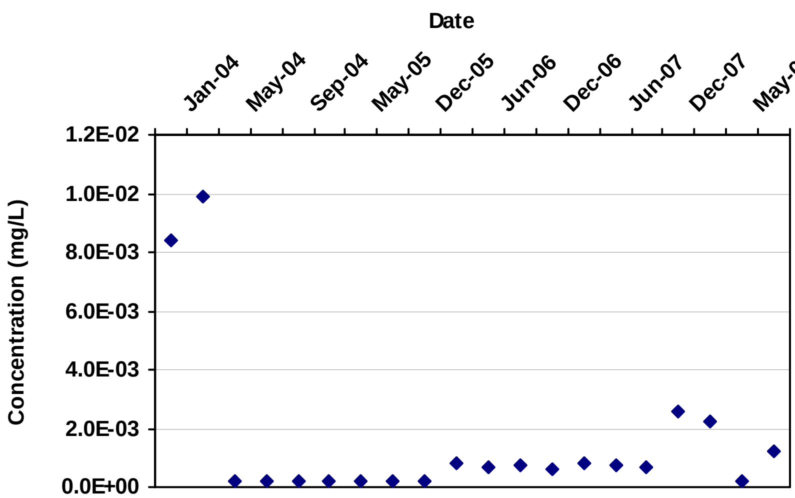
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-01	S	1/1/2004	Arsenic	1.3E-02		1	1
BA-01	S	3/1/2004	Arsenic	7.5E-03		1	1
BA-01	S	5/1/2004	Arsenic	1.8E-03		1	1
BA-01	S	7/1/2004	Arsenic	1.4E-03		1	1
BA-01	S	9/1/2004	Arsenic	2.0E-03		1	1
BA-01	S	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-01	S	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-01	S	10/1/2005	Arsenic	2.0E-04	ND	1	0
BA-01	S	12/1/2005	Arsenic	1.2E-03		1	1
BA-01	S	3/1/2006	Arsenic	7.2E-03		1	1
BA-01	S	6/1/2006	Arsenic	5.6E-04		1	1
BA-01	S	9/1/2006	Arsenic	1.3E-03		1	1
BA-01	S	12/1/2006	Arsenic	9.3E-04		1	1
BA-01	S	3/1/2007	Arsenic	2.9E-03		1	1
BA-01	S	6/1/2007	Arsenic	2.6E-03		1	1
BA-01	S	9/1/2007	Arsenic	2.8E-03		1	1
BA-01	S	12/1/2007	Arsenic	4.7E-03		1	1
BA-01	S	3/8/2008	Arsenic	1.3E-02		1	1
BA-01	S	5/8/2008	Arsenic	2.0E-04	ND	1	0
BA-01	S	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: MW-04
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: 43

Confidence in Trend: 91.3%

Coefficient of Variation: 1.74

Mann Kendall Concentration Trend: (See Note) PI

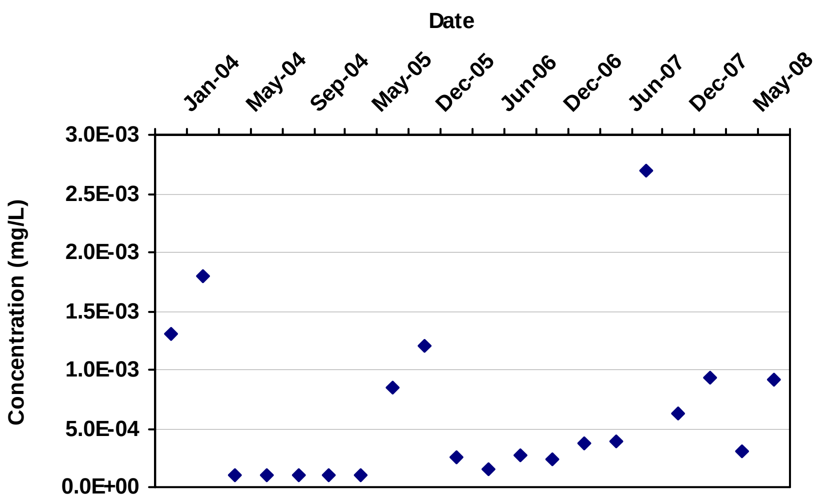
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-04	T	1/1/2004	Arsenic	8.4E-03		1	1
MW-04	T	3/1/2004	Arsenic	9.9E-03		1	1
MW-04	T	5/1/2004	Arsenic	2.0E-04	ND	1	0
MW-04	T	7/1/2004	Arsenic	2.0E-04	ND	1	0
MW-04	T	9/1/2004	Arsenic	2.0E-04	ND	1	0
MW-04	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
MW-04	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
MW-04	T	10/1/2005	Arsenic	2.0E-04	ND	1	0
MW-04	T	12/1/2005	Arsenic	2.0E-04	ND	1	0
MW-04	T	3/1/2006	Arsenic	8.1E-04		1	1
MW-04	T	6/1/2006	Arsenic	6.5E-04		1	1
MW-04	T	9/1/2006	Arsenic	7.2E-04		1	1
MW-04	T	12/1/2006	Arsenic	6.2E-04		1	1
MW-04	T	3/1/2007	Arsenic	8.4E-04		1	1
MW-04	T	6/1/2007	Arsenic	7.2E-04		1	1
MW-04	T	9/1/2007	Arsenic	6.9E-04		1	1
MW-04	T	12/1/2007	Arsenic	2.6E-03		1	1
MW-04	T	3/8/2008	Arsenic	2.2E-03		1	1
MW-04	T	5/8/2008	Arsenic	2.0E-04	ND	1	0
MW-04	T	8/8/2008	Arsenic	1.2E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-19
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 52

Confidence in Trend: 95.1%

Coefficient of Variation: 1.07

Mann Kendall Concentration Trend: (See Note) I

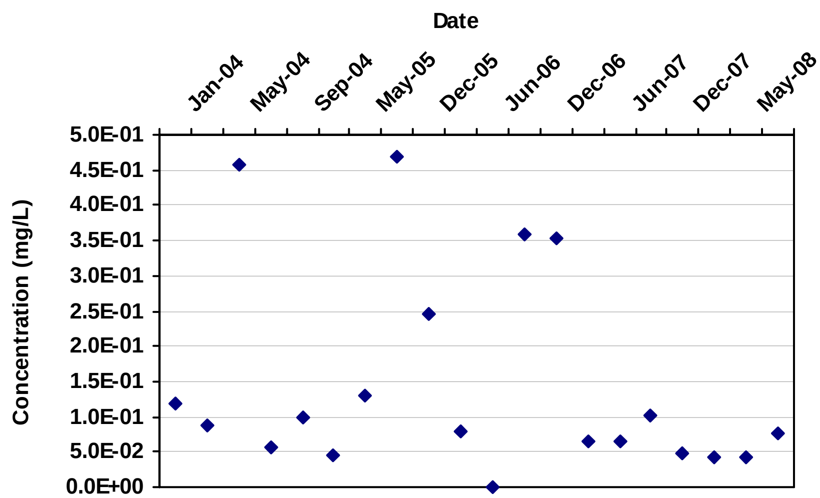
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-19	T	1/1/2004	Lead	1.3E-03		1	1
BC-19	T	3/1/2004	Lead	1.8E-03		1	1
BC-19	T	5/1/2004	Lead	1.0E-04	ND	1	0
BC-19	T	7/1/2004	Lead	1.0E-04	ND	1	0
BC-19	T	9/1/2004	Lead	1.0E-04	ND	1	0
BC-19	T	3/1/2005	Lead	1.0E-04	ND	1	0
BC-19	T	5/1/2005	Lead	1.0E-04	ND	1	0
BC-19	T	10/1/2005	Lead	8.5E-04		1	1
BC-19	T	12/1/2005	Lead	1.2E-03		1	1
BC-19	T	3/1/2006	Lead	2.5E-04		1	1
BC-19	T	6/1/2006	Lead	1.5E-04		1	1
BC-19	T	9/1/2006	Lead	2.7E-04		1	1
BC-19	T	12/1/2006	Lead	2.4E-04		1	1
BC-19	T	3/1/2007	Lead	3.8E-04		1	1
BC-19	T	6/1/2007	Lead	3.9E-04		1	1
BC-19	T	9/1/2007	Lead	2.7E-03		1	1
BC-19	T	12/1/2007	Lead	6.3E-04		1	1
BC-19	T	3/8/2008	Lead	9.3E-04		1	1
BC-19	T	5/8/2008	Lead	3.0E-04		1	1
BC-19	T	8/8/2008	Lead	9.2E-04		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-17
Well Type: S
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: -50

Confidence in Trend: 94.4%

Coefficient of Variation: 0.99

Mann Kendall Concentration Trend: (See Note) PD

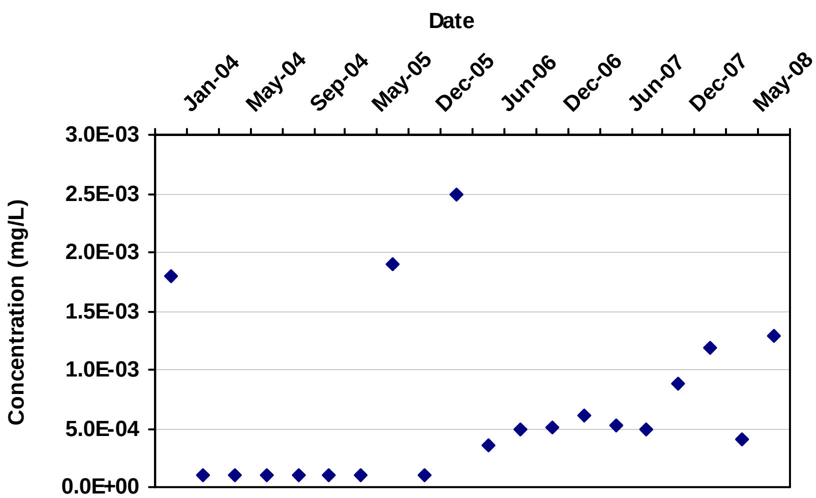
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-17	S	1/1/2004	Lead	1.2E-01		1	1
BC-17	S	3/1/2004	Lead	8.7E-02		1	1
BC-17	S	5/1/2004	Lead	4.6E-01		1	1
BC-17	S	7/1/2004	Lead	5.6E-02		1	1
BC-17	S	9/1/2004	Lead	9.9E-02		1	1
BC-17	S	3/1/2005	Lead	4.4E-02		1	1
BC-17	S	5/1/2005	Lead	1.3E-01		1	1
BC-17	S	10/1/2005	Lead	4.7E-01		1	1
BC-17	S	12/1/2005	Lead	2.5E-01		1	1
BC-17	S	3/1/2006	Lead	8.1E-02		1	1
BC-17	S	6/1/2006	Lead	2.3E-04		1	1
BC-17	S	9/1/2006	Lead	3.6E-01		1	1
BC-17	S	12/1/2006	Lead	3.5E-01		1	1
BC-17	S	3/1/2007	Lead	6.5E-02		1	1
BC-17	S	6/1/2007	Lead	6.6E-02		1	1
BC-17	S	9/1/2007	Lead	1.0E-01		1	1
BC-17	S	12/1/2007	Lead	4.9E-02		1	1
BC-17	S	3/8/2008	Lead	4.1E-02		1	1
BC-17	S	5/8/2008	Lead	4.3E-02		1	1
BC-17	S	8/8/2008	Lead	7.7E-02		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-07
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 70

Confidence in Trend: 98.8%

Coefficient of Variation: 1.03

Mann Kendall Concentration Trend: (See Note) I

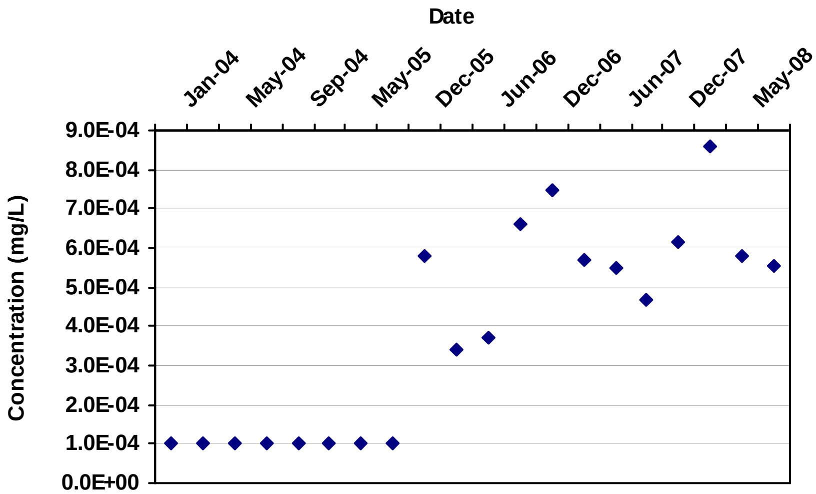
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-07	T	1/1/2004	Lead	1.8E-03		1	1
BC-07	T	3/1/2004	Lead	1.0E-04	ND	1	0
BC-07	T	5/1/2004	Lead	1.0E-04	ND	1	0
BC-07	T	7/1/2004	Lead	1.0E-04	ND	1	0
BC-07	T	9/1/2004	Lead	1.0E-04	ND	1	0
BC-07	T	3/1/2005	Lead	1.0E-04	ND	1	0
BC-07	T	5/1/2005	Lead	1.0E-04	ND	1	0
BC-07	T	10/1/2005	Lead	1.9E-03		1	1
BC-07	T	12/1/2005	Lead	1.0E-04	ND	1	0
BC-07	T	3/1/2006	Lead	2.5E-03		1	1
BC-07	T	6/1/2006	Lead	3.5E-04		1	1
BC-07	T	9/1/2006	Lead	4.9E-04		1	1
BC-07	T	12/1/2006	Lead	5.1E-04		1	1
BC-07	T	3/1/2007	Lead	6.1E-04		1	1
BC-07	T	6/1/2007	Lead	5.3E-04		1	1
BC-07	T	9/1/2007	Lead	4.9E-04		1	1
BC-07	T	12/1/2007	Lead	8.8E-04		1	1
BC-07	T	3/8/2008	Lead	1.2E-03		1	1
BC-07	T	5/8/2008	Lead	4.1E-04		1	1
BC-07	T	8/8/2008	Lead	1.3E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-09A
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 106

Confidence in Trend: 100.0%

Coefficient of Variation: 0.68

Mann Kendall Concentration Trend: (See Note) I

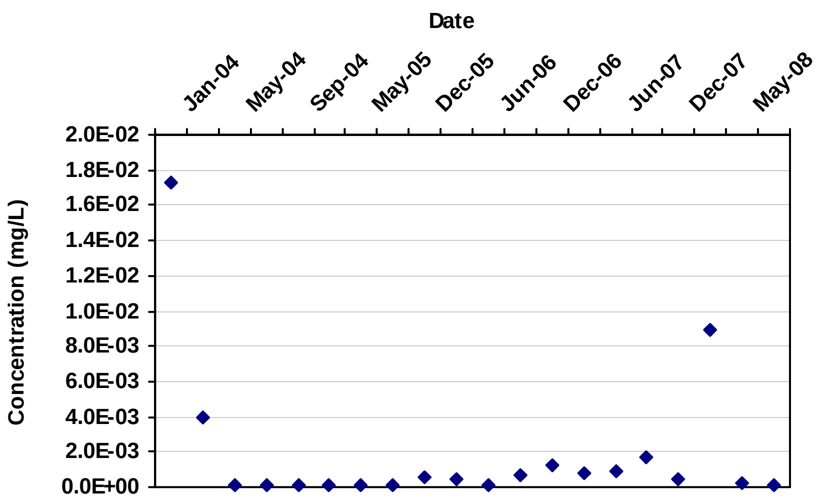
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-09A	T	1/1/2004	Lead	1.0E-04	ND	1	0
BA-09A	T	3/1/2004	Lead	1.0E-04	ND	1	0
BA-09A	T	5/1/2004	Lead	1.0E-04	ND	1	0
BA-09A	T	7/1/2004	Lead	1.0E-04	ND	1	0
BA-09A	T	9/1/2004	Lead	1.0E-04	ND	1	0
BA-09A	T	3/1/2005	Lead	1.0E-04	ND	1	0
BA-09A	T	5/1/2005	Lead	1.0E-04	ND	1	0
BA-09A	T	10/1/2005	Lead	1.0E-04	ND	1	0
BA-09A	T	12/1/2005	Lead	5.8E-04		1	1
BA-09A	T	3/1/2006	Lead	3.4E-04		1	1
BA-09A	T	6/1/2006	Lead	3.7E-04		1	1
BA-09A	T	9/1/2006	Lead	6.6E-04		1	1
BA-09A	T	12/1/2006	Lead	7.5E-04		1	1
BA-09A	T	3/1/2007	Lead	5.7E-04		1	1
BA-09A	T	6/1/2007	Lead	5.5E-04		1	1
BA-09A	T	9/1/2007	Lead	4.7E-04		1	1
BA-09A	T	12/1/2007	Lead	6.1E-04		1	1
BA-09A	T	3/8/2008	Lead	8.6E-04		1	1
BA-09A	T	5/8/2008	Lead	5.8E-04		1	1
BA-09A	T	8/8/2008	Lead	5.6E-04		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-01
Well Type: S
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 33

Confidence in Trend: 84.9%

Coefficient of Variation: 2.18

Mann Kendall Concentration Trend: (See Note) NT

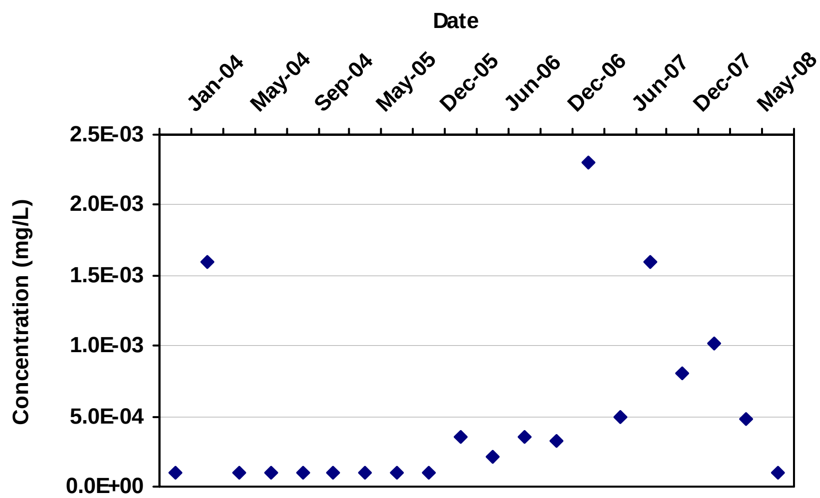
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-01	S	1/1/2004	Lead	1.7E-02		1	1
BA-01	S	3/1/2004	Lead	4.0E-03		1	1
BA-01	S	5/1/2004	Lead	1.0E-04	ND	1	0
BA-01	S	7/1/2004	Lead	1.0E-04	ND	1	0
BA-01	S	9/1/2004	Lead	1.0E-04	ND	1	0
BA-01	S	3/1/2005	Lead	1.0E-04	ND	1	0
BA-01	S	5/1/2005	Lead	1.0E-04	ND	1	0
BA-01	S	10/1/2005	Lead	1.0E-04	ND	1	0
BA-01	S	12/1/2005	Lead	6.1E-04		1	1
BA-01	S	3/1/2006	Lead	5.0E-04		1	1
BA-01	S	6/1/2006	Lead	1.3E-04		1	1
BA-01	S	9/1/2006	Lead	7.1E-04		1	1
BA-01	S	12/1/2006	Lead	1.2E-03		1	1
BA-01	S	3/1/2007	Lead	8.3E-04		1	1
BA-01	S	6/1/2007	Lead	9.3E-04		1	1
BA-01	S	9/1/2007	Lead	1.7E-03		1	1
BA-01	S	12/1/2007	Lead	4.9E-04		1	1
BA-01	S	3/8/2008	Lead	9.0E-03		1	1
BA-01	S	5/8/2008	Lead	2.3E-04		1	1
BA-01	S	8/8/2008	Lead	1.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BC-25
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 71

Confidence in Trend: 98.9%

Coefficient of Variation: 1.21

Mann Kendall Concentration Trend: (See Note) I

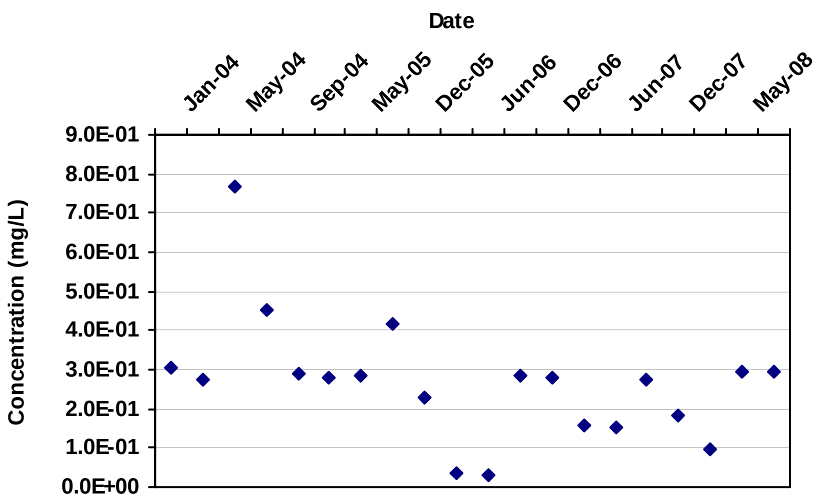
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-25	T	1/1/2004	Lead	1.0E-04	ND	1	0
BC-25	T	3/1/2004	Lead	1.6E-03		1	1
BC-25	T	5/1/2004	Lead	1.0E-04	ND	1	0
BC-25	T	7/1/2004	Lead	1.0E-04	ND	1	0
BC-25	T	9/1/2004	Lead	1.0E-04	ND	1	0
BC-25	T	3/1/2005	Lead	1.0E-04	ND	1	0
BC-25	T	5/1/2005	Lead	1.0E-04	ND	1	0
BC-25	T	10/1/2005	Lead	1.0E-04	ND	1	0
BC-25	T	12/1/2005	Lead	1.0E-04	ND	1	0
BC-25	T	3/1/2006	Lead	3.6E-04		1	1
BC-25	T	6/1/2006	Lead	2.1E-04		1	1
BC-25	T	9/1/2006	Lead	3.5E-04		1	1
BC-25	T	12/1/2006	Lead	3.2E-04		1	1
BC-25	T	3/1/2007	Lead	2.3E-03		1	1
BC-25	T	6/1/2007	Lead	4.9E-04		1	1
BC-25	T	9/1/2007	Lead	1.6E-03		1	1
BC-25	T	12/1/2007	Lead	8.0E-04		1	1
BC-25	T	3/8/2008	Lead	1.0E-03		1	1
BC-25	T	5/8/2008	Lead	4.7E-04		1	1
BC-25	T	8/8/2008	Lead	1.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BC-25
Well Type: T
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: -56

Confidence in Trend: 96.3%

Coefficient of Variation: 0.59

Mann Kendall Concentration Trend: (See Note) D

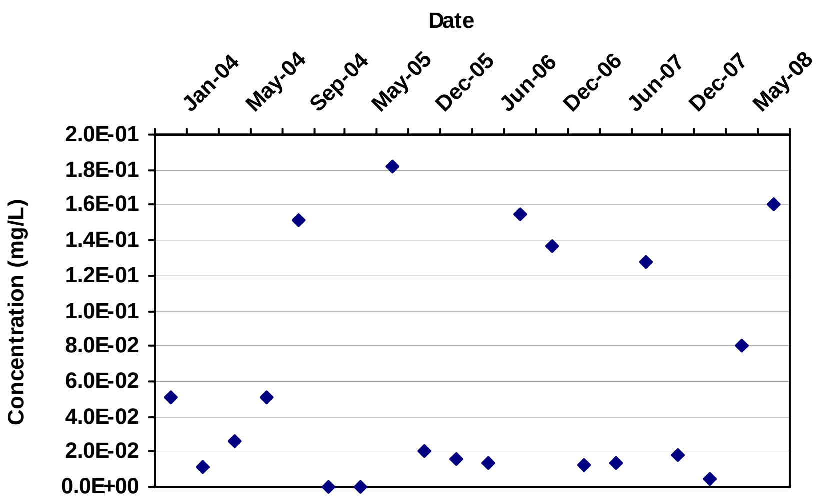
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-25	T	1/1/2004	Manganese	3.0E-01		1	1
BC-25	T	3/1/2004	Manganese	2.8E-01		1	1
BC-25	T	5/1/2004	Manganese	7.7E-01		1	1
BC-25	T	7/1/2004	Manganese	4.5E-01		1	1
BC-25	T	9/1/2004	Manganese	2.9E-01		1	1
BC-25	T	3/1/2005	Manganese	2.8E-01		1	1
BC-25	T	5/1/2005	Manganese	2.9E-01		1	1
BC-25	T	10/1/2005	Manganese	4.2E-01		1	1
BC-25	T	12/1/2005	Manganese	2.3E-01		1	1
BC-25	T	3/1/2006	Manganese	3.8E-02		1	1
BC-25	T	6/1/2006	Manganese	2.9E-02		1	1
BC-25	T	9/1/2006	Manganese	2.8E-01		1	1
BC-25	T	12/1/2006	Manganese	2.8E-01		1	1
BC-25	T	3/1/2007	Manganese	1.6E-01		1	1
BC-25	T	6/1/2007	Manganese	1.5E-01		1	1
BC-25	T	9/1/2007	Manganese	2.8E-01		1	1
BC-25	T	12/1/2007	Manganese	1.8E-01		1	1
BC-25	T	3/8/2008	Manganese	9.8E-02		1	1
BC-25	T	5/8/2008	Manganese	2.9E-01		1	1
BC-25	T	8/8/2008	Manganese	2.9E-01		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-21R
Well Type: T
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: 13

Confidence in Trend: 65.0%

Coefficient of Variation: 1.05

Mann Kendall Concentration Trend: (See Note) NT

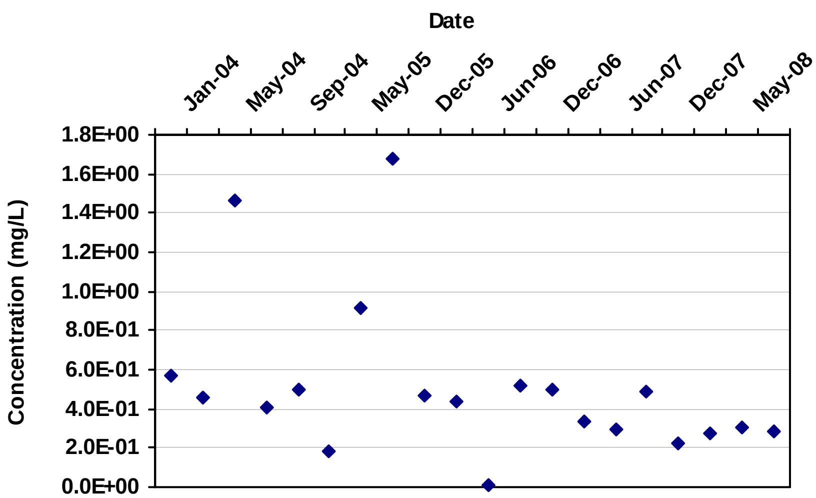
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-21R	T	1/1/2004	Manganese	5.1E-02		1	1
BC-21R	T	3/1/2004	Manganese	1.1E-02		1	1
BC-21R	T	5/1/2004	Manganese	2.6E-02		1	1
BC-21R	T	7/1/2004	Manganese	5.0E-02		1	1
BC-21R	T	9/1/2004	Manganese	1.5E-01		1	1
BC-21R	T	3/1/2005	Manganese	2.0E-04	ND	1	0
BC-21R	T	5/1/2005	Manganese	2.0E-04	ND	1	0
BC-21R	T	10/1/2005	Manganese	1.8E-01		1	1
BC-21R	T	12/1/2005	Manganese	2.0E-02		1	1
BC-21R	T	3/1/2006	Manganese	1.5E-02		1	1
BC-21R	T	6/1/2006	Manganese	1.3E-02		1	1
BC-21R	T	9/1/2006	Manganese	1.6E-01		1	1
BC-21R	T	12/1/2006	Manganese	1.4E-01		1	1
BC-21R	T	3/1/2007	Manganese	1.3E-02		1	1
BC-21R	T	6/1/2007	Manganese	1.3E-02		1	1
BC-21R	T	9/1/2007	Manganese	1.3E-01		1	1
BC-21R	T	12/1/2007	Manganese	1.8E-02		1	1
BC-21R	T	3/8/2008	Manganese	4.5E-03		1	1
BC-21R	T	5/8/2008	Manganese	8.0E-02		1	1
BC-21R	T	8/8/2008	Manganese	1.6E-01		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-17
Well Type: S
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: -70

Confidence in Trend: 98.8%

Coefficient of Variation: 0.79

Mann Kendall Concentration Trend: (See Note) D

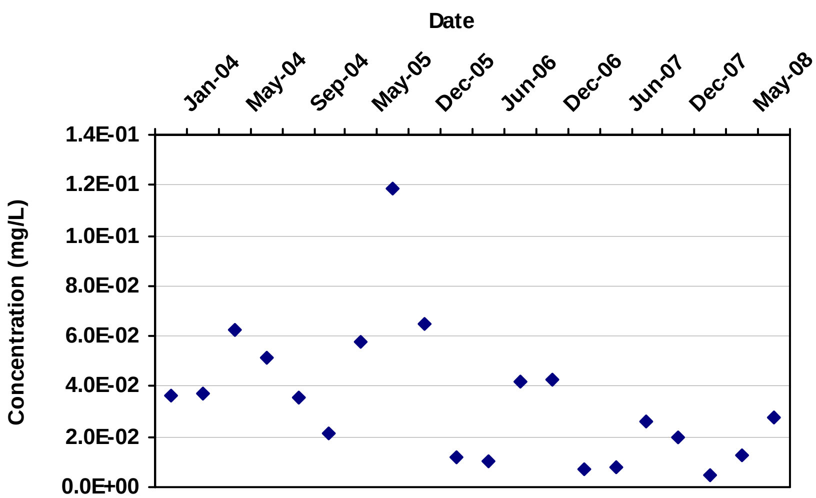
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-17	S	1/1/2004	Manganese	5.7E-01		1	1
BC-17	S	3/1/2004	Manganese	4.6E-01		1	1
BC-17	S	5/1/2004	Manganese	1.5E+00		1	1
BC-17	S	7/1/2004	Manganese	4.0E-01		1	1
BC-17	S	9/1/2004	Manganese	5.0E-01		1	1
BC-17	S	3/1/2005	Manganese	1.9E-01		1	1
BC-17	S	5/1/2005	Manganese	9.2E-01		1	1
BC-17	S	10/1/2005	Manganese	1.7E+00		1	1
BC-17	S	12/1/2005	Manganese	4.7E-01		1	1
BC-17	S	3/1/2006	Manganese	4.4E-01		1	1
BC-17	S	6/1/2006	Manganese	8.2E-03		1	1
BC-17	S	9/1/2006	Manganese	5.2E-01		1	1
BC-17	S	12/1/2006	Manganese	5.0E-01		1	1
BC-17	S	3/1/2007	Manganese	3.4E-01		1	1
BC-17	S	6/1/2007	Manganese	3.0E-01		1	1
BC-17	S	9/1/2007	Manganese	4.9E-01		1	1
BC-17	S	12/1/2007	Manganese	2.2E-01		1	1
BC-17	S	3/8/2008	Manganese	2.8E-01		1	1
BC-17	S	5/8/2008	Manganese	3.1E-01		1	1
BC-17	S	8/8/2008	Manganese	2.8E-01		1	1

MAROS Mann-Kendall Statistics Summary

Well: BC-03
Well Type: T
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: -68

Confidence in Trend: 98.6%

Coefficient of Variation: 0.78

Mann Kendall Concentration Trend: (See Note) D

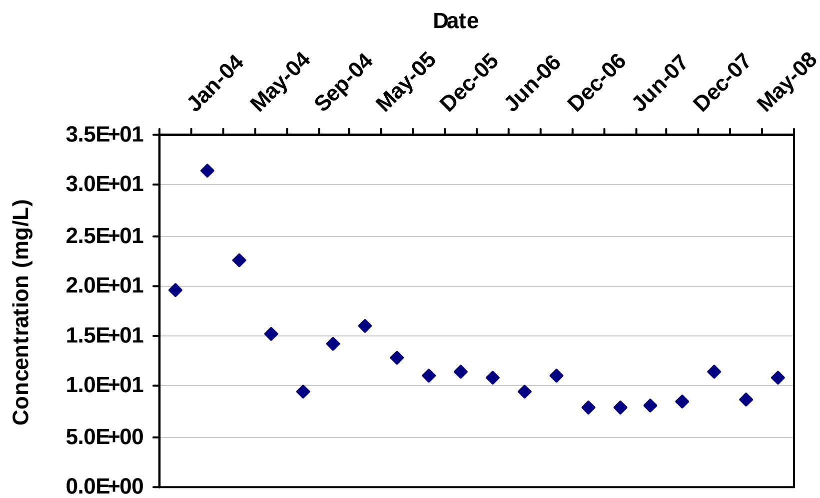
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BC-03	T	1/1/2004	Manganese	3.6E-02		1	1
BC-03	T	3/1/2004	Manganese	3.7E-02		1	1
BC-03	T	5/1/2004	Manganese	6.2E-02		1	1
BC-03	T	7/1/2004	Manganese	5.2E-02		1	1
BC-03	T	9/1/2004	Manganese	3.6E-02		1	1
BC-03	T	3/1/2005	Manganese	2.1E-02		1	1
BC-03	T	5/1/2005	Manganese	5.8E-02		1	1
BC-03	T	10/1/2005	Manganese	1.2E-01		1	1
BC-03	T	12/1/2005	Manganese	6.5E-02		1	1
BC-03	T	3/1/2006	Manganese	1.2E-02		1	1
BC-03	T	6/1/2006	Manganese	1.1E-02		1	1
BC-03	T	9/1/2006	Manganese	4.2E-02		1	1
BC-03	T	12/1/2006	Manganese	4.2E-02		1	1
BC-03	T	3/1/2007	Manganese	7.5E-03		1	1
BC-03	T	6/1/2007	Manganese	7.7E-03		1	1
BC-03	T	9/1/2007	Manganese	2.6E-02		1	1
BC-03	T	12/1/2007	Manganese	2.0E-02		1	1
BC-03	T	3/8/2008	Manganese	4.9E-03		1	1
BC-03	T	5/8/2008	Manganese	1.3E-02		1	1
BC-03	T	8/8/2008	Manganese	2.7E-02		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-05
Well Type: S
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: -106

Confidence in Trend: 100.0%

Coefficient of Variation: 0.45

Mann Kendall Concentration Trend: (See Note) D

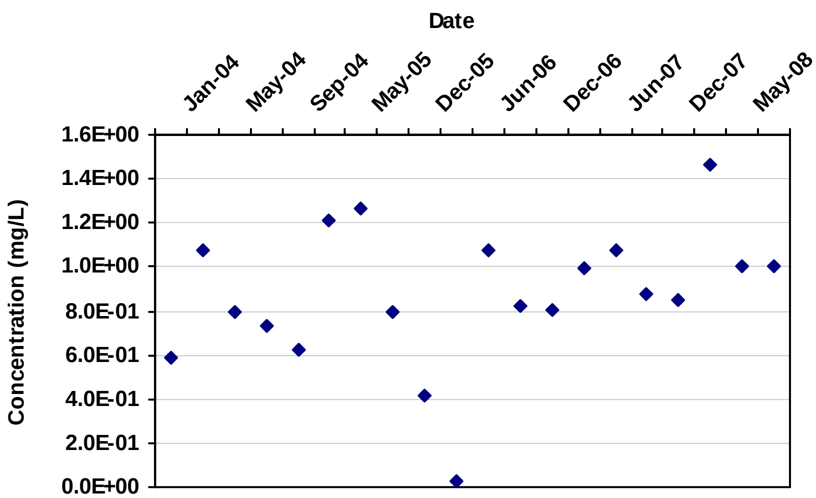
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-05	S	1/1/2004	Manganese	2.0E+01		1	1
BA-05	S	3/1/2004	Manganese	3.1E+01		1	1
BA-05	S	5/1/2004	Manganese	2.3E+01		1	1
BA-05	S	7/1/2004	Manganese	1.5E+01		1	1
BA-05	S	9/1/2004	Manganese	9.5E+00		1	1
BA-05	S	3/1/2005	Manganese	1.4E+01		1	1
BA-05	S	5/1/2005	Manganese	1.6E+01		1	1
BA-05	S	10/1/2005	Manganese	1.3E+01		1	1
BA-05	S	12/1/2005	Manganese	1.1E+01		1	1
BA-05	S	3/1/2006	Manganese	1.2E+01		1	1
BA-05	S	6/1/2006	Manganese	1.1E+01		1	1
BA-05	S	9/1/2006	Manganese	9.5E+00		1	1
BA-05	S	12/1/2006	Manganese	1.1E+01		1	1
BA-05	S	3/1/2007	Manganese	7.9E+00		1	1
BA-05	S	6/1/2007	Manganese	7.9E+00		1	1
BA-05	S	9/1/2007	Manganese	8.2E+00		1	1
BA-05	S	12/1/2007	Manganese	8.4E+00		1	1
BA-05	S	3/8/2008	Manganese	1.2E+01		1	1
BA-05	S	5/8/2008	Manganese	8.7E+00		1	1
BA-05	S	8/8/2008	Manganese	1.1E+01		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-01
Well Type: S
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: 48

Confidence in Trend: 93.6%

Coefficient of Variation: 0.36

Mann Kendall Concentration Trend: (See Note) PI

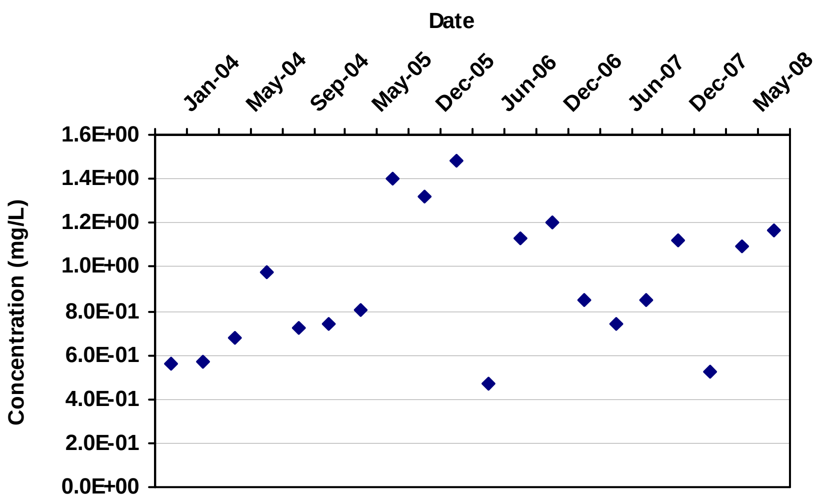
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-01	S	1/1/2004	Manganese	5.9E-01		1	1
BA-01	S	3/1/2004	Manganese	1.1E+00		1	1
BA-01	S	5/1/2004	Manganese	8.0E-01		1	1
BA-01	S	7/1/2004	Manganese	7.3E-01		1	1
BA-01	S	9/1/2004	Manganese	6.2E-01		1	1
BA-01	S	3/1/2005	Manganese	1.2E+00		1	1
BA-01	S	5/1/2005	Manganese	1.3E+00		1	1
BA-01	S	10/1/2005	Manganese	8.0E-01		1	1
BA-01	S	12/1/2005	Manganese	4.2E-01		1	1
BA-01	S	3/1/2006	Manganese	2.4E-02		1	1
BA-01	S	6/1/2006	Manganese	1.1E+00		1	1
BA-01	S	9/1/2006	Manganese	8.2E-01		1	1
BA-01	S	12/1/2006	Manganese	8.1E-01		1	1
BA-01	S	3/1/2007	Manganese	1.0E+00		1	1
BA-01	S	6/1/2007	Manganese	1.1E+00		1	1
BA-01	S	9/1/2007	Manganese	8.8E-01		1	1
BA-01	S	12/1/2007	Manganese	8.5E-01		1	1
BA-01	S	3/8/2008	Manganese	1.5E+00		1	1
BA-01	S	5/8/2008	Manganese	1.0E+00		1	1
BA-01	S	8/8/2008	Manganese	1.0E+00		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-03
Well Type: T
COC: Manganese

Time Period: 1/1/2004 **to** 8/8/2008
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: 45

Confidence in Trend: 92.3%

Coefficient of Variation: 0.33

Mann Kendall Concentration Trend: (See Note) PI

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-03	T	1/1/2004	Manganese	5.6E-01		1	1
MW-03	T	3/1/2004	Manganese	5.7E-01		1	1
MW-03	T	5/1/2004	Manganese	6.8E-01		1	1
MW-03	T	7/1/2004	Manganese	9.7E-01		1	1
MW-03	T	9/1/2004	Manganese	7.2E-01		1	1
MW-03	T	3/1/2005	Manganese	7.4E-01		1	1
MW-03	T	5/1/2005	Manganese	8.0E-01		1	1
MW-03	T	10/1/2005	Manganese	1.4E+00		1	1
MW-03	T	12/1/2005	Manganese	1.3E+00		1	1
MW-03	T	3/1/2006	Manganese	1.5E+00		1	1
MW-03	T	6/1/2006	Manganese	4.7E-01		1	1
MW-03	T	9/1/2006	Manganese	1.1E+00		1	1
MW-03	T	12/1/2006	Manganese	1.2E+00		1	1
MW-03	T	3/1/2007	Manganese	8.5E-01		1	1
MW-03	T	6/1/2007	Manganese	7.4E-01		1	1
MW-03	T	9/1/2007	Manganese	8.5E-01		1	1
MW-03	T	12/1/2007	Manganese	1.1E+00		1	1
MW-03	T	3/8/2008	Manganese	5.3E-01		1	1
MW-03	T	5/8/2008	Manganese	1.1E+00		1	1
MW-03	T	8/8/2008	Manganese	1.2E+00		1	1

September, 2009

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

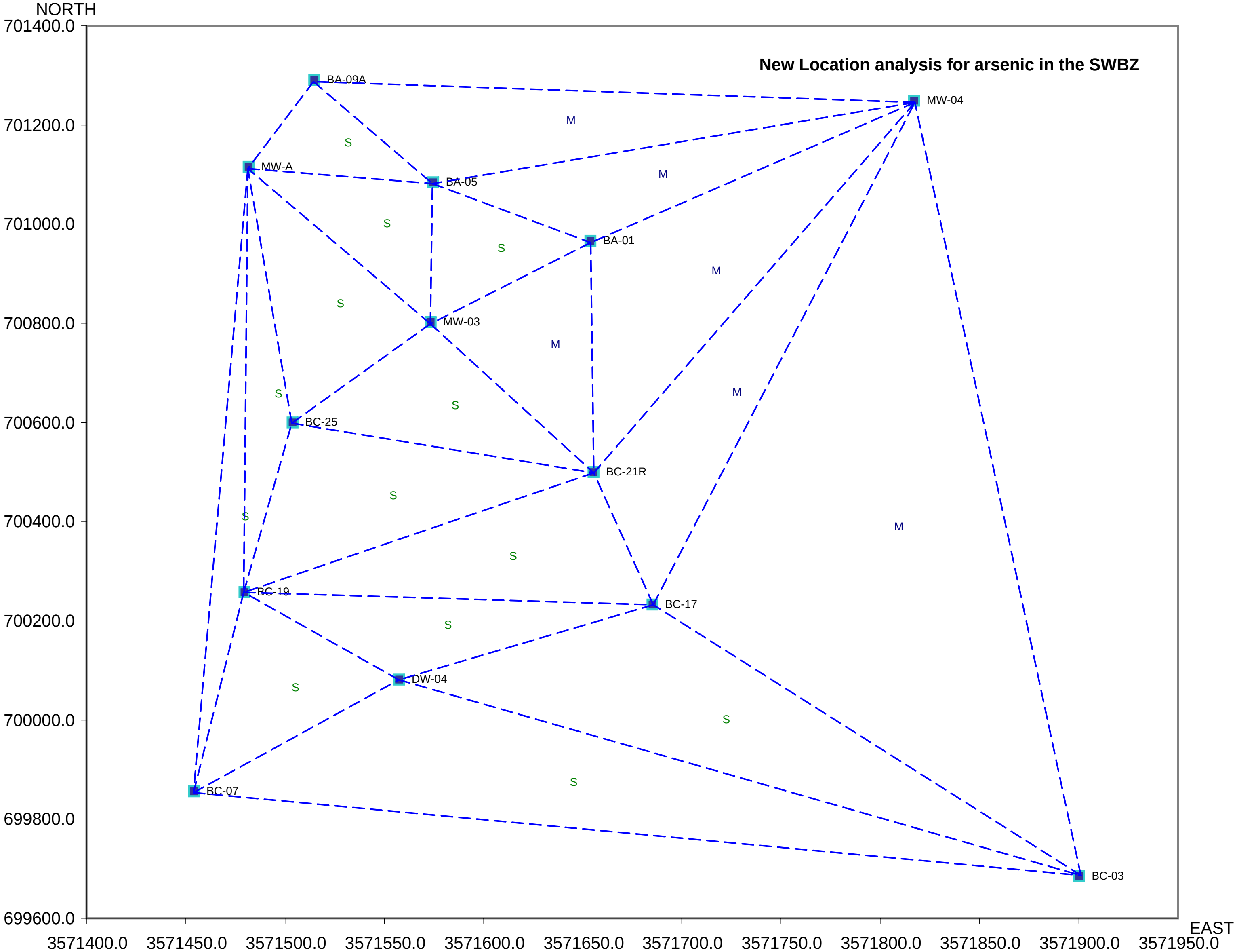
MAROS Reports

Second Water-Bearing Zone

Well Sufficiency Spatial Analysis Results

New Location Analysis for

Arsenic



Existing Locations

Potential areas for new locations are indicated by triangles with a high SF level.

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high estimation error -> possible need for new locations

Low SF -> low estimation error -> no need for new locations

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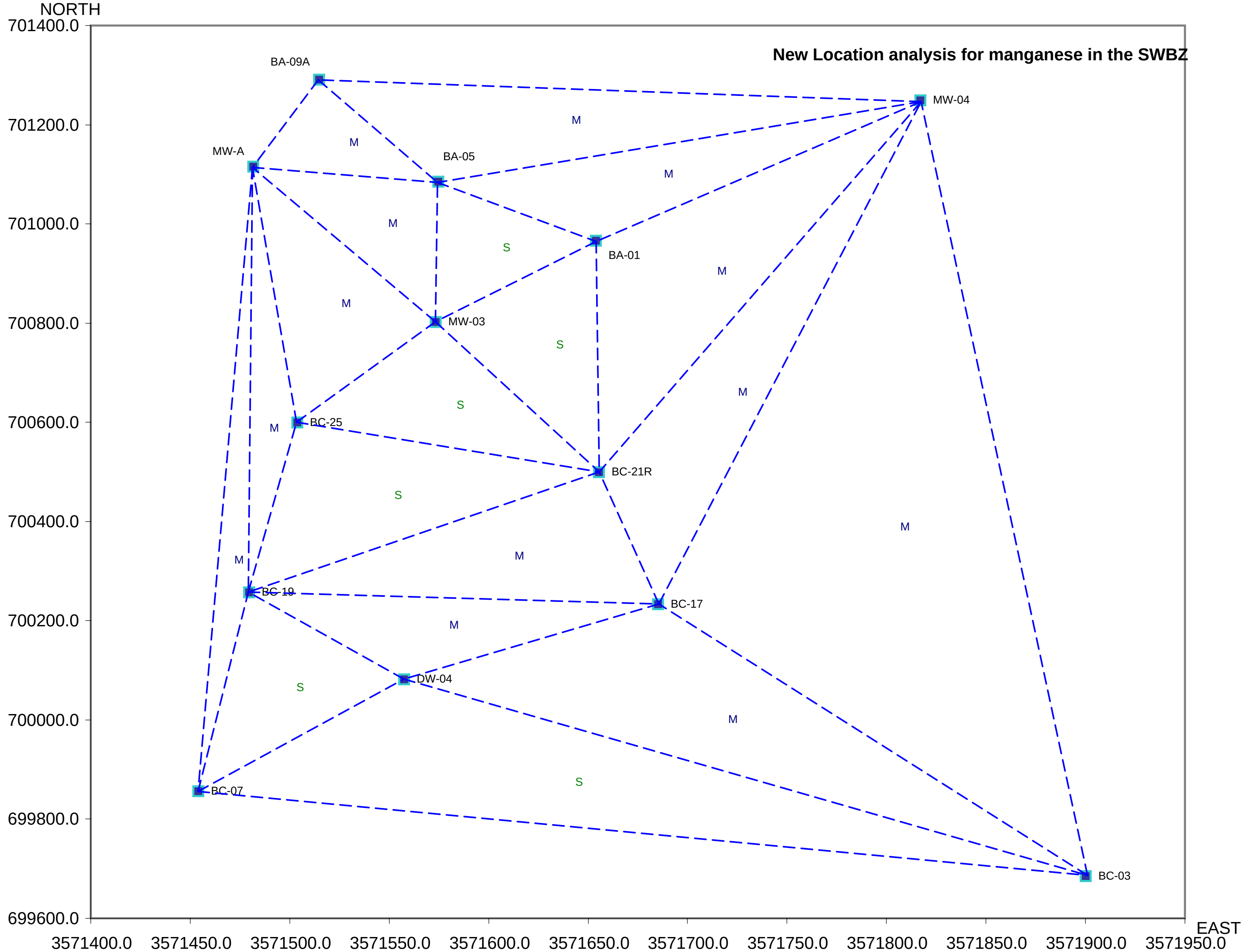

New Location Analysis for

Manganese

Existing Locations

Potential areas for new locations are indicated by triangles with a high SF level.

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high estimation error -> possible need for new locations

Low SF -> low estimation error -> no need for new locations

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September, 2009

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDIX B:

MAROS Reports

Third Water-Bearing Zone
Metals Trend Reports

MAROS Mann-Kendall Statistics Summary

Project: Delatte TWBZ

User Name: MV

Location: Ponchatoula

State: Louisiana

Time Period: 1/1/2004 **to** 8/8/2008

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Average

ND Values: Specified 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
Arsenic								
BA-01A	S	20	16	0.68	-57	96.6%	No	D
BA-03A	S	20	17	0.95	-66	98.3%	No	D
BA-05A	T	20	17	0.91	-55	96.0%	No	D
BB-01	T	20	17	0.72	-67	98.5%	No	D
Lead								
BA-01A	S	20	12	1.36	58	96.8%	No	I
BA-03A	S	20	17	0.71	-23	76.0%	No	S
BA-05A	T	20	11	1.02	32	84.1%	No	NT
BB-01	T	20	17	0.59	4	53.8%	No	NT
Manganese								
BA-01A	S	20	20	3.27	-65	98.2%	No	D
BA-03A	S	20	20	0.37	-74	99.2%	No	D
BA-05A	T	20	20	0.36	11	62.6%	No	NT
BB-01	T	20	18	0.70	36	87.0%	No	NT
Nickel								
BA-01A	S	20	16	2.04	-3	52.6%	No	NT
BA-03A	S	20	16	0.88	-17	69.6%	No	S
BA-05A	T	20	16	3.09	-6	56.4%	No	NT
BB-01	T	20	17	0.59	-2	51.3%	No	S
Thallium								
BA-01A	S	20	2	0.72	17	69.6%	No	NT
BA-03A	S	20	3	1.86	12	63.8%	No	NT
BA-05A	T	20	0	0.00	0	48.7%	Yes	ND
BB-01	T	20	0	0.00	0	48.7%	Yes	ND

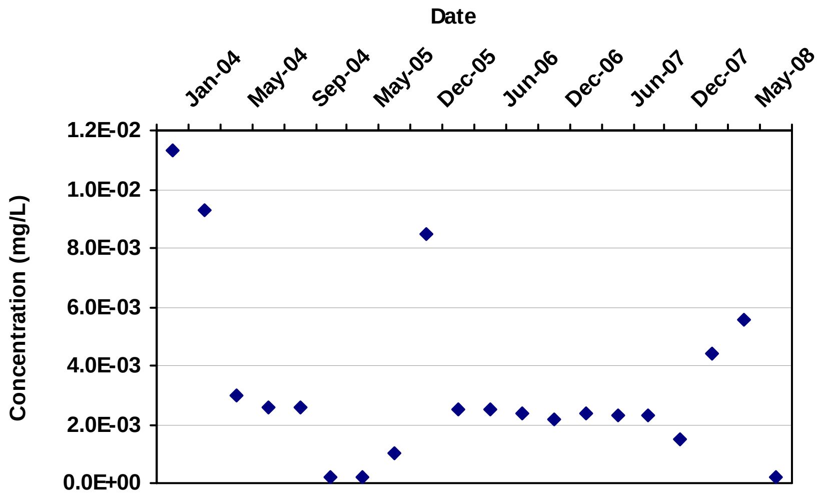
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

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

MAROS Mann-Kendall Statistics Summary

Well: BA-05A
Well Type: S
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -55

Confidence in Trend: 96.0%

Coefficient of Variation: 0.91

Mann Kendall Concentration Trend: (See Note) D

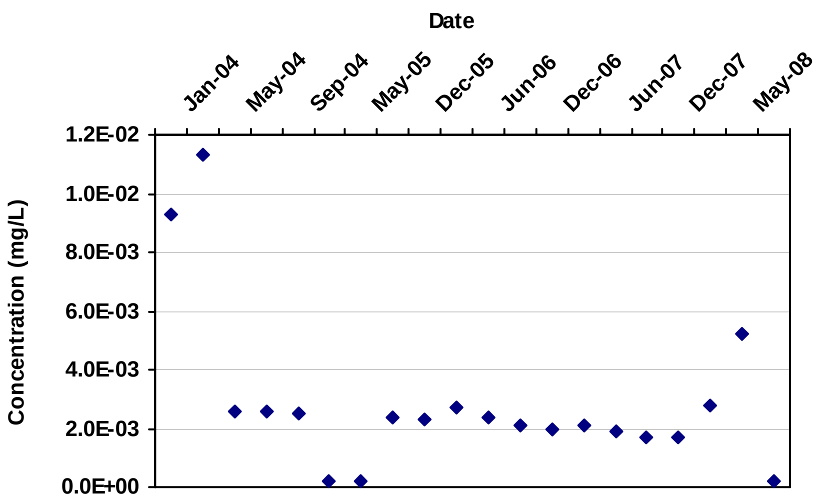
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-05A	S	1/1/2004	Arsenic	1.1E-02		1	1
BA-05A	S	3/1/2004	Arsenic	9.3E-03		1	1
BA-05A	S	5/1/2004	Arsenic	3.0E-03		1	1
BA-05A	S	7/1/2004	Arsenic	2.6E-03		1	1
BA-05A	S	9/1/2004	Arsenic	2.6E-03		1	1
BA-05A	S	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-05A	S	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-05A	S	10/1/2005	Arsenic	1.0E-03		1	1
BA-05A	S	12/1/2005	Arsenic	8.5E-03		1	1
BA-05A	S	3/1/2006	Arsenic	2.5E-03		1	1
BA-05A	S	6/1/2006	Arsenic	2.5E-03		1	1
BA-05A	S	9/1/2006	Arsenic	2.4E-03		1	1
BA-05A	S	12/1/2006	Arsenic	2.2E-03		1	1
BA-05A	S	3/1/2007	Arsenic	2.4E-03		1	1
BA-05A	S	6/1/2007	Arsenic	2.3E-03		1	1
BA-05A	S	9/1/2007	Arsenic	2.3E-03		1	1
BA-05A	S	12/1/2007	Arsenic	1.5E-03		1	1
BA-05A	S	3/8/2008	Arsenic	4.4E-03		1	1
BA-05A	S	5/8/2008	Arsenic	5.6E-03		1	1
BA-05A	S	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BA-03A
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -66

Confidence in Trend: 98.3%

Coefficient of Variation: 0.95

Mann Kendall Concentration Trend: (See Note) D

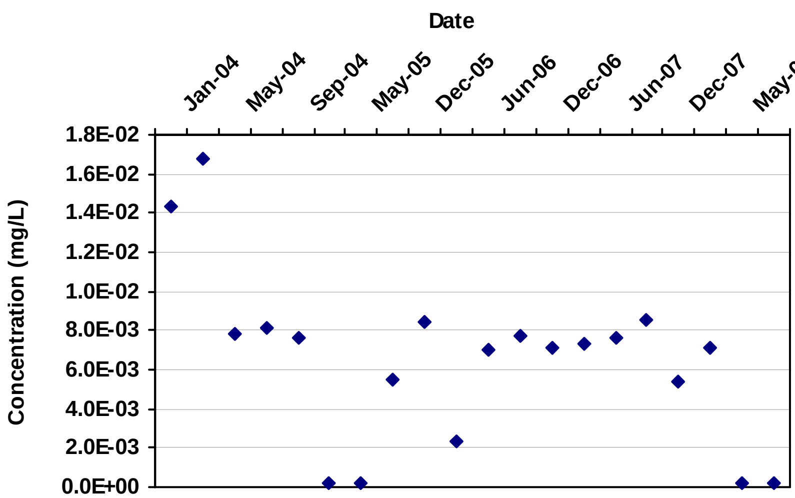
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-03A	T	1/1/2004	Arsenic	9.3E-03		1	1
BA-03A	T	3/1/2004	Arsenic	1.1E-02		1	1
BA-03A	T	5/1/2004	Arsenic	2.6E-03		1	1
BA-03A	T	7/1/2004	Arsenic	2.6E-03		1	1
BA-03A	T	9/1/2004	Arsenic	2.5E-03		1	1
BA-03A	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-03A	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-03A	T	10/1/2005	Arsenic	2.4E-03		1	1
BA-03A	T	12/1/2005	Arsenic	2.3E-03		1	1
BA-03A	T	3/1/2006	Arsenic	2.7E-03		1	1
BA-03A	T	6/1/2006	Arsenic	2.4E-03		1	1
BA-03A	T	9/1/2006	Arsenic	2.1E-03		1	1
BA-03A	T	12/1/2006	Arsenic	2.0E-03		1	1
BA-03A	T	3/1/2007	Arsenic	2.1E-03		1	1
BA-03A	T	6/1/2007	Arsenic	1.9E-03		1	1
BA-03A	T	9/1/2007	Arsenic	1.7E-03		1	1
BA-03A	T	12/1/2007	Arsenic	1.7E-03		1	1
BA-03A	T	3/8/2008	Arsenic	2.8E-03		1	1
BA-03A	T	5/8/2008	Arsenic	5.2E-03		1	1
BA-03A	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BA-01A
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -57

Confidence in Trend: 96.6%

Coefficient of Variation: 0.68

Mann Kendall Concentration Trend: (See Note) D

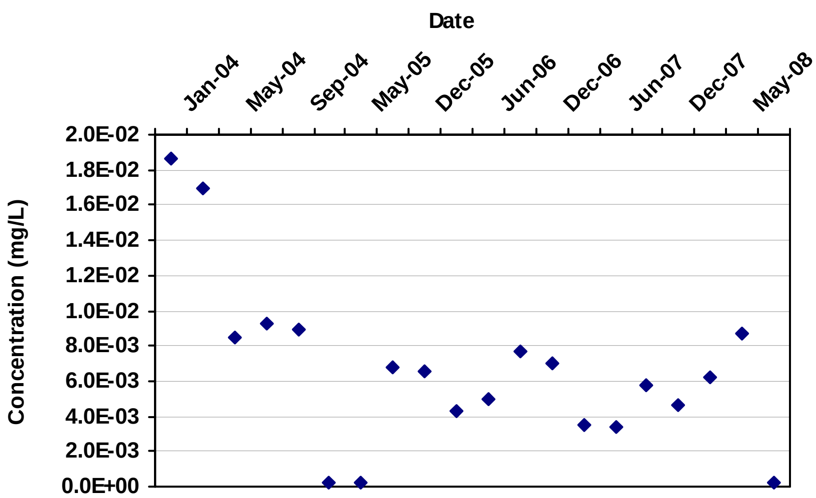
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-01A	T	1/1/2004	Arsenic	1.4E-02		1	1
BA-01A	T	3/1/2004	Arsenic	1.7E-02		1	1
BA-01A	T	5/1/2004	Arsenic	7.8E-03		1	1
BA-01A	T	7/1/2004	Arsenic	8.1E-03		1	1
BA-01A	T	9/1/2004	Arsenic	7.6E-03		1	1
BA-01A	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BA-01A	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BA-01A	T	10/1/2005	Arsenic	5.5E-03		1	1
BA-01A	T	12/1/2005	Arsenic	8.4E-03		1	1
BA-01A	T	3/1/2006	Arsenic	2.3E-03		1	1
BA-01A	T	6/1/2006	Arsenic	7.0E-03		1	1
BA-01A	T	9/1/2006	Arsenic	7.7E-03		1	1
BA-01A	T	12/1/2006	Arsenic	7.1E-03		1	1
BA-01A	T	3/1/2007	Arsenic	7.3E-03		1	1
BA-01A	T	6/1/2007	Arsenic	7.6E-03		1	1
BA-01A	T	9/1/2007	Arsenic	8.5E-03		1	1
BA-01A	T	12/1/2007	Arsenic	5.4E-03		1	1
BA-01A	T	3/8/2008	Arsenic	7.1E-03		1	1
BA-01A	T	5/8/2008	Arsenic	2.0E-04	ND	1	0
BA-01A	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BB-01
Well Type: T
COC: Arsenic

Time Period: 1/1/2004 **to** 8/8/2008
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: -67

Confidence in Trend: 98.5%

Coefficient of Variation: 0.72

Mann Kendall Concentration Trend: (See Note) D

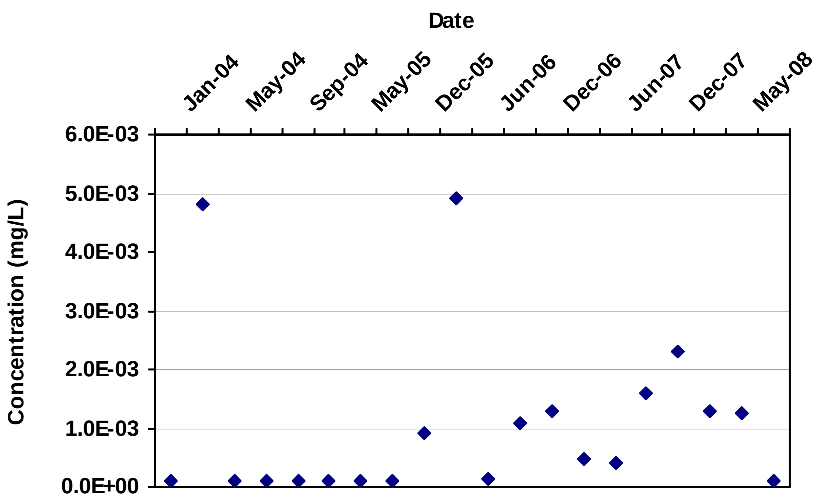
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BB-01	T	1/1/2004	Arsenic	1.9E-02		1	1
BB-01	T	3/1/2004	Arsenic	1.7E-02		1	1
BB-01	T	5/1/2004	Arsenic	8.5E-03		1	1
BB-01	T	7/1/2004	Arsenic	9.3E-03		1	1
BB-01	T	9/1/2004	Arsenic	8.9E-03		1	1
BB-01	T	3/1/2005	Arsenic	2.0E-04	ND	1	0
BB-01	T	5/1/2005	Arsenic	2.0E-04	ND	1	0
BB-01	T	10/1/2005	Arsenic	6.8E-03		1	1
BB-01	T	12/1/2005	Arsenic	6.5E-03		1	1
BB-01	T	3/1/2006	Arsenic	4.3E-03		1	1
BB-01	T	6/1/2006	Arsenic	5.0E-03		1	1
BB-01	T	9/1/2006	Arsenic	7.7E-03		1	1
BB-01	T	12/1/2006	Arsenic	7.0E-03		1	1
BB-01	T	3/1/2007	Arsenic	3.5E-03		1	1
BB-01	T	6/1/2007	Arsenic	3.4E-03		1	1
BB-01	T	9/1/2007	Arsenic	5.8E-03		1	1
BB-01	T	12/1/2007	Arsenic	4.6E-03		1	1
BB-01	T	3/8/2008	Arsenic	6.2E-03		1	1
BB-01	T	5/8/2008	Arsenic	8.7E-03		1	1
BB-01	T	8/8/2008	Arsenic	2.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BA-01A
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 58

Confidence in Trend: 96.8%

Coefficient of Variation: 1.36

Mann Kendall Concentration Trend: (See Note) I

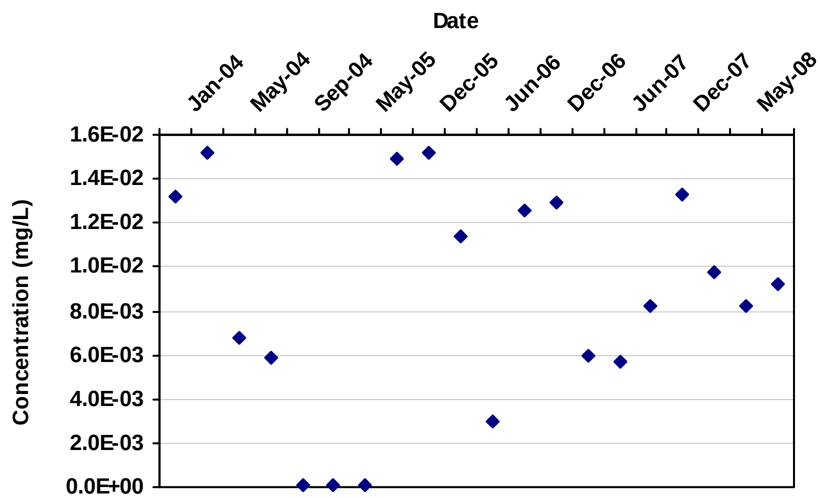
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BA-01A	T	1/1/2004	Lead	1.0E-04	ND	1	0
BA-01A	T	3/1/2004	Lead	4.8E-03		1	1
BA-01A	T	5/1/2004	Lead	1.0E-04	ND	1	0
BA-01A	T	7/1/2004	Lead	1.0E-04	ND	1	0
BA-01A	T	9/1/2004	Lead	1.0E-04	ND	1	0
BA-01A	T	3/1/2005	Lead	1.0E-04	ND	1	0
BA-01A	T	5/1/2005	Lead	1.0E-04	ND	1	0
BA-01A	T	10/1/2005	Lead	1.0E-04	ND	1	0
BA-01A	T	12/1/2005	Lead	9.0E-04		1	1
BA-01A	T	3/1/2006	Lead	4.9E-03		1	1
BA-01A	T	6/1/2006	Lead	1.3E-04		1	1
BA-01A	T	9/1/2006	Lead	1.1E-03		1	1
BA-01A	T	12/1/2006	Lead	1.3E-03		1	1
BA-01A	T	3/1/2007	Lead	4.8E-04		1	1
BA-01A	T	6/1/2007	Lead	4.2E-04		1	1
BA-01A	T	9/1/2007	Lead	1.6E-03		1	1
BA-01A	T	12/1/2007	Lead	2.3E-03		1	1
BA-01A	T	3/8/2008	Lead	1.3E-03		1	1
BA-01A	T	5/8/2008	Lead	1.3E-03		1	1
BA-01A	T	8/8/2008	Lead	1.0E-04	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: BB-01
Well Type: T
COC: Lead

Time Period: 1/1/2004 **to** 8/8/2008
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: 4

Confidence in Trend: 53.8%

Coefficient of Variation: 0.59

Mann Kendall Concentration Trend: (See Note) NT

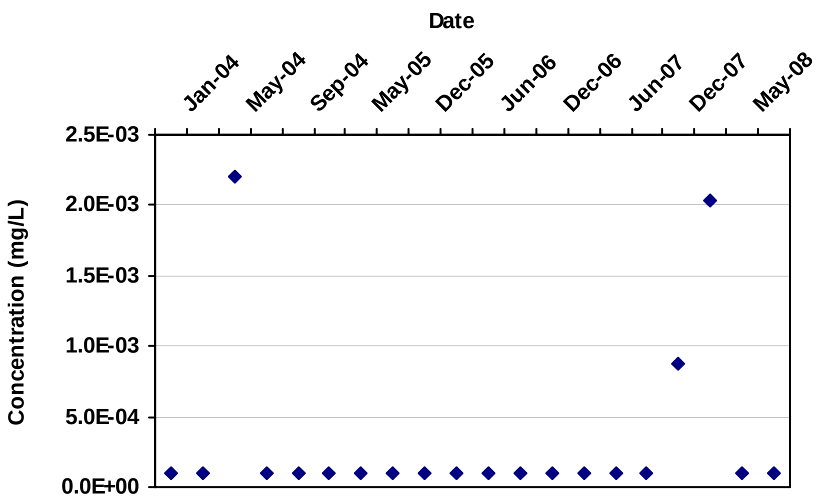
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
BB-01	T	1/1/2004	Lead	1.3E-02		1	1
BB-01	T	3/1/2004	Lead	1.5E-02		1	1
BB-01	T	5/1/2004	Lead	6.8E-03		1	1
BB-01	T	7/1/2004	Lead	5.9E-03		1	1
BB-01	T	9/1/2004	Lead	1.0E-04	ND	1	0
BB-01	T	3/1/2005	Lead	1.0E-04	ND	1	0
BB-01	T	5/1/2005	Lead	1.0E-04	ND	1	0
BB-01	T	10/1/2005	Lead	1.5E-02		1	1
BB-01	T	12/1/2005	Lead	1.5E-02		1	1
BB-01	T	3/1/2006	Lead	1.1E-02		1	1
BB-01	T	6/1/2006	Lead	3.0E-03		1	1
BB-01	T	9/1/2006	Lead	1.3E-02		1	1
BB-01	T	12/1/2006	Lead	1.3E-02		1	1
BB-01	T	3/1/2007	Lead	6.0E-03		1	1
BB-01	T	6/1/2007	Lead	5.7E-03		1	1
BB-01	T	9/1/2007	Lead	8.2E-03		1	1
BB-01	T	12/1/2007	Lead	1.3E-02		1	1
BB-01	T	3/8/2008	Lead	9.7E-03		1	1
BB-01	T	5/8/2008	Lead	8.3E-03		1	1
BB-01	T	8/8/2008	Lead	9.2E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: BA-03A
Well Type: T
COC: Thallium

Time Period: 1/1/2004 **to** 8/8/2008
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: 12

Confidence in Trend: 63.8%

Coefficient of Variation: 1.86

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
BA-03A	T	1/1/2004	Thallium	1.0E-04	ND	1	0
BA-03A	T	3/1/2004	Thallium	1.0E-04	ND	1	0
BA-03A	T	5/1/2004	Thallium	2.2E-03		1	1
BA-03A	T	7/1/2004	Thallium	1.0E-04	ND	1	0
BA-03A	T	9/1/2004	Thallium	1.0E-04	ND	1	0
BA-03A	T	3/1/2005	Thallium	1.0E-04	ND	1	0
BA-03A	T	5/1/2005	Thallium	1.0E-04	ND	1	0
BA-03A	T	10/1/2005	Thallium	1.0E-04	ND	1	0
BA-03A	T	12/1/2005	Thallium	1.0E-04	ND	1	0
BA-03A	T	3/1/2006	Thallium	1.0E-04	ND	1	0
BA-03A	T	6/1/2006	Thallium	1.0E-04	ND	1	0
BA-03A	T	9/1/2006	Thallium	1.0E-04	ND	1	0
BA-03A	T	12/1/2006	Thallium	1.0E-04	ND	1	0
BA-03A	T	3/1/2007	Thallium	1.0E-04	ND	1	0
BA-03A	T	6/1/2007	Thallium	1.0E-04	ND	1	0
BA-03A	T	9/1/2007	Thallium	1.0E-04	ND	1	0
BA-03A	T	12/1/2007	Thallium	8.8E-04		1	1
BA-03A	T	3/8/2008	Thallium	2.0E-03		1	1
BA-03A	T	5/8/2008	Thallium	1.0E-04	ND	1	0
BA-03A	T	8/8/2008	Thallium	1.0E-04	ND	1	0

APPENDIX C:

Supplemental Information from ROD and RI

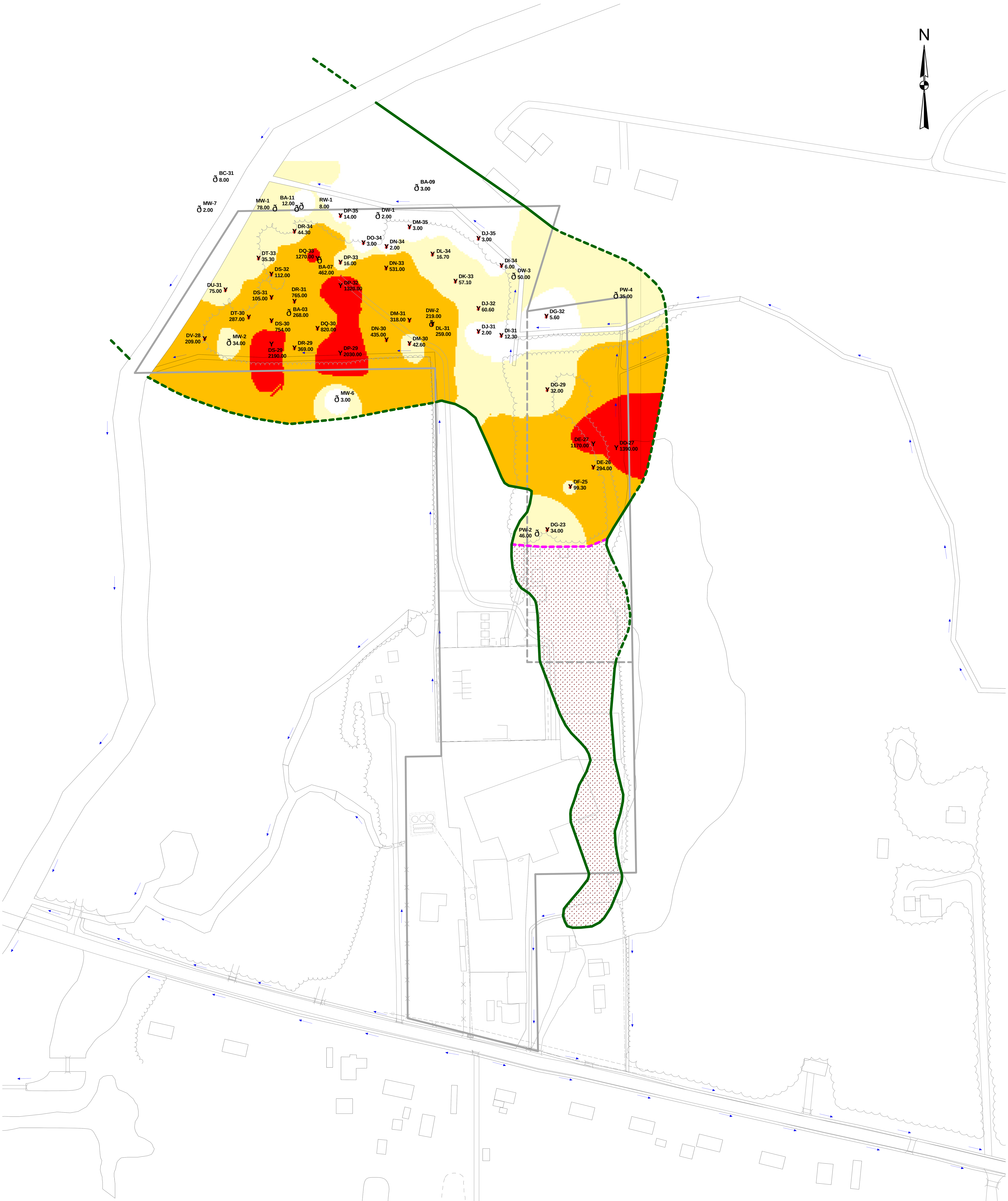
March, 2009

GROUNDWATER MONITORING NETWORK OPTIMIZATION
DELATTE METALS

Ponchatoula, Louisiana

APPENDICES:

Appendix C Supplemental Information from ROD



LEGEND

- EXTENT OF FIRST WATER BEARING ZONE
- ESTIMATED EXTENT OF FIRST WATER BEARING ZONE
- LIMIT OF SATURATED PORTION OF FIRST WATER BEARING ZONE DURING RI SAMPLING EVENT
- SURFACE WATER FLOW DIRECTION
- GEOPROBE
- MONITORING WELL
- UNSATURATED OR PARTIALLY SATURATED PORTION OF FIRST WATER-BEARING ZONE DURING THE RI SAMPLING EVENT

DG-23 # 34.00 LEAD CONCENTRATION (ug/l)

ug/l - MICROGRAMS PER LITER

LEAD CONTOUR INTERVALS (ug/l)

- < 15
- 15 - 100
- 100 - 1000
- 1000 -

100 0 100 200 Feet

NOTE: THE LEAD CONCENTRATION GRID CONTOURS WERE CONSTRUCTED USING INVERSE DISTANCE WEIGHTED INTERPOLATION (IDW).

THE GRID CONTOURS REPRESENT AN ESTIMATION OF THE CONCENTRATIONS BASED ON INTERPOLATION BETWEEN AVAILABLE DATA POINTS. ACTUAL SITE CONDITIONS MAY VARY.

THE FIRST WATER-BEARING ZONE IS GENERALLY LOCATED BETWEEN 5 AND 15 FT-BGS.

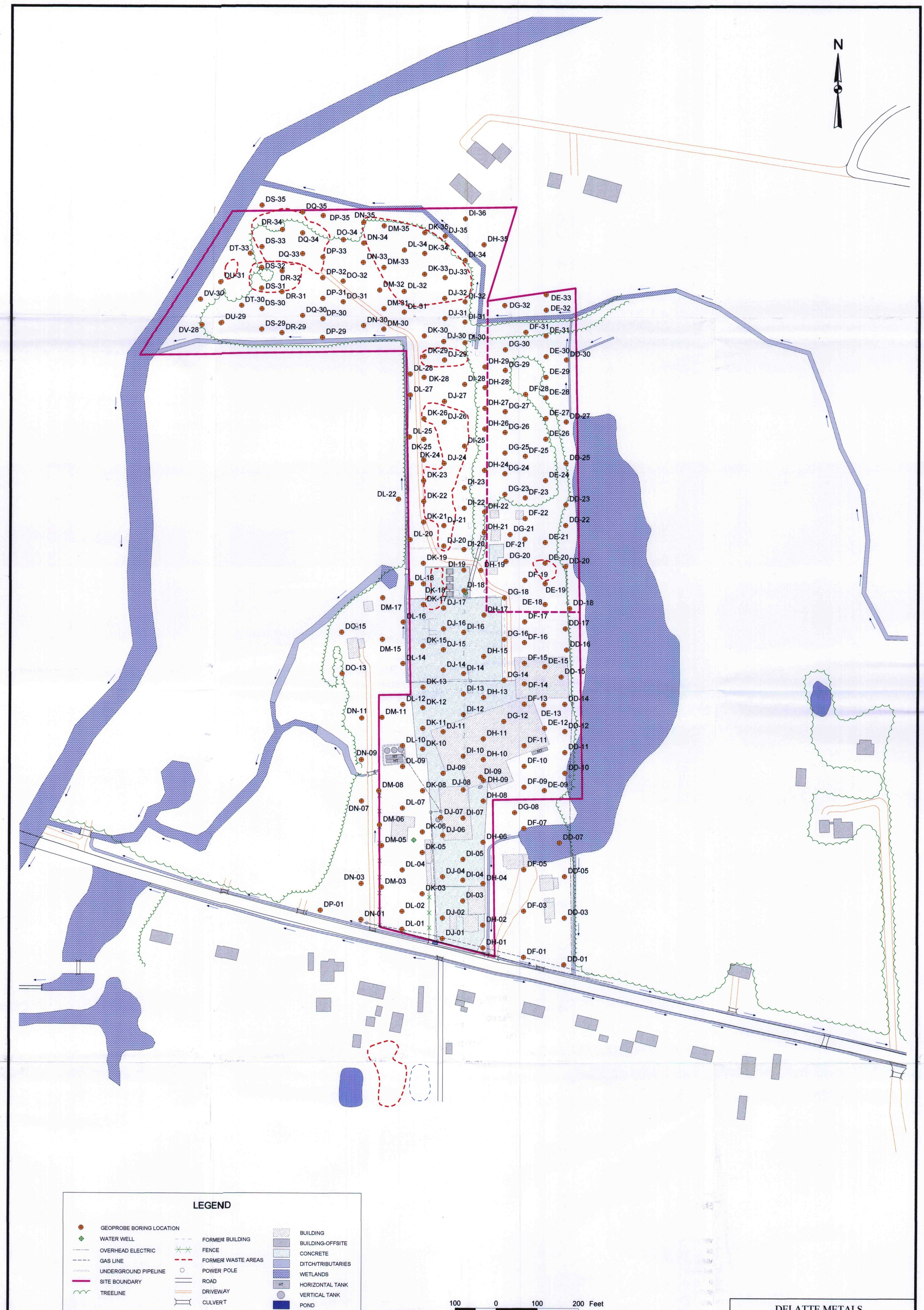
SOURCE: MODIFIED FROM ECOLOGY AND ENVIRONMENT, INC. SITE PLAN AND MORRIS P. HEBERT, INC. SURVEY, JUNE 1999.

DELATTE METALS
PONCHATOULA, LOUISIANA

FIGURE 5
FIRST WATER-BEARING ZONE
LEAD CONCENTRATION MAP

PREPARED FOR: EPA

BY: Tetra Tech EM Inc.



SOURCE:
MODIFIED FROM ECOLOGY AND ENVIRONMENT, INC. SITE PLAN AND MORRIS P. HEBERT, INC. SURVEY, JUNE 1999.

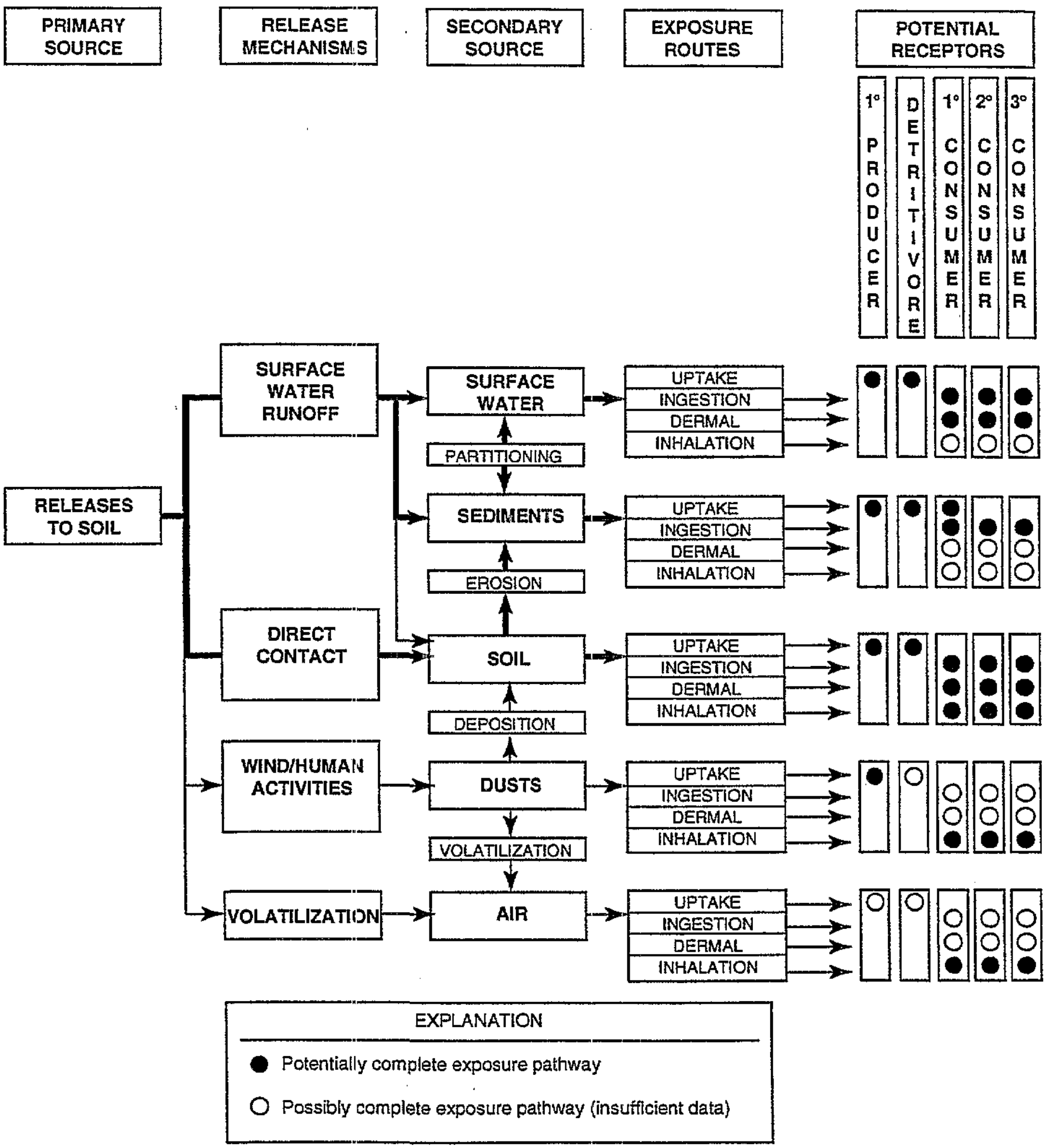
DELATTE METALS
PONCHATOULA, LOUISIANA

FIGURE 7
GEOPROBE BORING
LOCATION MAP

Tetra Tech EM Inc.

005796

024169



DELATTE METALS SITE

Figure 2.1
Conceptual Site Model

TETRA TECH EM INC.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TEXAS 75202-2733

024160

MEMORANDUM

SUBJECT: Recommended Remediation Goals for Delatte Metals Site

FROM: David Riley, Environmental Scientist
Superfund Technical Team (6SF-LT)

TO: Stephen Tzhone, Remedial Project Manager
Louisiana/New Mexico Project Management Section (6SF-LP)

DATE: 4/26/00

This memorandum recommends soil remediation goals based on risk estimates from the human health risk assessment for the Delatte Metals site. Remediation goals are presented for various media of concern.

Soil:
Off Site - 500 ppm Lead, 31 ppm Antimony
On site - 1697 ppm Lead

The Integrated Effects Uptake Biokinetic Model (IEUBK) was used to determine a remediation goal of 500 ppm for residential soils. The Adult Lead Model, which was used to calculate a commercial remediation goal for on-site soils, gave a concentration of 1697 ppm. Removal of lead-contaminated soils could also serve to reduce concentrations of another soil contaminant, antimony, as these contaminants on the site are closely collocated; however, a remediation goal (RG) of 31 ppm for antimony results in a HQ of 1.

Ground Water:

Arsenic	50 µg/L (MCL)
Lead	15 µg/L (MCL)
Manganese	1,700 µg/L (R6MSSLs, noncancer)
Nickel	100 µg/L (MCL)

Thallium	2 µg/L (MCL)
Bis(2-ethyhexyl)phthalate	6 µg/L (MCL)
Benzo[a]pyrene (or B[a]P-eqs)	0.2 µg/L (MCL)
Benzo[b]fluoranthene	0.092 µg/L (MCL)
Chrysene	9.2 µg/L (MCL)

The first water-bearing zone is a Class 3B aquifer, and the second water bearing zone is a Class 2C aquifer. The use of these two aquifers for drinking water is questionable, but the third water-bearing zone is a Class 1B aquifer. Contaminants in the first two aquifers, therefore, should be addressed in order to prevent contamination of the third. The ground water samples which exceeded 15 µg/L of lead are collocated with areas of lead contamination in soil, so addressing on-site soils could reduce concentrations of contaminants in ground water. It is recommended that ground water monitoring take place after removal of on-site soils to determine what levels of contamination may still be present. The recommended clean-up level for each ground water contaminant at the site is the Maximum Contaminant Level (MCL) for drinking water. If no MCL is available, a remediation goal was calculated using equations found in the Region 6 Medium-Specific Screening Levels (R6MSSLs).

Surface Water:

The surface water medium was only included for the trespasser/visitor scenario, as appropriate. No remediation goals are recommended for surface water, as the contaminants did not exceed the carcinogenic risk range or a HQ of 1. The issue with manganese is addressed in a separate memorandum dated April 26, 2000.

Sediment:

The sediment medium was only included for the trespasser/visitor scenario, as appropriate. No remediation goal is recommended for lead in sediment, as it cannot be calculated via the IEUBK or Adult Lead Model. In addition, no remediation goals are recommended for other contaminants in sediment, as they did not exceed the carcinogenic risk range or a HQ of 1.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TEXAS 75202-2733

024173

MEMORANDUM

SUBJECT: Recommended Preliminary Remediation Goals
Delatte Metals Superfund Site

FROM: Susan Roddy, Environmental Scientist (6SF-LT) Susan Roddy

TO: Stephen Tzhone, RPM, (6SF-LP)

DATE: April 26, 2000

This memorandum recommends ecological preliminary remediation goals (PRGs) based on risk estimates from the Ecological Risk Assessment (ERA) for the Delatte Metals site.

Soil: See the February 10, 2000 memorandum from Jon Rauscher to Stephen Tzhone.

Sediment: For the ERA, the commonly used Threshold Effect Level (TEL) and the Probable Effect Level (PEL) freshwater sediment ecotoxicity values from Smith and MacDonald et al (1996) were compared directly with sediment concentrations. The ERA provided TEL and PEL sediment concentration values as recommendations for cadmium, lead, and zinc to be protective of aquatic life. These are analogous in concept to the No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL) based protective concentrations recommended as the ecological risk range in EPA's 1997 Ecological Risk Assessment Guidance for Superfund. The TEL and PEL values include:

	TEL	PEL
Cadmium	0.6 mg/kg	3.5 mg/kg
Lead	35 mg/kg	91.3 mg/kg
Zinc	123 mg.kg	315 mg/kg

It would be acceptable to select the less conservative PEL values of 3.5 mg/kg for cadmium, 91.3 mg/kg for lead, and 315 mg/kg for zinc as ecological preliminary remediation goals for sediment because they are within the acceptable risk range, and given the results of the toxicity tests

024174

Surface Water: The ecological preliminary remediation goals recommended for surface water are EPA's chronic Ambient Water Quality Criteria (AWQC) for aquatic life. These include:

	EPA AWQC	
Aluminum	87	ug/l
Cadmium	0.9	ug/l
Copper	2.9	ug/l
Cyanide	5.2	ug/l
Lead	0.6	ug/l
Zinc	38.1	ug/l
Mercury*	0.012	ug/l
Selenium*	5	ug/l
Silver*	0.4	ug/l

*For mercury, selenium, and silver, the detection limits (reporting limits) exceeded the EPA chronic AWQC although these contaminants were not detected in most samples.

Ground Water: none applicable.

Air: none applicable

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TEXAS 75202-2733

024171

February 10, 2000

MEMORANDUM

Subject: Recommended soil preliminary remediation goals for the Delatte Metals site

From: Jon Rauscher, Ph.D. Jon Rauscher
Toxicologist

To: Stephen Tzhone
Remedial Project Manager

This memorandum recommends soil preliminary remediation goals (PRGs) based on risk estimates from the Ecological Risk Assessment for the Delatte Metals site. The following table presents the back-calculations from risk assessment for the east and west sides of the site, and for the No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL):

Chemical of concern	East-side NOAEL	East-side LOAEL	West-side NOAEL	West-side LOAEL
Aluminum	400 mg/kg	4000 mg/kg	300 mg/kg	3000 mg/kg
Antimony	0.2 mg/kg	4 mg/kg	0.5 mg/kg	6 mg/kg
Arsenic	0.4 mg/kg	300 mg/kg	0.4 mg/kg	400 mg/kg
Barium	10 mg/kg	40 mg/kg	10 mg/kg	50 mg/kg
Lead	7 mg/kg	70 mg/kg	9 mg/kg	90 mg/kg
Selenium	0.5 mg/kg	0.8 mg/kg	0.9 mg/kg	1 mg/kg

The LOAEL end of the potential PRG range is recommended as the final PRG for the Delatte Metal site. The LOAEL is recommended because of the conservative assumption that were used in the back-calculation of the estimated PRGs such considering the prey item with the highest concentration of the chemical. Exposures above the LOAEL PRGs are predicted to result in adverse effects to ecological receptors.

<u>Aluminum</u>

The back-calculation estimated a LOAEL PRGs of 4,000 and 3,000 ppm for the east and west sides, respectively; whereas, a "typical" background concentrations can be 45,000 mg/kg.

Aluminum is not present in a bioavailable form if soil pH is between 4.5 and 8.5. If soil pH at Delatte Metals site is adjusted to a pH of 4.5 to 8.5, no PRG is recommended for aluminum. 024172

Antimony

The back-calculation estimated a LOAEL PRGs for antimony of 4 and 6 ppm for the east and west sides, respectively. The recommended PRG for antimony is the mean of the LOAEL values which is a concentration of 5 ppm.

Arsenic

The back-calculation estimated a LOAEL PRGs for arsenic of 300 and 400 ppm for the east and west sides, respectively. The recommended PRG for antimony is the mean of the LOAEL values which is a concentration of 400 ppm.

Barium

The back-calculation estimated a LOAEL PRGs for barium of 40 and 50 ppm for the east and west sides, respectively. The recommended PRG for barium is the mean of the LOAEL values which is a concentration of 50 ppm.

Lead

The back-calculation estimated a LOAEL PRGs for lead of 70 and 90 ppm for the east and west sides, respectively. The recommended PRG for lead is the mean of the LOAEL values which is a concentration of 80 ppm.

Selenium

The back-calculation estimated a LOAEL PRGs for selenium of 0.8 and 1 ppm for the east and west sides, respectively. The recommended PRG for selenium is the mean of the LOAEL values which is a concentration of 0.9 ppm.

Background

The PRGs for antimony, barium and selenium should be compared to the background concentrations of these metals and may need to be adjusted to a higher concentration if background concentration exceeds the PRG.

Exhibit G-1: Evaluating Changes in Standards

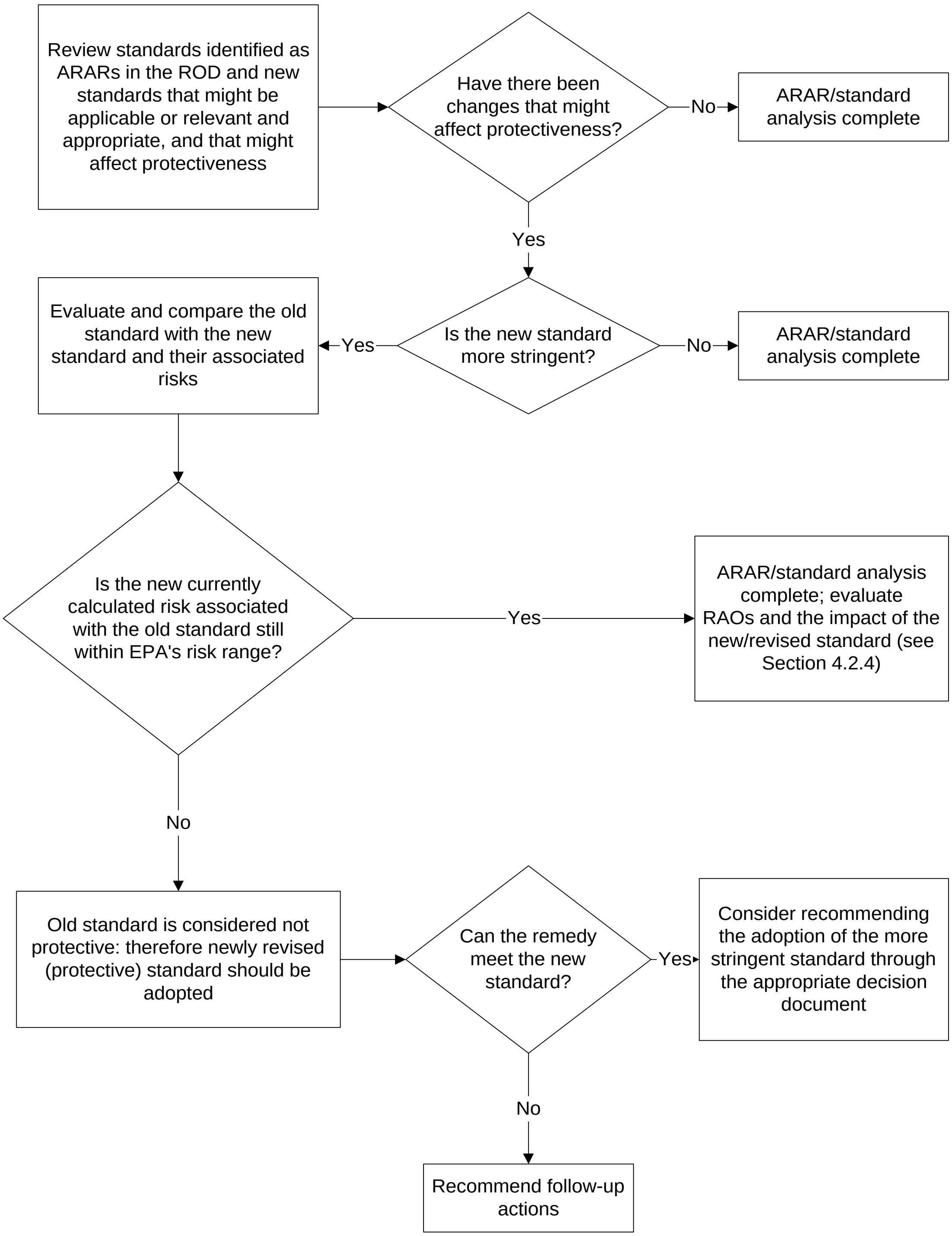


TABLE 11.2
MAXIMUM CONTAMINANT LEVELS OR REGION 6 TAP WATER SCREENING LEVELS FOR COPCs EXCEEDING TARGET LIMITS IN GROUND WATER AND SURFACE WATER
DELATTE METALS

022136

Compound of Potential Concern	MCL (ug/L)	Region 6 Tap Water Risk-Based Screening Levels[a] (ug/L)
Arsenic (noncancer endpoint)	50	--
Arsenic (cancer endpoint)	--	0.045 (C)
Lead	15	15
Manganese	--	1700 (N)
Nickel	100	730 (N)
Thallium	2	2.9 (N)
Bis(2-ethylhexyl)phthalate	6	4.8 (C)
Benzo(a)pyrene	0.2	0.0092 (C)
Benzo(b)fluoranthene	--	0.092 (C)
Chrysene	--	9.2 (C)
Pentachlorophenol	1	0.56 (C)

a Based on residential exposure via ingestion and inhalation pathways.
(N) Noncancer endpoint
(C) Cancer endpoint

022307

TABLE 3-3
TRENDS IN GROUND WATER CONTAMINATION

Analyte	COC Based on Mean and UCL_{95}	Chronic WQC (ug/L)
Aluminum	Y	87.00
Antimony	na	na
Arsenic	Y	150.00
Barium	na	na
Cadmium	Y	0.90
Chromium	Y	11.00
Copper	Y	2.90
Lead	Y	0.60
Mercury	Y[1]	0.01
Nickel	Y	16.60
Selenium	Y	5.00
Silver	Y[1]	0.40
Zinc	Y	38.10

Notes:

[1] Detection limit exceeded WQC; not detected in most samples

Bold indicates the chemical is a COC.

Ground water data are presented in Table E-3a.

COC	Chemical of concern
N	Not a chemical of concern
UCL_{95}	95th upper confidence limit
ug/L	Microgram per liter
WQC	Water qulity criteria
Y	Chemical of concern