Long-Term Groundwater Monitoring Optimization
Clare Water Supply Superfund Site
StageRight Area
Clare, Michigan

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ABBREVIATIONS

AOC	Area of Concern
BGS	Below Ground Surface
CES	Cost Effective Sampling
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Constituent of Concern
CUO	Clean-up Objective
DCE	*cis*-1,2-Dichloroethene
EDD	Electronic Data Deliverable
GIS	Geographic Information System
GSI	Groundwater Services, Inc.
HSCB	Hypothetical Statistical Compliance Boundary
LTM	Long-Term Monitoring
LTMO	Long-Term Monitoring Optimization
MAROS	Monitoring and Remediation Optimization Software
MCES	Modified Cost Effective Sampling
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NPL	National Priorities List
PCE	Tetrachloroethene (Perchloroethene)
PLSF	Preliminary Location Sampling Frequency
PRG	Preliminary Remediation Goal
PRP	Potentially-Responsible Party

RI	Remedial Investigation
SF	Slope Factor
TCE	Trichloroethene
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

March 22, 2007

GROUNDWATER MONITORING NETWORK OPTIMIZATION
STAGERIGHT AREA
CLARE WATER SUPPLY SUPERFUND SITE

The following memorandum contains a review of the long-term groundwater monitoring network for the StageRight (former Welltronics) Facility area near the Clare Public Water Supply, Clare Michigan. The current monitoring network was evaluated using a formal qualitative approach and statistical tools found in the Monitoring and Remediation Optimization System software (MAROS). (The network evaluation was conducted in September 2006 prior to activation of the new municipal well, MW-8). The goal of the groundwater monitoring program is to track changes in concentrations of priority chlorinated constituents that may affect the drinking water remediation system used to treat the public water supply. Recommendations are made for groundwater sample frequency and location based on current hydrogeologic, pumping, and contaminant conditions. The report evaluates the monitoring network west of Maple St. to the StageRight Facility on the west using analytical and hydrogeologic data from sampling events conducted between June 1988 and May 2006.

1.0 Project Objectives

The goal of the StageRight monitoring network optimization is to design a monitoring program that is cost and time efficient as well as protective of potential receptors. The monitoring program should provide sufficient data to support site management decisions. The evaluation of the monitoring program focuses on the following objectives:

- Evaluate well locations and screened intervals within the context of the hydrogeologic regime to determine if they meet site characterization and decision support objectives. Identify possible data gaps.
- Evaluate overall plume stability qualitatively and through trend and moment analysis.
- Evaluate individual well concentration trends over time for target constituents of concern (COCs) both qualitatively and statistically.
- Develop site-specific sampling location and frequency recommendations based on both qualitative and quantitative statistical analysis results.

2.0 Site Background

The StageRight Area of Concern (StageRight AOC) is part of the Clare Water Supply Superfund site (EPA ID# MID980002273) located in the southwest section of the City of Clare, Clare County, Michigan. The StageRight facility (former Weltronics facility) is part of a larger industrial complex located immediately upgradient of the municipal well field for the City of Clare, Michigan. Shallow public water supply wells in Clare are chronically affected by low levels of chlorinated solvents and hydrocarbons emanating from multiple sources in the industrial park. Affected groundwater is currently treated with air strippers and blended with uncontaminated groundwater prior to distribution to the public.

A Remedial Investigation (RI) report was completed by Dames and Moore on behalf of the potentially responsible parties (PRPs) in 1990. Based on soil sample results, the source area associated with the StageRight AOC is located under the main building just west of well MW-1-97 (see Figure 1). Contaminants from other source areas in the industrial park may migrate to the StageRight area by means of a remnant tile drain system from previous agricultural activity and under the influence of strong pumping in the area of the municipal wells.

The StageRight subsurface is characterized by 10-12 feet of layered sand, clay and silt in the upper soil column underlain by a sand and gravel unit with varying amounts of silt to a depth of 60 to 80 feet below ground surface (bgs). The municipal wells are drilled into the sand/gravel unit. A layer of low-permeability glacial till exists west of the StageRight area, but pinches out west of the current StageRight monitoring wells.

The groundwater system is unconfined in the StageRight area with a flow direction to the east/southeast influenced by pumping at the municipal well MW-5 (and currently MW-8 operational as of September 2006). The water table is present at a depth of approximately 20 to 25 feet bgs. Pumping increases the groundwater gradients in the area resulting in high groundwater velocities (see Table 2).

As part of a Time Critical Removal Action (ES&E, 2000), an ozone sparging system has been installed in the vicinities of wells MW-1-97 and MW3-99. The full ozone system has been operating since 2002. Additional monitoring wells were installed as part of the Removal Action. Monitoring data from the StageRight network was used to evaluate the efficacy of the Time Critical Removal Action.

3.0 Methods

Evaluation of the groundwater monitoring network in the vicinity of the StageRight Facility consisted of both qualitative evaluation of site analytical data and hydrogeologic conditions and a quantitative, statistical evaluation of site analytical data. These two methods were combined to recommend a final groundwater monitoring strategy to support site monitoring objectives.

3.1 Qualitative Evaluation

Multiple factors were considered in developing recommendations for continuation or cessation of groundwater monitoring at each well. In some cases, a recommendation was made to continue monitoring a particular well, but at a reduced frequency. A recommendation to discontinue groundwater quality monitoring at a particular well based on the information reviewed does not necessarily constitute a recommendation to physically abandon the well. A change in site conditions might warrant resumption of monitoring at some time in the future at wells that are not currently recommended for continued sampling. In general, continuation of water level measurements in all site wells to facilitate groundwater flow direction and hydraulic gradient evaluation is recommended. Typical factors considered in developing recommendations to retain a well in, or remove a well from, a long-term monitoring (LTM) program are summarized in the table below.

REASONS FOR RETAINING A WELL IN MONITORING NETWORK	REASONS FOR REMOVING A WELL FROM MONITORING NETWORK
Well is needed to further characterize the site or monitor changes in contaminant concentrations through time	Well provides spatially redundant information with a neighboring well (*e.g.*, same constituents, and/or short distance between wells).
Well is important for defining the lateral or vertical extent of contaminants .	Well has been dry for more than two years[a/]
Well is needed to monitor water quality at a compliance or receptor exposure point (*e.g.*, water supply well)	Contaminant concentrations are consistently below laboratory detection limits or cleanup goals
Well is important for defining background water quality	Well is completed in same water-bearing zone as nearby well(s)

a/ Periodic water-level monitoring should be performed in dry wells to confirm that the upper boundary of the saturated zone remains below the well screen. If the well becomes re-wetted, then its inclusion in the monitoring program should be evaluated.

Once the decision has been made to retain a well in the network, data are reviewed to determine a sample frequency supportive of site monitoring objectives. Typical factors considered in developing recommendations for monitoring frequency are summarized below.

REASONS FOR INCREASING SAMPLING FREQUENCY	REASONS FOR DECREASING SAMPLING FREQUENCY
Groundwater velocity is high	Groundwater velocity is low
Change in contaminant concentration would significantly alter a decision or course of action	Change in contaminant concentration would not significantly alter a decision or course of action

REASONS FOR INCREASING SAMPLING FREQUENCY	REASONS FOR DECREASING SAMPLING FREQUENCY
Well is necessary to monitor source area or operating remedial system	Well is distal from source area and remedial system
Cannot predict if concentrations will change significantly over time, or recent significant increasing trend in contaminant concentrations at a monitoring location resulting in concentrations approaching or exceeding a cleanup goal, possibly indicating plume expansion	Concentrations are not expected to change significantly over time, or contaminant levels have been below groundwater cleanup objectives for some prescribed period of time

3.2 MAROS Statistical Methods

Statistical methods in the MAROS 2.2 software were used along with the qualitative evaluation of the network to evaluate concentration trends, plume stability and spatial uncertainty in the StageRight area. MAROS is a collection of tools in one software package that is used in an explanatory, non-linear but linked fashion to statistically evaluate groundwater monitoring programs. The software includes individual well trend and plume stability analysis tools, spatial statistics, and empirical relationships to assist the user in improving a groundwater monitoring network system. Results generated from the software tool were used to develop lines of evidence, which, in combination with results of the qualitative analysis, were used to recommend an optimized monitoring network for the StageRight area. A description of each tool used in the MAROS software is provided as Attachment B. For a 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/software/maros/Maros.htm) and Aziz et al., 2003.

3.3 Data Input, Consolidation and Site Assumptions

Data from the StageRight area were supplied by Progressive Engineering and Construction, Inc (Progressive, 2006), supplemented with information from historic site reports. Progressive is in the process of assembling analytical data from the various areas of concern into a site-wide database. Chemical analytical data were organized in a database, from which summary statistics were calculated. It should be noted that the electronic dataset transmitted by Progressive was not complete in that many non-detect analytical results from StageRight wells (collected by MACTEC) have not been entered into the site database at this time. For example, analytical results for vinyl chloride or *cis*-1,2-dichloroethene (DCE) were not included for some wells with trichloroethene (TCE) detections. The following evaluation assumed that the missing data were non-detect for these constituents. Complete validated historic constituent concentrations should be entered into a site-wide electronic database available to all stakeholders.

Wells and sample frequencies in the current StageRight groundwater monitoring program are shown on Table 1. The qualitative evaluation included both current and historic monitoring locations in an area bounded by Maple St. to the east and the StageRight building to the west. In all, 34 locations were considered in the qualitative evaluation. Details of the qualitative evaluation are shown on Table 3 and on Figure 2. Data from the current monitoring network (21 wells) were used in the quantitative (MAROS) analysis.

Well screened intervals were used to group locations into shallow, intermediate, and deep groundwater zone monitoring points. Screened intervals for wells are illustrated in Figure 3. Fourteen locations were considered part of the intermediate groundwater zone (approximately 30-50 ft bgs), and seven locations were assigned to the deep zone (approximately 50- 80 ft bgs.). The two groundwater zones were considered separately as two-dimensional slices for the quantitative evaluation and as largely independent zones for the qualitative evaluation. The number of wells screened in the shallow zone was insufficient to perform spatial statistical analyses.

A list of aquifer physical parameters assumed for the analysis is shown in Table 2. Two screening levels were identified for concentrations of TCE in groundwater. A cleanup objective (CUO) of 0.3 mg/L was established as a remediation goal under the Time Critical Removal Action for the StageRight Facility. The USEPA Maximum Contaminant Level (MCL) of 0.005 mg/L was used as a general screening level and long-term goal for water quality in the aquifer. A consensus groundwater seepage velocity was not available from the stakeholder group, so a seepage velocity was estimated for the area (see Attachment A below).

4.0 Results

Results from the, qualitative evaluation, analytical program review, stability analysis, temporal trend analyses, moment analysis, and sampling frequency determination for the StageRight facility are summarized below.

4.1 Qualitative Review

- The qualitative review included an estimation of the groundwater velocity in the StageRight area. The seepage velocity was estimated to be approximately 13 ft/day for the intermediate zone and 18 ft/day for the deep zone (see Attachment A). Recommendations for future monitoring in the StageRight area were influenced by the large magnitude of the estimated seepage velocity and are contingent on the future stability and magnitude of the seepage velocity (i.e., recommendations are based on the assumption that the estimated seepage velocity is reasonably accurate and that this relatively rapid velocity will continue in the future).

- Details of the qualitative evaluation are shown on Figures 2 and 3 and Table 3. The potentially rapid groundwater velocity and the proximity of the public water supply well (MW-5) result in the recommendation to sample several locations along the centerline of the plume monthly. However, several wells were recommended for reduction in sample frequency or elimination from the monitoring program. Three intermediate zone wells (MW-2-99, MW-6-97 and WS-10) and four deep zone wells (211, MW-106D, MW-107D and WD-10) are recommended for exclusion from the program.

- The plume in the intermediate groundwater zone to the east of MW-1-02 and MW-6-97 is not well bounded. With the addition of the new municipal water supply well in the area of MW-2 but closer to the plume (MW-8), there is concern that groundwater and dissolved contaminants could be migrating into the uncharacterized area north of MW-5. For this reason, installation of a new well pair screened in the intermediate and deep groundwater zones should be considered for the area north of MW-5 and east of MW-6-97.

- Available information indicates that groundwater samples collected from StageRight wells by MACTEC are analyzed for volatile organic compounds (VOCs) using Method SW8260B, chloride using Method E300.0, total alkalinity using Method E310.1, and total dissolved solids (TDS) using Method E160.1. Information presented in the *2005 Annual Monitoring Report* prepared by Progressive Environmental (February 2006) indicates that other area wells sampled by Progressive are analyzed for VOCs (method not known but assumed to be SW8260B), and the field parameters pH, conductivity, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential.

  Information presented in the *Monthly Progress Report* submitted to the USEPA by MACTEC on September 7, 2005 indicates that, as of July 2005, the inorganic parameters had been targeted for analysis up to 67 times beginning in May 2001 (actual number of analyses varies by well). The basis for performing these inorganic analyses is not clear. Chloride can be used as a natural attenuation indicator parameter but this is not a monitored natural attenuation site and other important natural attenuation indicator parameters are not targeted for analysis. If the purpose is to support the suitability of the water for human use then samples from the production wells can be analyzed for these parameters; it should not be necessary to analyze samples from all monitoring wells for these inorganic parameters every sampling event. The following recommendations pertaining to the groundwater analytical program should be considered:

  Discuss optimizing the target VOC list to a short-list of key contaminants of concern (e.g., chlorinated ethenes) with the analytical laboratories. Potential advantages include lower laboratory analytical costs and lower data management/validation/reporting costs.

Review the basis for collecting samples for chloride, alkalinity, and TDS in StageRight monitoring wells. Concentrations of these analytes in site groundwater have been thoroughly documented, and it appears that significant optimization/reduction of the inorganic constituent sampling program should be possible.

4.2 MAROS Statistical Review

- The MAROS Constituent of Concern (COC) Assessment ranked TCE as the highest priority constituent in terms of toxicity and prevalence. Tetrachloroethene (PCE) ranked lower than TCE in terms of prevalence and toxicity; however, the data set supplied for the evaluation did not include analytical results for PCE and DCE for many locations. The qualitative and quantitative evaluation centered on characterizing distribution of TCE, with other constituents considered as secondary drivers for the monitoring program.

- Individual well trend analyses for priority constituents were determined in MAROS using analytical data collected between 1999 and 2006. For some locations, more recent trends were determined and compared to the long-term trends. Results indicate that the majority of sample locations have Decreasing long-term concentration trends for TCE using both Mann-Kendall and Linear Regression techniques (see Table 4). Results for the Mann-Kendall trend evaluation are illustrated on Figure 4.

  Source wells MW-1-97 and MW-5-97 and high concentration well MW-3-99 show Decreasing to Probably Decreasing trends for TCE. Only two locations in the intermediate zone showed Increasing trends for TCE. Upgradient location MW-1-01 shows an Increasing trend from 1999-2006, but has an average concentration below the screening levels (MCL = 0.005 mg/L). The recent trend (2004-2006) at MW-1-01 is Stable, indicating MW-1-01 may have been influenced by remediation activities during the 2000-2001 timeframe. An Increasing trend was found at location MW-6-97 from 1999-2006; however, as with MW-1-01, the average concentration is below the screening levels. The recent trend at MW-6-97 (2004-2006) is Decreasing. With the initiation of pumping at new municipal well MW-8, concentration trends in the StageRight area should be evaluated after each sample event.

  Individual wells in the deep groundwater zone have largely Decreasing trends for TCE or show non-detect results. Average concentrations in this zone are below the screening levels. Results of the well trend analysis are shown in Table 4 and on Figure 4.

- The total dissolved mass estimate (zeroth moment) for TCE showed a "Decreasing" trend between 1999 and 2006 for the intermediate groundwater zone. Recent estimates of total dissolved mass in the intermediate zone plume show approximately 0.4 Kg in 2001 dropping to 0.20 Kg in 2006. Decreasing total mass along with Decreasing trends at individual wells indicate that remediation efforts in the area appear to be effective. (Moments for the deep zone could not be evaluated due to the small number of monitoring locations.)

The movement of the center of mass (first moment) of the plume relative to the source area shows a Decreasing trend, indicating a stable to shrinking plume. First moments are illustrated on Figure 5, and indicate very little change in the center of mass of the plume over the time-frame analyzed. Plume stability is most likely enhanced by the continuous pumping at the municipal wells, which dramatically reduces the opportunity for the plume to expand.. Evaluation of plume spread about the center of mass (second moment) indicates Increasing trends both parallel and perpendicular to groundwater flow. Increasing second moments indicate reduced mass in the center of the plume relative to the edges, which supports the conclusion that the sparging system is effectively removing contaminant mass from the plume.

- Spatial analysis of the plume suggests that preferential flow paths exist in the StageRight area. Intermediate zone wells MW-3-99, MW-1-02, MW-8-97, and MW-7-97 show higher TCE concentrations than adjacent wells MW-1-99, MW-2-99 and MW-6-97. For this reason, the MAROS statistical evaluation indicates a moderately high degree of uncertainty in the center of the plume (see Figure 6). Installation of a new well pair is recommended for the area just east of the current network, as the area of high concentration at MW1-02 is not bounded immediately to the east. Channelization within the sand/gravel matrix could provide a flow path for constituents to the east before turning south to the pumping wells. A recommendation is made to exclude wells MW-2-99 and MW-6-97 from the monitoring program, as they do not contribute information to support characterization of the movement of plume mass (see also Table 3 for additional details on rationale for exclusion of these wells). Well WS-10 is also recommended for exclusion as it is north of the plume and shows low levels of constituents.

  Deep zone wells 211, D-106 (MW-106D), D-107 (MW-107D) and well WD-10 are also recommended for exclusion from the StageRight monitoring program, based on their low levels of TCE and their position outside the main plume flow path. These wells may be retained for hydrogeologic monitoring and/or as part of a regional groundwater quality assessment.

  While no areas within the current network were identified by MAROS as requiring additional sampling locations, areas of concentration uncertainty were identified. The deep groundwater zone beneath the plume core between MW-10-97 and P-202 is not monitored. However, as this area of the plume is decreasing in concentration for both the intermediate and deep zones, a new deep well is not recommended in this area under current conditions.

Upgradient well MW-1-01 has an average concentration below the screening levels; however, the well exhibits a long-term Increasing concentration trend for TCE. Concentrations at this well may have been influenced by a combination of pumping intensity at municipal wells mobilizing affected groundwater to the north and by recent activity associated with remedy installation. No new well is recommended for the area north of MW-1-01 at this time as concentration trends have been Stable for the past two years. However, wells on the northern edge of the StageRight Facility should be monitored periodically for any changes in dissolved contaminant concentrations in the future.

An area of higher concentration uncertainty was identified during the qualitative evaluation. The groundwater quality in the intermediate groundwater zone to the east of MW-1-02 and MW-6-97 is not well characterized. This area is outside of the current network and could not be evaluated using MAROS spatial statistical tools.

- Results from the qualitative evaluation and the MAROS well sampling frequency tool (the Modified CES method) were used to develop a sample frequency for groundwater using conservative assumptions. An overall sample schedule was developed after considering site hydrogeology, the location of each well in relation to the plume and the water supply wells, individual well trends, non-detect values, and recent sample frequency. (Note: the sample frequency recommendations are based on the assumption that the groundwater flow velocity in the MW-5 area is extremely rapid but that plume conditions at the site are largely stable to decreasing. Deviations from these assumptions should result in reevaluation of the sample frequency and modification of the monitoring program.)

  The final well sampling recommendation developed using both qualitative and quantitative methods is illustrated on Figure 7 and detailed in Tables 3, 6, and 7. The optimized sampling program recommends:
  - Monthly sampling for flow path wells MW-1-02, MW-8-97, MW-7-97, P-202, and MW-5.
  - Semiannual sampling (every 6 months) for source area wells MW-1-97, MW-3-99, MW-5-97.
  - Annual sampling for wells MW-1-01, MW-3-01, MW-2-01, MW-1-99, WS-5 and deep well MW-10-97. Wells WS-5 and MW-5-97 may be reduced in frequency or excluded from the monitoring program if further sampling indicates consistent Decreasing trends (see Table 3 for details).

  The total recommended program results in 71 groundwater samples annually.

5.0 Recommendations

- Monthly chemical sampling and water level measurements are recommended for five wells along the flow path of constituents to public supply well MW-5 (illustrated on Figures 2 and 7). Data from these monitoring events should be reviewed promptly after each sample event and evaluated for increasing concentration trends.

- Installation of a new monitoring well pair is recommended for the intermediate and deep groundwater zones east of MW-6-97. Two additional areas of concentration uncertainty should be monitored for increasing trends using the proposed network and sample frequency: Continue monitoring the intermediate zone north near MW-1-01 and the area around MW-1-02 and MW-8-97. Monitor deep zone wells MW-10-97 and P-202 for any increasing concentration trends.

- Exclude intermediate zone wells WS-10, MW-2-99 and MW-6-97 from the routine analytical monitoring program for the StageRight area. These wells should be maintained for water-level measurement and may be included in periodic (e.g., every 5 years) confirmation sampling to ensure plume stability

  Exclude deep zone wells 211, D-106 (MW-106D), D-107 (MW-107D) and well WD-10 from routine analytical monitoring at the StageRight area. As with the intermediate zone wells, these locations should be maintained for water-level monitoring and periodic confirmation sampling. As the Site-Wide groundwater monitoring plan was not evaluated in this report, the deep wells listed above may provide useful information on groundwater quality for broader regional groundwater quality evaluations. If wells 211, D-106 and D-107 are included in the Site-Wide monitoring network, they may be sampled at a frequency appropriate for regional groundwater management decisions.

- Semiannual monitoring is recommended for three high concentration ‘source’ wells: MW-1-97, MW-5-97 and MW-3-99.

- Annual sampling is recommended for six locations that support plume delineation: MW-1-01, MW-2-01, MW-3-01, MW1-99, MW-10-97, and WS-5. Annual sampling is recommended due to the stability of the plume under the current pumping regime, as demonstrated by the stationary position of the first moments.

- If current trends continue at locations MW-5-97 and WS-5, these wells may be considered for removal from the program in the future as described more fully in Table 3.

- Cost and data management benefits may be gained from optimizing the chemical analytical program to a short list of target VOCs that include key contaminants of concern (e.g., chlorinated ethenes). Review the basis for collecting samples for chloride, alkalinity, and TDS in StageRight monitoring wells. Concentrations of these analytes in site groundwater have been thoroughly documented, and it appears that significant optimization/reduction of the inorganics sampling program should be possible.

- Combine groundwater elevation data collected from StageRight wells by MACTEC with data collected from area wells by Progressive and other stakeholders to facilitate a more complete evaluation of groundwater flow directions and hydraulic gradients. Neither data set, by itself, provides a sufficiently complete picture of groundwater hydraulics east of the StageRight facility.

- Development of a comprehensive site-wide database should continue. Current and future analytical results should be available from laboratories in electronic data deliverable (EDD) format, which should simplify the validation and importation process. Results of historical analyses should be added to the database where possible, particularly when these data are used to support management decisions. The site-wide database should be made available to all stakeholders.

6.0 Long-Term Monitoring Program Flexibility

The LTM program recommendations described above are based on available data regarding current (and expected future) site conditions. Changing site conditions, such as changes in hydraulic (pumping-related) stresses brought on by installation of the new municipal well or remedial system operation, could affect contaminant fate and transport. Therefore, the LTM program should be reviewed if site conditions change significantly, and revised as necessary to adequately track changes in the magnitude and extent of COCs in groundwater over time.

7.0 Reference Cited

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Tables

GROUNDWATER SERVICES, INC.

TABLE 1
GROUNDWATER MONITORING LOCATIONS STAGERIGHT AREA

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

Well Type	Well Name	Top of Screen [ft bgs]	Bottom of Screen [ft bgs]	Recent Sampling Frequency
Intermediate Zone Wells				
T	MW-1-01	38	43	Monthly
T	MW-1-02	39.1	44.1	Monthly
S	MW-1-97	32	42	Monthly
T	MW-1-99	35	45	Monthly
T	MW-2-01	40	45	Monthly
T	MW-2-99	35	45	Monthly
T	MW-3-01	37	42	Monthly
S	MW-3-99	30	40	Monthly
S	MW-5-97	35	45	Monthly
T	MW-6-97	39	49	Monthly
T	MW-7-97	40	50	Monthly
T	MW-8-97	35	45	Monthly
T	WS-5	35	40	Semi-annual
T	WS-10	44.5	49.5	Semi-annual
Deep Zone Wells				
T	211	50	55	Semi-annual
T	D-106	57.25	62.25	Semi-annual
T	D-107	58	63	Semi-annual
S	MW-10-97	55	65	Monthly
T	MW-5	53	80	Quarterly
T	P-202	65	85	Monthly
T	WD-10	64	69	Semi-annual

Notes:
1. S = Source area; T = Tail area (designations for MAROS software).
2. Wells listed above had sufficient data to be included in both quantitative and qualitative evaluations. Well locations are shown on Figure 1.
3. Screened intervals from Progressive, 2006.
4. ft bgs = feet below ground surface.
5. Deep wells P-201, P-203, P-204, P-205, and WD-5 have insufficient data for quantitative analysis.
6. Intermediate zone wells MW-4-97, S-107, WD-21 and 108 had insufficient data for quantitative analysis.
7. Shallow zone wells were not evaluated.

GROUNDWATER SERVICES, INC.

TABLE 2
AQUIFER INPUT PARAMETERS: STAGERIGHT AREA

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

Parameter	Value	Units
Current Plume Length	300	ft
Maximum Plume Length	700	ft
PlumeWidth	200	ft
SeepageVelocity Intermediate (ft/yr)*	4600	ft/yr
SeepageVelocity Deep (ft/yr)*	6700	ft/yr
Distance to Receptors (Source to MW-5)	300	ft
GWFluctuations	No	--
SourceTreatment	Ozone Sparge (Air stripping at well head)	--
PlumeType	Chlorinated Solvent	--
NAPLPresent	No	--
Trichloroethene (TCE)	**Screening Levels**	
Cleanup Objective (Removal Action)	0.3	mg/L
MCL	0.005	mg/L
Parameter	**Value**	
Groundwater flow direction	E/SE	345
Porosity	0.31	--
Source Location near Well	MW-1-97	--
Source X-Coordinate	13015427.53	ft
Source Y-Coordinate	845280.636	ft
Saturated Thickness Intermediate Zone	20	ft
Saturated Thickness Deep Zone	40	ft
Parameter	**Value**	
Shallow Zone Aquifer	< 22	ft bgs
Intermediate Zone Aquifer	30 - 50	ft bgs
Deep Zone Aquifer	50-85	ft bgs

Notes:

1. Aquifer data from Progressive database (2006).
2. Priority COCs defined by prevalence, toxicty and mobility.
3. Saturated thickness represents the span of the shallow to intermediate aquifer.
5. ft = Coordinates in NAD 1983 State Plane Michigan Central feet.
6. Cleanup Objectives for removal action -- StageRight property (Progressive, 2006).
7. * = Seepage velocity estimated from site data. See Attachment A.

TABLE 3
QUALITATIVE EVALUATION OF STAGERIGHT GROUNDWATER MONITORING NETWORK

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

Well Name	Hydrologic Unit	Current Sampling Frequency	Qualitative Analysis			
			Exclude	Retain	Monitoring Frequency Recommendation	Rationale
StageRight Wells						
MW-1-01	Intermediate	Monthly		X	Annual	Upgradient to cross-gradient from plume; TCE varied from ND to 5.7 ug/L during 58 sampling events over 4.8 yr from 8/01 to 4/06; maximum change of only 3.1 ug/L over last 45 sampling events since 8/02, increasing trend prior to 2004. 1,2-DCE exhibits slow increasing trend but well below MCL. Retain at relatively low frequency to provide upgradient/background groundwater quality data.
MW-1-02	Intermediate	Monthly		X	Monthly	Located along approximate longitudinal axis of TCE plume immediately downgradient of 'hotspot' well MW3-99; decreasing TCE levels but becoming asymptotic; relatively stable PCE levels; good indication of remediation effectiveness; retain at high frequency given potential high groundwater flow velocity to provide early warning of hotspot migration toward production well MW-5 in the event that subsurface conditions change and plume expansion occurs. Note that estimated groundwater flow velocity is based on very limited data; if actual velocity is lower, then lower sampling frequency (e.g., quarterly) may be appropriate.
MW-1-97	Intermediate	Monthly		X	Semiannual	Measures effectiveness of ozone sparging system at reducing relatively elevated TCE levels at east edge of StageRight building; well contains 2nd-highest levels of TCE at site.
MW-1-99	Intermediate	Monthly		X	Annual	No MCL exceedances in 54 events since 10/01; no evidence of increasing trend. Retain at relatively low frequency to monitor southern (cross-gradient) boundary of plume over time.
MW-2-01	Intermediate	Monthly		X	Annual	Retain to monitor potentially increasing 1,2-DCE concentrations (TCE stable since late 2002); low magnitude of COC concentrations and lack of substantial changes from event to event justify relatively low frequency.
MW-2-99	Intermediate	Monthly	X		NA	TCE non-detect during 20 events from 9/04 to 4/06; redundant with MW-1-99 which is screened in same zone and can be sampled to monitor southern extent of plume over time in this area.
MW-3-01	Intermediate	Monthly		X	Annual	Retain to monitor northern (cross-gradient) plume boundary over time. Relatively low frequency justified by decreasing 1,2 DCE levels over time and consistent non-detect for other COCs.
MW-3-99	Intermediate	Monthly		X	Semiannual	Retain to monitor highest TCE concentrations detected in site groundwater and effectiveness of ozone sparge system; relatively stable concentrations over past few years following early decreasing trend from 2000 to 2001.
MW-5-97	Intermediate	Monthly		X*	Semiannual	Retain only if data from this well are needed to make decisions regarding continued operation of sparge system in this area. Otherwise, this well is redundant with MW-1-97, which has consistently higher COC concentrations and will be the limiting factor on achieving compliance with cleanup goals in this area.
MW-6-97	Intermediate	Monthly	X		NA	Only 1 slight cleanup goal exceedance (TCE = 5.6 ug/L in March 04) over 4 yrs and 48 sampling events; TCE stable since about Jan 04; 1,2-DCE historically less than 10 ug/L and ND last 5 events ending 4/06. Stable to decreasing trends since 2004, low magnitude of concentrations, and proximity of well MW-1-02 which has higher COC levels and is recommended for retention support exclusion of this well from LTM program. This well does not appear to be in the primary flowpath of groundwater and dissolved contamination emanating from StageRight Facility.
MW-7-97	Intermediate	Monthly		X	Monthly	Retain as sentry well at high frequency given potential for high groundwater flow velocity for early warning of COC concentrations migrating toward production well MW-5. Note that estimated groundwater flow velocity is based on very limited data; if actual velocity is lower, then lower sampling frequency (e.g., quarterly) may be appropriate.
MW-8-97	Intermediate	Monthly		X	Monthly	Retain at high frequency given potential for high groundwater flow velocity to monitor concentrations along approximate plume axis and flowpath between source area and production well MW-5; apparent increasing trend in PCE levels. Note that estimated groundwater flow velocity is based on very limited data; if actual velocity is lower, then lower sampling frequency (e.g., quarterly) may be appropriate.
WS-5	Intermediate	Semiannual		X*	Annual	Decreasing trend for TCE, cross-gradient location, and distance from main plume area support relatively infrequent monitoring; discontinue monitoring or decrease to every other year if concentrations remain at low levels through 2007 unless hydraulic regime changes or remediation system is shut down.
WS-10	Intermediate	Semiannual	X		NA	Stable trends for COCs since 2002, low-magnitude concentrations (at or below cleanup goals), cross-gradient location, and distance from main plume all support exclusion of this well from continued regular LTM. TCE below 10 ug/L for 19 events from Sept 98 to May 06.

NA = not applicable.
* = conditional recommendation; see comments

TABLE 3
QUALITATIVE EVALUATION OF STAGERIGHT GROUNDWATER MONITORING NETWORK

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

Well Name	Hydrologic Unit	Current Sampling Frequency	Qualitative Analysis			
			Exclude	Retain	Monitoring Frequency Recommendation	Rationale
StageRight Wells						
StageRight Area Deep Wells						
211	Deep	Semiannual	X		NA	Consistently low-magnitude concentrations below cleanup goals; no need to continue obtaining deep zone data for this plume-periphery area
MW-106D (D-106)	Deep	Semiannual	X		NA	Consistently similar or lower concentrations than in production wells MW-2 and MW-5; no discernible temporal trends; historical data indicate that continued sampling would not add significantly useful information.
MW-107D (D-107)	Deep	Semiannual	X		NA	Mostly non-detect for COCs with a few trace-level detections below cleanup goals; no evidence of increasing trends; distant from main plume area and production wells; no need to continue regular groundwater quality monitoring in this outlying area.
MW-10-97	Deep	Monthly		X	Annual	Only 9 TCE detections in 76 sampling events; only 1 detection since 2/01 (4 ug/L in 1/04). More consistent 1,2-DCE detections well below MCL. Retain as vertical sentry well to monitor vertical plume extent over time at east edge of StageRight building and potentially increasing 1,2-DCE concentrations.
MW-5	Deep	Semiannual		X	Monthly	Production well used for drinking water purposes. Stable to decreasing, low-magnitude COC concentrations. Increase sampling frequency due to presence of high COC concentrations potentially within 1 month's travel time of well.
P-202	Deep	Monthly		X	Monthly	Retain as deep sentry well at high frequency given potential for high groundwater flow velocity to monitor TCE concentrations exceeding cleanup goal near production well MW-5 (also screened in deep zone). Note that estimated groundwater flow velocity is based on very limited data; if actual velocity is lower, then lower sampling frequency (e.g., quarterly) may be appropriate.
WD-10	Deep	Semiannual	X		NA	Mostly non-detect for COCs with a few trace-level detections below cleanup goals; no evidence of increasing trends; distant from main plume area and production wells; no need to continue regular groundwater quality monitoring in this outlying, relatively uncontaminated zone.
Groundwater Remedy Wells						
MW-105S	Shallow	Semiannual				No Data
MW-106S	Shallow	Semiannual				No Data
MW-2	Deep	Semiannual		X	Semiannual	Production well used for drinking water purposes. Low-magnitude COC concentrations support maintaining current sampling frequency; overall increasing in cis-1,2-DCE concentrations up to approx May 05 should be watched carefully.
Wells Not Currently Sampled						
MW4-97		NA				No Data
MW-107S	Intermediate	NA	X		NA	1 data point for March 04; all non-detect; no need to monitor groundwater quality in this outlying area; conclusion supported by data for well D-107.
WD-5	Deep	NA	X		NA	1 data point for June 1989; all non-detect; no need for continued monitoring based on data for 211, which is screened higher in deep zone.
WD-21	Intermediate	NA	X		NA	3 data points from 1988 to 1994; TCE evidenced decreasing trend to non-detect in 1994. Distant and cross-gradient from main plume; no need to continue monitoring in this relatively uncontaminated area.
WS-21	Shallow	NA	X		NA	1 data point for March 04; all non-detect; no need to monitor groundwater quality in this outlying area; conclusion supported by data for well WD-21.
P-201	Deep	NA	X*		NA	1 data point for March 04; all non-detect except for 8.5 ug/L 1,2-DCE. Available data indicate that deep zone cross-gradient from plume is not significantly contaminated and does not merit additional monitoring. However, recommend one update sampling of P-201 to confirm this conclusion, followed by continued exclusion of well from LTM program unless results of update sampling indicate otherwise.
P-203	Deep	NA	X		NA	1 data point for March 04; all non-detect; no need to monitor groundwater quality in this outlying area.
P-204	Deep	NA	X		NA	1 data point for March 04; all non-detect except for 10 ug/L 1,2-DCE; no need to monitor groundwater quality in this outlying area; well is not located between StageRight plume and receptors such as production wells so provides no value in assessing contaminant migration from source area to production wells.
P-205	Deep	NA	X*		NA	1 data point for March 04; comparison of P-205 data and MW-2 data indicates MW-2 is pulling in contaminated groundwater from an interval not intercepted by P-205, making data for P-205 of little use. Recommend one update sampling of P-205 to confirm this conclusion, followed by continued exclusion of well from LTM program unless results of update sampling indicate otherwise.
219	Deep	NA			NA	No Data. However, top of screen is 100 ft bgs; well is probably too deep to provide useful information.

NA = not applicable.
* = conditional recommendation; see comments

GROUNDWATER SERVICES, INC.

TABLE 4
WELL TREND SUMMARY RESULTS: 1999-2006

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

WellName	Number of Samples	Number of Detects	Maximum Result [mg/L]	Max Result Above CUO?	Average Result [mg/L]	Average Result Above MCL?	Mann Kendall Trend	Linear Regression Trend	Overall Trend Result
Trichloroethene -- Intermediate Zone									
MW-1-01	20	16	0.049	No	0.004	No	I	I	I
MW-1-02	16	16	0.75	Yes	0.218	Yes	D	D	D
MW-1-97	25	25	3.3	Yes	0.535	Yes	PD	D	D
MW-1-99	25	22	0.024	No	0.003	No	D	D	D
MW-2-01	20	20	0.012	No	0.008	Yes	NT	I	PI
MW-2-99	25	10	0.026	No	0.002	No	S	S	S
MW-3-01	20	0	<0.002	No	0.001	No	--	--	ND
MW-3-99	25	25	2.8	Yes	1.626	Yes	D	D	D
MW-5-97	25	25	0.68	Yes	0.175	Yes	D	D	D
MW-6-97	17	17	0.021	No	0.003	No	I	I	I
MW-7-97	25	25	0.018	No	0.012	Yes	D	D	D
MW-8-97	25	25	0.59	Yes	0.238	Yes	D	D	D
WS-5	15	15	0.26	No	0.024	Yes	D	D	D
WS-10	15	14	0.084	No	0.005	Yes	NT	NT	NT
Trichloroethene -- Deep Zone									
211	15	7	0.002	No	0.001	No	S	S	S
D-106	15	15	0.008	No	0.003	No	NT	D	S
D-107	15	1	<0.001	No	0.001	No	--	--	ND*
MW-10-97	25	4	0.030	No	0.002	No	PD	D	D
MW-5	24	24	0.012	No	0.007	Yes	D	D	D
P-202	26	26	0.017	No	0.011	Yes	D	D	D
WD-10	15	1	<0.001	No	0.001	No	--	--	ND*

Notes

1. Trends were evaluated for data collected between 1/1/1999 and 5/30/2006.
2. Intermediate zone is approximately between 30 and 50 ft bgs (809 and 793 ft AMSL). Deep zone is between 50 and 85 ft bgs (below 793 ft AMSL).
3. Number of Samples is the number of samples consolidated by quarter for the compound at this location.
   Number of Detects is the number of times the compound has been detected for data consolidated by quarter at this location.
4. Maximum Result is the maximum concentration for the COC indicated between 1999 and 2006.
5. CUO = Clean-up Objective, 0.3 mg/L. MCL = 0.005 mg/L 'Above MCL' indicates that the result value is above the screening level'.
6. 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.
7. Mann-Kendall trend results are illustrated on Figure 4.

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TABLE 5
WELL REDUNDANCY ANALYSIS SUMMARY RESULTS

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

WellName	TCE Average Slope Factor	TCE Minimum Slope Factor	TCE Maximum Slope Factor	Preliminary Statistical Result	Recommendation After Qualitative Review
Intermediate Zone Wells					
MW-1-01	0.57	0.21	1.00	Retain	Retain
MW-1-02	0.56	0.46	0.73	Retain	Retain
MW-1-97	0.36	0.16	0.50	Retain	Retain
MW-1-99	0.87	0.65	1.00	Retain	Retain
MW-2-01	0.29	0.19	0.81	Exclude	Retain at reduced frequency
MW-2-99	0.83	0.09	1.00	Exclude (based on minimum slope factor)	**Exclude**
MW-3-01	1.00	1.00	1.00	Retain	Retain
MW-3-99	0.76	0.69	0.89	Retain	Retain
MW-5-97	0.90	0.62	1.00	Retain	Retain
MW-6-97	0.70	0.58	1.00	Retain	**Exclude**
MW-7-97	0.27	0.14	0.42	Exclude	Retain, eliminate MW-6-97
MW-8-97	0.75	0.55	0.87	Retain	Retain
WS-10	0.19	0.01	0.91	Exclude	**Exclude**
WS-5	0.22	0.05	0.71	Exclude	Retain, eliminate after confirmation sampling
Deep Zone Wells					
211	1.00	1.00	1.00	Retain	**Exclude**
D-106	0.09	0.02	0.13	Exclude	**Exclude**
D-107	1.00	1.00	1.00	Retain	**Exclude**
MW-10-97	1.00	1.00	1.00	Retain	Retain
MW-5	0.10	0.10	0.10	Exclude	Retain
P-202	0.53	0.49	0.55	Retain	Retain
WD-10	1.00	1.00	1.00	Retain	**Exclude**

Notes:
1. Slope Factor is the difference between the actual concentration and the concentration estimated from nearest neighbors normalized by the actual concentration. Slope factors close to 1 show the concentrations cannot be estimated from the nearest neighbors, and the well is important in the network.
2. Slope factors were calculated using data between January 2002 and May 2006.
3. Locations with slope factors below 0.3 were considered for elimination.

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TABLE 6
MCES SAMPLING FREQUENCY ANALYSIS RESULTS

LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

Well Type	Well Name	Number of Samples	Original Frequency[2]	TCE Preliminary Sample Frequency Recommendation	Final Recommendation After Qualitative Evaluation*	Rationale
T	MW-1-01	20	Monthly	Annual	Annual	Upgradient location, below MCL. Retain to monitor Increasing TCE trend.
T	MW-1-02	16	Monthly	Annual	Monthly	High GW velocity, downgradient from high concentration area, upgradient from public supply well.
S	MW-1-97	25	Monthly	Quarterly	Semiannual	Monitors source area, Probably Decreasing trend supports reduced frequency.
T	MW-1-99	25	Monthly	Annual	Annual	Decreasing trend, located in low concentration area
T	MW-2-01	20	Monthly	Annual	Annual	Increasing overall trend, but Stable recent trends, reduce frequency
T	MW-2-99	25	Monthly	Annual	**Exclude**	Stable trend, TCE below screening levels, redundant with MW-1-99.
T	MW-3-01	20	Monthly	Biennial	Annual	Monitors northern edge, largely non-detect. Continued low concentration, may result in lowered sample frequency in future.
S	MW-3-99	25	Monthly	Annual	Semiannual	Area of highest concentration, monitor with source area wells.
S	MW-5-97	25	Monthly	Annual	Semiannual	Monitors source area, Decreasing trend supports reduced frequency, possible removal from routine monitoring if continued Decreasing trends.
T	MW-6-97	17	Monthly	Annual	**Exclude**	In area of low concentrations, redundant with MW-1-02 and MW-8-97.
T	MW-7-97	25	Monthly	Annual	Monthly	Retain at monthly frequency to signal movement of constituents toward supply well MW-5.
T	MW-8-97	25	Monthly	Annual	Monthly	Retain at monthly frequency to signal movement of constituents toward supply well MW-5.
T	WS-5	15	Semi-annual	Annual	Annual	Monitors souther edge of plume.
T	WS-10	15	Semi-annual	Annual	**Exclude**	Upgradient location, low concentration.
Deep Zone						
T	211	15	Semi-annual	Biennial	**Exclude**	Stable, low concentrations south of plume, below MCL
T	D-106	15	Semi-annual	Annual	**Exclude**	Stable, low concentrations, below MCL
T	D-107	15	Semi-annual	Biennial	**Exclude**	Stable, largely non-detect concentrations south of plume, below MCL
S	MW-10-97	25	Monthly	Annual	Semi-annual	Deep source area, continue monitoring source
T	MW-5	24	Quarterly	Annual	Monthly	Monitor water supply well to prevent failure of treatment system.
T	P-202	26	Monthly	Annual	Monthly	Sentry well for MW-5 supply well.
T	WD-10	15	Semi-annual	Biennial	**Exclude**	Largely non-detect, upgradient of plume.

Notes:
1. S = Source well; T = Tail well. MCES - Modified Cost Effective Sampling.
2. Number of Samples is the number of quarterly results found by averaging monthly sampling 1999-2006.
3. The Preliminary Sample Frequency is the sampling frequency recommended by the MCES algorithm in the MAROS software.
4. * See details of Qualitative evaluation Table 3. The Qualitative evaluation includes other COCs and hydraulic parameters.
   Final Recommendation is the sampling frequency suggested after both qualitative and quantitative review of the well condition and function.
5. Exclude = Do not sample during routine monitoring. Does not indicate well should be abandoned.

GROUNDWATER SERVICES, INC.

TABLE 7
FINAL RECOMMENDED MONITORING NETWORK STAGERIGHT AREA

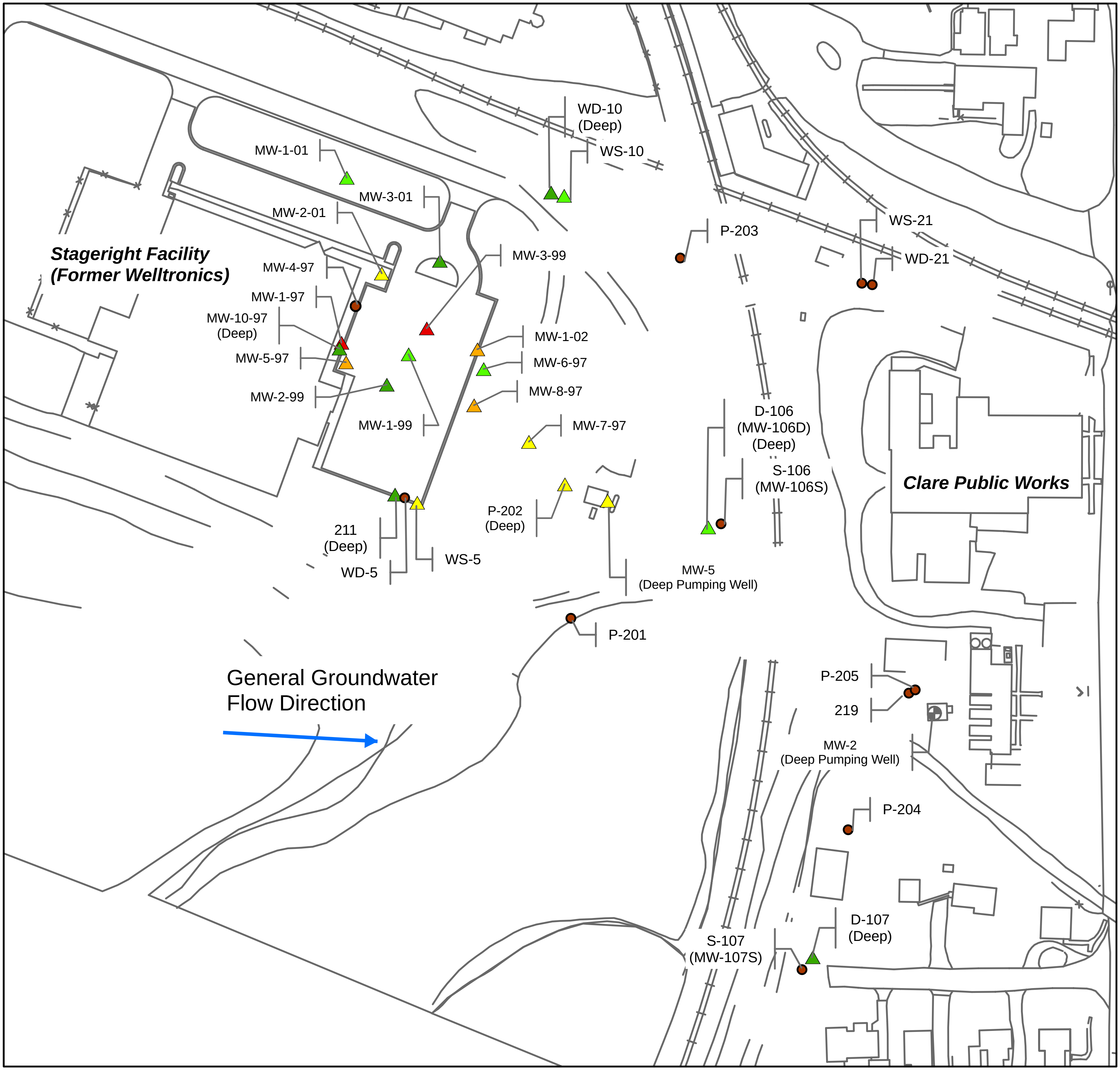
LONG-TERM MONITORING OPTIMIZATION
CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN

WellName	Number of Samples	Number of Detects	Average Result [mg/L]	Average Result Above CUO?	TCE Mann Kendall Trend	TCE Linear Regression Trend	TCE Overall Trend Result	Recommendation After Qualitative and Quantitative Review	Preliminary Sample Frequency Recommendation	Final Recommended Sample Frequency
Intermediate Zone										
MW-1-01	20	16	0.004	No	I	I	I	Retain	Annual	Annual
MW-1-02	16	16	0.218	Yes	D	D	D	Retain	Annual	Monthly
MW-1-97	25	25	0.535	Yes	PD	D	D	Retain	Quarterly	Semiannual
MW-1-99	25	22	0.003	No	D	D	D	Retain	Annual	Annual
MW-2-01	20	20	0.008	Yes	NT	I	PI	Retain at reduced frequency	Annual	Annual
MW-2-99	25	10	0.002	No	S	S	S	Exclude	Annual	Exclude
MW-3-01	20	0	0.001	No	--	--	ND	Retain	Biennial	Annual
MW-3-99	25	25	1.626	Yes	D	D	D	Retain	Annual	Semiannual
MW-5-97	25	25	0.175	Yes	D	D	D	Retain	Annual	Semiannual
MW-6-97	17	17	0.003	No	I	I	I	Exclude	Annual	Exclude
MW-7-97	25	25	0.012	Yes	D	D	D	Retain, eliminate MW-6-97	Annual	Monthly
MW-8-97	25	25	0.238	Yes	D	D	D	Retain	Annual	Monthly
WS-10	15	14	0.005	Yes	NT	NT	NT	Exclude	Annual	Exclude
WS-5	15	15	0.024	Yes	D	D	D	Retain, eliminate after confirmation sampling	Annual	Annual, sample to confirm trend
Deep Zone										
211	15	7	0.001	No	S	S	S	Exclude	Biennial	Exclude*
D-106	15	15	0.003	No	NT	D	S	Exclude	Annual	Exclude*
D-107	15	1	0.001	No	--	--	ND*	Exclude	Biennial	Exclude*
MW-10-97	25	4	0.002	No	PD	D	D	Retain	Annual	Annual
MW-5	24	24	0.007	No	D	D	D	Retain	Annual	Monthly
P-202	26	26	0.011	No	D	D	D	Retain	Annual	Monthly
WD-10	15	1	0.001	No	--	--	ND*	Exclude	Biennial	Exclude*

Notes

1. Intermediate zone is approximately between 30 and 50 ft bgs (809 and 793 ft AMSL). Deep zone is between 50 and 85 ft bgs (below 793 ft AMSL).
2. Number of Samples is the number of samples consolidated by quarter for the compound at this location.
   Number of Detects is the number of times the compound has been detected for data consolidated by quarter at this location.
3. Average Result is the average concentration for TCE between 1999 and 2006.
4. CUO = Clean-up Objective, 0.005 mg/L. 'Above CUO' indicates that the result value is above the objective standard.
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.
6. All recommendations are contingent upon stable plume status under current conditions.
   Changes in groundwater flow velocity or head in response to the new municipal well may require increasing or decreasing sample locations and frequency.
7. Sample locations are illustrated on Figure 7.
8. Exclude* = While these wells do not provide unique information for StageRight management decisions, they may be retained
   for Site -Wide groundwater monitoring, which was not evaluated.

Figures



Legend

Active Well Locations Average Concentration TCE 1999-2006

- ND - 0.0025 mg/L
- 0.0025 - 0.005 mg/L
- 0.005 - 0.100000 mg/L
- 0.100 - 0.300 mg/L
- 0.300 - 1.62 mg/L
- Inactive Locations or Locations with No Data

Notes:

1. Average concentrations were determined for trichloroethene (TCE) between 1999 and 2006.
2. Clean-up Objective (CUO) for TCE = 0.3 mg/L; MCL = 0.005 mg/L..
3. Wells screened in intermediate zone of aquifer except where indicated.
4. Data source Progressive Environmental and Construction, August 2006.

Scale (ft)

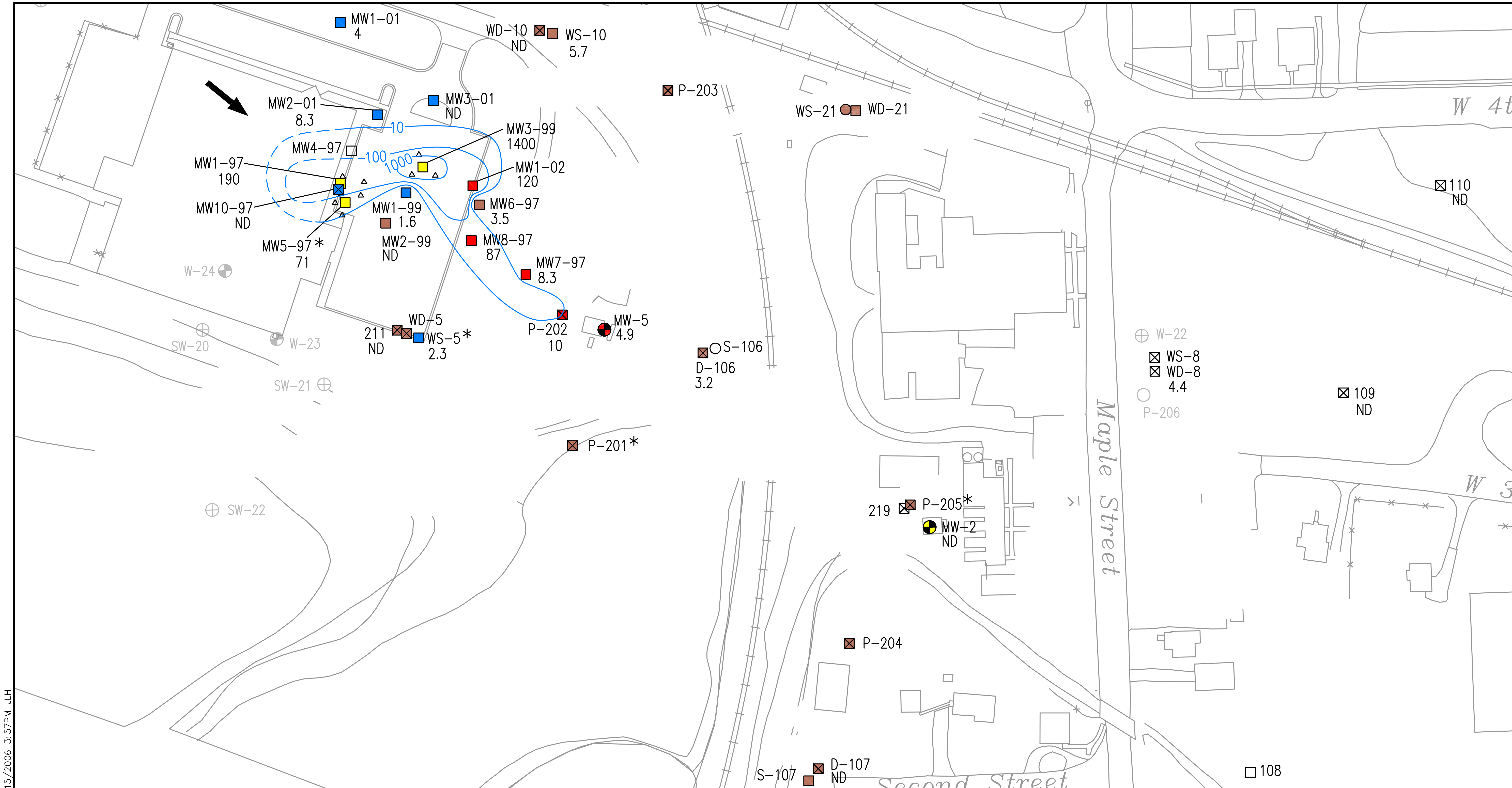
0 60 120

GROUNDWATER SERVICES, INC.

STAGERIGHT AREA WELL LOCATIONS AND AVERAGE TCE CONCENTRATIONS

Clare Water Supply
Clare, Michigan

GSI Job No.	G-3138-105	Drawn by:	MV
Issued:	03/22/2007	Chk'd by:	MV
Figure 1		Appv'd by:	MV



LEGEND

WS-21 ○ SHALLOW MONITORING WELL
MW3-01 □ INTERMEDIATE MONITORING WELL
WD-5 ⊠ DEEP MONITORING WELL
MW-5 ◐ DEEP PRODUCTION WELL
△ AIR SPARGE WELL
⊕ DUAL PHASE EXTRACTION WELL
ND NOT DETECTED
* = CONDITIONAL RECOMMENDATION, SEE COMMENTS IN TABLE 3

—10— INFERRED LINE OF EQUAL TCE CONCENTRATION, APRIL–MAY 2006 (μg/L)

← INFERRED GROUNDWATER FLOW DIRECTION

RECOMMENDED SAMPLE FREQUENCY

- MONTHLY
- SEMIANNUAL
- ANNUAL
- EXCLUDE

0' 50' 100'
SCALE: 1"=100'

FIGURE 2

QUALITATIVE EVALUATION RESULTS FOR STAGERIGHT FACILITY

Long-Term Monitoring Network Optimization
Clare Water Supply Superfund Site

PARSONS
Denver, Colorado

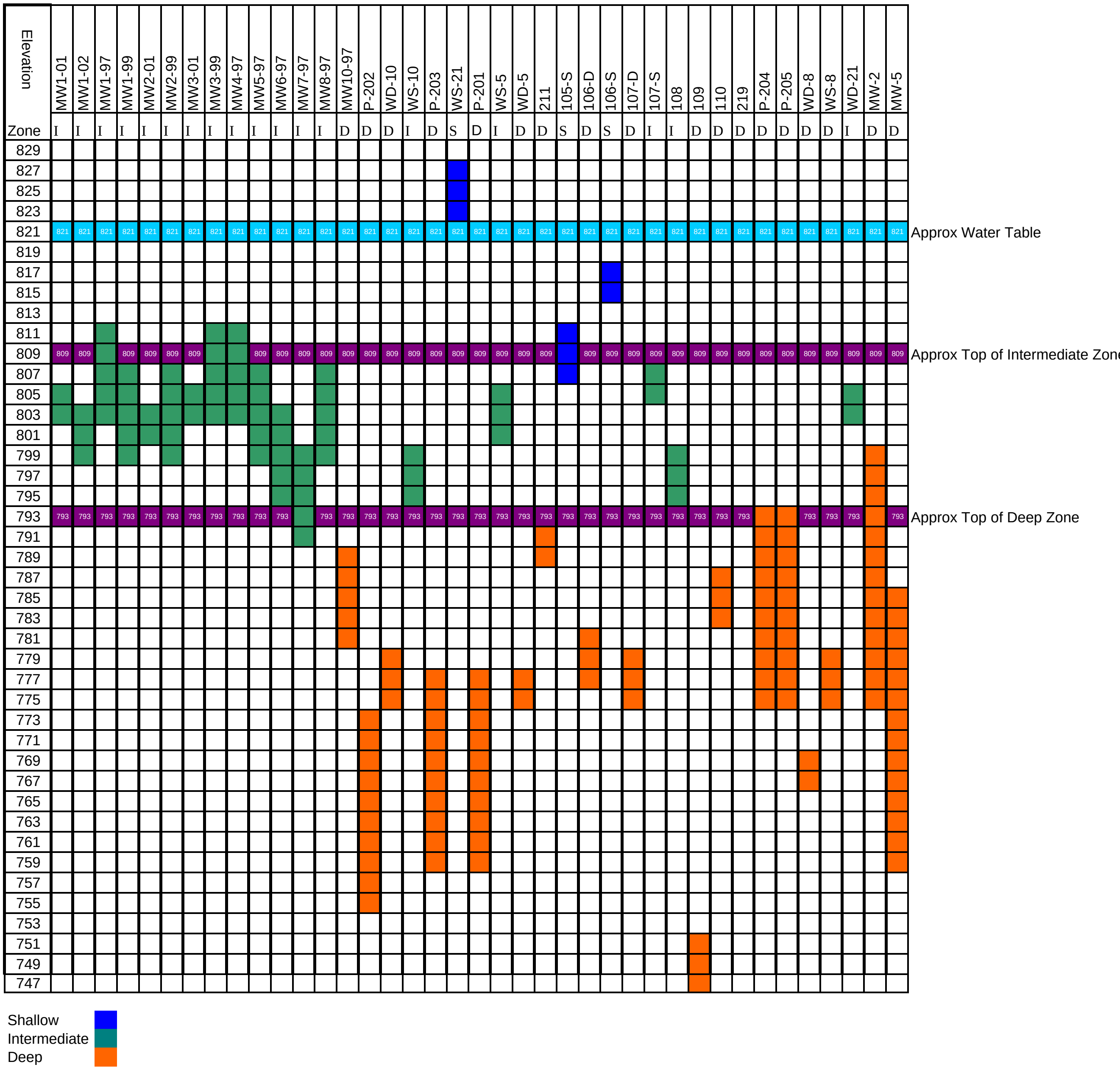
S:\ES\cad\744461\06DN0246.dwg 09/15/2006 3:57PM JLH

FIGURE 3

APPROXIMATE WELL SCREEN INTERVALS FOR STAGERIGHT VICINITY

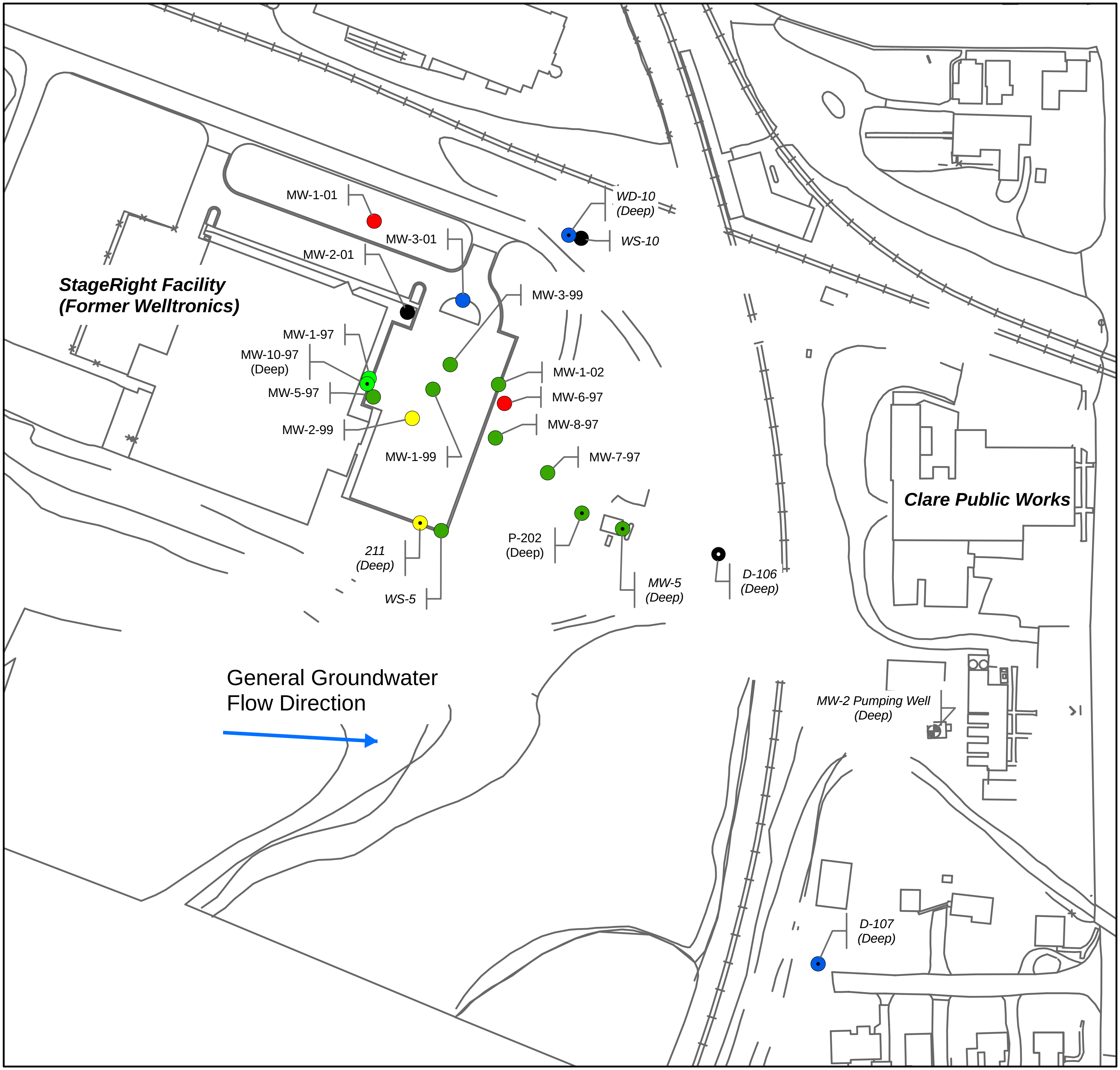
LONG-TERM MONITORING OPTIMIZATION EVALUATION

CLARE WATER SUPPLY SUPERFUND SITE, MICHIGAN



Note: Well 219 is screened from approximately 729 to 734 feet above mean sea level, below the bottom of this figure.

PARSONS



N

Legend

- Deep Zone Wells
- Intermediate Zone Wells

Mann-Kendall Trend Trichloroethene

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- No Trend
- Non detect

Notes:
1. Trends were determined for trichloroethene data between 1999 and 2006.
2. Wells screened in intermediate zone of aquifer except where indicated.
3. Data source Progressive Environmental and Construction, August 2006.

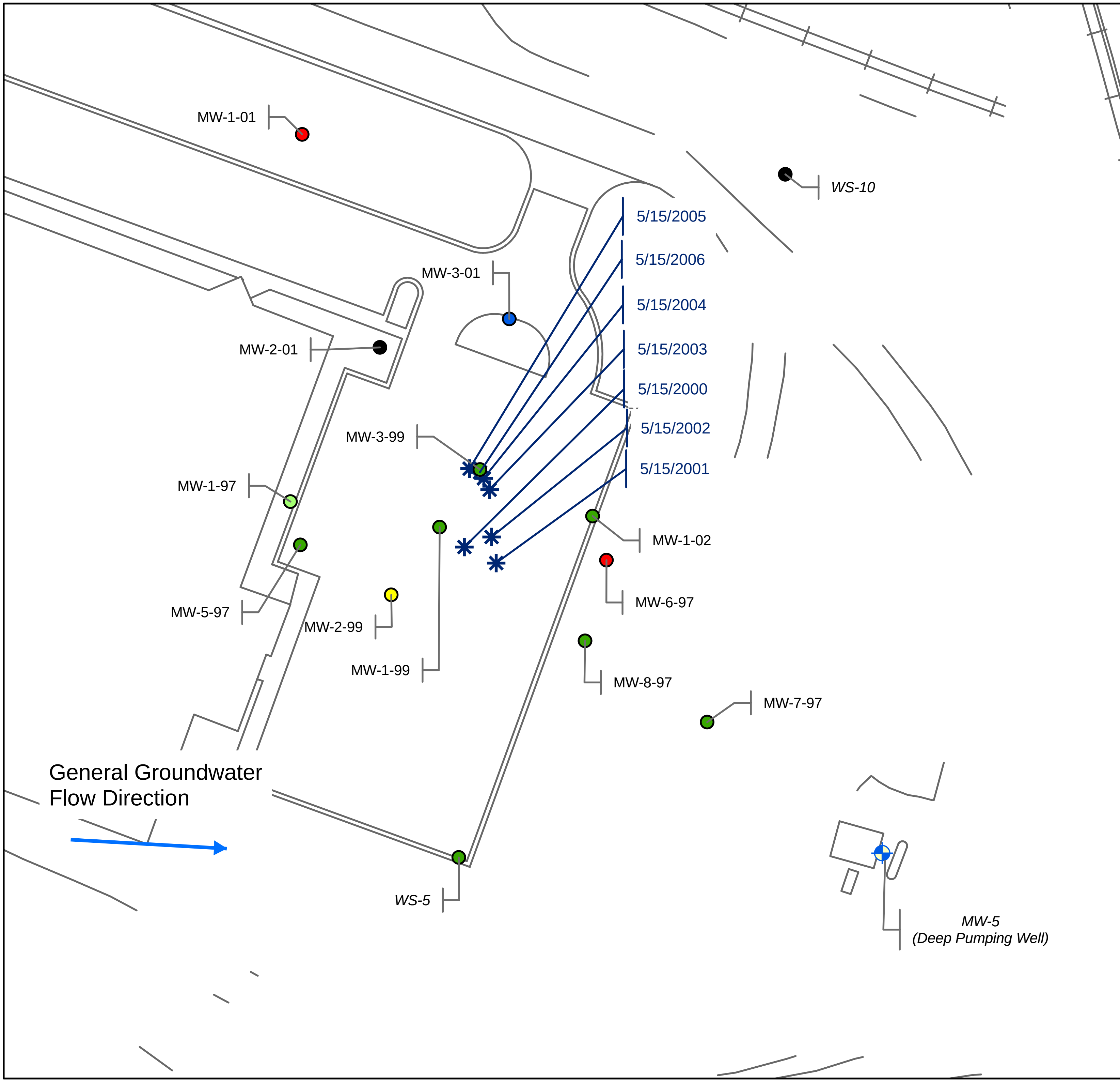
Scale (ft)
0 70 140

GROUNDWATER SERVICES, INC.

STAGERIGHT AREA TCE TEMPORAL TREND RESULTS

Clare Water Supply
Clare, Michigan

GSI Job No.	G-3138-105	Drawn by:	MV
Issued:	03/22/2007	Chk'd by:	MV
Figure 4		Appv'd by:	MV



N

Legend

Plume Center of Mass (First Moments)

5/15/2001 Effective Date of Center of Mass Calculation

Water Supply Well

Mann-Kendall Trends Intermediate Zone

- D
- PD
- S
- PI
- I
- NT
- ND

Notes:
1. Trends were determined for TCE data between 1999 and 2006.
2. All wells screened in Intermediate zone of aquifer except pumping well MW-5.
3. Data source Progressive Environmental and Construction, August 2006.

Scale (ft)
0 30 60

GROUNDWATER SERVICES, INC.

STAGERIGHT AREA
TCE FIRST MOMENTS
INTERMEDIATE ZONE

Clare Water Supply
Clare, Michigan

GSI Job No.	G-3138-105	Drawn by:	MV
Issued:	03/22/2007	Chk'd by:	MV
Figure 5		Appv'd by:	MV

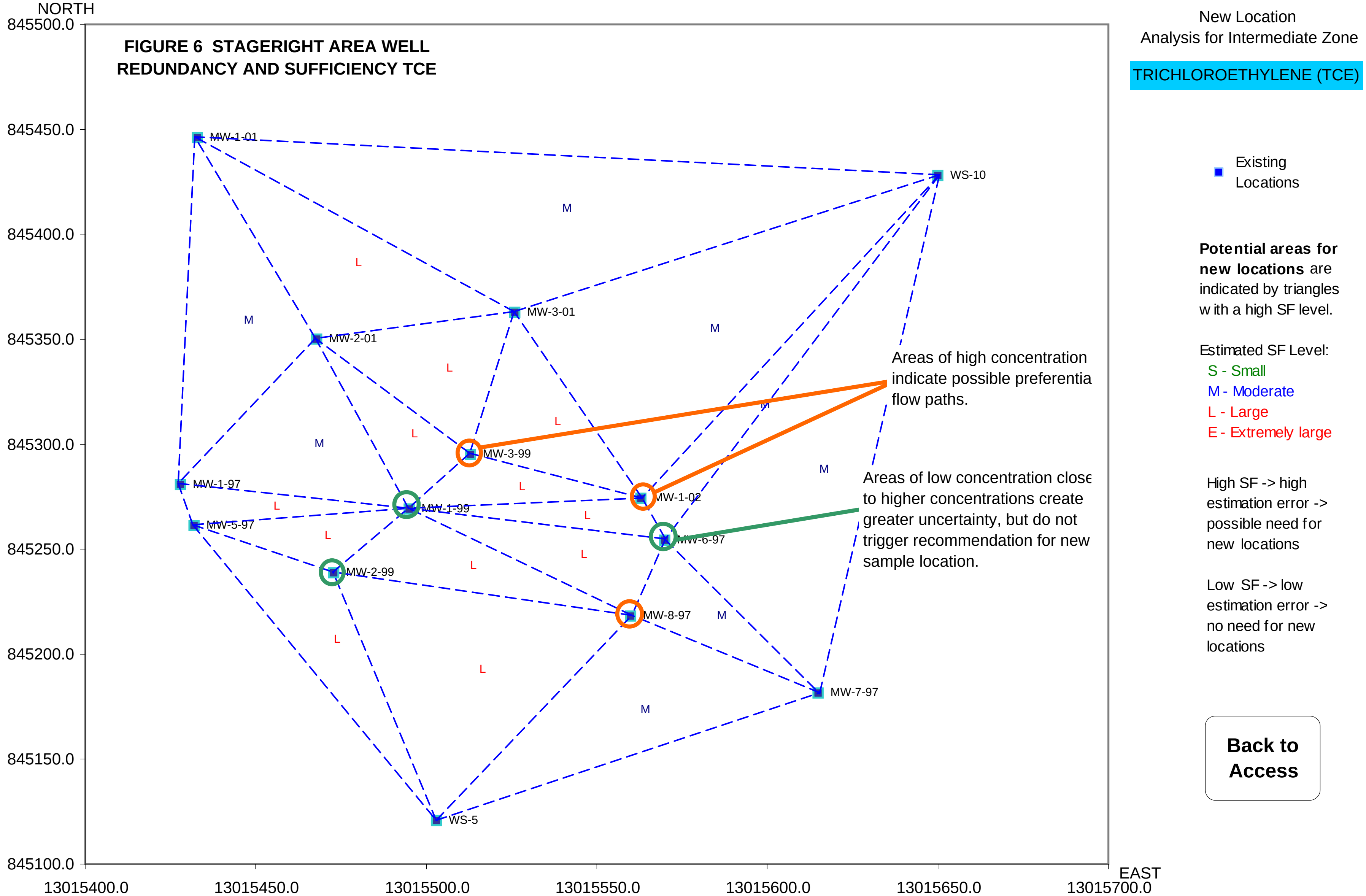
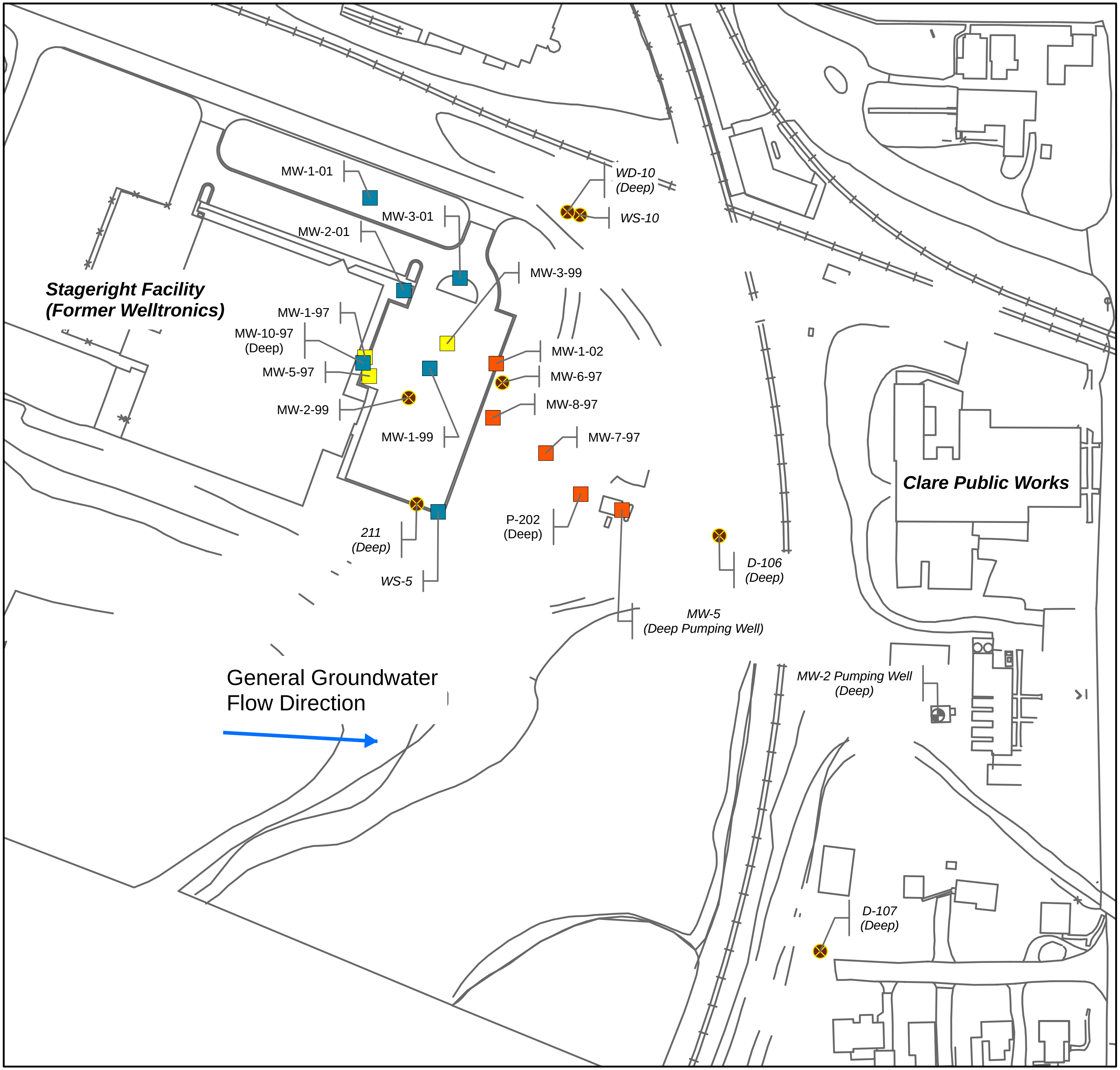


FIGURE 6 STAGERIGHT AREA WELL REDUNDANCY AND SUFFICIENCY TCE



Legend

Recommended Sample Frequency

- Monthly
- Semiannual
- Annual
- Exclude

Notes:
1. Sample locations and recommended frequencies based on combined qualitative and quantitative approach.
2. Wells screened in intermediate zone of aquifer except where indicated.
3. Monthly sampling triggered by high groundwater velocity in the area of MW-5.
4. Data source Progressive Environmental and Construction, August 2006.

Scale (ft)
0 70 140

GROUNDWATER SERVICES, INC.

FINAL RECOMMENDED MONITORING NETWORK STAGERIGHT AREA

Clare Water Supply
Clare, Michigan

GSI Job No.	G-3138-105	Drawn by:	MV
Issued:	03/22/2007	Chk'd by:	MV
Figure 7		Appv'd by:	MV

ATTACHMENT A

GROUNDWATER SEEPAGE VELOCITY CALCULATIONS
StageRight Area

$V = Ki/n_e$ where:

V = groundwater seepage velocity (ft/day)
K = hydraulic conductivity (ft/day)
i = hydraulic gradient (ft/ft)
n_e = effective porosity (unitless)

Zone	K (ft/day)	i (ft/ft)	n_e	V (ft/day)
intermediate	425	0.009	0.3	**13**
deep	425	0.013	0.3	**18**

Notes:
1. K based on average 0.15 cm/sec for MW-5 and MW-2 vicinities as obtained from Dames and Moore RI and transmitted by Progressive.
2. i for intermediate zone based on calculations using equipotential lines for May and Nov 05 on potentiometric surface maps provided by Progressive.
3. i for deep zone based on average of calculated gradients between WD-10 and P 202 for May and Nov 05 and calculated gradient between WD-5 and P-202 for May 05.
4. n_e is based on estimate for permeable, well-sorted sand or sand and gravel.

ATTACHMENT B
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. 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 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/software/MAROS_V2_1Manual.pdf) 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 with interpretive trend analysis based on temporal trend analysis and plume stability information; and 2) a more detailed statistical optimization based on spatial and temporal redundancy reduction 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 analysis assesses the general monitoring system category by considering individual well concentration trends, overall plume stability, hydrogeologic factors (e.g., seepage velocity, and current plume length), and the location of potential receptors (e.g., property boundaries or drinking water wells). The method relies on temporal trend analysis to assess plume stability, which is then used to determine the general monitoring system category. Since the monitoring system category is evaluated for both source and tail regions of the plume, the site wells are divided into two different zones: the source zone and the tail zone.

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. The source zone generally contains locations with historical high ground water concentrations of the COCs. The tail zone is usually the area downgradient of the contaminant source zone. 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 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 statistics level of analysis or sampling optimization consists of well redundancy and well sufficiency analyses using the Delaunay method, a sampling frequency analysis using the Modified Cost Effective Sampling (MCES) method and a data sufficiency analysis including statistical power analysis. The well redundancy analysis is designed to minimize monitoring locations and the Modified CES method is designed to minimize the frequency of sampling. 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 in terms of evaluating concentrations at downgradient locations.

2.0 Data Management

In MAROS, ground water 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 terminal analytical tool designed for long-term planning, 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 Site Details 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 identity of wells in the network.

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 exceedence of the screening level. The evaluation of prevalence is performed by determining a representative concentration for each well location and evaluating the total exceedences (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 have been measured irregularly in time or contain many non-detects, trace level results, and duplicates. 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 there are historical data analyses that support a conclusion about plume stability (e.g., increasing plume, etc.) through statistical trend analysis of historical monitoring data. 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. The two trend methods are used to estimate the concentration trend for each well and each COC based on a statistical trend analysis of concentrations versus time at each well. These trend analyses are then consolidated to give the user a general plume stability estimate and general monitoring frequency and density recommendations (see Figures A.1 through A.3 for further step-by-step details). Both qualitative and quantitative plume information can be gained by these evaluations 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. 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 or detailed statistics optimization analysis.

6.1 Mann-Kendall Analysis

The Mann-Kendall test is a statistical procedure that is well suited for analyzing trends in data over time. The Mann-Kendall test can be viewed as a non-parametric test for zero slope of the first-order regression of time-ordered concentration data versus time. One advantage of the Mann-Kendall test is that it does not require any assumptions as to the statistical distribution of the data (e.g. normal, lognormal, etc.) and can be used with data sets which 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 S statistic measures the trend in the data: positive values indicate an increase in concentrations over time and negative values indicate a decrease in concentrations over time. The strength of the trend is proportional to the magnitude of the Mann-Kendall statistic (i.e., a large value indicates a strong trend). The confidence in the trend is determined by consulting the S statistic and the sample size, n, in a Kendall probability table such as the one reported in Hollander and Wolfe (1973).

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 decision matrix for this evaluation is shown in Table 3. 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).

These trend estimates are then analyzed to identify the source and tail region overall stability category (see Figure 2 for further details).

6.2 Linear Regression Analysis

Linear Regression is a parametric statistical procedure that is typically used for analyzing trends in data over time. 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. The linear regression analysis is based on the first-order linear regression of the log-transformed concentration data versus time. The slope obtained from this log-transformed regression, the confidence level for this log-slope, and the COV of the untransformed data are used to determine the concentration trend. The decision matrix for this evaluation is shown in Table 4.

To estimate the confidence in the log-slope, the standard error of the log-slope is calculated. 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 Linear Regression Analysis is designed for analyzing a single groundwater constituent; multiple constituents are analyzed separately, (up to five COCs simultaneously). For this evaluation, a decision matrix developed by Groundwater Services, Inc. is also used to determine the “Concentration Trend” category (plume stability) for each well.

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).

The resulting confidence in the trend, together with the log-slope and the COV of the untransformed data, are used in the linear regression analysis decision matrix to determine the concentration trend. For example, a positive log-slope with a confidence of less than 90% is categorized as having No Trend whereas a negative log-slope is considered Stable if the COV is less than 1 and categorized as No Trend if the COV is greater than 1.

6.3 Overall Plume Analysis

General recommendations for the monitoring network frequency and density are suggested based on heuristic rules applied to the source and tail trend results. Individual well trend results are consolidated and weighted by the MAROS 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. Based on

- **i)** the consolidated trend analysis,
- **ii)** hydrogeologic factors (e.g., seepage velocity), and
- **iii)** location of potential receptors (e.g., wells, discharge points, or property boundaries),

the software suggests a general optimization plan for the current monitoring system in order to efficiently but effectively monitor groundwater in the future. A flow chart utilizing the trend analysis results and other site-specific parameters to form a general sampling frequency and well density recommendation is outlined 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 generic 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).

6.4 Moment Analysis

An analysis of moments can help resolve plume trends, where the zeroth moment shows change in dissolved mass vs. time, the first moment shows the center of mass location vs. time, and the second moment shows the spread of the plume vs. time. Moment calculations can predict how the plume will change in the future if further statistical analysis is applied to the moments to identify a trend (in this case, Mann Kendall Trend Analysis is applied). The trend analysis of moments can be summarized as:

- Zeroth Moment: An estimate of the total mass of the constituent 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

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 for complex well networks. 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.

Plume stability may vary by constituent, therefore the MAROS Moment analysis can be used to evaluate multiple COCs simultaneously which can be used to provide a quick way of comparing individual plume parameters to determine the size and movement of constituents relative to one another. Moment analysis in the MAROS software can also be used to assist the user in evaluating the impact on plume delineation in future sampling events by removing identified “redundant” wells from a long-term monitoring program (this analysis was not performed as part of this study, for more details on this application of moment analysis refer to the MAROS Users Manual (AFCEE, 2003)).

The **zeroth moment** is the sum of concentrations for all monitoring wells and is a mass estimate. The zeroth moment calculation can show high variability over time, largely due to the fluctuating concentrations at the most contaminated wells as well as varying monitoring well network. Plume analysis and delineation based exclusively on concentration can exhibit fluctuating temporal and spatial values. The mass estimate is also sensitive to the extent of the site monitoring well network over time. The zeroth moment trend over time is determined by using the Mann-Kendall Trend Methodology. The zeroth Moment trend test allows the user to understand how the plume mass has changed over time. Results for the trend include: Increasing, probably Increasing, no trend, stable, probably decreasing, decreasing or not applicable (N/A) (Insufficient Data). When considering the results of the zeroth moment trend, the following factors should be considered which 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 well within the network). 3) Adequate versus inadequate delineation of the plume over time

The **first moment** estimates the center of mass, coordinates (Xc and Yc) for each sample event and COC. The changing center of mass locations indicate the movement of the center of mass over time. Whereas, the distance from the original source location to the center of mass locations indicate the movement of the center of mass over time relative to the original source. Calculation of the first moment normalizes the spread by the concentration indicating the center of mass. The first moment trend of the distance to the center of mass over time shows movement of the plume in relation to the original source location over time. Analysis of the movement of mass should be viewed as it relates to 1) the original source location of contamination 2) the direction of groundwater flow and/or 3) source removal or remediation. Spatial and temporal trends in the center of mass can indicate spreading or shrinking or transient movement based on season variation in rainfall or other hydraulic considerations. No appreciable movement or a neutral 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. The Second Moment represents the spread of the plume over time in both the x and y directions. The Second Moment trend indicates the spread of the plume about the center of mass. Analysis of the spread of the plume should be viewed as it relates to the direction of groundwater flow. An Increasing trend in the second moment indicates an expanding plume, whereas a declining trend in the second moment indicates a shrinking plume. No appreciable movement or a neutral trend in the center of mass would indicate plume stability. The second moment provides a measure of the spread of the concentration distribution about the plume's center of mass. However, changes in the second 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 Second Moment trend should be compared to the zeroth moment trend (mass change over time).

7.0 Detailed Statistics: Optimization Analysis

Although the overall plume analysis shows a general recommendation regarding sampling frequency reduction and a general sampling density, a more detailed analysis is also available with the MAROS 2.2 software in order to allow for further reductions on a well-by-well basis for frequency, well redundancy, well sufficiency and sampling sufficiency. The MAROS Detailed Statistics allows for a quantitative analysis for spatial and temporal optimization of the well network on a well-by-well basis. The results from the Overview Statistics should be considered along with the MAROS optimization recommendations gained from the Detailed Statistical Analysis described previously. The MAROS Detailed Statistics results should be reassessed in view of site knowledge and regulatory requirements as well as in consideration of the Overview Statistics (Figure 2).

The Detailed Statistics or Sampling Optimization MAROS modules can be used to determine the minimal number of sampling locations and the lowest frequency of sampling that can still meet the requirements of sampling spatially and temporally for an existing monitoring program. It also provides an analysis of the sufficiency of data for the monitoring program.

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 CES 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 a contaminant plume. An extended method or wells sufficiency analysis, based on the Delaunay method, can also be used for recommending new sampling locations. Details about the Delaunay method can be found in Appendix A.2 of the MAROS Manual (AFCEE, 2003).

Sampling Location determination uses the Delaunay triangulation method to determine the significance of the current sampling locations relative to the overall monitoring network. The Delaunay method calculates the network Area and Average concentration of the plume using data from multiple monitoring wells. A slope factor (SF) is calculated for each well to indicate the significance of this well in the system (i.e. how removing a well changes the average concentration.)

The Sampling Location optimization process is performed in a stepwise fashion. Step one involves assessing the significance of the well in the system, if a well has a small SF (little significance to the network), the well may be removed from the monitoring network. Step two involves evaluating the information loss of removing a well from the network. If one well has a small SF, it may or may not be eliminated depending on whether the information loss 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 plume characterization. If the MAROS algorithm calculates a high level of uncertainty in predicting the constituent concentration for a particular area, a new sampling location is recommended. The Slope Factor (SF) values obtained from the redundancy evaluation described above are used to calculate the concentration estimation error for each triangle area formed in the Delaunay triangulation. The estimated SF value for each area is then classified into four levels: Small, Moderate, Large, or Extremely large (S, M, L, E) because the larger the estimated SF value, the higher the estimation error at this area. 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 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.

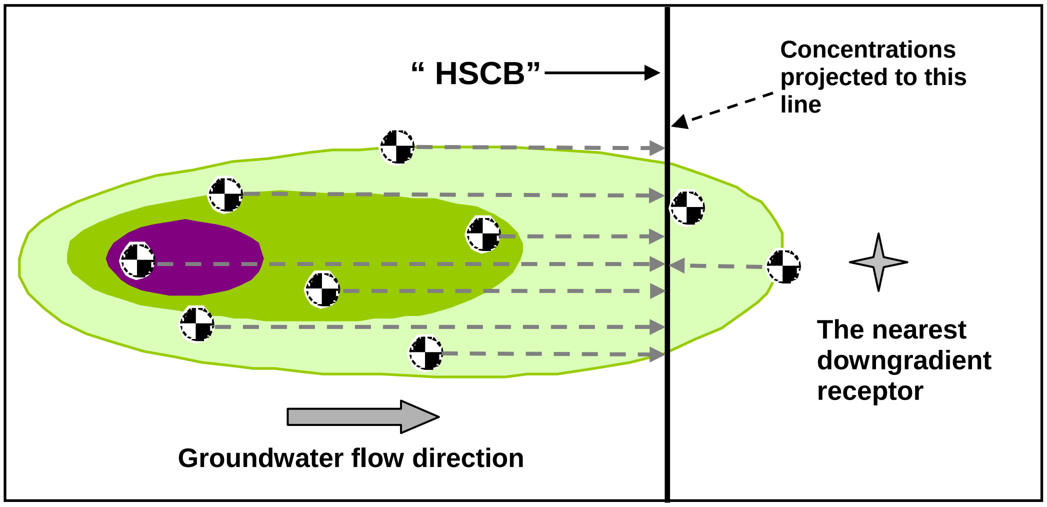
7.4 Data Sufficiency Analysis – Power Analysis

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.

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TABLE 1 **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 ≥ 1	No Trend
$S \leq 0$	< 90% and COV < 1	Stable
$S < 0$	90 - 95%	Probably Decreasing
$S < 0$	> 95%	Decreasing

TABLE 2 **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

GROUNDWATER SERVICES, INC.

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

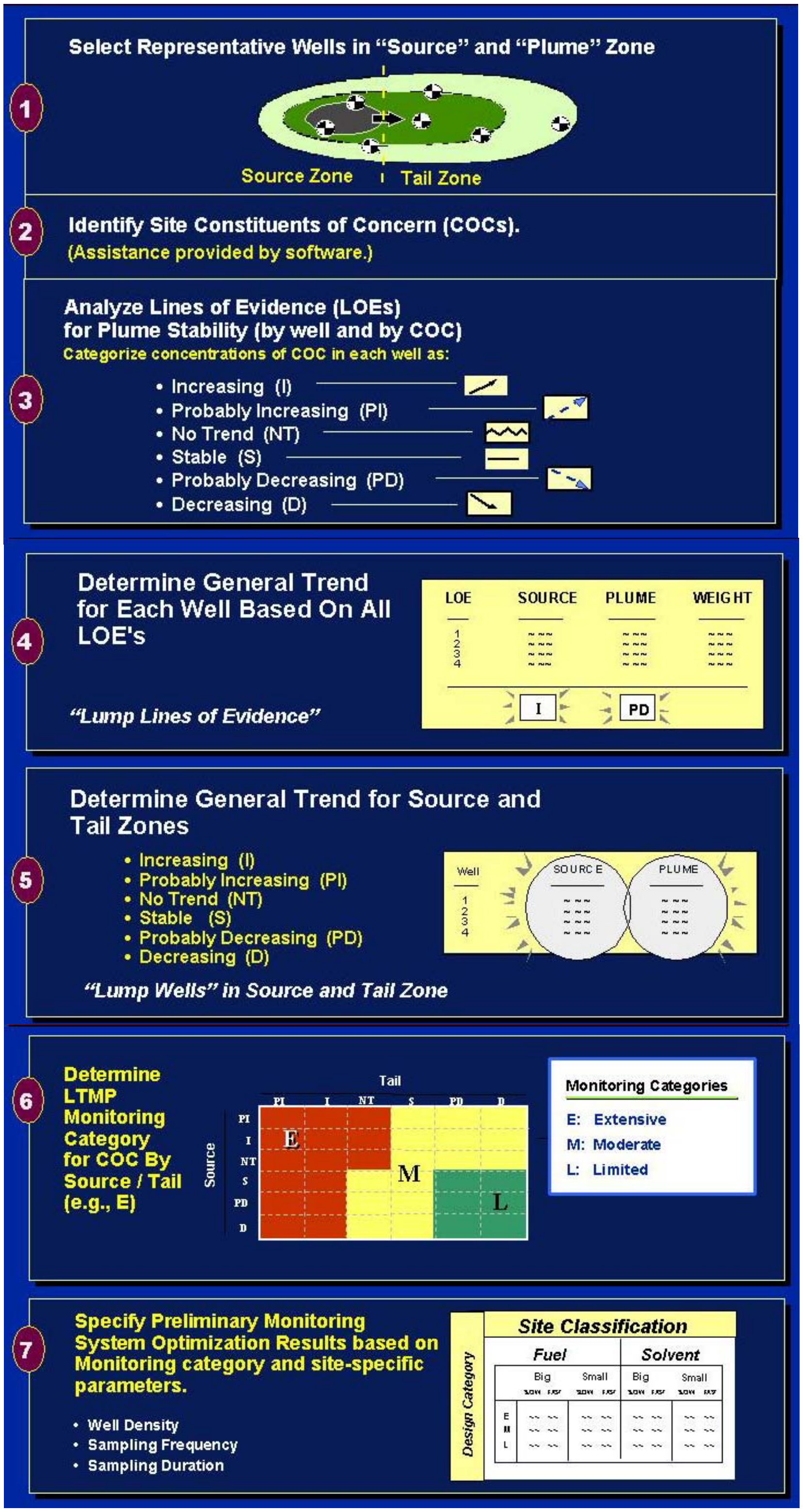


Figure 2:
MAROS Overview Statistics Trend Analysis Methodology

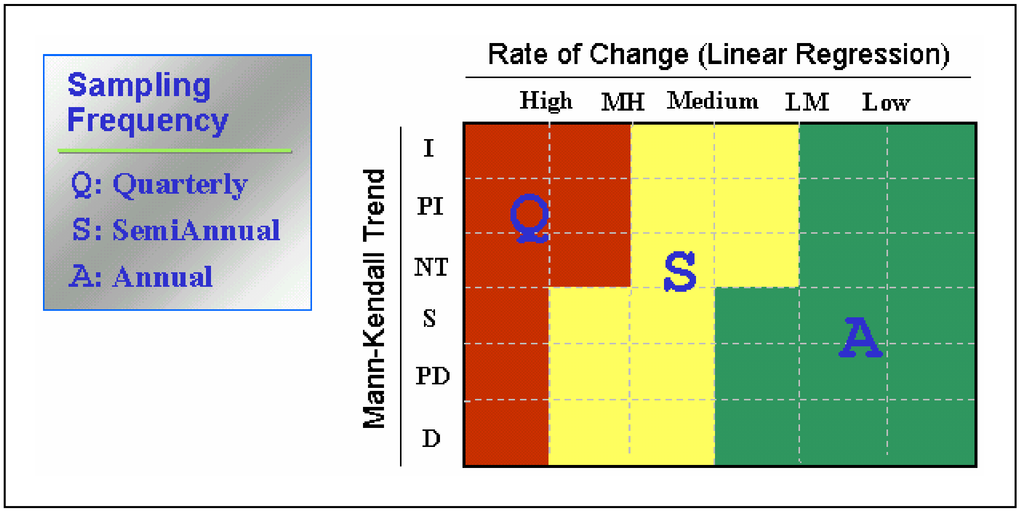


Figure 3. Decision Matrix for Determining Provisional Frequency (*Figure A.3.1 of the MAROS Manual (AFCEE 2003*)

March 22, 2007

LONG-TERM
MONITORING NETWORK OPTIMIZATION
STAGERIGHT AREA

Clare Water Supply Superfund Site
Clare, Michigan

ATTACHMENT C:

MAROS Reports

StageRight Area

COC Assessment Report

Mann-Kendall Reports Selected Wells

Zeroth Moment Report (Estimate of Total Dissolved Mass in Plume)

MAROS COC Assessment

Project: Clare Water Supply **User Name:** MV

Location: Stageright **State:** Michigan

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
TRICHLOROETHYLENE (TCE)	2.1E-01	5.0E-03	4078.5%
TETRACHLOROETHYLENE(PCE)	2.3E-02	5.0E-03	355.2%

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 excedence from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Excedences	Percent Excedences	Total detects
TRICHLOROETHYLENE (TCE)	ORG	14	9	64.3%	13
TETRACHLOROETHYLENE(PCE)	ORG	4	2	50.0%	2

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total excedences (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
TRICHLOROETHYLENE (TCE)	0.297
TETRACHLOROETHYLENE(PCE)	0.923

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).

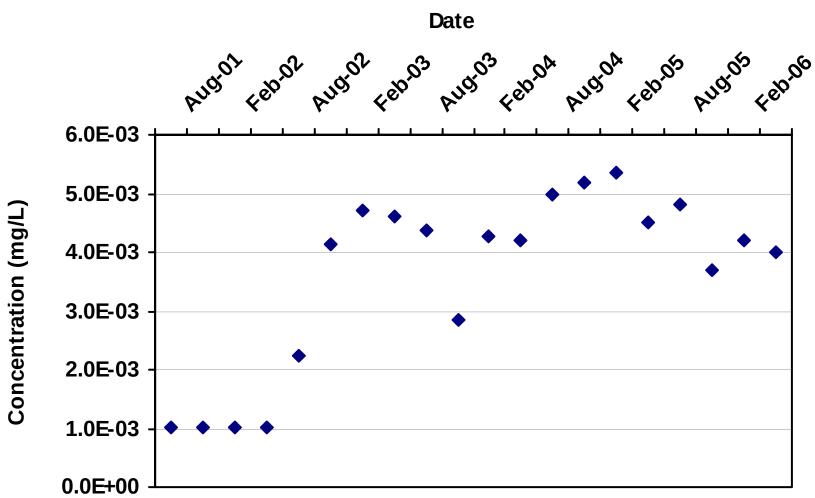
Contaminants of Concern (COC's)

TRICHLOROETHYLENE (TCE)

MAROS Mann-Kendall Statistics Summary

Well: MW-1-01
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 75

Confidence in Trend: 99.3%

Coefficient of Variation: 0.42

Mann Kendall Concentration Trend: (See Note) I

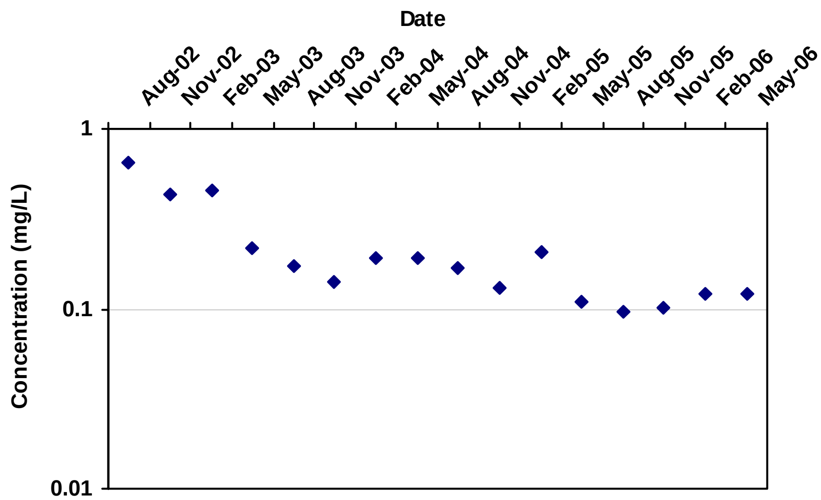
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-1-01	T	8/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-1-01	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-1-01	T	2/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-1-01	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-1-01	T	8/15/2002	TRICHLOROETHYLENE (TCE)	2.2E-03		2	2
MW-1-01	T	11/15/2002	TRICHLOROETHYLENE (TCE)	4.1E-03		1	1
MW-1-01	T	2/15/2003	TRICHLOROETHYLENE (TCE)	4.7E-03		3	3
MW-1-01	T	5/15/2003	TRICHLOROETHYLENE (TCE)	4.6E-03		2	2
MW-1-01	T	8/15/2003	TRICHLOROETHYLENE (TCE)	4.4E-03		2	2
MW-1-01	T	11/15/2003	TRICHLOROETHYLENE (TCE)	2.8E-03		1	1
MW-1-01	T	2/15/2004	TRICHLOROETHYLENE (TCE)	4.3E-03		1	1
MW-1-01	T	5/15/2004	TRICHLOROETHYLENE (TCE)	4.2E-03		3	2
MW-1-01	T	8/15/2004	TRICHLOROETHYLENE (TCE)	5.0E-03		1	1
MW-1-01	T	11/15/2004	TRICHLOROETHYLENE (TCE)	5.2E-03		3	3
MW-1-01	T	2/15/2005	TRICHLOROETHYLENE (TCE)	5.4E-03		2	2
MW-1-01	T	5/15/2005	TRICHLOROETHYLENE (TCE)	4.5E-03		3	3
MW-1-01	T	8/15/2005	TRICHLOROETHYLENE (TCE)	4.8E-03		3	3
MW-1-01	T	11/15/2005	TRICHLOROETHYLENE (TCE)	3.7E-03		3	3
MW-1-01	T	2/15/2006	TRICHLOROETHYLENE (TCE)	4.2E-03		3	3
MW-1-01	T	5/15/2006	TRICHLOROETHYLENE (TCE)	4.0E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-1-02
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -79

Confidence in Trend: 100.0%

Coefficient of Variation: 0.72

Mann Kendall Concentration Trend: (See Note) D

Data Table:

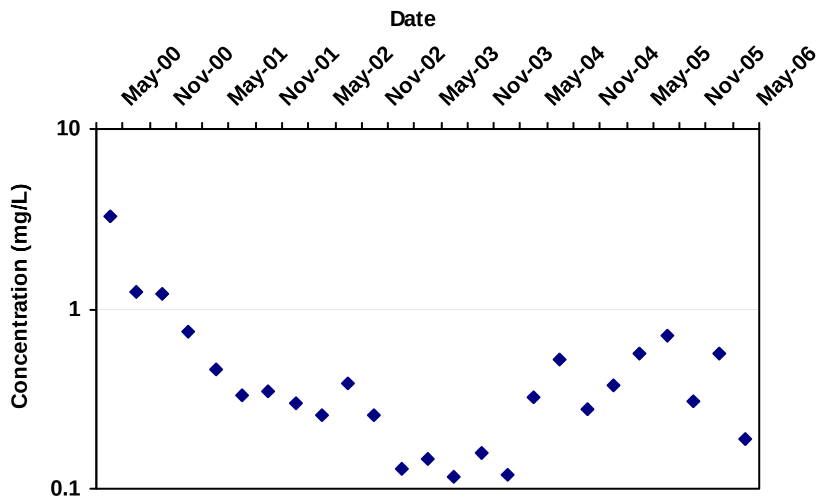
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-1-02	T	8/15/2002	TRICHLOROETHYLENE (TCE)	6.6E-01		2	2
MW-1-02	T	11/15/2002	TRICHLOROETHYLENE (TCE)	4.3E-01		1	1
MW-1-02	T	2/15/2003	TRICHLOROETHYLENE (TCE)	4.5E-01		3	3
MW-1-02	T	5/15/2003	TRICHLOROETHYLENE (TCE)	2.2E-01		2	2
MW-1-02	T	8/15/2003	TRICHLOROETHYLENE (TCE)	1.7E-01		2	2
MW-1-02	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.4E-01		1	1
MW-1-02	T	2/15/2004	TRICHLOROETHYLENE (TCE)	1.9E-01		1	1
MW-1-02	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.9E-01		3	3
MW-1-02	T	8/15/2004	TRICHLOROETHYLENE (TCE)	1.7E-01		1	1
MW-1-02	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.3E-01		3	3
MW-1-02	T	2/15/2005	TRICHLOROETHYLENE (TCE)	2.1E-01		2	2
MW-1-02	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.1E-01		3	3
MW-1-02	T	8/15/2005	TRICHLOROETHYLENE (TCE)	9.6E-02		3	3
MW-1-02	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-01		3	3
MW-1-02	T	2/15/2006	TRICHLOROETHYLENE (TCE)	1.2E-01		3	3
MW-1-02	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.2E-01		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-1-97
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:
-71

Confidence in Trend:
94.9%

Coefficient of Variation:
1.21

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-1-97	S	5/15/2000	TRICHLOROETHYLENE (TCE)	3.3E+00		1	1
MW-1-97	S	8/15/2000	TRICHLOROETHYLENE (TCE)	1.3E+00		3	3
MW-1-97	S	11/15/2000	TRICHLOROETHYLENE (TCE)	1.2E+00		2	2
MW-1-97	S	2/15/2001	TRICHLOROETHYLENE (TCE)	7.5E-01		1	1
MW-1-97	S	5/15/2001	TRICHLOROETHYLENE (TCE)	4.7E-01		1	1
MW-1-97	S	8/15/2001	TRICHLOROETHYLENE (TCE)	3.3E-01		2	2
MW-1-97	S	11/15/2001	TRICHLOROETHYLENE (TCE)	3.5E-01		1	1
MW-1-97	S	2/15/2002	TRICHLOROETHYLENE (TCE)	3.0E-01		1	1
MW-1-97	S	5/15/2002	TRICHLOROETHYLENE (TCE)	2.5E-01		1	1
MW-1-97	S	8/15/2002	TRICHLOROETHYLENE (TCE)	3.8E-01		2	2
MW-1-97	S	11/15/2002	TRICHLOROETHYLENE (TCE)	2.5E-01		1	1
MW-1-97	S	2/15/2003	TRICHLOROETHYLENE (TCE)	1.3E-01		3	3
MW-1-97	S	5/15/2003	TRICHLOROETHYLENE (TCE)	1.5E-01		2	2
MW-1-97	S	8/15/2003	TRICHLOROETHYLENE (TCE)	1.2E-01		2	2
MW-1-97	S	11/15/2003	TRICHLOROETHYLENE (TCE)	1.6E-01		1	1
MW-1-97	S	2/15/2004	TRICHLOROETHYLENE (TCE)	1.2E-01		1	1
MW-1-97	S	5/15/2004	TRICHLOROETHYLENE (TCE)	3.2E-01		3	3
MW-1-97	S	8/15/2004	TRICHLOROETHYLENE (TCE)	5.3E-01		1	1
MW-1-97	S	11/15/2004	TRICHLOROETHYLENE (TCE)	2.8E-01		3	3
MW-1-97	S	2/15/2005	TRICHLOROETHYLENE (TCE)	3.8E-01		2	2
MW-1-97	S	5/15/2005	TRICHLOROETHYLENE (TCE)	5.7E-01		3	3
MW-1-97	S	8/15/2005	TRICHLOROETHYLENE (TCE)	7.1E-01		3	3

MAROS Mann-Kendall Statistics Summary

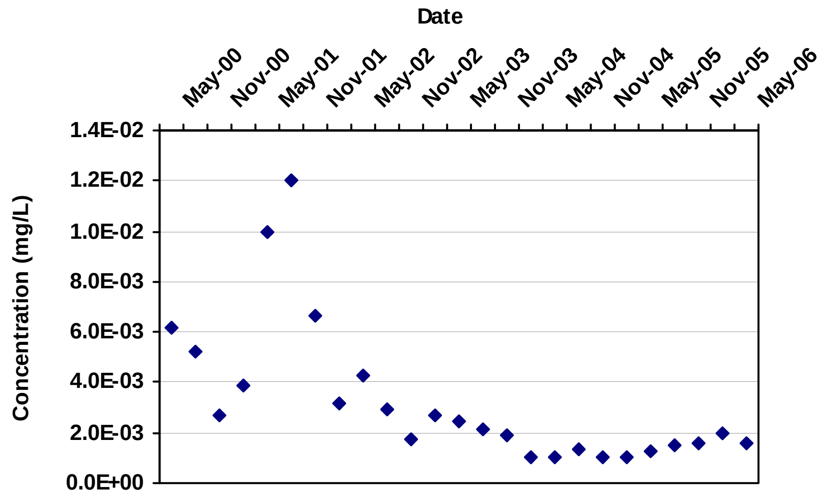
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-1-97	S	11/15/2005	TRICHLOROETHYLENE (TCE)	3.1E-01		3	3
MW-1-97	S	2/15/2006	TRICHLOROETHYLENE (TCE)	5.6E-01		3	3
MW-1-97	S	5/15/2006	TRICHLOROETHYLENE (TCE)	1.9E-01		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-1-99
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -173

Confidence in Trend: 100.0%

Coefficient of Variation: 0.87

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-1-99	T	5/15/2000	TRICHLOROETHYLENE (TCE)	6.2E-03		1	1
MW-1-99	T	8/15/2000	TRICHLOROETHYLENE (TCE)	5.3E-03		3	3
MW-1-99	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.7E-03		2	2
MW-1-99	T	2/15/2001	TRICHLOROETHYLENE (TCE)	3.9E-03		3	2
MW-1-99	T	5/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-02		2	2
MW-1-99	T	8/15/2001	TRICHLOROETHYLENE (TCE)	1.2E-02		2	2
MW-1-99	T	11/15/2001	TRICHLOROETHYLENE (TCE)	6.6E-03		1	1
MW-1-99	T	2/15/2002	TRICHLOROETHYLENE (TCE)	3.2E-03		1	1
MW-1-99	T	5/15/2002	TRICHLOROETHYLENE (TCE)	4.2E-03		1	1
MW-1-99	T	8/15/2002	TRICHLOROETHYLENE (TCE)	2.9E-03		2	2
MW-1-99	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.7E-03		1	1
MW-1-99	T	2/15/2003	TRICHLOROETHYLENE (TCE)	2.7E-03		3	3
MW-1-99	T	5/15/2003	TRICHLOROETHYLENE (TCE)	2.4E-03		2	2
MW-1-99	T	8/15/2003	TRICHLOROETHYLENE (TCE)	2.2E-03		2	2
MW-1-99	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.9E-03		1	1
MW-1-99	T	2/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-1-99	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-1-99	T	8/15/2004	TRICHLOROETHYLENE (TCE)	1.4E-03		1	1
MW-1-99	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03		3	1
MW-1-99	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-1-99	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.3E-03		3	3
MW-1-99	T	8/15/2005	TRICHLOROETHYLENE (TCE)	1.5E-03		3	3

MAROS Mann-Kendall Statistics Summary

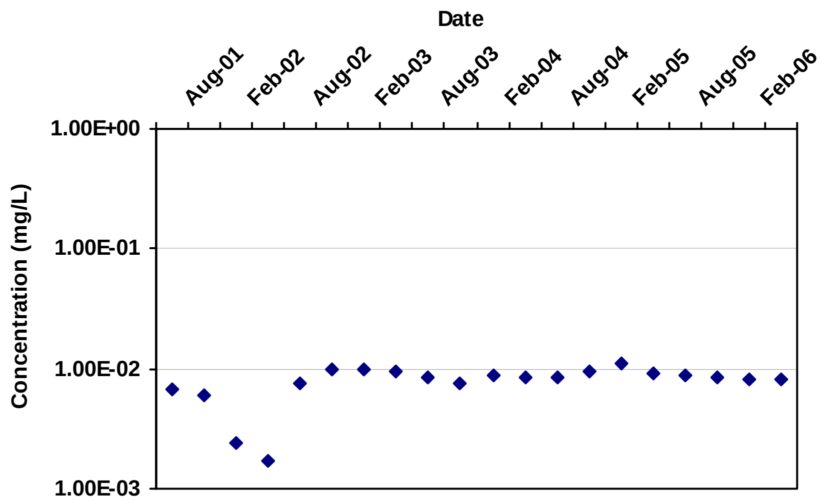
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-1-99	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.6E-03		3	2
MW-1-99	T	2/15/2006	TRICHLOROETHYLENE (TCE)	2.0E-03		3	3
MW-1-99	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.6E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-2-01
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 37

Confidence in Trend: 87.7%

Coefficient of Variation: 0.29

Mann Kendall Concentration Trend: (See Note) NT

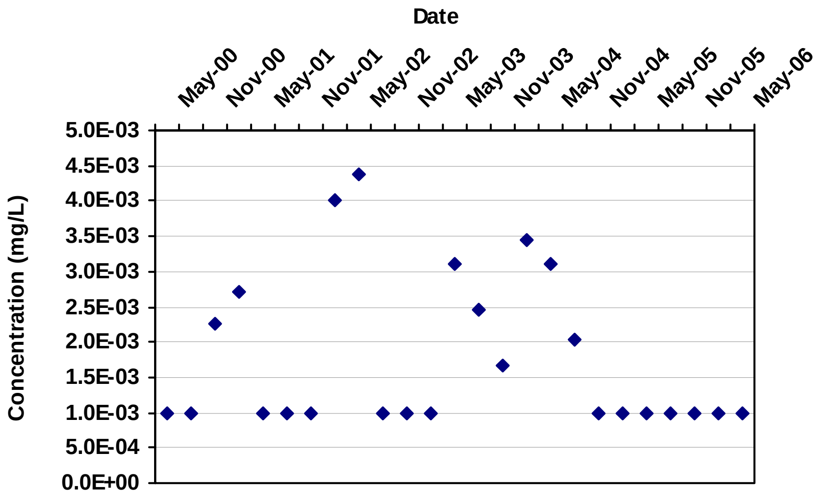
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-2-01	T	8/15/2001	TRICHLOROETHYLENE (TCE)	6.6E-03		2	2
MW-2-01	T	11/15/2001	TRICHLOROETHYLENE (TCE)	5.9E-03		1	1
MW-2-01	T	2/15/2002	TRICHLOROETHYLENE (TCE)	2.4E-03		1	1
MW-2-01	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.7E-03		1	1
MW-2-01	T	8/15/2002	TRICHLOROETHYLENE (TCE)	7.7E-03		2	2
MW-2-01	T	11/15/2002	TRICHLOROETHYLENE (TCE)	9.8E-03		1	1
MW-2-01	T	2/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-02		3	3
MW-2-01	T	5/15/2003	TRICHLOROETHYLENE (TCE)	9.4E-03		2	2
MW-2-01	T	8/15/2003	TRICHLOROETHYLENE (TCE)	8.5E-03		2	2
MW-2-01	T	11/15/2003	TRICHLOROETHYLENE (TCE)	7.5E-03		1	1
MW-2-01	T	2/15/2004	TRICHLOROETHYLENE (TCE)	8.8E-03		1	1
MW-2-01	T	5/15/2004	TRICHLOROETHYLENE (TCE)	8.5E-03		3	3
MW-2-01	T	8/15/2004	TRICHLOROETHYLENE (TCE)	8.6E-03		1	1
MW-2-01	T	11/15/2004	TRICHLOROETHYLENE (TCE)	9.5E-03		3	3
MW-2-01	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.1E-02		2	2
MW-2-01	T	5/15/2005	TRICHLOROETHYLENE (TCE)	9.0E-03		3	3
MW-2-01	T	8/15/2005	TRICHLOROETHYLENE (TCE)	8.7E-03		3	3
MW-2-01	T	11/15/2005	TRICHLOROETHYLENE (TCE)	8.5E-03		3	3
MW-2-01	T	2/15/2006	TRICHLOROETHYLENE (TCE)	8.2E-03		3	3
MW-2-01	T	5/15/2006	TRICHLOROETHYLENE (TCE)	8.3E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well: MW-2-99
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -32

Confidence in Trend: 76.3%

Coefficient of Variation: 0.62

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-2-99	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-2-99	T	8/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.3E-03		2	1
MW-2-99	T	2/15/2001	TRICHLOROETHYLENE (TCE)	2.7E-03		3	2
MW-2-99	T	5/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-2-99	T	8/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-2-99	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-2-99	T	2/15/2002	TRICHLOROETHYLENE (TCE)	4.0E-03		1	1
MW-2-99	T	5/15/2002	TRICHLOROETHYLENE (TCE)	4.4E-03		1	1
MW-2-99	T	8/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-2-99	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-2-99	T	2/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	5/15/2003	TRICHLOROETHYLENE (TCE)	3.1E-03		2	2
MW-2-99	T	8/15/2003	TRICHLOROETHYLENE (TCE)	2.5E-03		2	2
MW-2-99	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.7E-03		1	1
MW-2-99	T	2/15/2004	TRICHLOROETHYLENE (TCE)	3.4E-03		1	1
MW-2-99	T	5/15/2004	TRICHLOROETHYLENE (TCE)	3.1E-03		3	3
MW-2-99	T	8/15/2004	TRICHLOROETHYLENE (TCE)	2.0E-03		1	1
MW-2-99	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-2-99	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	8/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0

MAROS Mann-Kendall Statistics Summary

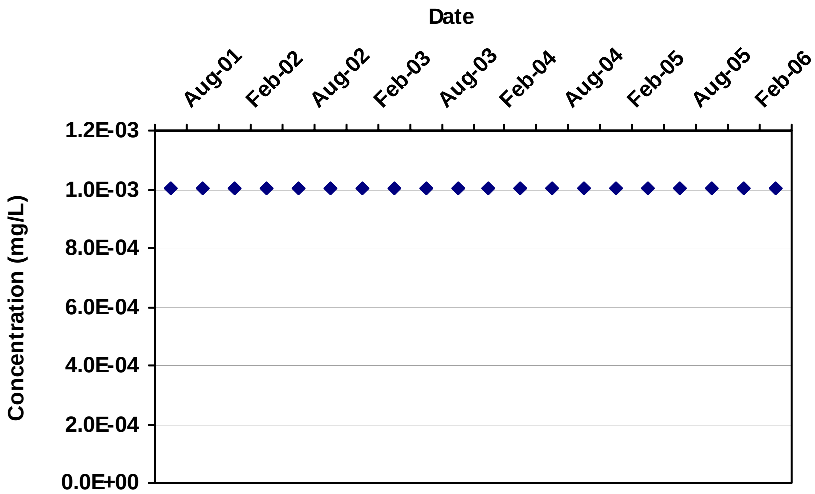
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-2-99	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	2/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-2-99	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

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

MAROS Mann-Kendall Statistics Summary

Well: MW-3-01
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 0

Confidence in Trend: 48.7%

Coefficient of Variation: 0.00

Mann Kendall Concentration Trend: (See Note) S

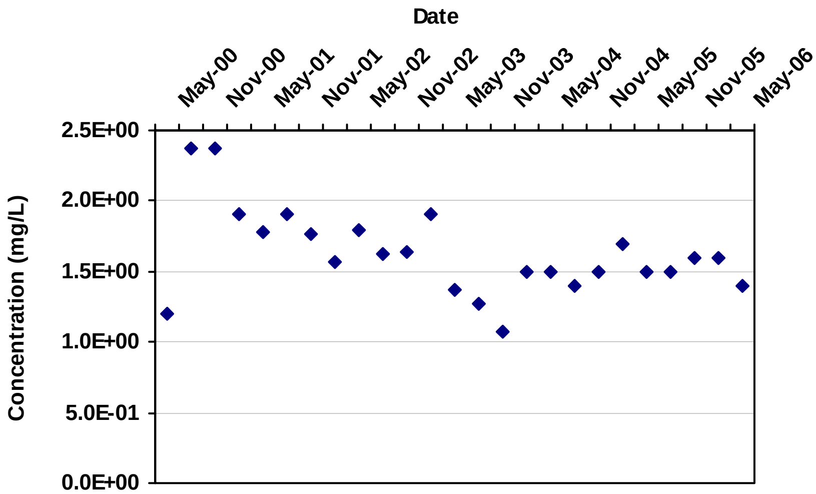
Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-3-01	T	8/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-3-01	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	2/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	8/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-3-01	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	2/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-3-01	T	8/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-3-01	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	2/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	8/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-3-01	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	2	0
MW-3-01	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	8/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	2/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-3-01	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

MAROS Mann-Kendall Statistics Summary

Well: MW-3-99
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -101

Confidence in Trend: 99.1%

Coefficient of Variation: 0.19

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-3-99	S	5/15/2000	TRICHLOROETHYLENE (TCE)	1.2E+00		1	1
MW-3-99	S	8/15/2000	TRICHLOROETHYLENE (TCE)	2.4E+00		3	3
MW-3-99	S	11/15/2000	TRICHLOROETHYLENE (TCE)	2.4E+00		2	2
MW-3-99	S	2/15/2001	TRICHLOROETHYLENE (TCE)	1.9E+00		1	1
MW-3-99	S	5/15/2001	TRICHLOROETHYLENE (TCE)	1.8E+00		1	1
MW-3-99	S	8/15/2001	TRICHLOROETHYLENE (TCE)	1.9E+00		2	2
MW-3-99	S	11/15/2001	TRICHLOROETHYLENE (TCE)	1.8E+00		1	1
MW-3-99	S	2/15/2002	TRICHLOROETHYLENE (TCE)	1.6E+00		1	1
MW-3-99	S	5/15/2002	TRICHLOROETHYLENE (TCE)	1.8E+00		1	1
MW-3-99	S	8/15/2002	TRICHLOROETHYLENE (TCE)	1.6E+00		2	2
MW-3-99	S	11/15/2002	TRICHLOROETHYLENE (TCE)	1.6E+00		1	1
MW-3-99	S	2/15/2003	TRICHLOROETHYLENE (TCE)	1.9E+00		3	3
MW-3-99	S	5/15/2003	TRICHLOROETHYLENE (TCE)	1.4E+00		2	2
MW-3-99	S	8/15/2003	TRICHLOROETHYLENE (TCE)	1.3E+00		2	2
MW-3-99	S	11/15/2003	TRICHLOROETHYLENE (TCE)	1.1E+00		1	1
MW-3-99	S	2/15/2004	TRICHLOROETHYLENE (TCE)	1.5E+00		1	1
MW-3-99	S	5/15/2004	TRICHLOROETHYLENE (TCE)	1.5E+00		3	3
MW-3-99	S	8/15/2004	TRICHLOROETHYLENE (TCE)	1.4E+00		1	1
MW-3-99	S	11/15/2004	TRICHLOROETHYLENE (TCE)	1.5E+00		3	3
MW-3-99	S	2/15/2005	TRICHLOROETHYLENE (TCE)	1.7E+00		2	2
MW-3-99	S	5/15/2005	TRICHLOROETHYLENE (TCE)	1.5E+00		3	3
MW-3-99	S	8/15/2005	TRICHLOROETHYLENE (TCE)	1.5E+00		3	3

MAROS Mann-Kendall Statistics Summary

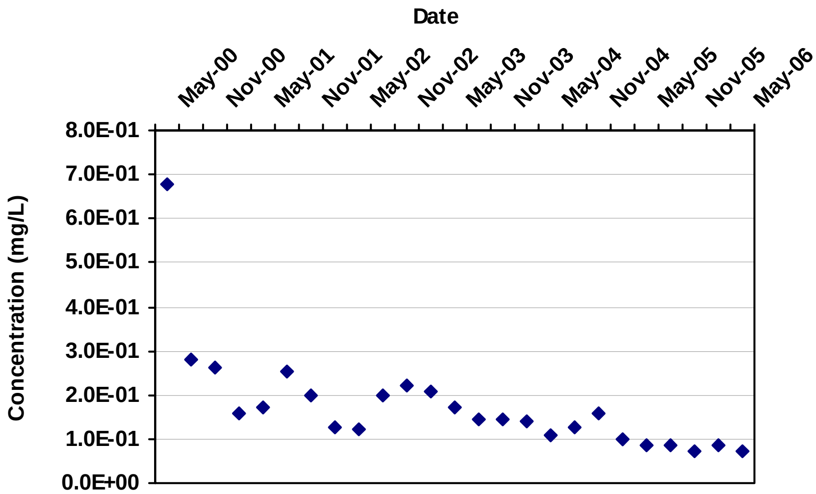
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-3-99	S	11/15/2005	TRICHLOROETHYLENE (TCE)	1.6E+00		3	3
MW-3-99	S	2/15/2006	TRICHLOROETHYLENE (TCE)	1.6E+00		3	3
MW-3-99	S	5/15/2006	TRICHLOROETHYLENE (TCE)	1.4E+00		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-5-97
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -212

Confidence in Trend: 100.0%

Coefficient of Variation: 0.69

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-5-97	S	5/15/2000	TRICHLOROETHYLENE (TCE)	6.8E-01		1	1
MW-5-97	S	8/15/2000	TRICHLOROETHYLENE (TCE)	2.8E-01		3	3
MW-5-97	S	11/15/2000	TRICHLOROETHYLENE (TCE)	2.6E-01		2	2
MW-5-97	S	2/15/2001	TRICHLOROETHYLENE (TCE)	1.6E-01		3	3
MW-5-97	S	5/15/2001	TRICHLOROETHYLENE (TCE)	1.7E-01		2	2
MW-5-97	S	8/15/2001	TRICHLOROETHYLENE (TCE)	2.5E-01		2	2
MW-5-97	S	11/15/2001	TRICHLOROETHYLENE (TCE)	2.0E-01		1	1
MW-5-97	S	2/15/2002	TRICHLOROETHYLENE (TCE)	1.3E-01		1	1
MW-5-97	S	5/15/2002	TRICHLOROETHYLENE (TCE)	1.2E-01		1	1
MW-5-97	S	8/15/2002	TRICHLOROETHYLENE (TCE)	2.0E-01		2	2
MW-5-97	S	11/15/2002	TRICHLOROETHYLENE (TCE)	2.2E-01		1	1
MW-5-97	S	2/15/2003	TRICHLOROETHYLENE (TCE)	2.1E-01		3	3
MW-5-97	S	5/15/2003	TRICHLOROETHYLENE (TCE)	1.7E-01		2	2
MW-5-97	S	8/15/2003	TRICHLOROETHYLENE (TCE)	1.4E-01		2	2
MW-5-97	S	11/15/2003	TRICHLOROETHYLENE (TCE)	1.5E-01		1	1
MW-5-97	S	2/15/2004	TRICHLOROETHYLENE (TCE)	1.4E-01		1	1
MW-5-97	S	5/15/2004	TRICHLOROETHYLENE (TCE)	1.1E-01		3	3
MW-5-97	S	8/15/2004	TRICHLOROETHYLENE (TCE)	1.3E-01		1	1
MW-5-97	S	11/15/2004	TRICHLOROETHYLENE (TCE)	1.6E-01		3	3
MW-5-97	S	2/15/2005	TRICHLOROETHYLENE (TCE)	9.9E-02		2	2
MW-5-97	S	5/15/2005	TRICHLOROETHYLENE (TCE)	8.4E-02		3	3
MW-5-97	S	8/15/2005	TRICHLOROETHYLENE (TCE)	8.6E-02		3	3

MAROS Mann-Kendall Statistics Summary

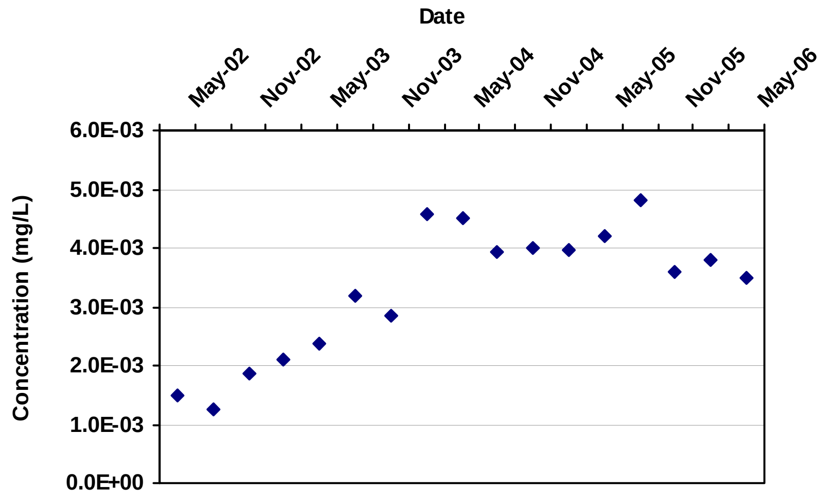
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-5-97	S	11/15/2005	TRICHLOROETHYLENE (TCE)	7.4E-02		3	3
MW-5-97	S	2/15/2006	TRICHLOROETHYLENE (TCE)	8.4E-02		3	3
MW-5-97	S	5/15/2006	TRICHLOROETHYLENE (TCE)	7.1E-02		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-6-97
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 66

Confidence in Trend: 99.7%

Coefficient of Variation: 0.34

Mann Kendall Concentration Trend: (See Note) I

Data Table:

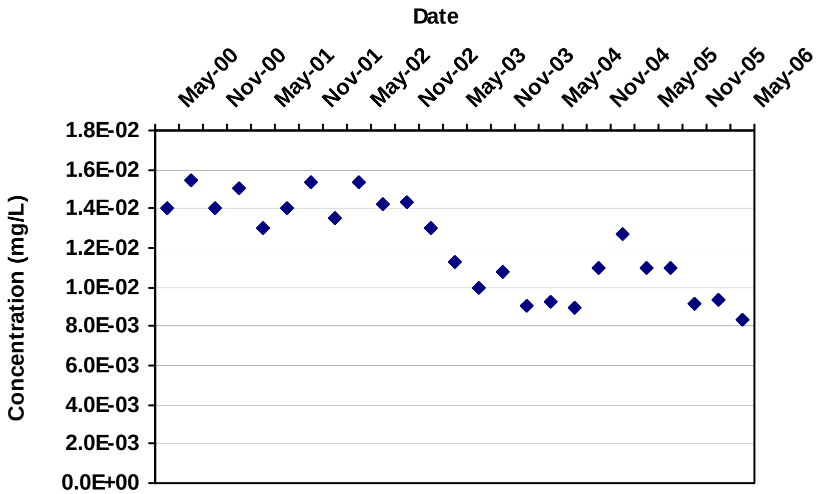
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-6-97	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.5E-03		1	1
MW-6-97	T	8/15/2002	TRICHLOROETHYLENE (TCE)	1.3E-03		2	1
MW-6-97	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.9E-03		1	1
MW-6-97	T	2/15/2003	TRICHLOROETHYLENE (TCE)	2.1E-03		3	3
MW-6-97	T	5/15/2003	TRICHLOROETHYLENE (TCE)	2.4E-03		2	2
MW-6-97	T	8/15/2003	TRICHLOROETHYLENE (TCE)	3.2E-03		2	2
MW-6-97	T	11/15/2003	TRICHLOROETHYLENE (TCE)	2.8E-03		1	1
MW-6-97	T	2/15/2004	TRICHLOROETHYLENE (TCE)	4.6E-03		1	1
MW-6-97	T	5/15/2004	TRICHLOROETHYLENE (TCE)	4.5E-03		3	3
MW-6-97	T	8/15/2004	TRICHLOROETHYLENE (TCE)	3.9E-03		1	1
MW-6-97	T	11/15/2004	TRICHLOROETHYLENE (TCE)	4.0E-03		3	3
MW-6-97	T	2/15/2005	TRICHLOROETHYLENE (TCE)	4.0E-03		2	2
MW-6-97	T	5/15/2005	TRICHLOROETHYLENE (TCE)	4.2E-03		3	3
MW-6-97	T	8/15/2005	TRICHLOROETHYLENE (TCE)	4.8E-03		3	3
MW-6-97	T	11/15/2005	TRICHLOROETHYLENE (TCE)	3.6E-03		3	3
MW-6-97	T	2/15/2006	TRICHLOROETHYLENE (TCE)	3.8E-03		3	3
MW-6-97	T	5/15/2006	TRICHLOROETHYLENE (TCE)	3.5E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-7-97
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -177

Confidence in Trend: 100.0%

Coefficient of Variation: 0.19

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-7-97	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.4E-02		1	1
MW-7-97	T	8/15/2000	TRICHLOROETHYLENE (TCE)	1.6E-02		3	3
MW-7-97	T	11/15/2000	TRICHLOROETHYLENE (TCE)	1.4E-02		2	2
MW-7-97	T	2/15/2001	TRICHLOROETHYLENE (TCE)	1.5E-02		3	3
MW-7-97	T	5/15/2001	TRICHLOROETHYLENE (TCE)	1.3E-02		2	2
MW-7-97	T	8/15/2001	TRICHLOROETHYLENE (TCE)	1.4E-02		2	2
MW-7-97	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.5E-02		1	1
MW-7-97	T	2/15/2002	TRICHLOROETHYLENE (TCE)	1.4E-02		1	1
MW-7-97	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.5E-02		1	1
MW-7-97	T	8/15/2002	TRICHLOROETHYLENE (TCE)	1.4E-02		2	2
MW-7-97	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.4E-02		1	1
MW-7-97	T	2/15/2003	TRICHLOROETHYLENE (TCE)	1.3E-02		3	3
MW-7-97	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.1E-02		2	2
MW-7-97	T	8/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-02		2	2
MW-7-97	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.1E-02		1	1
MW-7-97	T	2/15/2004	TRICHLOROETHYLENE (TCE)	9.0E-03		1	1
MW-7-97	T	5/15/2004	TRICHLOROETHYLENE (TCE)	9.3E-03		3	3
MW-7-97	T	8/15/2004	TRICHLOROETHYLENE (TCE)	8.9E-03		1	1
MW-7-97	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3
MW-7-97	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.3E-02		2	2
MW-7-97	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3
MW-7-97	T	8/15/2005	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3

MAROS Mann-Kendall Statistics Summary

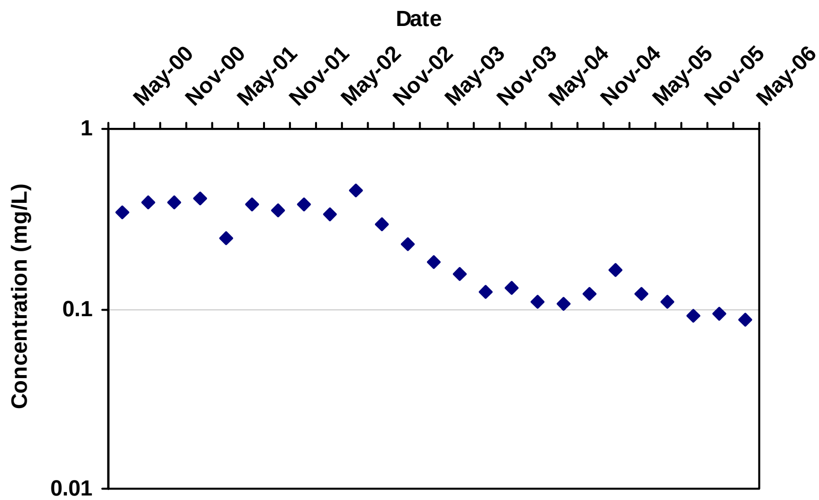
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-7-97	T	11/15/2005	TRICHLOROETHYLENE (TCE)	9.2E-03		3	3
MW-7-97	T	2/15/2006	TRICHLOROETHYLENE (TCE)	9.4E-03		3	3
MW-7-97	T	5/15/2006	TRICHLOROETHYLENE (TCE)	8.3E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-8-97
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 4/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:
-224

Confidence in Trend:
100.0%

Coefficient of Variation:
0.55

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-8-97	T	5/15/2000	TRICHLOROETHYLENE (TCE)	3.4E-01		1	1
MW-8-97	T	8/15/2000	TRICHLOROETHYLENE (TCE)	4.0E-01		3	3
MW-8-97	T	11/15/2000	TRICHLOROETHYLENE (TCE)	4.0E-01		2	2
MW-8-97	T	2/15/2001	TRICHLOROETHYLENE (TCE)	4.1E-01		1	1
MW-8-97	T	5/15/2001	TRICHLOROETHYLENE (TCE)	2.5E-01		1	1
MW-8-97	T	8/15/2001	TRICHLOROETHYLENE (TCE)	3.9E-01		2	2
MW-8-97	T	11/15/2001	TRICHLOROETHYLENE (TCE)	3.6E-01		1	1
MW-8-97	T	2/15/2002	TRICHLOROETHYLENE (TCE)	3.8E-01		1	1
MW-8-97	T	5/15/2002	TRICHLOROETHYLENE (TCE)	3.3E-01		1	1
MW-8-97	T	8/15/2002	TRICHLOROETHYLENE (TCE)	4.5E-01		2	2
MW-8-97	T	11/15/2002	TRICHLOROETHYLENE (TCE)	2.9E-01		1	1
MW-8-97	T	2/15/2003	TRICHLOROETHYLENE (TCE)	2.3E-01		3	3
MW-8-97	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.8E-01		2	2
MW-8-97	T	8/15/2003	TRICHLOROETHYLENE (TCE)	1.6E-01		2	2
MW-8-97	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.2E-01		1	1
MW-8-97	T	2/15/2004	TRICHLOROETHYLENE (TCE)	1.3E-01		1	1
MW-8-97	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.1E-01		3	3
MW-8-97	T	8/15/2004	TRICHLOROETHYLENE (TCE)	1.1E-01		1	1
MW-8-97	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.2E-01		3	3
MW-8-97	T	2/15/2005	TRICHLOROETHYLENE (TCE)	1.7E-01		2	2
MW-8-97	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.2E-01		3	3
MW-8-97	T	8/15/2005	TRICHLOROETHYLENE (TCE)	1.1E-01		3	3

MAROS Mann-Kendall Statistics Summary

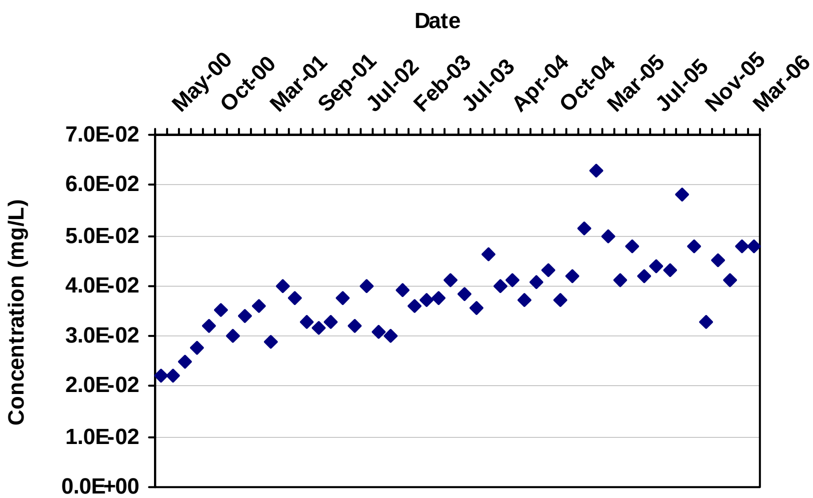
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-8-97	T	11/15/2005	TRICHLOROETHYLENE (TCE)	9.1E-02		3	3
MW-8-97	T	2/15/2006	TRICHLOROETHYLENE (TCE)	9.3E-02		3	3
MW-8-97	T	5/15/2006	TRICHLOROETHYLENE (TCE)	8.7E-02		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: MW-8-97
Well Type: T
COC: TETRACHLOROETHYLENE(PCE)

Time Period: 1/1/1999 **to** 5/30/2006
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: 766

Confidence in Trend: 100.0%

Coefficient of Variation: 0.21

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
MW-8-97	T	5/4/2000	TETRACHLOROETHYLENE(PCE	2.2E-02		1	1
MW-8-97	T	7/26/2000	TETRACHLOROETHYLENE(PCE	2.2E-02		4	3
MW-8-97	T	8/24/2000	TETRACHLOROETHYLENE(PCE	2.5E-02		2	2
MW-8-97	T	9/29/2000	TETRACHLOROETHYLENE(PCE	2.8E-02		2	2
MW-8-97	T	10/27/2000	TETRACHLOROETHYLENE(PCE	3.2E-02		1	1
MW-8-97	T	12/28/2000	TETRACHLOROETHYLENE(PCE	3.5E-02		2	2
MW-8-97	T	1/22/2001	TETRACHLOROETHYLENE(PCE	3.0E-02		1	1
MW-8-97	T	2/28/2001	TETRACHLOROETHYLENE(PCE	3.4E-02		1	1
MW-8-97	T	3/28/2001	TETRACHLOROETHYLENE(PCE	3.6E-02		1	1
MW-8-97	T	4/27/2001	TETRACHLOROETHYLENE(PCE	2.9E-02		1	1
MW-8-97	T	5/22/2001	TETRACHLOROETHYLENE(PCE	4.0E-02		2	2
MW-8-97	T	8/24/2001	TETRACHLOROETHYLENE(PCE	3.8E-02		2	2
MW-8-97	T	9/26/2001	TETRACHLOROETHYLENE(PCE	3.3E-02		1	1
MW-8-97	T	10/30/2001	TETRACHLOROETHYLENE(PCE	3.2E-02		3	3
MW-8-97	T	2/19/2002	TETRACHLOROETHYLENE(PCE	3.3E-02		3	3
MW-8-97	T	4/30/2002	TETRACHLOROETHYLENE(PCE	3.8E-02		3	3
MW-8-97	T	7/31/2002	TETRACHLOROETHYLENE(PCE	3.2E-02		2	2
MW-8-97	T	8/27/2002	TETRACHLOROETHYLENE(PCE	4.0E-02		1	1
MW-8-97	T	11/20/2002	TETRACHLOROETHYLENE(PCE	3.1E-02		3	3
MW-8-97	T	1/24/2003	TETRACHLOROETHYLENE(PCE	3.0E-02		1	1
MW-8-97	T	2/26/2003	TETRACHLOROETHYLENE(PCE	3.9E-02		1	1
MW-8-97	T	2/27/2003	TETRACHLOROETHYLENE(PCE	3.6E-02		1	1

MAROS Mann-Kendall Statistics Summary

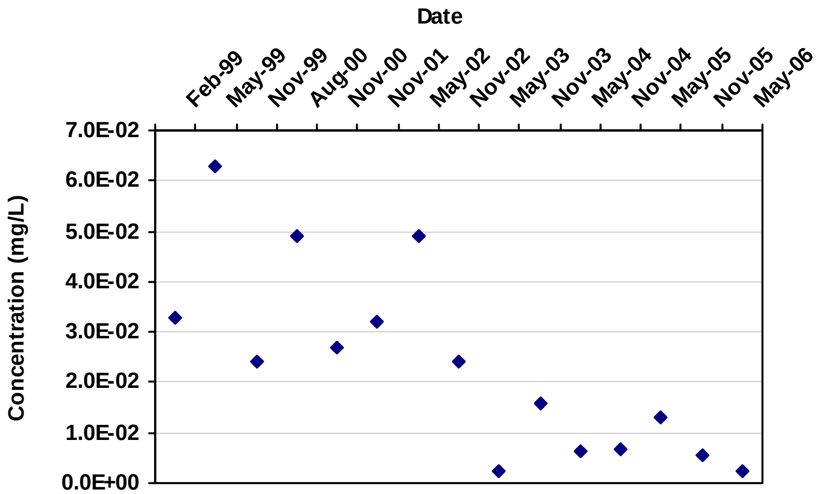
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-8-97	T	4/25/2003	TETRACHLOROETHYLENE(PCE	3.7E-02		1	1
MW-8-97	T	5/30/2003	TETRACHLOROETHYLENE(PCE	3.8E-02		2	2
MW-8-97	T	7/30/2003	TETRACHLOROETHYLENE(PCE	4.1E-02		1	1
MW-8-97	T	8/28/2003	TETRACHLOROETHYLENE(PCE	3.9E-02		2	2
MW-8-97	T	10/24/2003	TETRACHLOROETHYLENE(PCE	3.6E-02		3	3
MW-8-97	T	2/19/2004	TETRACHLOROETHYLENE(PCE	4.6E-02		3	3
MW-8-97	T	4/28/2004	TETRACHLOROETHYLENE(PCE	4.0E-02		1	1
MW-8-97	T	5/25/2004	TETRACHLOROETHYLENE(PCE	4.1E-02		1	1
MW-8-97	T	6/26/2004	TETRACHLOROETHYLENE(PCE	3.7E-02		1	1
MW-8-97	T	8/24/2004	TETRACHLOROETHYLENE(PCE	4.1E-02		3	3
MW-8-97	T	10/21/2004	TETRACHLOROETHYLENE(PCE	4.3E-02		1	1
MW-8-97	T	10/28/2004	TETRACHLOROETHYLENE(PCE	3.7E-02		1	1
MW-8-97	T	12/21/2004	TETRACHLOROETHYLENE(PCE	4.2E-02		1	1
MW-8-97	T	2/28/2005	TETRACHLOROETHYLENE(PCE	5.2E-02		2	2
MW-8-97	T	3/28/2005	TETRACHLOROETHYLENE(PCE	6.3E-02		1	1
MW-8-97	T	4/26/2005	TETRACHLOROETHYLENE(PCE	5.0E-02		1	1
MW-8-97	T	5/30/2005	TETRACHLOROETHYLENE(PCE	4.1E-02		1	1
MW-8-97	T	6/28/2005	TETRACHLOROETHYLENE(PCE	4.8E-02		1	1
MW-8-97	T	7/25/2005	TETRACHLOROETHYLENE(PCE	4.2E-02		1	1
MW-8-97	T	8/29/2005	TETRACHLOROETHYLENE(PCE	4.4E-02		1	1
MW-8-97	T	9/29/2005	TETRACHLOROETHYLENE(PCE	4.3E-02		1	1
MW-8-97	T	10/25/2005	TETRACHLOROETHYLENE(PCE	5.8E-02		1	1
MW-8-97	T	11/28/2005	TETRACHLOROETHYLENE(PCE	4.8E-02		1	1
MW-8-97	T	12/15/2005	TETRACHLOROETHYLENE(PCE	3.3E-02		1	1
MW-8-97	T	1/30/2006	TETRACHLOROETHYLENE(PCE	4.5E-02		1	1
MW-8-97	T	2/22/2006	TETRACHLOROETHYLENE(PCE	4.1E-02		1	1
MW-8-97	T	3/23/2006	TETRACHLOROETHYLENE(PCE	4.8E-02		1	1
MW-8-97	T	4/19/2006	TETRACHLOROETHYLENE(PCE	4.8E-02		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: WS-5
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -67

Confidence in Trend: 100.0%

Coefficient of Variation: 0.80

Mann Kendall Concentration Trend: (See Note) D

Data Table:

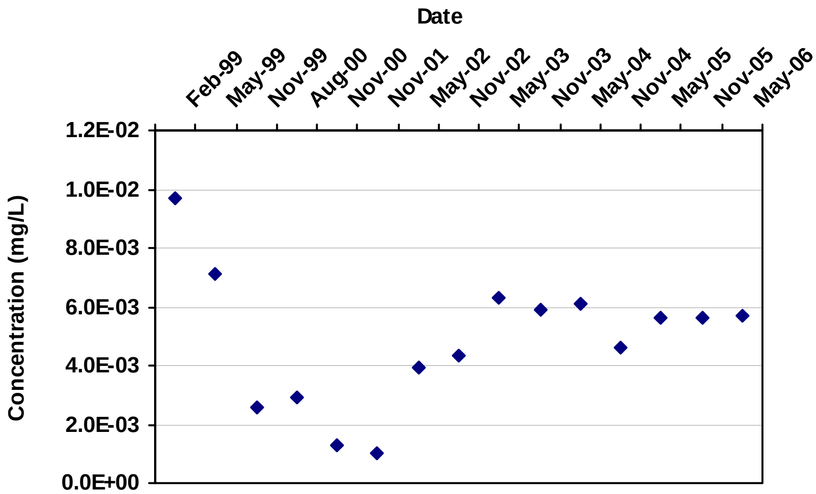
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
WS-5	T	2/15/1999	TRICHLOROETHYLENE (TCE)	3.3E-02		1	1
WS-5	T	5/15/1999	TRICHLOROETHYLENE (TCE)	6.3E-02		1	1
WS-5	T	11/15/1999	TRICHLOROETHYLENE (TCE)	2.4E-02		1	1
WS-5	T	8/15/2000	TRICHLOROETHYLENE (TCE)	4.9E-02		1	1
WS-5	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.7E-02		1	1
WS-5	T	11/15/2001	TRICHLOROETHYLENE (TCE)	3.2E-02		1	1
WS-5	T	5/15/2002	TRICHLOROETHYLENE (TCE)	4.9E-02		1	1
WS-5	T	11/15/2002	TRICHLOROETHYLENE (TCE)	2.4E-02		1	1
WS-5	T	5/15/2003	TRICHLOROETHYLENE (TCE)	2.4E-03		1	1
WS-5	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.6E-02		1	1
WS-5	T	5/15/2004	TRICHLOROETHYLENE (TCE)	6.5E-03		1	1
WS-5	T	11/15/2004	TRICHLOROETHYLENE (TCE)	6.7E-03		1	1
WS-5	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.3E-02		1	1
WS-5	T	11/15/2005	TRICHLOROETHYLENE (TCE)	5.6E-03		1	1
WS-5	T	5/15/2006	TRICHLOROETHYLENE (TCE)	2.3E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: WS-10
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/30/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 12

Confidence in Trend: 70.4%

Coefficient of Variation: 0.47

Mann Kendall Concentration Trend: (See Note) NT

Data Table:

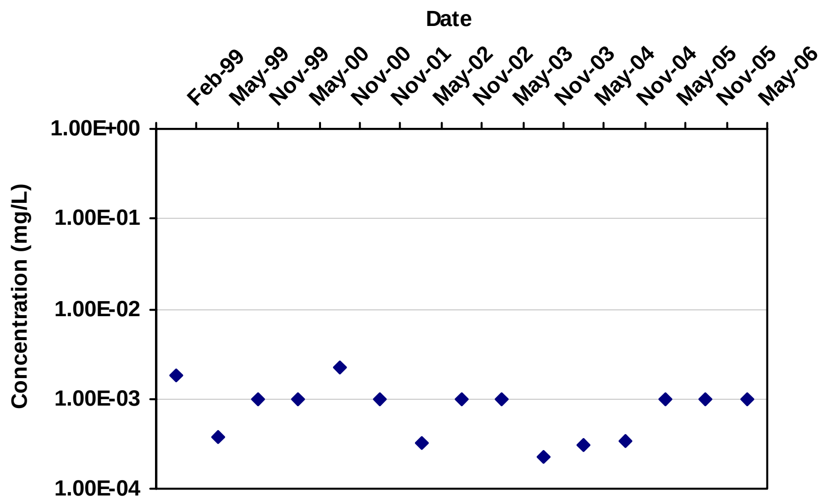
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
WS-10	T	2/15/1999	TRICHLOROETHYLENE (TCE)	9.7E-03		1	1
WS-10	T	5/15/1999	TRICHLOROETHYLENE (TCE)	7.1E-03		1	1
WS-10	T	11/15/1999	TRICHLOROETHYLENE (TCE)	2.6E-03		1	1
WS-10	T	8/15/2000	TRICHLOROETHYLENE (TCE)	2.9E-03		1	1
WS-10	T	11/15/2000	TRICHLOROETHYLENE (TCE)	1.3E-03		1	1
WS-10	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WS-10	T	5/15/2002	TRICHLOROETHYLENE (TCE)	3.9E-03		1	1
WS-10	T	11/15/2002	TRICHLOROETHYLENE (TCE)	4.4E-03		1	1
WS-10	T	5/15/2003	TRICHLOROETHYLENE (TCE)	6.3E-03		1	1
WS-10	T	11/15/2003	TRICHLOROETHYLENE (TCE)	5.9E-03		1	1
WS-10	T	5/15/2004	TRICHLOROETHYLENE (TCE)	6.1E-03		1	1
WS-10	T	11/15/2004	TRICHLOROETHYLENE (TCE)	4.6E-03		1	1
WS-10	T	5/15/2005	TRICHLOROETHYLENE (TCE)	5.6E-03		1	1
WS-10	T	11/15/2005	TRICHLOROETHYLENE (TCE)	5.6E-03		1	1
WS-10	T	5/15/2006	TRICHLOROETHYLENE (TCE)	5.7E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: 211
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 3/3/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -17

Confidence in Trend: 78.2%

Coefficient of Variation: 0.61

Mann Kendall Concentration Trend: (See Note) S

Data Table:

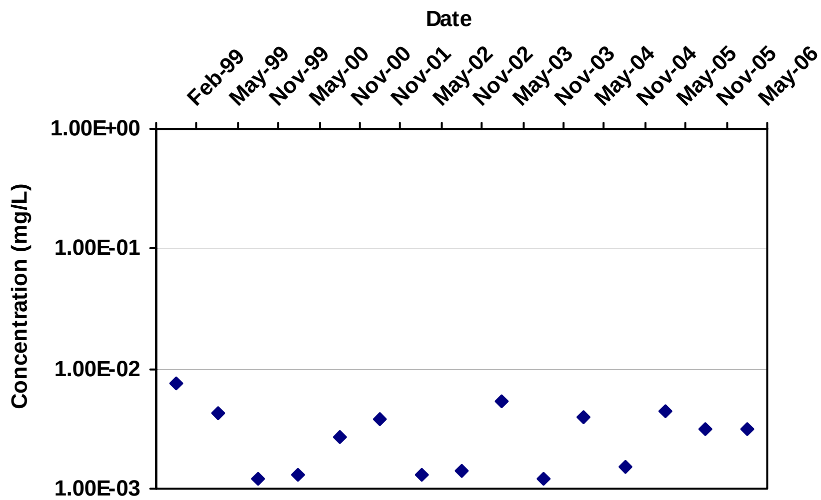
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
211	T	2/15/1999	TRICHLOROETHYLENE (TCE)	1.8E-03		1	1
211	T	5/15/1999	TRICHLOROETHYLENE (TCE)	3.7E-04		1	1
211	T	11/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.2E-03		1	1
211	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	5/15/2002	TRICHLOROETHYLENE (TCE)	3.3E-04		1	1
211	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	11/15/2003	TRICHLOROETHYLENE (TCE)	2.3E-04		1	1
211	T	5/15/2004	TRICHLOROETHYLENE (TCE)	3.1E-04		1	1
211	T	11/15/2004	TRICHLOROETHYLENE (TCE)	3.4E-04		1	1
211	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
211	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

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

MAROS Mann-Kendall Statistics Summary

Well: D-106
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 3/3/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 5

Confidence in Trend: 57.7%

Coefficient of Variation: 0.60

Mann Kendall Concentration Trend: (See Note) NT

Data Table:

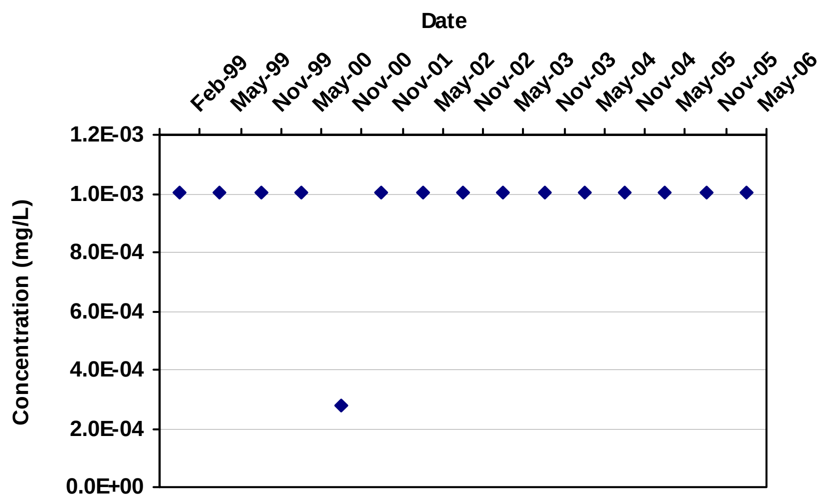
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
D-106	T	2/15/1999	TRICHLOROETHYLENE (TCE)	7.6E-03		1	1
D-106	T	5/15/1999	TRICHLOROETHYLENE (TCE)	4.2E-03		1	1
D-106	T	11/15/1999	TRICHLOROETHYLENE (TCE)	1.2E-03		1	1
D-106	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.3E-03		1	1
D-106	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.7E-03		1	1
D-106	T	11/15/2001	TRICHLOROETHYLENE (TCE)	3.8E-03		1	1
D-106	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.3E-03		1	1
D-106	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.4E-03		1	1
D-106	T	5/15/2003	TRICHLOROETHYLENE (TCE)	5.3E-03		1	1
D-106	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.2E-03		1	1
D-106	T	5/15/2004	TRICHLOROETHYLENE (TCE)	4.0E-03		1	1
D-106	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.5E-03		1	1
D-106	T	5/15/2005	TRICHLOROETHYLENE (TCE)	4.4E-03		1	1
D-106	T	11/15/2005	TRICHLOROETHYLENE (TCE)	3.1E-03		1	1
D-106	T	5/15/2006	TRICHLOROETHYLENE (TCE)	3.2E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: D-107
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 6

Confidence in Trend: 59.6%

Coefficient of Variation: 0.20

Mann Kendall Concentration Trend: (See Note) NT

Data Table:

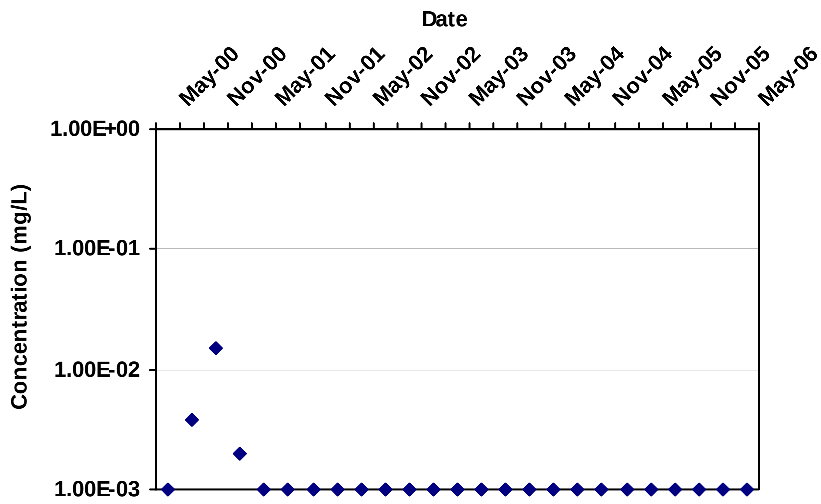
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
D-107	T	2/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/2000	TRICHLOROETHYLENE (TCE)	2.8E-04		1	1
D-107	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
D-107	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

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

MAROS Mann-Kendall Statistics Summary

Well: MW-10-97
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 3/3/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -61

Confidence in Trend: 91.9%

Coefficient of Variation: 1.67

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-10-97	S	5/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
MW-10-97	S	8/15/2000	TRICHLOROETHYLENE (TCE)	3.9E-03		3	2
MW-10-97	S	11/15/2000	TRICHLOROETHYLENE (TCE)	1.5E-02		2	2
MW-10-97	S	2/15/2001	TRICHLOROETHYLENE (TCE)	2.0E-03		3	2
MW-10-97	S	5/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	8/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	2/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	5/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	8/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	2/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	5/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	8/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	11/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	2/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03		3	1
MW-10-97	S	5/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	8/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	2/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	8/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0

MAROS Mann-Kendall Statistics Summary

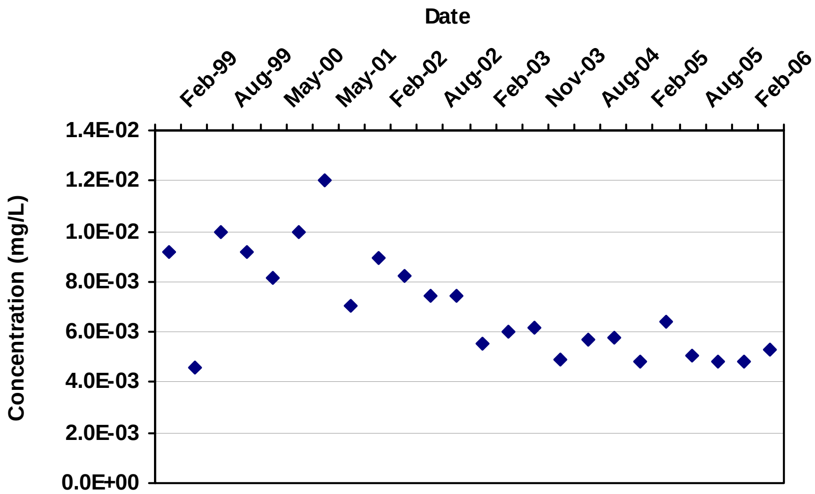
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-10-97	S	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	2/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	3	0
MW-10-97	S	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

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

MAROS Mann-Kendall Statistics Summary

Well: MW-5
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 3/3/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -152

Confidence in Trend: 100.0%

Coefficient of Variation: 0.30

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-5	S	2/15/1999	TRICHLOROETHYLENE (TCE)	9.2E-03		1	1
MW-5	S	5/15/1999	TRICHLOROETHYLENE (TCE)	4.6E-03		1	1
MW-5	S	8/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-02		1	1
MW-5	S	11/15/1999	TRICHLOROETHYLENE (TCE)	9.2E-03		1	1
MW-5	S	5/15/2000	TRICHLOROETHYLENE (TCE)	8.2E-03		1	1
MW-5	S	11/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-02		1	1
MW-5	S	5/15/2001	TRICHLOROETHYLENE (TCE)	1.2E-02		1	1
MW-5	S	11/15/2001	TRICHLOROETHYLENE (TCE)	7.0E-03		2	2
MW-5	S	2/15/2002	TRICHLOROETHYLENE (TCE)	8.9E-03		1	1
MW-5	S	5/15/2002	TRICHLOROETHYLENE (TCE)	8.3E-03		2	2
MW-5	S	8/15/2002	TRICHLOROETHYLENE (TCE)	7.4E-03		1	1
MW-5	S	11/15/2002	TRICHLOROETHYLENE (TCE)	7.5E-03		2	2
MW-5	S	2/15/2003	TRICHLOROETHYLENE (TCE)	5.5E-03		1	1
MW-5	S	5/15/2003	TRICHLOROETHYLENE (TCE)	6.0E-03		2	2
MW-5	S	11/15/2003	TRICHLOROETHYLENE (TCE)	6.2E-03		1	1
MW-5	S	5/15/2004	TRICHLOROETHYLENE (TCE)	4.9E-03		1	1
MW-5	S	8/15/2004	TRICHLOROETHYLENE (TCE)	5.7E-03		1	1
MW-5	S	11/15/2004	TRICHLOROETHYLENE (TCE)	5.8E-03		2	2
MW-5	S	2/15/2005	TRICHLOROETHYLENE (TCE)	4.8E-03		1	1
MW-5	S	5/15/2005	TRICHLOROETHYLENE (TCE)	6.4E-03		1	1
MW-5	S	8/15/2005	TRICHLOROETHYLENE (TCE)	5.1E-03		3	3
MW-5	S	11/15/2005	TRICHLOROETHYLENE (TCE)	4.8E-03		2	2

MAROS Mann-Kendall Statistics Summary

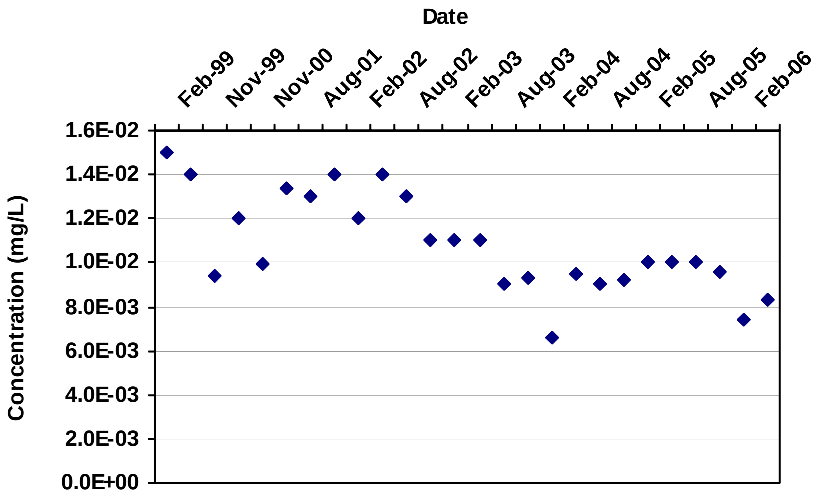
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-5	S	2/15/2006	TRICHLOROETHYLENE (TCE)	4.8E-03		1	1
MW-5	S	5/15/2006	TRICHLOROETHYLENE (TCE)	5.3E-03		1	1

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

MAROS Mann-Kendall Statistics Summary

Well: P-202
Well Type: S
COC: TRICHLOROETHYLENE (TCE)

Time Period: 3/3/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: -167

Confidence in Trend: 100.0%

Coefficient of Variation: 0.20

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
P-202	S	2/15/1999	TRICHLOROETHYLENE (TCE)	1.5E-02		1	1
P-202	S	5/15/1999	TRICHLOROETHYLENE (TCE)	1.4E-02		1	1
P-202	S	11/15/1999	TRICHLOROETHYLENE (TCE)	9.4E-03		1	1
P-202	S	5/15/2000	TRICHLOROETHYLENE (TCE)	1.2E-02		1	1
P-202	S	11/15/2000	TRICHLOROETHYLENE (TCE)	9.9E-03		1	1
P-202	S	5/15/2001	TRICHLOROETHYLENE (TCE)	1.3E-02		2	2
P-202	S	8/15/2001	TRICHLOROETHYLENE (TCE)	1.3E-02		3	3
P-202	S	11/15/2001	TRICHLOROETHYLENE (TCE)	1.4E-02		3	3
P-202	S	2/15/2002	TRICHLOROETHYLENE (TCE)	1.2E-02		3	3
P-202	S	5/15/2002	TRICHLOROETHYLENE (TCE)	1.4E-02		3	3
P-202	S	8/15/2002	TRICHLOROETHYLENE (TCE)	1.3E-02		3	3
P-202	S	11/15/2002	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3
P-202	S	2/15/2003	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3
P-202	S	5/15/2003	TRICHLOROETHYLENE (TCE)	1.1E-02		3	3
P-202	S	8/15/2003	TRICHLOROETHYLENE (TCE)	9.0E-03		3	3
P-202	S	11/15/2003	TRICHLOROETHYLENE (TCE)	9.3E-03		3	3
P-202	S	2/15/2004	TRICHLOROETHYLENE (TCE)	6.6E-03		3	3
P-202	S	5/15/2004	TRICHLOROETHYLENE (TCE)	9.5E-03		3	3
P-202	S	8/15/2004	TRICHLOROETHYLENE (TCE)	9.0E-03		3	3
P-202	S	11/15/2004	TRICHLOROETHYLENE (TCE)	9.2E-03		3	3
P-202	S	2/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-02		3	3
P-202	S	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-02		3	3

MAROS Mann-Kendall Statistics Summary

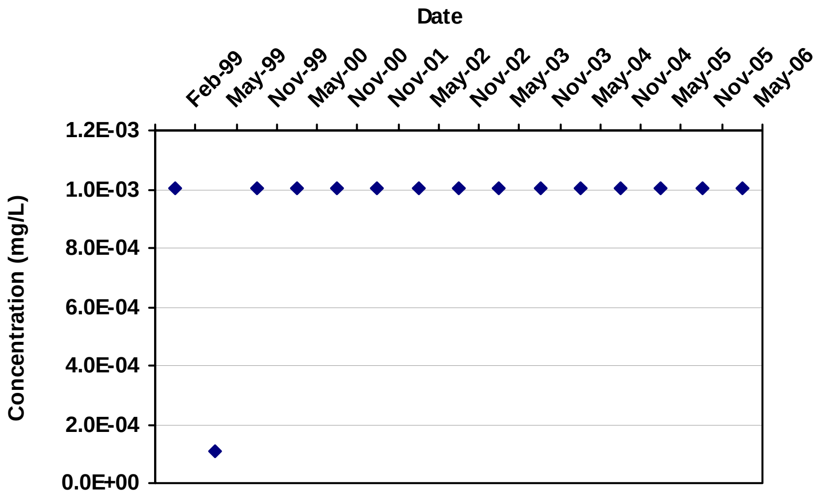
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
P-202	S	8/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-02		3	3
P-202	S	11/15/2005	TRICHLOROETHYLENE (TCE)	9.6E-03		3	3
P-202	S	2/15/2006	TRICHLOROETHYLENE (TCE)	7.4E-03		3	3
P-202	S	5/15/2006	TRICHLOROETHYLENE (TCE)	8.4E-03		2	2

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

MAROS Mann-Kendall Statistics Summary

Well: WD-10
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 1/1/1999 **to** 5/5/2006
Consolidation Period: Quarterly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: Specified Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic: 12

Confidence in Trend: 70.4%

Coefficient of Variation: 0.24

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
WD-10	T	2/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/1999	TRICHLOROETHYLENE (TCE)	1.1E-04		1	1
WD-10	T	11/15/1999	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2000	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2001	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2002	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2003	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2004	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	11/15/2005	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0
WD-10	T	5/15/2006	TRICHLOROETHYLENE (TCE)	1.0E-03	ND	1	0

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

MAROS Zeroth Moment Analysis

Project: Stageright

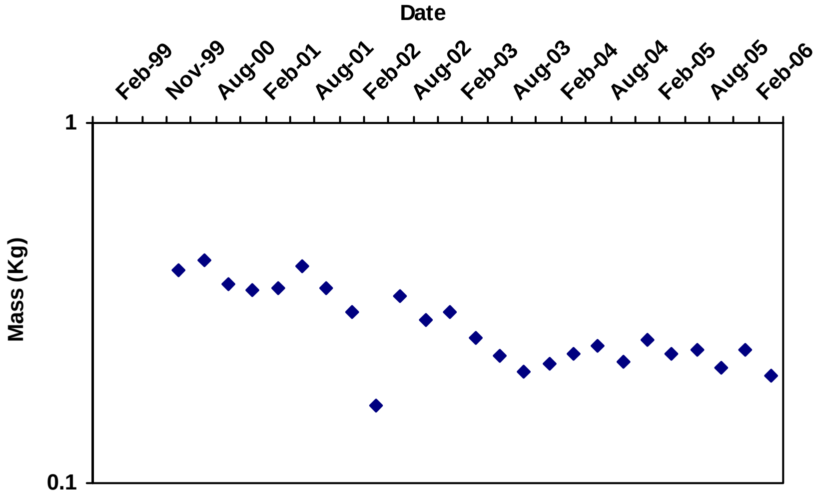
User Name: MV

Location: Stageright

State: Michigan

COC: TRICHLOROETHYLENE (TCE)

Change in Dissolved Mass Over Time



Porosity: 0.31

Saturated Thickness:

Uniform: 50 ft

Mann Kendall S Statistic:

-105

Confidence in Trend:

98.0%

Coefficient of Variation:

0.45

Zeroth Moment Trend:

D

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
2/15/1999	TRICHLOROETHYLENE (TCE)	0.0E+00	1
5/15/1999	TRICHLOROETHYLENE (TCE)	0.0E+00	1
11/15/1999	TRICHLOROETHYLENE (TCE)	0.0E+00	1
5/15/2000	TRICHLOROETHYLENE (TCE)	3.9E-01	8
8/15/2000	TRICHLOROETHYLENE (TCE)	4.1E-01	9
11/15/2000	TRICHLOROETHYLENE (TCE)	3.6E-01	9
2/15/2001	TRICHLOROETHYLENE (TCE)	3.4E-01	8
5/15/2001	TRICHLOROETHYLENE (TCE)	3.5E-01	9
8/15/2001	TRICHLOROETHYLENE (TCE)	4.0E-01	12
11/15/2001	TRICHLOROETHYLENE (TCE)	3.5E-01	12
2/15/2002	TRICHLOROETHYLENE (TCE)	3.0E-01	12
5/15/2002	TRICHLOROETHYLENE (TCE)	1.6E-01	13
8/15/2002	TRICHLOROETHYLENE (TCE)	3.3E-01	14
11/15/2002	TRICHLOROETHYLENE (TCE)	2.8E-01	14
2/15/2003	TRICHLOROETHYLENE (TCE)	3.0E-01	14
5/15/2003	TRICHLOROETHYLENE (TCE)	2.5E-01	14
8/15/2003	TRICHLOROETHYLENE (TCE)	2.3E-01	14
11/15/2003	TRICHLOROETHYLENE (TCE)	2.0E-01	14
2/15/2004	TRICHLOROETHYLENE (TCE)	2.2E-01	14
5/15/2004	TRICHLOROETHYLENE (TCE)	2.3E-01	14
8/15/2004	TRICHLOROETHYLENE (TCE)	2.4E-01	14
11/15/2004	TRICHLOROETHYLENE (TCE)	2.2E-01	14

MAROS Zeroth Moment Analysis

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
2/15/2005	TRICHLOROETHYLENE (TCE)	2.5E-01	14
5/15/2005	TRICHLOROETHYLENE (TCE)	2.3E-01	14
8/15/2005	TRICHLOROETHYLENE (TCE)	2.3E-01	14
11/15/2005	TRICHLOROETHYLENE (TCE)	2.1E-01	14
2/15/2006	TRICHLOROETHYLENE (TCE)	2.3E-01	14
5/15/2006	TRICHLOROETHYLENE (TCE)	2.0E-01	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

ATTACHMENT D

RESPONSE TO MDEQ COMMENTS ON THE DRAFT LONG-TERM GROUNDWATER MONITORING OPTIMIZATION CLARE WATER SUPPLY SUPERFUND SITE

Comments on the preliminary Long-Term Monitoring Optimization memoranda for the Stageright, PRB and Soil Remedy areas of the Clare Water Supply Superfund site were received from three parties at MDEQ: Barbara Vetort, Mark Henry and John Spielberg. The comments are addressed below, with comments grouped according to similar topic areas.

Commenter	Area	Page/Line/Para	Comment	Response
JS Comment 1a BV Comment 4 (page 2 paragraph 3)	General		(JS) The agencies and the PRPs would really benefit from having data in electronic format all in one place. The data should include all the source areas: Mitchell, Ex-Cell-O, StageRight, American Dry Cleaners, Stanley Oil, Standard Oil, MDOT bulk storage, etc. The data should be raw data as reported by the laboratories, including detection limits and qualifiers. CAS numbers for the parameters tested is also a good idea. Most laboratories can provide data in electronic, database format. (BV) The recommendation to combine groundwater elevation data collected from Stageright wells with data collected from the rest of the site wells to facilitate a more complete picture of groundwater hydraulics east of Stageright should be implemented. The current level of plume definition is not acceptable in the Stageright area.	The authors agree that all site analytical data should be maintained in an electronic database, accessible to all stakeholders. Proper data management is central to all site optimization efforts. Progressive Engineering is maintaining a *site-wide electronic database*, and they have done an excellent job under the circumstances. The Progressive database contains both analytical and hydraulic monitoring data for the entire site. The authors suggest that the site database be made available to all stakeholders. An updated database should be distributed to stakeholders after the results of each sample event are added. Inclusion of validated data in the database as opposed to raw data (assuming that data validation is performed) is recommended. The database used for the LTMO efforts will be included on CD in the final report. As a general observation, the addition of current and future monitoring data to the database is a fairly simple matter as data are now delivered in electronic format from most labs. The addition of historic information to the electronic database is more problematic. Often, these data are only available in hard-copy and must be added

Commenter	Area	Page/Line/Para	Comment	Response
				manually. Frequently, data are missing detection limits, method names or data flags. Manual addition of data is an expensive process and the opportunity for introducing transcription errors is extremely high. Specific elements of the historic data set should be prioritized and added to the database as time and budgets permit. Priority data include concentrations of constituents that exceed screening levels and detected compounds. The authors would also suggest that a sample location table be maintained in the site database. Sample locations tables generally include information such as the well name (and any historic names), the depth, top of casing, screened intervals, geographic coordinates, and date of installation. A location table can be useful for documenting details such as VAS. A table with groundwater parameters such as K values would be extremely helpful for a site this complex.
JS Comment 2a	Stageright		The MDEQ believes this area is the highest priority area at the site to be dealt with	The authors agree.
JS Comment 2b	Stageright		The MDEQ supports the objective of determining whether this area was characterized sufficiently. One way this can be evaluated is by finding out which wells were vertically sampled prior to setting the well screens. If vertical aquifer sampling (VAS) was insufficient, then this may need to be completed prior to implementing an LTMO in this area, or in conjunction with the LTMO.	Generally speaking, characterization of the vertical extent of contamination is desirable. Vertical sampling is generally part of site characterization. The authors were not provided with VAS information. Some sites benefit from a formal *conceptual site model* document detailing well installation details, groundwater parameters, source areas, transport mechanisms, geotechnical evaluations, receptors etc. It can be very useful to put all of the site data in one location for all stakeholders.

Commenter	Area	Page/Line/Para	Comment	Response
				In most cases, consensus on site characterization and site conceptual model should be largely complete *before* monitoring networks are optimized. As a general rule, the LTMO scope of work is limited to determining if a sufficient number of wells exist spatially to achieve monitoring objectives. The authors are not funded or scoped to performed a detailed review of the site investigation as part of the LTMO evaluation.
JS Comment 2c	Stageright		The MDEQ agrees that the shallow zone has not been well characterized. This zone needs better definition. The shallow water-bearing zone and the vadose zone above it may potentially contain a smear zone containing a continuing source of TCE and other contaminants. Past contamination near the water table could have moved up and down with rising and falling water levels, thus causing the vertical smearing of contamination in this zone.	See comment 2b above. A 'smear zone' is typically present at sites that have had floating free product (e.g., petroleum product), whereas TCE does not float on the groundwater surface. Continuing sources of contamination would be an element included in a conceptual site model.
JS Comment 2d	Stageright		Any new wells installed should be completed with the benefit of VAS to determine the zones of highest contamination	Comment noted. The authors agree that long-term monitoring wells should be screened within the zone containing the highest dissolved contaminant concentrations to the extent practical.
JS Comment 2e	Stageright		MDEQ agrees that chloride, alkalinity and TDS sampling and analysis can be reduced	Comment noted.
JS Comment 2f and BV	Stageright		(JS) Would be best to have the complete data set for this area rather than just summaries that show exceedances of cleanup objectives. Electronic format data in spreadsheets would be better than hard copy.	See comment 1a, above.

Commenter	Area	Page/Line/Para	Comment	Response
Comment (page 1 paragraph 3)			(BV) The MDEQ Superfund staff has not received the majority of the necessary TCRA data to include the boring logs and analytical data. Therefore, the MDEQ Superfund staff cannot verify the technical information used for the optimization.	
JS Comment 2f And BV Comment 2 (page 2, paragraph 1)	Stageright		(JS) An assumption was made by the optimizers that missing data meant that concentrations were non-detect. MDEQ agrees that evaluating this assumption with more complete historical data is a good idea. (BV) This report states that Progressive Engineering provided the data for optimization. Progressive Engineering is not the Stageright TCRA consultant. This report states that not all the data collected by the Stageright consultant, MACTEC, was included, therefore the Optimizers assumed the results were non-detect. The Optimizers state that historical constituent concentrations should be confirmed before the Long-Term Monitoring Program is finalized. The Agencies need to confirm that all the Stageright data and well logs are comprehensive and accurate.	Many times it is difficult to track historic data from former or uncooperative consultants and to translate it from hard-copy to electronic data. (See comment 1a above). The authors were told by Progressive that 'missing data' were assumed to be non-detect results. The authors did not have access to hard-copy data from previous site investigations to verify concentrations and detection limits, so, had to accept the dataset as delivered. As a general note, most LTM networks are optimized for one to two major contaminants of concern (COCs), when the less prevalent contaminants are contained within the plume of the priority COCs. In the case of Stageright, TCE is the parent compound, and appears to be most widespread with the most exceedances. Data for TCE in the Stageright area are recorded in the site database, and include non-detect results. For this reason, the authors proceeded with the analysis. The optimization was performed for TCE with other compounds considered qualitatively to evaluate and confirm recommendations.

Commenter	Area	Page/Line/Para	Comment	Response
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JS Comment 2g And BV Comment 3 (page 2, paragraph 2)	Stageright		(JS): Exclusion of site-wide monitoring wells in this area (e.g., 211, D-106, D-107, WD-10) should not be assumed to mean they should be excluded from site-wide monitoring. (BV): I agree with the majority of recommendations that are outlined on pages eight and nine. One exception, the recommendations include excluding wells that are not associated with the Stageright TCRA. Therefore, excluding wells 211, D106, D107, and WD10 is not appropriate for the well field remedial action.	One of the central activities of LTMO is to determine to what extent an individual monitoring location provides unique information in support of *site monitoring objectives*. A major issue of the Clare Water Supply ROD and associated documents is that groundwater monitoring objectives are not explicitly defined. Without explicit monitoring objectives the goal and significance of monitoring any individual location can be interpreted differently by each stakeholder. Based on qualitative and statistical evaluation, the deep wells recommended for removal from routine monitoring did not provide unique information significant to Stageright site management decisions. However, as MDEQ has expressed concern over removal of these locations, their contribution and suggested sample frequency will be revisited and any recommendations will be better explained in the final report. Even if these wells are not recommended for further sampling connected to the Stageright site, they could be retained for the site-wide monitoring program, which was not evaluated.
JS Comment 2h	Stageright		Deep zone well P-202 is too close to municipal well MW-5 to be useful as a sentinel well. The optimizers say this area is not well monitored. Therefore, better characterization of this zone is needed. Another deep zone well should be installed near the east edge of the StageRight parking lot, just south of MW-8-97.	Given an estimated deep aquifer seepage velocity of approximately 18 ft/d, all current wells are too close to MW-5 to function as sentinel wells in the short term. Well MW-10-97 is approximately 2 weeks travel time to MW-5. Most analytical samples require at least 2 weeks to process. Data review is usually much slower than analysis, and action, slower, yet. With these limitations, sampling P-202 provides a

Commenter	Area	Page/Line/Para	Comment	Response
				long-term, well-documented metric of plume stability. The well shows decreasing trends. Installation of another deep zone well should be accompanied by an explicit monitoring objective the well will fulfill and, if necessary, expedited chemical analysis to achieve the objective.
JS Comment 2i			MDEQ would like an explanation of how the average TCE concentration reported in Tables 4 and 7 is used. Is it used in any other calculation or statistic? Or, is it just a benchmark to compare against the CUO and MCL?	Average TCE concentration is a simple statistical benchmark used in a general way to identify high, medium and low concentration wells relative to the regulatory screening levels. Taken together with the maximum concentration, sample size, and concentration trend, the average concentration provides a summary of information relevant to defining the area of regulatory concern and the function of the location in the monitoring network.
JS Comment 2j and 3a			The new municipal well, MW-8, was not mentioned. It should be noted on the site maps, and considered in the LTMO evaluation. Even though this well is outside the StageRight area, it is a potential receptor of contaminants from StageRight. Because of this, it should be considered in the evaluation.	The new municipal well was installed as we finished the draft report. The authors were not informed of its construction until after the analysis was performed. We do not have the coordinates for the well or any information on its screened interval, pumping rate or preliminary concentrations of priority COCs. Because this well was installed near an existing contaminant plume, it should be sampled periodically same as other nearby active water supply wells.
BV Comment 1 (page 1,	Stageright	General	There is no site conceptual model presented to provide the basis for the optimization effort. Were the remedial design MODFLOW files used for this project? Since they	As far as the authors know, there is no single document describing a consensus site conceptual model for the areas of concern. (For further discussion of site conceptual model and site

Commenter	Area	Page/Line/Para	Comment	Response
paragraph 2)			were not cited, we assume these files were not used.	characterization, see Comment 2b) The site conceptual model was not detailed in the draft memorandum for the Stageright Area (or PRB/Soil Remedy). A brief summary of relevant conceptual model information provided to the authors will be included in the final memorandum. The authors reviewed the data received, which included the RODs, 5-year review, potentiometric surface maps, cross-sections and analytical database. Supplemental data on seepage velocity, porosity, groundwater flow direction, etc. were supplied by Progressive. LTMO is not generally a groundwater flow modeling effort. MODFLOW files were neither requested nor made available to us, nor were the results of site modeling made available.
BV Comment 4 (page 2, paragraph 4)	Stageright		The Long-Term Monitoring Optimization (LTMO) states that a change in site conditions might warrant resumption of monitoring at some time in the future at wells that are not currently recommended for continued sampling. A contingency plan specifying this should be a part of any changes to the groundwater monitoring program. In addition, every five years a complete round of analytical sampling for all wells should be performed to verify that the LTMO remains effective. This comprehensive monitoring was stated as a requirement by the former Potentially Responsible Party's consultant in the 1994 Remedial Design Remedial Action Work Plan.	The authors agree. Contingency plans should be related to the stated monitoring objectives. Both should be published in a site management document.
BV Comment 5	PRB Area		I am concerned that the MDEQ technical support staff was not given adequate input on the site conceptual	CSM information was provided to the authors by Progressive and the USEPA, and is summarized in

Commenter	Area	Page/Line/Para	Comment	Response
(page 2 paragraph 5)			model used as the basis for the LTMO.	Section 2 of the LTMO report. Groundwater input parameters are listed in Table 2 of the LTMO report.
BV Comment 6 (page 2 paragraph 6)	PRB Area		For example, in Section 2.1 PRB area, it states that the shallow groundwater flow direction is south-to-southeast across the PRBs. This has not been verified by existing site data. The remedial investigation reports the shallow aquifer permeabilities range from 10^{-3} to 10^{-5}, rather than 10^{-7}.	Existing potentiometric surface data indicate that the groundwater flow direction is roughly S/SE in the vicinity of the PRB; however, the authors concur that the site is not fully characterized as detailed in Section 4.1 of the LTMO report. The hydraulic gradient information derived from water level measurements was used to infer the groundwater flow direction; this is the standard practice at a majority of contaminated sites. It appears that a range of aquifer hydraulic conductivities have been reported for various geologic units; consensus values should be determined as part of the CSM review. At least some of the K values reported in the RI report appear to have been derived from laboratory tests of soil samples, and may not accurately represent field-scale K values. The range of 1E-07 to 5E-07 cm/sec given in the text of the report was derived from lithologic cross-sections provided by Progressive and contained in Attachment A of the report. The Dames & Moore RI report states that the till has a hydraulic conductivity on the order of 10^{-7} cm/sec.
BV Comment 7 (page 3 paragraph 1)	PRB Area		The PRB remedial action area is still completing the first two years of remedial action monitoring. The MDEQ Superfund staff has stated that the PRB should not be optimized until the remedy is demonstrated to be operating effectively. It is premature to optimize the monitoring program at the PRB area. The current level of plume definition is not acceptable in this area.	Comment noted. The authors concur, for the most part. Concrete metrics should be developed for determining if the remedy is operating effectively. As a general note, given a sufficiently long sample record, recommendations for *current* sampling locations and frequency can be made while site characterization efforts are on-going. While areas of site characterization uncertainty can be *identified* during LTMO, specific actions to address site

Commenter	Area	Page/Line/Para	Comment	Response
				characterization must be based on stakeholder consensus. The authors believe that the LTMO recommendations made in the report are reasonable; however, they should be reassessed as noew data are obtained.
BV Comment 8 (page 3 paragraph 3	Soil Remedy		The last sentence in the second paragraph states that the groundwater monitoring wells DMW1S, DMW2S, and DMW3S, in May and November 2005 ranged from 8 to 13 feet bgs. The report states this is a few feet below the bottom of the emplaced soils and near the top of the till. The emplaced soils (soil from Mitchell area) are essentially at the former ground surface, the till is below the upper aquifer. Please clarify this sentence.	A reference to cross-sections drawn by Secor and contained in Appendix A will be added to this text. These cross-sections show the water table being present a few feet below the bottom of the emplaced 'Mitchell' soils.
BV Comment 9 (page 3 paragraph 4)	Soil Remedy		The receptors for the upper aquifer are the municipal well field. The seepage velocities for this area are too low. The Dames & Moore Remedial Investigation (RI) reports the upper aquifer to be 10^{-5}.	Seepage velocities appear to vary across the site. Consensus representative velocities are needed for LTMO, and should be supplied by the stakeholders. As stated in Section 2.2 of the report, we agree that the seepage velocity obtained from Progressive for the area outside the soil treatment cell is too low.
BV Comment 10 (page 3 paragraph 5)	Soil Remedy		The Optimizers state that they did not have a complete data set for Vinyl Chloride for this area. The soil remedy area should have a complete data set for the wells discussed, back to their installation date, which is the same as the soil remedy completion date, circa 1999. RI wells are present around the soil remedy area, were their data sets complete? Some of the issues with the data set are related to Quality Assurance/Quality Control problems that were experienced during the groundwater monitoring sampling events.	For wells DMW 1S-3S and 1D-3D, the site database contains vinyl chloride results from 2005 – 2006. TCE data are recorded from 1999 -2006. (See Comment 1a). Other wells in the area have a more complete data set for vinyl chloride, with results for SW-9 extending to 1988. These wells are not closely associated with the soil remedy area.
BV Comment 11 (page 3 paragraph 6)	Soil Remedy		I agree with the recommendations for the Soil Remedy Area. However, I recommend annual rather than biennial sampling for UMW1D and UMW1S. This evaluation does not look at any data older than 1999. There is data for many of the existing wells that	Annual sampling for UMW1D and UMW1S to address 'background' water quality or to determine if constituents from outside the soil remedy area are migrating toward it is potentially reasonable. However, if the groundwater flow velocity in this area is indeed very low, then annual sampling may

Commenter	Area	Page/Line/Para	Comment	Response
			goes back to the 1980s. Why isn't this data evaluated for at least some key wells? The current level of plume definition seems adequate in this area.	be overkill because abrupt changes in upgradient groundwater quality that could impact the soil remedy area would be unlikely. For LTMO, 'recent' analytical data are given higher priority as historic data may have been collected under different sampling or analysis protocols. Often historic data have higher detection limits, and outliers that can skew statistics. Recent data are more likely to be comparable. Of the wells evaluated, only well 215 had data collected prior to 1999; these data were used in the qualitative evaluation of this well.
MH Comment 1	Stageright General Comment		1) From the information provided is seems that there are very few shallow monitoring wells associated with the part of the site. Has the shallow of the aquifer been shown to be clean? The data indicates that a rather substantial source of contamination exists at the site. If this source material is in the vadose zone, then there would be substantial contamination in the shallow portion of the aquifer which could discharge to the nearby wetlands.	Comment noted, see Comment 2b on site characterization.
MH Comment 2	Stageright General Comment		2) Since this document deals with optimization of the monitoring well network, it would be best if the Agencies took into account whether or not the individual monitoring well locations had been characterized using vertical aquifer sampling (VAS) techniques. More weight should placed on the value of the data from a particular part of the sight where VAS has been used to define the vertical and horizontal extent of contamination. MACTEC should be able to provide this information.	Comment noted, see Comment 2b on site characterization. Well weighting is possible for both qualitative and MAROS evaluations.
MH Comment 3	Stageright		3) There is a column in Table 4 that indicates the average concentrations found in the individual wells. I'm not sure that the average concentrations are very	Comment noted. See comment response 2i above.

Commenter	Area	Page/Line/Para	Comment	Response
	General Comment		appropriate for decision making purposes unless the geochemistry at that location is at steady-state.	
MH Comment 4	Stageright General Comment		4) The documentation for the MAROS software package (Appendix B) that was used for the evaluation does not speak to the basic assumption that the site is well characterized and that the existing monitoring well network actually represents the plume. This presumed assumption has been violated at each of the 3 source areas (Stageright, Mitchell and ExCello). At each of these areas there exists groundwater contamination that has not been delineated in magnitude or area. Integral to a "moment analysis" would be a thorough understanding of the distribution of that mass. The MAROS evaluations of these areas identified these deficiencies. The MAROS evaluations reinforce the fact that these sources are not fully defined – especially in the deeper portions of the aquifer. The lack of definition of the individual sources precludes an understanding of the interactions between them, or the cumulative effects of the three.	Comment noted, see Comment 2b on site characterization and BV Comment 7. While the extent of all identified groundwater contamination has not been fully delineated (based on data supplied to the authors) sufficient data are available for a subset of wells to optimize the monitoring approach in limited areas. Collecting more data than is needed in one area does not help the lack of data in another. The authors maintain that some current locations can be monitored at a reduced frequency while the site undergoes further characterization.
MH Comment 5	Stageright General Comment		5) There has been no discussion of the capture zone of the municipal wells in the vicinity of the site. I suspect that all parts of the site are within the capture zone of the municipal system.	No data were provided on the pumping rate and capture zone of the public supply wells. The authors assumed (based on gw flow velocity and potentiometric surface) that the capture zone extended across the entire Stageright area. It was also assumed that the Stageright plume does not extend east of the municipal well MW-2.
MH Comment 6	Stageright General Comment		6) This optimization process should be repeated once the site-wide data gaps have been filled and we have a better understanding of the contaminant distributions and transport pathways.	Comment noted; the authors concur with this comment. Optimization should be a dynamic process and LTMO conclusions and recommendations should be reassessed as new data are obtained.

Commenter	Area	Page/Line/Para	Comment	Response
MH Specific Comment 1	Stageright Specific Comment		1) Page 4, pp 1; The documents states that there was an assumption made that all the missing data are non-detect. This should be checked into, and if found not to be true, the entire process should be reevaluated.	Comment noted. The authors do not have access to the missing data, which may be in hard copy form.
MH Specific Comment 2	Stageright Specific Comment		2) Page 4, pp 3; The end of the paragraph states that the number of wells screened in the shallow zone was insufficient to perform a statistical analysis. From this one could conclude that the contamination in the shallow zones cannot be statistically evaluated using the software employed.	The number of wells screened in the shallow zone was insufficient to perform a spatial statistical analysis using MAROS. Concentration trends at individual well locations could be evaluated if there were sufficient sample events, but these wells have not been sampled regularly. Is there a reason these wells are not sampled? Dry?
MH Specific Comment 3	Stageright Specific Comment		3) Page 5, pp 1; This paragraph discusses the recommendations being based on the assumption that the "relatively rapid [groundwater] velocity will continue in the future". I also suggest that the In this part of the facility, the groundwater velocity is high because of its proximity to municipal production wells. A new production well has been installed in a near proximity to the Stageright facility. If the new well is not pumping at the same rate or from the same vertical interval as the pumping parameters used in the assumptions of the optimization model, the model may have to be reevaluated.	The authors agree. The new well was added, unknown to the authors, near the end of the analysis. However, the groundwater velocity in this area most likely will not decrease significantly due to installation of a new extraction well.
MH Specific Comment 4	Stageright Specific Comment		4) Page 5, pp 3; This paragraph suggests that the site characterization should be performed and suggests an additional monitoring well pair be installed. Any site wells should be installed using VAS techniques. Beyond just installing two additional wells additional characterization should be undertaken to determine the distribution and magnitude of the source.	Comment noted.

Commenter	Area	Page/Line/Para	Comment	Response
MH Specific Comment 5	Stageright Specific Comment		5) Page 5, last paragraph; The document suggests that fewer contaminants could be analyzed during sampling events. If the Agencies agree that this is the best approach, then I suggest that periodically the entire list of contaminants included in an EPA Method 8260B analysis be evaluated	The rationale for this approach should be clearly identified. Once COCs are identified, analysis for other contaminants should not be necessary unless new releases occur or hydraulic conditions change. However, given that the cost of a full 8260 analysis is not likely to be substantially more expensive than an abbreviated analysis, periodic analysis for a full analyte list should not have significant cost impacts.
MH Specific Comment 6	Stageright Specific Comment		6) Page 6, pp 2; I would agree, continuing to monitor the groundwater for chloride, TDS and alkalinity on a regular basis is not providing information that cannot be gained on a much less frequent basis.	Comment noted.
MH Specific Comment 7	Stageright Specific Comment		7) Page 7, pp 3; The recommendation is made to exclude MW-2-99 and MW-6-97 from the monitoring program, yet in the first paragraph of the following page the statement is made that near MW-6-97 the aquifer is "not well defined". This is counterintuitive.	Groundwater flow and contaminant transport in the Stageright area appears to be heterogeneous and channelized, with high concentrations (MW-1-02) adjacent to low concentrations (MW-6-97). The nature of the hydrogeology at and between the six points identified in Figure 6 should be clarified as part of a consensus conceptual site model. This said, MW-2-99 and MW-6-97 do not help characterize the contaminated part of the aquifer. They probably identify an area with lower flow velocity or some sort of hydrogeological discontinuity. Because they do not characterize the contaminated zone very well, they do not provide significant information to support management decisions. Routine monitoring of these wells is not particularly efficient.
MH Specific Comment 8	Stageright Specific Comment		8) Page 8, pp 1; The document states the intermediate groundwater zone to the east of MW1-02 and MW-6-97 is not well defined. I suggest that VAS be performed and/or a monitoring well cluster be installed in this area.	The groundwater quality is not delineated to the east of wells MW-1-02, MW-6-97 and MW-8-97. Plume delineation efforts are recommended for this area.

RESPONSE TO MDEQ's COMMENTS ON THE DRAFT LONG-TERM GROUNDWATER MONITORING OPTIMIZATION CLARE WATER SUPPLY SUPERFUND SITE (Continued)

Commenter	Area	Page/Line/Para	Comment	Response
MH Specific Comment 9	Stageright Specific Comment		9) Page 8, pp 2; The document points out that the groundwater velocity near MW-5 is extremely rapid and that concentrations are largely stable or decreasing. This indicates to me that that there is a moderately large source of parent contaminant at the site that may exist as a non-aqueous phase liquid.	Decisions on source area treatment can be complicated. The reference in footnote 4 below may be of help. This is outside the scope of LTMO. All we can say now is that under current conditions, the plume appears to be stable. The magnitudes of dissolved contaminant concentrations are not indicative of the presence of significant NAPL. It is possible that sorbed contaminants are continually 'bleeding' into the groundwater in the source area.
MH Specific Comment 10	Stageright Specific Comment		10) Page 8, pp 5; This paragraph in the recommendations suggests additional monitoring is needed east of MW-6-97. This should include VAS.	See response to Comment 8
MH PRB Comment 1	PRB General Comment		1) The document does not discuss any data gaps surrounding the permeable reactive barrier (PRB) wall.	Data gaps for the PRB area are discussed in Section 4.1 of the report.
MH PRB Comment 2	PRB General Comment		2) Are there institutional controls in place for all parts of the site to which contamination exists or could migrate to?	We have been told that institutional controls cover the entire Clare Water Supply site. However, the exact nature and extent of the institutional controls are unknown to us.
MH PRB Comment 3	PRB General Comment		3) How much sensitivity analysis was performed for the models and statistical software packages to bracket the range of values used in their assumptions?	None. We requested values for the input parameters from Progressive, and received, what should be, the consensus values established after a thorough site investigation. The LTMO analysis was not a modeling effort. However, as part of the qualitative evaluation, groundwater potentiometric surface maps, reports and analytical data were reviewed. The memoranda indicate cases where the data reviewed did not mesh with input parameters supplied.

RESPONSE TO MDEQ's COMMENTS ON THE DRAFT LONG-TERM GROUNDWATER MONITORING OPTIMIZATION CLARE WATER SUPPLY SUPERFUND SITE (Continued)

Commenter	Area	Page/Line/Para	Comment	Response
MH PRB Comment 4	PRB General Comment		4) The hydrogeology of the entire site should be looked at as a whole. Isopotential maps should include all parts of the site and should be updated following each monitoring event.	Comment noted.
MH PRB Comment 1	PRB Specific Comment		1) Page 2, pp 1; The document describes the surficial unconfined aquifer as perched water. "Perched" suggests that the aquifer rests above some dry vadose soils. This is not the case. This unconfined portion of the aquifer becomes continuous with the main (deeper) aquifer to the east of the PRB.	Perched aquifers are aquifers that have a relatively low-permeability confining layer (aquiclude) below the groundwater, and sit above the main water table. Information supplied to the authors suggests that the surficial aquifer is perched above a relatively low-permeability till unit in the area of the PRB. Perched water is usually more susceptible to fluctuations caused by seasonal influences. While the perched water may discharge to the main aquifer to the east or to the ditch to the south, in the area of the PRB, the surficial unit is technically perched.
MH PRB Comment 2	PRB Specific Comment		2) Page 2 bullet 1; To the best of my knowledge, monitored natural attenuation (MNA) is not part of the ROD remedy. In this bulleted section, one of the goals should be to effect reliable source control measures.	In order to collect data in support of monitoring objectives, it is good to have monitoring objectives. As there are no explicitly defined monitoring goals for the PRB area, the authors created some. The first bullet includes evaluating the effectiveness of source control measures, which is essential in implementing 'reliable source control measures' as stated in the comment. Under monitoring goals for the PRB, the authors do not mention monitored natural attenuation (MNA) as a remedy strategy. However, the authors do acknowledge the existence of natural attenuation processes. Vinyl chloride is biodegraded aerobically (see reference Note 5), and physical processes such as dilution and dispersion contribute to reduced concentrations downgradient from a source. Collectively, these processes are known as 'natural attenuation', and this is what was meant in

Commenter	Area	Page/Line/Para	Comment	Response
				the statement. Although MNA is not a formal part of the remedy identified in the ROD, in reality it is part of the remedy that is being relied upon because there are VOC concentrations that exceed cleanup goals that are not being treated by the PRB. This should not be ignored, regardless of whether or not MNA is included in the ROD. The combined influence of the PRB and natural attenuation processes limit the extent of groundwater affected with constituents above regulatory limits. The goal of the monitoring program should be to evaluate the extent of groundwater above regulatory screening levels. Later in the report, the authors point out that MNA appears to be a tacit remedy for intermediate and deep groundwater in the PRB area, as the PRB's do not extend to deeper areas of contamination. This comment will be edited, as it is misleading. The authors did not include confirmation of source control as a monitoring objective, as no source of constituents was identified to us. However, the authors would support monitoring of the source area, once it is identified. The ROD (1992) states that "a source removal action was undertaken by one of the PRPs in this area under an order from the MDNR", but it is not clear if this was the source of vinyl chloride in the PRB area. In the future, identification of the source of vinyl chloride and a complete statement of monitoring objectives may be included as part of a Site Conceptual Model.
MH PRB	PRB		3) Page 2, Section 2.1, pp 2; The statement is made that the shallow groundwater direction is south to	Comment noted. The groundwater flow direction was inferred from the measured hydraulic potentials,

Commenter	Area	Page/Line/Para	Comment	Response
Comment 3	Specific Comment		southeast, across the PRB. Simply demonstrating a hydraulic potential across the PRB (4 times per year) is not equivalent to demonstrating flow through the PRB.	which is a typical practice. The authors agree that the flow direction is inferred, and not specifically demonstrated. The text will be revised to better indicate this.
MH PRB Comment 4	PRB Specific Comment		4) Page 2, Section 2.1, pp 4; The document states that the wetlands area directly recharges the aquifer. Is this known or assumed?	The ROD (1992) states "The drainage ditch empties into a small wetlands area which directly recharges the aquifer in the vicinity of the two contaminated wells." Both the ROD and the maps received are not clear in distinguishing the various ditches across the site. The ROD statement was assumed to apply to the ditch south of the PRB which appears to flow to the east. Clarifying the interaction between area surface water and groundwater may be a goal of a site conceptual model.
MH PRB Comment 5	PRB Specific Comment		5) Page 3, Section 2.2, pp 3; The authors state that at the ExCello site, that some impacts" remained in place near DMW1S, 2S, and 3S. This area should be defined and the impacts monitored.	Comment noted.
MH PRB Comment 6	PRB Specific Comment		6) Page 3, Section 2.2, pp 4; I would like to know how much water PRP-1 is pumping and at what rate in a 10^{-7} cm/sec formation. Does PRP-1 even pump water? If the MAROS software(s) used this hydraulic conductivity, then a sensitivity analysis should be performed or pneumatic slug testing of the existing site monitoring wells.	PRP-1 is approximately 400 ft W/SW of the Ex-Cello area. The PRP-1 area was not analyzed as part of the LTMO evaluation, and the authors do not have any details about this well. Hydraulic conductivity in this area may be different from the soil cell as the clay/till unit disappears to the east. For the Ex-Cello/Soil Remedy area, seepage velocity was used as a qualitative metric of the propensity for the groundwater plume to expand. The combination of low groundwater velocity and decreasing to non-detect concentrations indicates the plume does not require an extensive monitoring effort. The authors do recommend further groundwater testing to delineate the groundwater quality north and east of the soil cell as described in

Commenter	Area	Page/Line/Para	Comment	Response
				Section 5.1 of the report.
MH PRB Comment 7	PRB Specific Comment		7) Page 5, Section 3.3; The statement is made that the "Dataset transmitted by Progressive was not complete…". This should be looked into. If the MAROS evaluation can be influenced by data that was omitted, that data should be provided and reevaluated. I would like to know why "data for vinyl chloride and tetrachloroethylene collected prior to 2005 were not included for most wells	This statement will be corrected. The data set for the PRB provides what appears to be a full set of data for PCE, TCE, cDCE and VC. The soil remedy data set does not have results for PCE and VC prior to 2005 for many wells. See Comment 1a on historic data.
MH PRB Comment 8	PRB Specific Comment		8) Page 6, Section 3.3, pp 3; The dynamics of the groundwater flow at the site should be evaluated and should include the entire range of groundwater directions that would result from seasonal variation.	Comment noted.
MH PRB Comment 9	PRB Specific Comment		9) Page 8, pp 3; The last sentence in this bullet indicates that surface water exposure pathway is not a concern. This should be discussed among the agencies. If this result influences the MAROS data evaluation, the site should be reevaluated.	The potential for groundwater to discharge to the ditch is of concern to the authors. The LTMO analysis indicates that the southerly (inferred downgradient) extent of the VOC plume is not well defined.south of the PRBs. Unless additional sample data are available for shallow groundwater and the groundwater/surface water interface, the LTMO evaluation will not change.
MH PRB Comment 10	PRB Specific Comment		10) Page 8, pp 4; The contamination in the intermediate and deeper portions of the aquifer should be defined and monitored.	Comment noted.
MH PRB Comment 11	PRB Specific Comment		11) Page 8, last paragraph; MNA is not part of the ROD remedy.	Comment noted. MNA was not considered as a remedial alternative in the ROD (1992). This will be edited.
MH PRB Comment 12	PRB Specific		12) Page 9, Section 4.2, bullet 3; I have to raise the question of how can one reliably estimate the center of mass if that mass has not been defined and is not monitored?	The center of mass is calculated only for the area covered by the wells. Mass outside of the well network is not considered.

Commenter	Area	Page/Line/Para	Comment	Response
	Comment			
MH PRB Comment 13	PRB Specific Comment		13) Page 10, pp 2; This paragraph describes an order of magnitude change in concentration over the course of the past year yet earlier in this document the authors recommend that this well no longer be monitored due to its redundancy. This would seem to be a valuable well, why would we not monitor it?	The authors state that well MW-305 "is recommended for *retention* in the monitoring program at a semiannual frequency". The initial statistical evaluation found this well to be redundant because, over the length of the monitoring record, the concentration at MW-305 could be estimated from surrounding wells. Statistically, the well was not unique. However, the well was retained in the network after the qualitative evaluation (see Table 6) because of reasons laid out in Table 3. The preliminary frequency analysis indicated that MW-305 should be sampled Quarterly, because of the jump in concentration. However, after the qualitative evaluation the recommendation was made for semi-annual sampling. MW-305 is a good example of why all statistical evaluations should be reviewed qualitatively.
MH PRB Comment 14	PRB Specific Comment		14) Page 10, Section 4.3, bullet 3; Once again, MNA is not part of the ROD remedy.	Comment noted. See response to MH PRB comment 2.
MH PRB Comment 15	Soil Remedy Specific Comment		15) Page 11, pp 3; Before the "risks to receptors" is evaluated, shouldn't we define the limits of the groundwater and soil contamination?	Comment noted. Definition of extent of contamination is typically performed prior to completion of risk analysis.
MH PRB	Soil Remedy		16) Page 11, pp 4; As Parsons points out, the institutional controls should be evaluated in light of where contamination is and can potentially migrate	Comment noted.

Commenter	Area	Page/Line/Para	Comment	Response
Comment 16	Specific Comment		to.	
MH PRB Comment 17	Soil Remedy Specific Comment		17) Page 11, Last paragraph; This paragraph details a data gap in the current monitoring well network. This data gap should be filled with a VAS investigation and an appropriate monitoring well or two.	Comment noted.
MH PRB Comment 18	Soil Remedy Specific Comment		18) Page 12, pp 2; This paragraph correctly reiterates the need for additional characterization and some additional monitoring to demonstrate that the ExCello remedy is working effectively.	Comment noted.
MH PRB Comment 19	Soil Remedy Specific Comment		19) Page 12, pp 4; Hydraulic conductivity measurements in a distribution of site monitoring wells should be measured to resolve this data gap. I suggest pneumatic slug testing as it is fairly inexpensive and easy to perform.	Comment noted.
MH PRB Comment 20	Soil Remedy Specific Comment		20) Page 12, last paragraph; The statement is made that "this TCE detection does not appear to be of concern given the lack of nearby receptors." This should be looked at in light of the 10-year capture zone for the municipal well system, ARAR's, and the availability of adequate institutional controls.	A formal site conceptual model may be a good place to evaluate these issues.
MH PRB Comment 21	Soil Remedy Specific Comment		21) Page 13, pp 1; Perhaps the ExCello remedy needs to be reevaluated. Since water is being pumped from within the enclosure, even after years of operation, it may be that the cap, sidewalls or floor may be leaking. Is it time to sample the soil within the enclosure (I did not see any soil gas probes) to determine if the treatment objectives have been met? How do the soil/groundwater concentrations outside the cell compare to those media within the cell?	The authors do not have access to sampling data within the cell.

Notes:

1. JS = Comment received from John Spielberg MDEQ
2. BV = Comment received from Barbara Vetorts MDEQ.
3. MH = Comment received from Mark Henry.
4. DNAPL References: Kavanaugh et al. (2003) The DNAPL Remediation Challenge: Is there a case for source depletion. USEPA EPA/600/R-03/143.
5. Bradley, P.M. and F.H. Chapelle, Effect of Contaminant Concentration on Aerobic Microbial Mineralization of DCE and VC in Stream-Bed Sediments. Environmental Science and Technology, 1998. **32**(5): p. 553-557.