APPENDIX F

GROUNDWATER MONITORING NETWORK OPTIMIZATION EVALUATION FOR SITE OT-24

WURTSMITH AIR FORCE BASE, MICHIGAN

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SITE OT-24 GROUNDWATER MONITORING NETWORK OPTIMIZATION EVALUATION
WURTSMITH AIR FORCE BASE, MICHIGAN

INTRODUCTION

Groundwater monitoring programs have two primary objectives (U.S. Environmental Protection Agency [USEPA], 1994b; Gibbons, 1994):

1. Evaluate long-term temporal trends in contaminant concentrations at one or more points within or outside of the remediation zone, as a means of monitoring the performance of the remedial measure (*temporal objective*); and

2. Evaluate the extent to which contaminant migration is occurring, particularly if a potential exposure point for a susceptible receptor exists (*spatial objective*).

The relative success of any remediation system and its components (including the monitoring network) must be judged based on the degree to which it achieves the stated objectives of the system. Designing an effective groundwater monitoring program involves locating monitoring points and developing a site-specific strategy for groundwater sampling and analysis so as to maximize the amount of relevant information that can be obtained while minimizing incremental costs. Relevant information is that required to effectively address the temporal and spatial objectives of monitoring. The effectiveness of a monitoring network in achieving these two primary objectives can be evaluated quantitatively using statistical techniques. In addition, there may be other important considerations associated with a particular monitoring network that are most appropriately addressed through a qualitative assessment of the network. The qualitative evaluation may consider such factors as hydrostratigraphy, locations of potential receptor exposure points with respect to a dissolved contaminant plume, and the direction(s) and rate(s) of contaminant migration.

This report presents a description and evaluation of the groundwater monitoring program associated with Site OT-24 at Wurtsmith Air Force Base (AFB), Michigan. The current monitoring program at this site was evaluated to identify potential opportunities to streamline monitoring activities while still maintaining an effective monitoring network. A monitoring network evaluation, consisting of a qualitative evaluation and an evaluation of temporal trends in contaminant concentrations was conducted to assess the degree to which the monitoring network addresses each of the two primary objectives of monitoring, and other important considerations. A spatial statistical analysis, which is typically conducted as part of the monitoring network optimization, was not appropriate for this site due to the inconsistent groundwater flow direction due to pumping, and the limited number of monitoring wells in each zone. The results of the evaluations were combined and used to assess the optimal frequency of monitoring and the spatial distribution of the components of the monitoring network. The results of the analysis were then used to develop recommendations for optimizing the monitoring program at OT-24.

SECTION 2

SITE BACKGROUND INFORMATION

The location, operational history, geology, and hydrogeology of site OT-24 at Wurtsmith AFB are briefly described in the following subsections.

2.1 INSTALLATION AND SITE DESCRIPTIONS

Wurtsmith AFB (WAFB) was closed on 30 June 1993 per the Base Realignment and Closure (BRAC) Act. The property that comprised WAFB is located in the northeastern part of Michigan's lower peninsula, about one mile from Lake Huron in Oscoda County. The facility is bordered to the north and northeast by Van Etten Lake, on the northwest by Au Sable State Forest, on the west and south by forested wetlands, on the southwest by Allen Lake, and on the southeast and east by the Village of Oscoda. The former base covered 5,223 acres, 1,943 of which were owned by the U.S. Air Force. The remainder of the acreage was leased primarily from the state (2,466 acres) or was registered as easement tracts.

Site OT-24 is located in the residential area in the southeast portion of the base, approximately along Mission Drive from Perimeter Road to the former Base boundary, the Three Pipes Drainage Ditch and Au Sable River (Figure 2.1). TCE contamination was discovered in base supply wells in November 1977. Groundwater contaminants are believed to have originated at sites to the north near the flight-line, but these sites are no longer sourcing groundwater contaminants to Site OT-24. Groundwater at the site currently exceeds site-specific alternate cleanup levels for TCE on-base, and Michigan Department of Environmental Quality (MDEQ) residential drinking water clean up criteria for TCE and cis 1,2-DCE off-base. Selected remedies are pump and treat for the northern part of the plume (operated since 1987), and MNA for the southern part of the plume (URS, 2002).

2.2 GEOLOGY AND HYDROGEOLOGY

Information on the geology and hydrogeology of Wurtsmith AFB and Site OT-24 was derived primarily from ICF Technologies, Inc. (ICF) (1996) and US Geological Survey (USGS) (1990).

2.2.1 Geology

Wurtsmith lies on the relatively flat Oscoda Lake plain physiographic district. The plain extends approximately 5 miles from the shores of Lake Huron to a line of 80-foot bluffs west of the former base. The base and surrounding area has relatively flat topography,

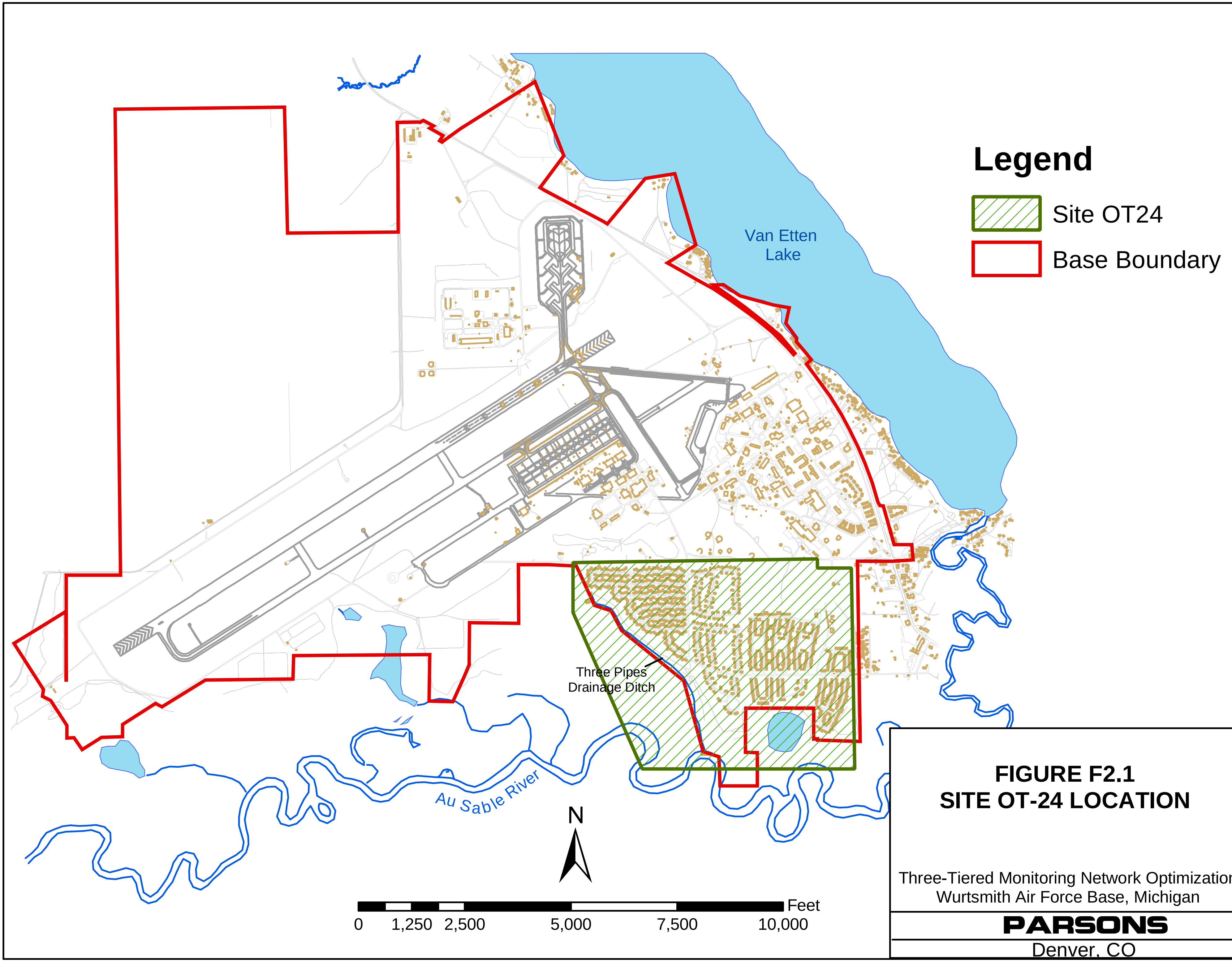

FIGURE F2.1
SITE OT-24 LOCATION

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with the western portion of the base sloping very gently to the southeast. Surface elevations range from approximately 630 feet above msl in the western portions of the base to 538 feet above msl at Van Etten Lake near the eastern boundary of the base.

The geology of the area consists of unconsolidated glacial deposits and underlying bedrock. The bedrock is composed predominately of clastic sedimentary rocks. The unconsolidated sediments are the result of continental glaciation that ended approximately 13,000 years ago. Bedrock beneath in the area consists of Mississippian sandstone and shale formations that have a structural dip to the southwest into the Michigan Basin. The topographic surface of the bedrock dips to the east and depth to bedrock varies from 100 to 250 feet beneath the base. Unconsolidated sediments deposited during glaciation episodes overlie the bedrock. Glacial till and other ice-contact sediments consisting of clay rich sand, gravel, and silt were deposited directly on the bedrock erosional surface (USGS, 1990)

2.2.2 Hydrogeology

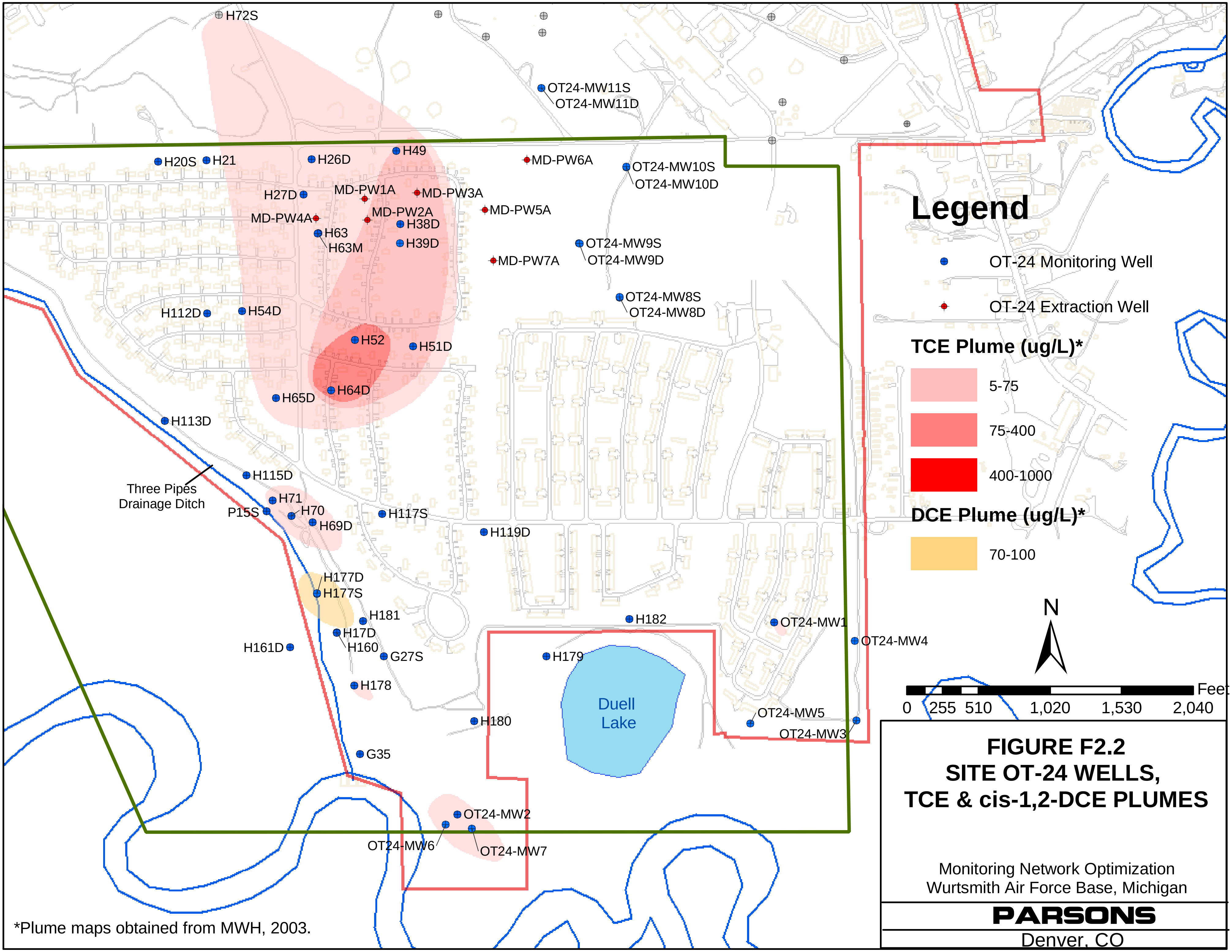
A sand and gravel water-table aquifer is present across the entire area of the base, with an average depth of approximately 65 feet below ground surface and an average saturated thickness of 45 feet. This sand aquifer was once the principal water supply source for WAFB. The aquifer consists of brown to gray, medium- to coarse-grained sand containing some gravel lenses. Most of the sands are moderately well-sorted. Hydraulic conductivity in the upper sand aquifer ranges from 75 to 310 feet per day (USGS, 1986). Hydraulic gradients generally range from 0.002 to 0.005 ft per ft, and groundwater velocities generally range between 0.3 and 0.8 ft/day, but in some locations are as high as 5 ft/day.

A groundwater divide runs diagonally across the base from northwest to southeast with water south of the divide flowing toward the Au Sable River and groundwater north of the divide flowing easterly toward Van Etten Lake. Site OT-24 is south of the divide, and groundwater discharges to Three-Pipes Ditch or the Au Sable River. The sand and gravel water-table aquifer is underlain by a thick confining layer of silty-clay. The silty-clay aquitard is up to 250 feet thick and effectively isolates the sand and gravel water-table aquifer and restricts vertical migration of groundwater contaminants between the sand and gravel aquifer and deeper hydrogeologic units. Hydrogeologic units below the silty-clay aquitard have been found undesirable as a public water supply because of high dissolved solids or high chloride concentrations.

2.3 NATURE AND EXTENT OF CONTAMINATION

The VOCs of concern in groundwater beneath OT-24 are trichloroethene (TCE) and cis 1,2-dichloroethene (cis 1,2-DCE). TCE exceeds the Alternate Cleanup Criteria (94 μg/l) on base, and both TCE and cis 1,2-DCE exceed the MDEQ residential drinking water cleanup criteria in off-base monitoring wells.

Figure 2.2 shows the site OT-24 TCE and cis-1,2-DCE plumes (MWH, 2003) as well as the monitoring and extraction wells. The Mission Drive TCE plume has reduced in size and concentration since its discovery in 1977. Wells in the vicinity of the presumed source at Site SS08 no longer indicate a continuing source of contamination. Higher levels of TCE remain in the vicinity of Mission Drive. TCE concentrations currently range about



*Plume maps obtained from MWH, 2003.

FIGURE F2.2
SITE OT-24 WELLS,
TCE & cis-1,2-DCE PLUMES

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20-124 μg/l east of Mission Drive in the vicinity of pumping wells MD-PW1A and MD-PW3A, and concentrations in this area have been decreasing steadily since the pumping system was optimized in 2001. South of the capture zone, TCE concentrations have remained relatively steady since 1994, and have been measured as high as 980 μg/l in 2002 (530 μg/l in 2003) in monitoring well H52D (MWH, 2002c). Groundwater in this southern lobe the plume is subject to very small hydraulic gradients. Lower levels of TCE exist north of Perimeter Road and west of Mission Drive (5-20 μg/l). These lower concentrations of TCE appear to be the trailing edge of the plume that originated from SS08, but the plume in this area is not well-defined and it's extent is estimated from measurements in single well (H72S).

TCE exists in isolated monitoring wells to the south and east of the Mission Drive plume; concentrations along Three-Pipes drainage ditch in 2002 were as high as 47 μg/l on-base and 9 μg/l off-base (MWH, 2003c). To the west of the Mission Drive plume (near the Oil-Water Separator), TCE was detected in geoprobe groundwater samples as high as 130 μg/l at isolated elevations in 2003 (confirming earlier detections in this area). TCE concentrations along Three-Pipes drainage ditch have decreased by an order of magnitude over the past four years, most likely due to groundwater-surface water interaction and decreased source flux from upgradient. TCE has been detected up to 11 μg/l in Three-Pipes drainage ditch surface water, apparently caused by groundwater discharge to the ditch (TolTest, 2003j). Concentrations off-base southwest of Duell Lake were as high as 39 μg/l. Although the TCE concentrations do exceed MDEQ residential drinking water criteria, all of these groundwater concentrations were below the MDEQ Groundwater/Surface-water Interaction criteria of 200 μg/l.

The presence of cis 1,2-DCE indicates anaerobic degradation of TCE. DCE does not cover as wide an area as does TCE at Site OT-24, and the extent and concentrations of DCE have generally been decreasing across the entire site since 1994. There are some relatively high concentrations (>200 μg/l in 2002) in well H177S at the toe of the Mission Drive plume adjacent to Three-Pipes Drainage Ditch. This concentration decreased to 1 μg/l in 2003, but DCE concentration downgradient in H178D increased from non-detect to 150 μg/l over the same time period. Well OT-24-MW11 (on-base, northeast of the Mission Drive Plume and south of SS06) had DCE concentrations >100 μg/l in 2002 which declined to 55 μg/l in 2003, and MDPTS pumping wells MD-PW5A and MD-PW6A have recovered DCE at concentrations >40 μg/l since June 2001. The on-base ACL for cis 1,2-DCE is 232 μg/l, and the MDEQ residential drinking water cleanup criteria (applicable off-base) is 70 μg/l.

SECTION 3

REMEDIAL ACTION-OPERATIONS (RA-O) MONITORING PROGRAM AT OT-24

The current groundwater monitoring program at site OT-24 was examined to identify potential opportunities for streamlining monitoring activities while still maintaining an effective performance and compliance monitoring program. The current monitoring program at site OT-24 is reviewed in the following subsections.

3.1 DESCRIPTION OF MONITORING PROGRAM

The monitoring program at Site OT-24 is still evolving. There were 53 existing monitoring wells at Site OT-24 in 2003, and 38 of those wells are scheduled for annual sampling of VOCs. The earliest any of these wells was sampled was in 1993, but many were installed after 2000. Additional wells were installed in 2003, particularly to the northern part of the plume, and to the western part of the site. The wells are screened three different zones to monitor the vertical distribution of contamination. Of the 38 wells currently sampled, 17 wells are designated as "shallow", one well (H63M) is designated as intermediate, and the remaining 20 wells are designated as "deep" wells. Figure 3.1 shows the 38 wells that are currently monitored on an annual basis, the seven extraction wells, and the 2003 TCE and DCE concentrations for each of the wells in the current monitoring program. The wells in the current monitoring program, their sampling frequency, zone, and date first sampled are listed in Table 3.1. The wells are sampled for VOCs using method SW-846 8260B.

3.2 SUMMARY OF ANALYTICAL DATA

The groundwater monitoring program at OT-24 was evaluated using results for the 38 wells in the current sampling program during sampling events performed from December 1993 through July 2003. Historical data spanning the complete monitoring history does not exist for all wells, because several wells were installed after wells were installed after 1995. The first monitoring event results available for each well are listed in Table 3.1. Data was obtained from the Wurtsmith AFB Spatial Management System through a custom-built site OT-24 query.

Table 3.2 presents a summary of the occurrence of the two primary COCs in groundwater based on the data collected from the 38 current monitoring wells from December 1993 through July 2003. As indicated in this table, TCE is the COC detected most frequently and at the greatest concentrations in groundwater OT-24. TCE has been detected in 64 percent of samples, and has exceeded the MDEQ residential drinking water clean up criteria of 5 μg/L in approximately 23 percent of the samples. TCE has been

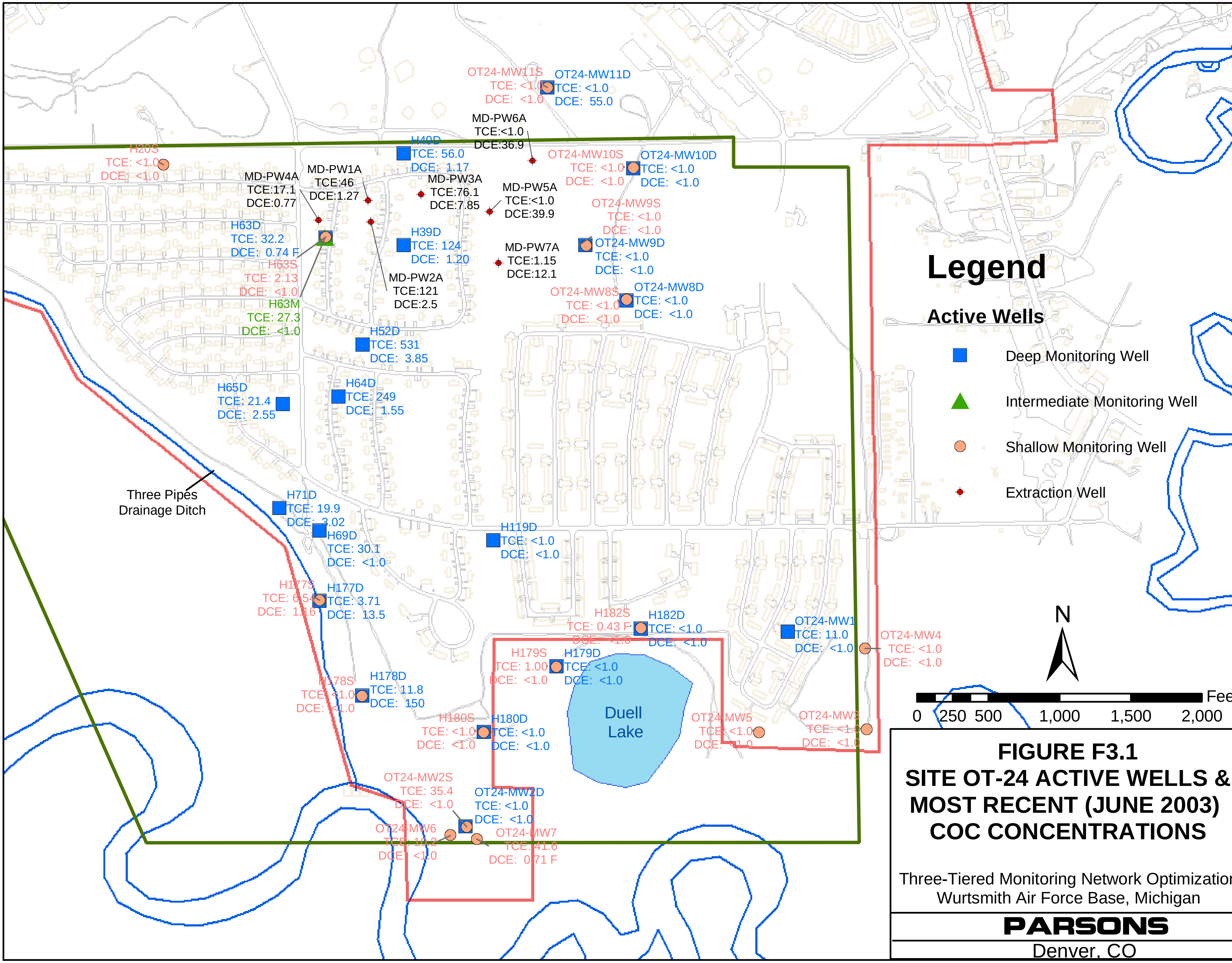

FIGURE F3.1
SITE OT-24 ACTIVE WELLS & MOST RECENT (JUNE 2003) COC CONCENTRATIONS

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TABLE 3.1
CURRENT GROUNDWATER MONITORING PROGRAM
MONITORING NETWORK OPTIMIZATION
SITE OT-24
WURTSMITH AFB, MICHIGAN

Well ID	Vertical Zone	Sampling Frequency [a/]	First Sampling Event
Monitoring Wells			
H119D	DEEP	Annual	11/2/2000
H177D	DEEP	Annual	10/16/2000
H177S	SHALLOW	Annual	10/16/2000
H178D	DEEP	Annual	10/16/2000
H178S	SHALLOW	Annual	10/16/2000
H179D	DEEP	Annual	5/19/1995
H179S	SHALLOW	Annual	5/19/1995
H180D	DEEP	Annual	5/19/1995
H180S	SHALLOW	Annual	5/19/1995
H182D	DEEP	Annual	12/1/1993
H182S	SHALLOW	Annual	12/1/1993
H20S	SHALLOW	Annual	10/31/2000
H39D	DEEP	Annual	8/21/2001
H49D	DEEP	Annual	5/22/1995
H52D	DEEP	Annual	5/18/1995
H63D	DEEP	Annual	10/18/2000
H63M	INTERMEDIATE	Annual	8/8/2001
H63S	SHALLOW	Annual	4/3/1997
H64D	DEEP	Annual	11/24/1997
H65D	DEEP	Annual	8/13/2001
H69D	DEEP	Annual	10/19/2000
H71D	DEEP	Annual	12/1/1993
OT24-MW1	DEEP	Annual	5/22/1995
OT24-MW10D	DEEP	Annual	2/5/2002
OT24-MW10S	SHALLOW	Annual	2/5/2002
OT24-MW11D	DEEP	Annual	7/1/2002
OT24-MW11S	SHALLOW	Annual	7/1/2002
OT24-MW2D	DEEP	Annual	5/24/1995
OT24-MW2S	SHALLOW	Annual	5/24/1995
OT24-MW3	SHALLOW	Annual	1/30/2002
OT24-MW4	SHALLOW	Annual	1/29/2002
OT24-MW5	SHALLOW	Annual	1/29/2002
OT24-MW6	SHALLOW	Annual	2/4/2002
OT24-MW7	SHALLOW	Annual	2/4/2002
OT24-MW8D	DEEP	Annual	2/5/2002
OT24-MW8S	SHALLOW	Annual	2/5/2002
OT24-MW9D	DEEP	Annual	2/5/2002
OT24-MW9S	SHALLOW	Annual	2/5/2002
Extraction Wells			
MD-PW1A	Not Applicable	Annual	11/2/2000
MD-PW2A	Not Applicable	Annual	11/3/2000
MD-PW3A	Not Applicable	Annual	11/3/2000

TABLE 3.1 (Continued)
CURRENT GROUNDWATER MONITORING PROGRAM
MONITORING NETWORK OPTIMIZATION
SITE OT-24
WURTSMITH AFB, MICHIGAN

Well ID	Vertical Zone	Sampling Frequency [a/]	First Sampling Event
MD-PW4A	Not Applicable	Annual	11/6/2000
MD-PW5A	Not Applicable	Annual	11/6/2000
MD-PW6A	Not Applicable	Annual	11/7/2000
MD-PW7A	Not Applicable	Annual	11/7/2000

[a/] Based on Sampling and Analysis Plan for Basewide Remedial Action-Opera

TABLE 3.2
SUMMARY OF OCCURRENCE OF GROUNDWATER CONTAMINANTS OF CONCERN
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Parameter	Total Samples[a/]	Number of Detects	Percentage of Detects	Range of Detects (µg/L)[b/]	MDEQ[c/] (µg/L)	Percentage of Samples with MCL Exceedances	Number of Wells with Results	Number of Wells with Detections
TCE	161	103	64.0%	0.16 - 1493	5	49.07%	38	23
cis-1,2-DCE	140	46	32.9%	0.12 - 510	70	7.86%	38	15

[a/] Analytical data analyzed includes sampling results from December 1993 through July 2003.

[b/] µg/L = micrograms per liter.

[c/] MDEQ = Michigan Department of Environmental Quality residential drinking water clean up criteria.

detected in 23 of the 38 wells in the monitoring program, and has exceeded the MDEQ residential drinking water clean up criteria in 17 of these wells. *cis*-1,2-DCE is the second-most prevalent compound, and has been detected in 33 percent of the collected samples. Detected concentrations of *cis*-1,2-DCE have exceeded the MDEQ residential drinking water clean up criteria of 70 µg/L in approximately 8 percent of samples. TCE and cis-1,2-DCE are used to evaluate the network in both the qualitative and temporal evaluations.

SECTION 4

QUALITATIVE MNO EVALUATION

An effective groundwater monitoring program will provide information regarding contaminant plume migration and changes in chemical concentrations through time at appropriate locations, enabling decision-makers to verify that contaminants are not endangering potential receptors, and that remediation is occurring at rates sufficient to achieve RAOs within a reasonable time frame. The design of the monitoring program should therefore include consideration of existing receptor exposure pathways, as well as exposure pathways arising from potential future use of the groundwater.

Performance monitoring wells located upgradient, within, and immediately downgradient from a plume provide a means of evaluating the effectiveness of a groundwater remedy relative to performance criteria. RA-O monitoring of these wells also provides information about migration of the plume and temporal trends in chemical concentrations. Groundwater monitoring wells located downgradient from the leading edge of a plume (i.e., sentry wells) are used to evaluate possible changes in the extent of the plume and, if warranted, to trigger a contingency response action if contaminants are detected.

Primary factors to consider when developing a groundwater monitoring program include at a minimum:

- Aquifer heterogeneity,
- Types of contaminants,
- Distance to potential receptor exposure points,
- Groundwater seepage velocity,
- Potential surface-water impacts, and
- The effects of the remediation system.

These factors will influence the locations and spacing of monitoring points and the sampling frequency. Typically, the greater the seepage velocity and the shorter the distance to receptor exposure points, the more frequently groundwater sampling should be conducted.

One of the most important purposes of RA-O monitoring is to confirm that the contaminant plume is behaving as predicted. Graphical and statistical tests can be used to evaluate plume stability. If a groundwater remediation system or strategy is effective, then over the long term, groundwater-monitoring data should demonstrate a clear and meaningful decreasing trend in concentrations at appropriate monitoring points. The current groundwater monitoring program at Wurtsmith AFB Site OT-24 was evaluated to identify potential optimization opportunities.

4.1 METHODOLOGY FOR QUALITATIVE EVALUATION OF MONITORING NETWORK

The MNO evaluation of the groundwater RA-O monitoring program at site OT-24 considered information for 38 monitoring wells and seven extraction wells that currently are included in the monitoring program. These wells, their respective monitoring zones, and their current monitoring frequency are listed in Table 3.1, and their locations are depicted on Figure 3.1.

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 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. Typical factors considered in developing recommendations to retain a well in, or remove a well from, the monitoring program are summarized in Table 4.1. Typical factors considered in developing recommendations for monitoring frequency are summarized in Table 4.2.

4.2 RESULTS OF QUALITATIVE MNO EVALUATION

The results of the qualitative evaluation of the 38 monitoring wells currently included in the RA-O monitoring program at site OT-24 is summarized in Table 4.3, and described in the following subsections. The table includes recommendations for retaining or deleting each existing monitoring well, and for changing the sampling frequency, and lists the rationale for the recommendations.

4.2.1 Monitoring Network and Sampling Frequency

As described in Section 3.1, a total of 38 monitoring wells at Site OT-24 are currently sampled annually. As detailed in Table 4.3, the recommended monitoring program includes annual sampling of 24 monitoring wells and quarterly sampling of three extraction wells. The recommended monitoring program is based on the results of sampling data from sampling events performed from 1993 to July 2003.

The monitoring results for OT-24 indicates that contaminants of concern exist in deeper portions of the aquifer (D wells) for most of the plume, but appear to move to the shallow zones (S wells) along the southern portions of Three-Pipes Drainage ditch (from monitoring well H177S south) and near Duell Lake (H179S). Shallower wells in the northern parts of the site (H63S, H63M, OT-24-MW8S, OT-24-MW9S, OT-24-MW10S,

TABLE 4.1
MONITORING NETWORK OPTIMIZATION DECISION LOGIC
MONITORING NETWORK OPTIMIZATION
SITE OT-24
WURTSMITH AFB, MICHIGAN

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 2 years
Well is needed to monitor water quality at compliance point or receptor exposure point (e.g., domestic 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)

TABLE 4.2
MONITORING FREQUENCY DECISION LOGIC
MONITORING NETWORK OPTIMIZATION
SITE OT-24
WURTSMITH AFB, MICHIGAN

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
Well is close to source area or operating remedial system	Well is distal from source area or remedial system
Cannot predict if concentrations will change significantly over time	Concentrations are not expected to change significantly over time, or contaminant levels have been below groundwater cleanup objectives for some prescribed period of time

TABLE 4.3

QUALITATIVE EVALUATION OF GROUNDWATER MONITORING NETWORK
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	Current Sampling Frequency[a/]	Qualitative Analysis			Rationale
		Remove	Retain	Monitoring Frequency Recommendation	
In Mission Drive Pumping System Capture Zone					
H20S	Annual	✓			Upgradient of plume, COCs consistently non-detect or very low
H39D	Annual		✓	Annual	Monitor changes in COCs as result of pump and treat system
H49D	Annual		✓	Annual	Monitor changes in COCs as result of pump and treat system
H63D	Annual		✓	Annual	Monitor changes in COCs as result of pump and treat system
H63M	Annual	✓			COCs are primarily in deeper zone, monitored by H63D
H63S	Annual	✓			COCs are primarily in deeper zone, monitored by H63D
South of Mission Drive Pumping System Capture Zone and North of Three-Pipes Drainage Ditch					
H52D	Annual		✓	Annual	High levels of COCs, outside capture zone.
H64D	Annual		✓	Annual	High levels of COCs, outside capture zone.
H65D	Annual		✓	Annual	High levels of COCs, outside capture zone.
Along Three-Pipes Drainage Ditch					
H69D	Annual	✓			Spatially redundant to H71D (H71D has longer monitoring history)
H71D	Annual		✓	Annual	Monitor changes in COCs along Three-Pipes Drainage Ditch
H177D	Annual		✓	Annual	Monitor changes in COCs along Three-Pipes Drainage Ditch
H177S	Annual		✓	Annual	Monitor changes in COCs along Three-Pipes Drainage Ditch
H178D	Annual		✓	Annual	Monitor changes in COCs along Three-Pipes Drainage Ditch
H178S	Annual		✓	Annual	Monitor changes in COCs along Three-Pipes Drainage Ditch
Southeast Portion of Site and Near Duell Lake					
H119D	Annual		✓	Annual	COCs consistently non-detect or very low, but useful for lateral definition of plume.
H179D	Annual	✓			COCs consistently non-detect or very low. Location monitored with H179S.
H179S	Annual		✓	Annual	Monitor changes in COCs near Duell Lake
H180D	Annual		✓	Annual	Compliance point
H180S	Annual		✓	Annual	Compliance point
H182D	Annual		✓	Annual	Compliance point
H182S	Annual		✓	Annual	Compliance point
OT24-MW1	Annual		✓	Annual	Monitor changes in COCs in the southeast quadrant of the site.
OT24-MW2D	Annual	✓			COCs consistently non-detect or very low. Location monitored with OT24-MW2S.
OT24-MW2S	Annual		✓	Annual	Monitor changes in COCs near Au Sable River
OT24-MW3	Annual		✓	Annual	Compliance point
OT24-MW4	Annual		✓	Annual	Compliance point
OT24-MW5	Annual		✓	Annual	Compliance point
OT24-MW6	Annual	✓			Location monitored by OT24-MW2S (that well has longer monitoring history)
OT24-MW7	Annual	✓			Location monitored by OT24-MW2S (that well has longer monitoring history)
East of Capture Zone or in Benzene Plant Capture Zone					
OT24-MW8D	Annual	✓			COCs consistently non-detect or very low. COCs escaping north of capture zone would be detected in OT24-MW10D
OT24-MW8S	Annual	✓			COCs consistently non-detect or very low. COCs escaping north of capture zone would be detected in OT24-MW10D
OT24-MW9D	Annual	✓			COCs consistently non-detect or very low. COCs escaping north of capture zone would be detected in OT24-MW10D
OT24-MW9S	Annual	✓			COCs consistently non-detect or very low. COCs escaping north of capture zone would be detected in OT24-MW10D
OT24-MW10D	Annual		✓	Annual	COCs consistently non-detect or very low, but contaminants escaping north of capture zone would be first detected by this well
OT24-MW10S	Annual	✓			COCs consistently non-detect or very low. Any COCs would more likely be in deeper well OT24-MW10D
OT24-MW11D	Annual		✓	Annual	Monitors potential migration of COCs from pumping area to the north.

TABLE 4.3 (Continued)

QUALITATIVE EVALUATION OF GROUNDWATER MONITORING NETWORK
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	Current Sampling Frequency[a/]	Qualitative Analysis			Rationale
		Remove	Retain	Monitoring Frequency Recommendation	
OT24-MW11S	Annual	✓			COCs consistently non-detect or very low. COCs are in deeper well OT24-MW11D.
Extraction Wells					
MD-PW1A	Annual		✓	Quarterly	Purpose of well is mass removal. More frequent monitoring should help future pumping optimization.
MD-PW2A	Annual		✓	Quarterly	Purpose of well is mass removal. More frequent monitoring should help future pumping optimization.
MD-PW3A	Annual		✓	Quarterly	Purpose of well is mass removal. More frequent monitoring should help future pumping optimization.
MD-PW4A	Annual	✓			Well removes very little COC mass. Discontinue pumping and monitoring.
MD-PW5A	Annual	✓			Well removes DCE, but concentrations are below clean up level. Discontinue pumping and monitoring.
MD-PW6A	Annual	✓			Well removes DCE, but concentrations are below clean up level. Discontinue pumping and monitoring.
MD-PW7A	Annual	✓			Well removes very little COC mass. Discontinue pumping and monitoring.

[a/] Based on Sampling and Analysis Plan for Basewide Remedial Action-Operation (TolTest, 2003) and OT-24-MW11S) were recommended to be removed from the annual monitoring system because sampling results from deeper wells will govern the time-to-cleanup. Similarly, some deeper wells in the southern portion of the site (H179D and OT-24-MW2D) were recommended for removal for similar reasons.

A few wells appeared to be spatially redundant. In those cases, we recommended that the well with the longest sampling history be retained. Monitoring well H69D was recommended for elimination in favor of H71D, and wells OT-24-MW6 and OT-24-MW7 were recommended for elimination in favor of OT-24-MW2S. Monitoring wells OT-24-MW8D, OT-24-MW9D, and OT-24-MW10D have not detected any contaminants after three rounds of sampling. These wells appeared to be designed to detect any contaminants escaping south and east from between the capture zones of the Mission Drive and Benzene Plant treatment systems. Any contaminants migrating in this direction should be detected first by OT-24-MW10D, so OT-24-MW8 and OT-24-MW9 were recommended for elimination from the annual sampling program. Well H20S appears to be up-gradient of the plume and has been consistently clean, so it was also recommended for elimination from the sampling program.

The seven extraction wells are experiencing very different mass recovery. Wells MD-PW4A and MD-PW7A are recovering very little contaminants. Wells MD-PW5A and MD-PW6A have been recovering cis 1,2-DCE, but concentrations in monitoring wells are already below on-site clean-up criteria. Virtually all of the TCE mass removal is accomplished by MD-PW1A, MD-PW2A, and MD-PW3A, and groundwater in this area is rapidly approaching clean up criteria. A reasonable course of action for this pumping system is that the first three wells continue pumping, but wells MD-PW4A – PW7A be removed from the extraction system and new extraction wells be installed further south to extend the capture zone into the remaining high TCE concentrations. Since groundwater is approaching TCE clean-up criteria in the northern part of the plume, more frequent (quarterly) VOC analysis of the first three extraction wells would be useful for future pumping optimization.

4.2.2 Laboratory Analytical Program

COCs in groundwater at Site OT-24 have been well-defined by the annual monitoring performed to date. The target analyte list for VOCs was reduced to a base-specific short-list of COCs (23 analytes) for the 2003 sampling round, which should have also reduced analytical costs. While this shortened target analyte list is appropriate for the former base as whole, it is still much larger than the two VOCs (TCE and cis 1,2-DCE) that are COCs for Site OT-24. In addition, the cost for analysis of a short-list of VOCs in groundwater using Method SW8021B (a gas-chromatographic [GC] method) should be investigated for comparison to the cost for the current method (SW8260B) if this has not already been performed. If the cost for this alternate analytical method is lower than that of SW8260B, the ability of the subcontract laboratory to confidently identify the target analytes and determine their concentrations using this method should be assessed.

4.2.3 RA-O Monitoring Program Flexibility

The RA-O monitoring program recommendations made in Sections 4.2.1 are based on available data regarding current (and expected future) site conditions. Changing site conditions could affect plume behavior. Therefore, the RA-O monitoring program should be reviewed if hydraulic or geochemical conditions change significantly (especially changes to existing pumping strategies at the Mission Drive and Benzene Plant extraction systems), and revised as necessary to adequately track changes in plume magnitude and extent over time. Groundwater sampling events should be accompanied by complete water-level measurement rounds in all intact wells at OT-24 to facilitate evaluation of groundwater flow directions over time.

SECTION 5

TEMPORAL STATISTICAL EVALUATION

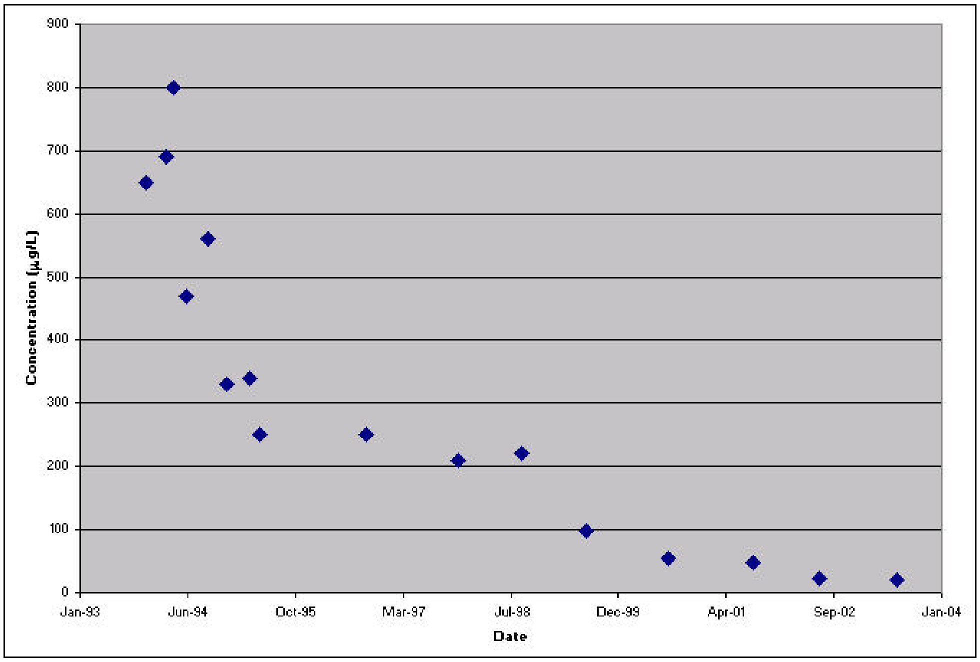
Temporal data (chemical concentrations measured at different points in time) can be examined graphically, or using statistical tests, to evaluate dissolved-contaminant plume stability. If removal of chemical mass is occurring in the subsurface as a consequence of attenuation processes or operation of a remediation system, mass removal will be apparent as a decrease in chemical concentrations through time at a particular sampling location, as a decrease in chemical concentrations with increasing distance from chemical source areas, and/or as a change in the suite of chemicals through time or with increasing migration distance.

5.1 METHODOLOGY FOR TEMPORAL TREND ANALYSIS OF CONTAMINANT CONCENTRATIONS

Temporal chemical-concentration data can be evaluated by plotting contaminant concentrations through time for individual monitoring wells (Figure 5.1), or by plotting contaminant concentrations versus downgradient distance from the contaminant source for several wells along the groundwater flowpath, over several monitoring events. Plotting temporal concentration data is recommended for any analysis of plume stability (Wiedemeier and Haas, 2000); however, visual identification of trends in plotted data may be a subjective process, particularly if (as is likely) the concentration data do not exhibit a uniform trend, but are variable through time (Figure 5.2).

The possibility of arriving at incorrect conclusions regarding plume stability on the basis of visual examination of temporal concentration data can be reduced by examining temporal trends in chemical concentrations using various statistical procedures, including regression analyses and the Mann-Kendall test for trends. The Mann-Kendall nonparametric test (Gibbons, 1994) is well-suited for evaluation of environmental data because the sample size can be small (as few as four data points), no assumptions are made regarding the underlying statistical distribution of the data, and the test can be adapted to account for seasonal variations in the data. The Mann-Kendall test statistic can be calculated at a specified level of confidence (in this analysis a confidence level of 90% is used) to evaluate whether a temporal trend is exhibited by contaminant concentrations detected through time in samples from an individual well. If a trend is identified, a nonparametric slope of the trend line (change in concentration per unit time) also can be estimated using the test procedure. A negative slope (indicating decreasing contaminant concentrations through time) or a positive slope (increasing concentrations through time) provides statistical confirmation of temporal trends that may have been identified visually from plotted data (Figure 5.2).

FIGURE 5.1
TCE CONCENTRATIONS THROUGH TIME
AT WELL H71D
MONITORING NETWORK OPTIMIZATION
SITE OT-24
WURTSMITH AFB, MICHIGAN



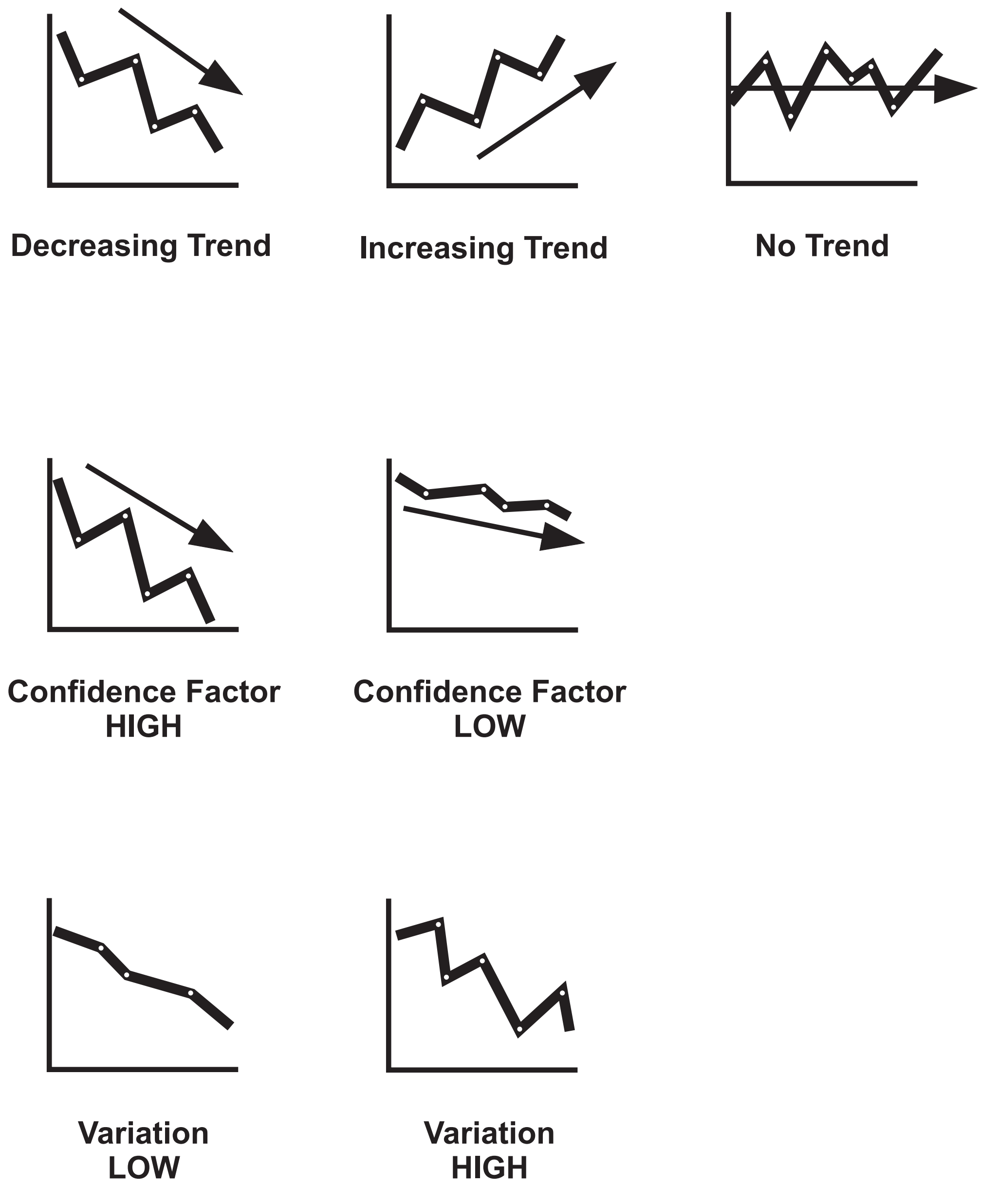


FIGURE 5.2

CONCEPTUAL REPRESENTATION OF TEMPORAL TRENDS AND TEMPORAL VARIATIONS IN CONCENTRATIONS

Three-Tiered Monitoring Network Optimization
Wurtsmith AFB, Michigan

The relative value of information obtained from periodic monitoring at a particular monitoring well can be evaluated by considering the location of the well with respect to the dissolved contaminant plume and potential receptor exposure points, and the presence or absence of temporal trends in contaminant concentrations in samples collected from the well. The degree to which the amount and quality of information that can be obtained at a particular monitoring point serve the two primary (i.e., temporal and spatial) objectives of monitoring must be considered in this evaluation. For example, the continued non-detection of a target contaminant in groundwater at a particular monitoring location provides no information about temporal trends in contaminant concentrations at that location, or about the extent to which contaminant migration is occurring, unless the monitoring location lies along a groundwater flowpath between a contaminant source and a potential receptor exposure point (e.g., downgradient of a known contaminant plume). Therefore, a monitoring well having a history of contaminant concentrations below detection limits may be providing little or no useful information, depending on its location.

A trend of increasing contaminant concentrations in groundwater at a location between a contaminant source and a potential receptor exposure point may represent information critical in evaluating whether contaminants are migrating to the exposure point, thereby completing an exposure pathway. Identification of a trend of decreasing contaminant concentrations at the same location may be useful in evaluating decreases in the areal extent of dissolved contaminants, but does not represent information that is critical to the protection of a potential receptor. Similarly, a trend of decreasing contaminant concentrations in groundwater near a contaminant source may represent important information regarding the progress of remediation near, and downgradient from the source.. By contrast, the absence of a statistically significant (as defined by the Mann-Kendall test with a 90% confidence level) temporal trend in contaminant concentrations at a particular location within or downgradient from a plume indicates that virtually no additional information can be obtained by frequent monitoring of groundwater at that location, in that the results of continued monitoring through time are likely to fall within the historic range of concentrations that have already been detected (Figure 5.3). Continued monitoring at locations where no temporal trend in contaminant concentrations is present serves merely to confirm the results of previous monitoring activities at that location.

The temporal trends and relative location of wells can be weighed to determine if a well should be retained, excluded, or continue in the program with reduced sampling. Figure 5.4 presents a flowchart demonstrating the methodology for utilizing trend results to draw these conclusions.

5.2 TEMPORAL EVALUATION RESULTS

The analytical data for groundwater samples collected from the 38 monitoring wells and seven extraction wells in OT-24 were examined for temporal trends using the Mann-Kendall test. The objective of the evaluation was to identify those wells having increasing or decreasing concentration trends for each COC, and to consider the quality of information represented by the existence or absence of concentration trends in terms of the location of each monitoring point. Increasing or decreasing trends are those identified as with positive or negative slopes, respectively, by the Mann-Kendall trend analysis with a confidence level of 90%.

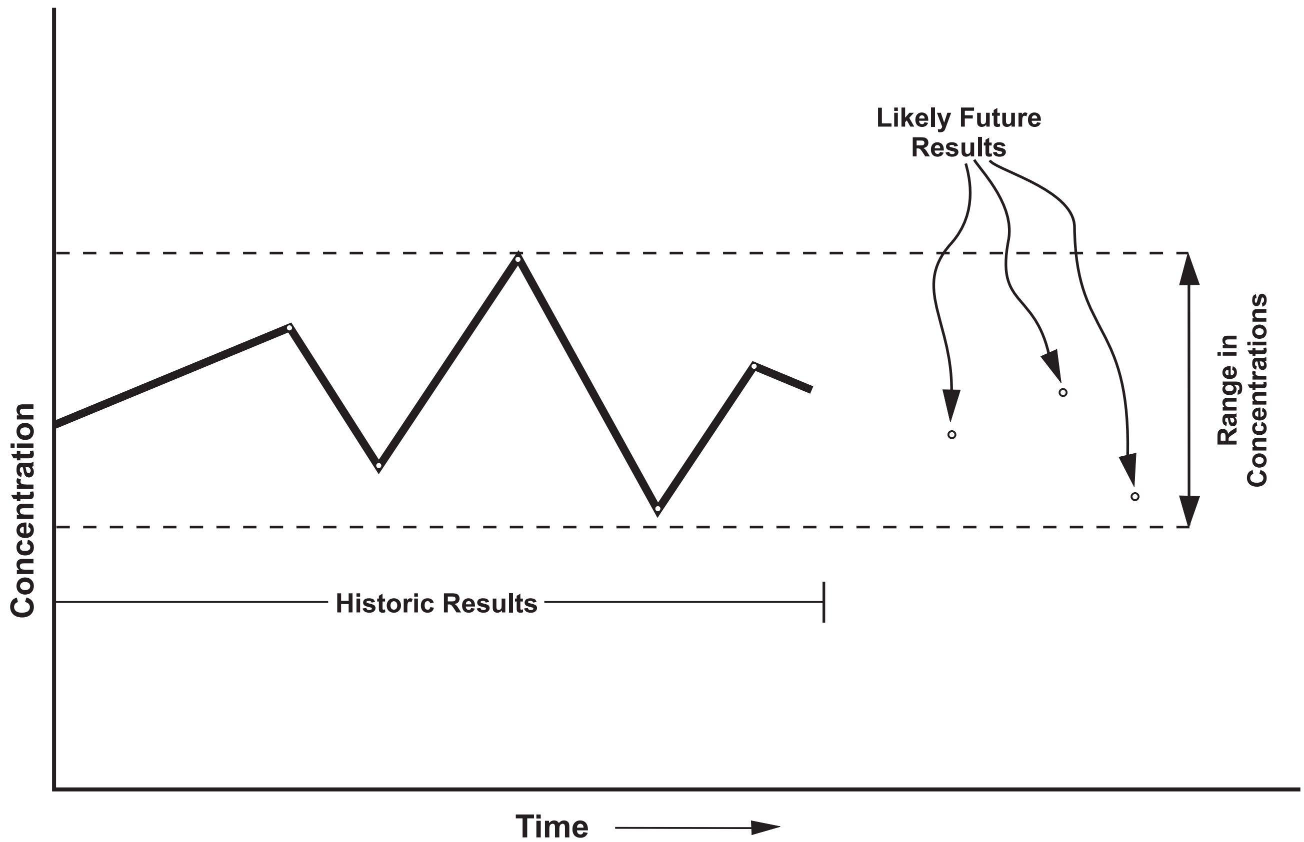


FIGURE 5.3

CONCEPTUAL REPRESENTATION OF CONTINUED MONITORING AT LOCATION WHERE NO TEMPORAL TREND IN CONCENTRATIONS IS PRESENT

Three-Tiered Monitoring Network Optimization
Wurtsmith AFB, Michigan

draw\739732\diffusion\williamsA.cdr pg2 nap 4/3/02

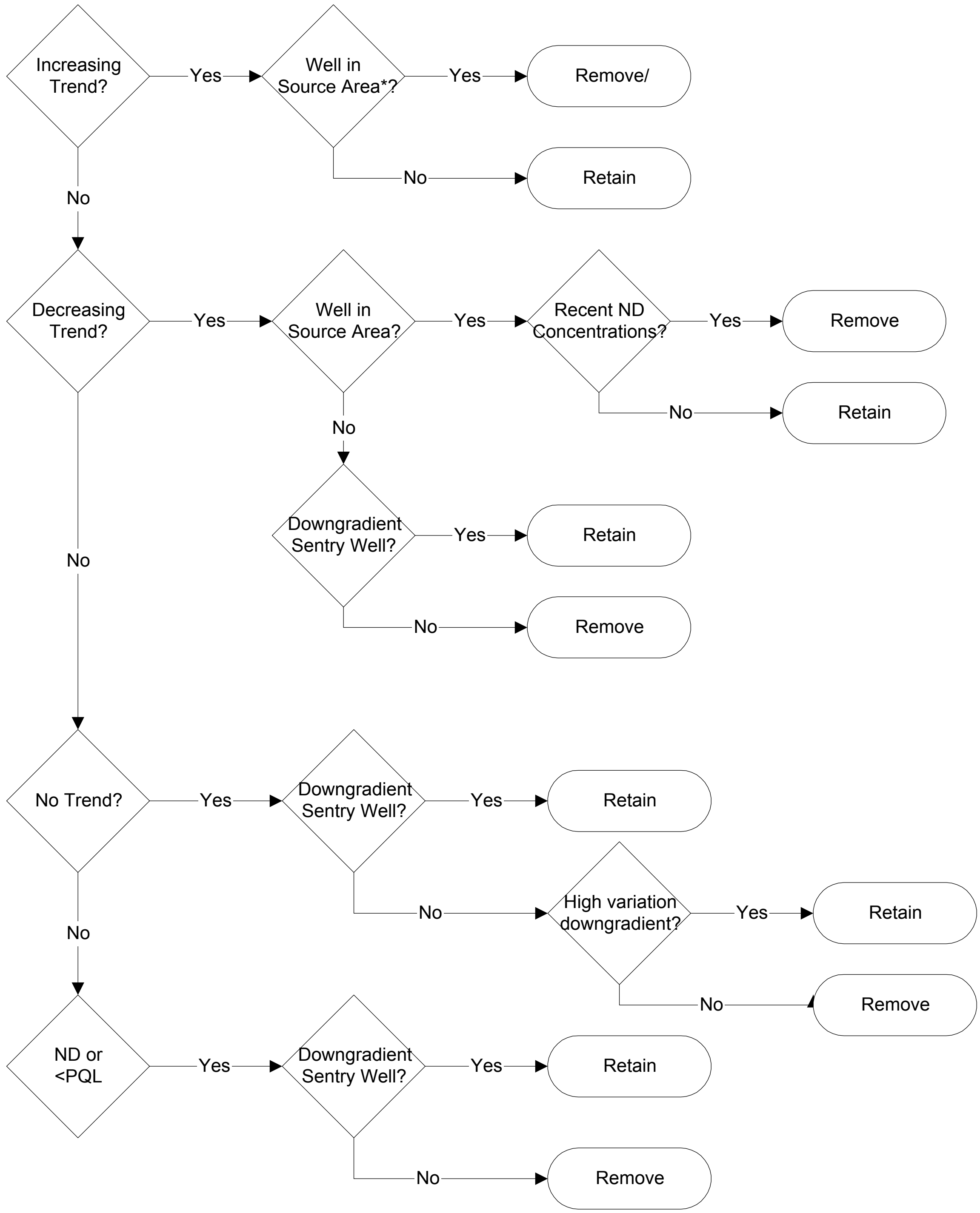


FIGURE 5.4
TEMPORAL TREND DECISION RATIONALE FLOW CHART

Monitoring Network Optimization
Wurtsmith AFB, Michigan

PARSONS
Denver, Colorado

Summary results of Mann-Kendall temporal trend analyses for COCs in groundwater samples from wells in the OT-24 area are presented in Table 5.1. As implemented, the algorithm used to evaluate concentration trends assigned a value of "ND" (not detected) to those wells with sampling results that were consistently below analytical detection limits through time, rather than assigning a surrogate value corresponding to the detection limit – a procedure that could generate potentially misleading and anomalous "trends" in concentrations. In addition, a value of "<PQL" was assigned to those constituents for which no values were measured above the practical quantitation limit. For example, TCE results for groundwater samples from well H178S includes one trace detections that was less than the PQLs (0.69 µg/L on 8/22/01), and three measurements in which TCE was not detected during the remaining sampling events. In the absence of the "<PQL" classification category, the results of trend analysis would indicate no trend for TCE in these samples, which is primarily an artifact of the analytical procedures, and could generate false conclusions regarding concentration trends. The color-coding of the Table 5.1 entries denotes the presence/absence of temporal trends, and allows those monitoring points having nondetectable concentrations, concentrations below PQLs, decreasing concentrations, or no discernible trend in concentrations to be readily identified. A Mann-Kendall analysis could not be conducted at 20 of the 38 monitoring wells because of the limited sampling history (fewer than four monitoring events).

The basis of the decision to remove or retain a well in the monitoring program based on the value of its temporal information is described in the "Rationale" column of Table 5.1. In general, monitoring wells upgradient, crossgradient or far from a plume (e.g., H20S and) for which concentrations of chemicals consistently have been non-detected or <PQL through time provide relatively little information and can be recommended for removal or reduction in frequency. Additionally, monitoring wells (e.g., wells H177D, H49D, and H63D) that have decreasing temporal trends in a remediation area are valuable and should be retained because they provide information on the effectiveness of plume-area remediation. Conversely, wells that are decreasing in concentration downgradient of a plume (e.g., well OT24-MW1) and have relatively low levels of COCs provide limited continued temporal information. Finally, wells that have highly variable concentrations downgradient (e.g., H177S, 177D) should continue to be monitored to track potential future swings in concentration levels. A flow chart of the decision logic applied to the temporal trend analysis results is presented in Figure 5.5.

Table 5.1 summarizes recommendations to retain 10 of the 18 monitoring wells evaluated with the Mann-Kendall analysis (i.e., those with four or greater monitoring results) and 5 of the seven extraction wells in the OT-24 area. The other 10 wells are recommended for either exclusion or monitoring frequency reduction. Note that the recommendations provided in Table 5.1 are based on the evaluation of temporal statistical results only, and must be used in conjunction with the results of the qualitative and spatial evaluations to generate final recommendations regarding retention of monitoring points in the RA-O monitoring program, and the frequency of monitoring at particular location at Site OT-24.

TABLE 5.1
RESULTS OF TEMPORAL TREND ANALYSIS OF GROUNDWATER MONITORING RESULTS
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	cis-1,2-DCE	TCE	Remove/ Reduce	Retain	Rationale
Monitoring Wells					
H119D	<4 Meas (ND)	<PQL	✓		ND or <PQL >1000ft from plume.
H177D	Decreasing	No Trend		✓	Decreasing DCE trend within plume measures remedial progress.
H177S	No Trend	No Trend		✓	Highly variable DCE concentrations downgradient.
H178D	No Trend	No Trend		✓	Highly variable DCE concentrations downgradient.
H178S	<PQL	<PQL	✓		<PQL throughout monitoring history. Contamination in lower zone.
H179D	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H179S	<4 Meas (ND)	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H180D	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H180S	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H182D	ND	No Trend	✓		All measurements <1µg/L during last 3 years. Limited continued temporal information
H182S	ND	Decreasing	✓		Decreasing trends downgradient. TCE <5 µg/L, limited continued temporal information.
H20S	<4 Meas (ND)	ND	✓		ND upgradient of plume.
H39D	<4 Meas	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H49D	No Trend	Decreasing		✓	Decreasing trend of TCE concentrations > ACL measures remediation within capture zone.
H52D	Decreasing	No Trend		✓	Highly variable TCE in hot spot. Decreasing DCE trend measures remedial progress.
H63D	No Trend	Decreasing		✓	Decreasing trend of TCE concentrations measures remediation within capture zone.
H63M	<4 Meas	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H63S	ND	No Trend	✓		TCE concentrations consistently <8 µg/L. Limited continued temporal information.
H64D	Decreasing	No Trend		✓	Highly variable TCE in hot spot. Decreasing DCE trend measures remedial progress.
H65D	<4 Meas	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
H69D	<PQL	Decreasing		✓	Decreasing trends >MCL near base boundary. Sentry well.
H71D	No Trend	Decreasing		✓	Decreasing trends >MCL near base boundary. Sentry well.
OT24-MW1	ND	Decreasing	✓		Decreasing trends downgradient. TCE <12 mg/L, limited continued temporal information.
MW10D	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
MW10S	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
MW11D	< 4meas	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
MW11S	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW2D	ND	<PQL	✓		ND or <PQL; OT24-MW7 provides sentry monitoring.
OT24-MW2S	ND	Decreasing		✓	Decreasing trends >MCL near base boundary. Sentry well.
OT24-MW3	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW4	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW5	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW6	<4 Meas (ND)	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW7	<4 Meas	<4 Meas	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW8D	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW8S	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
OT24-MW9D	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.

TABLE 5.1 (Continued)
RESULTS OF TEMPORAL TREND ANALYSIS OF GROUNDWATER MONITORING RESULTS
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	cis-1,2-DCE	TCE	Remove/ Reduce	Retain	Rationale
OT24-MW9S	<4 Meas (ND)	<4 Meas (ND)	not analyzed		Fewer than 4 measurements. Mann-Kendall trends not calculated.
Extraction Wells					
MD-PW1A	Decreasing	Decreasing		✓	Decreasing trends measure mass removal and remedial progress.
MD-PW2A	Decreasing	Decreasing		✓	Decreasing trends measure mass removal and remedial progress.
MD-PW3A	No Trend	Decreasing		✓	Decreasing TCE trend measures mass removal and remedial progress.
MD-PW4A	<PQL	Decreasing	✓		TCE << ACL. Limited continued temporal information.
MD-PW5A	Decreasing	No Trend	✓		TCE < 1µg/L. DCE<<ACL. Limited continued temporal information
MD-PW6A	Increasing	No Trend		✓	TCE < 1µg/L. DCE<<ACL. Monitor increasing trend in extraction zone.
MD-PW7A	Increasing	Decreasing		✓	TCE < 1µg/L. DCE<<ACL. Monitor increasing trend in extraction zone.

ND	= Constituent has not been detected during history of monitoring at indicated well.
No Trend	= No statistically significant temporal trend in concentrations.
Decreasing	= Statistically significant decreasing trend in concentrations.
<PQL	= Concentrations consistently below practical quantitation limit.
Increasing	= Statistically significant increasing trend in concentration.
<4 Meas (ND)	= fewer than four monitoring events; not analyzed; consituent not detected.
<4 Meas	= fewer than four monitoring events; not analyzed.

SECTION 6

MONITORING NETWORK EVALUATION SUMMARY

The 38 monitoring and seven extraction wells included in the groundwater monitoring program at site OT-24 were evaluated using qualitative hydrogeologic and extraction-system information and temporal statistical techniques. At both phases in the evaluation, monitoring points that provide relatively greater amounts of information regarding the occurrence and distribution of COCs in groundwater were identified, and were distinguished from those monitoring points that provide relatively lesser amounts of information. In this section, the results of the evaluations are combined to generate a refined monitoring program that potentially could provide information sufficient to address the primary objectives of monitoring, at reduced cost. Monitoring wells not retained in the refined monitoring network could be removed from the monitoring program with relatively little loss of information. The results of the evaluations were combined and summarized in accordance with the following decision logic:

1. Each well retained in the monitoring network on the basis of the qualitative hydrogeologic evaluation is recommended to be retained in the refined monitoring program.

2. Those wells recommended for removal from the monitoring program on the basis of both evaluations should be removed from the monitoring program.

3. If a well is recommended for removal based on the qualitative evaluation and recommended for retention based on the temporal or spatial evaluation, the final recommendation is based on a case-by-case review of well information.

4. If a well is recommended for retention based on the qualitative evaluation and recommended for removal based on the temporal evaluation, the recommended sampling frequency is based on a case-by-case review of well information.

The results of the qualitative, temporal, and spatial evaluations are summarized in Table 6.1. These results indicate that 14 of the 38 active monitoring wells and 4 of the 7 extraction wells could be removed from the groundwater monitoring program with little loss of information. Wells H69D, MD-PW6A and MD-PW7A fall into case 3 of the decision logic (recommended for removal based on the qualitative evaluation and retention based on the temporal evaluation); all three wells are recommended for removal from the monitoring network. The qualitative evaluation identifies H69D as redundant with retained well H71D, and although the concentrations of DCE are increasing for extraction wells MD-PW6A and MD-PW7A, the levels are well below cleanup standards and investigation of the data shows that the increasing trends have not occurred over the last several years.

TABLE 6.1
SUMMARY OF EVALUATION OF CURRENT GROUNDWATER MONITORING PROGRAM
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	Current Sampling Frequency[a/]	Qualitative Evaluation		Temporal Evaluation		Summary		
		Remove	Retain	Remove/ Reduce	Retain	Remove	Retain	Recommended Monitoring Frequency
Monitoring Wells								
H119D	Annual		✓	✓			✓	Biennial
H177D	Annual		✓		✓		✓	Annual
H177S	Annual		✓		✓		✓	Annual
H178D	Annual		✓		✓		✓	Annual
H178S	Annual		✓	✓			✓	Biennial
H179D	Annual	✓		not analyzed		✓		--
H179S	Annual		✓	not analyzed			✓	Annual
H180D	Annual		✓	not analyzed			✓	Annual[b/]
H180S	Annual		✓	not analyzed			✓	Annual[b/]
H182D	Annual		✓	✓			✓	Biennial
H182S	Annual		✓	✓			✓	Biennial
H20S	Annual	✓		✓		✓		--
H39D	Annual		✓	not analyzed			✓	Annual
H49D	Annual		✓		✓		✓	Annual
H52D	Annual		✓		✓		✓	Annual
H63D	Annual		✓		✓		✓	Annual
H63M	Annual	✓		not analyzed		✓		--
H63S	Annual	✓		✓		✓		--
H64D	Annual		✓		✓		✓	Annual
H65D	Annual		✓	not analyzed			✓	Annual
H69D	Annual	✓			✓	✓		--
H71D	Annual		✓		✓		✓	Annual
OT24-MW1	Annual		✓	✓			✓	Biennial
OT24-MW10D	Annual		✓	not analyzed			✓	Annual
OT24-MW10S	Annual	✓		not analyzed		✓		--
OT24-MW11D	Annual		✓	not analyzed			✓	Annual
OT24-MW11S	Annual	✓		not analyzed		✓		--
OT24-MW2D	Annual	✓		✓		✓		--
OT24-MW2S	Annual		✓		✓		✓	Annual
OT24-MW3	Annual		✓	not analyzed			✓	Annual[b/]

TABLE 6.1 (Continued)
SUMMARY OF EVALUATION OF CURRENT GROUNDWATER MONITORING PROGRAM
MONITORING NETWORK OPTIMIZATION
SITE OT24
WURTSMITH AFB, MICHIGAN

Well ID	Current Sampling Frequency[a/]	Qualitative Evaluation		Temporal Evaluation		Summary		
		Remove	Retain	Remove/ Reduce	Retain	Remove	Retain	Recommended Monitoring Frequency
OT24-MW4	Annual		✓	not analyzed			✓	Annual[b/]
OT24-MW5	Annual		✓	not analyzed			✓	Annual[b/]
OT24-MW6	Annual	✓		not analyzed		✓		--
OT24-MW7	Annual	✓		not analyzed		✓		--
OT24-MW8D	Annual	✓		not analyzed		✓		--
OT24-MW8S	Annual	✓		not analyzed		✓		--
OT24-MW9D	Annual	✓		not analyzed		✓		--
OT24-MW9S	Annual	✓		not analyzed		✓		--
Extraction Wells								
MD-PW1A	Annual		✓		✓		✓	Quarterly
MD-PW2A	Annual		✓		✓		✓	Quarterly
MD-PW3A	Annual		✓		✓		✓	Quarterly
MD-PW4A	Annual	✓		✓		✓		--
MD-PW5A	Annual	✓		✓		✓		--
MD-PW6A	Annual	✓			✓	✓		--
MD-PW7A	Annual	✓			✓	✓		--

[a/] Based on Sampling and Analysis Plan for Basewide Remedial Action-Operation (TolTest, 2003)

[b/] Sampling frequency should be reduced to bienniel after 4 rounds of sampling results with no detections.

Wells H182D, H182S, H119D, and H178S all are recommended for retention in the qualitative evaluation and removal/reduction in the temporal evaluation (decision logic case 4). The recommended monitoring frequency was reduced to biennial for these wells.

A refined monitoring program, consisting of 24 monitoring wells (5 to be sampled biennially, and 19 be sampled annually) and 3 extraction wells (to be sampled quarterly) would be adequate to address the two primary objectives of monitoring. This refined monitoring network would result in an average of 33.5 sampling events per year, compared to 45 events per year in the current monitoring program. ***Implementing these recommendations for optimizing the RA-O monitoring program at OT-24 could reduce future RA-O annual monitoring events by 25.5 percent.***

SECTION 7

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