DEPARTMENT OF THE AIR FORCE
60TH CIVIL ENGINEER SQUADRON (AMC)

July 28, 2010

MEMORANDUM FOR DISTRIBUTION

FROM: 60 CES/CEANR
411 Airmen Drive
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SUBJECT: Final Natural Attenuation Assessment Report

1. The attached final Natural Attenuation Assessment report describes the results of a three-phase assessment of Monitored Natural Attenuation (MNA) at groundwater sites on Travis Air Force Base (AFB). This report will support the evaluation of remedial alternatives in the upcoming Travis AFB Focused Feasibility Study.

2. The report also includes response to comments tables, which contains responses to agency comments on the draft Natural Attenuation Assessment Report. If you have any questions concerning this report, please contact Mr. Glenn Anderson at (707) 424-4359.

Mark H. Smith

MARK H. SMITH
Chief, Environmental Restoration

Attachment:
Final Natural Attenuation Assessment Report

Distribution: (see attached)

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TRAVIS AIR FORCE BASE
ENVIRONMENTAL RESTORATION PROGRAM

Final

Natural Attenuation Assessment Report

USACE Contract No. W91238-06-D-0013

Delivery Order DK01

Prepared for:

U.S. Army Corps of Engineers
Omaha District

60 CES
Travis Air Force Base, California

Prepared by:

CH2MHILL

July 2010

Executive Summary

ES.1 Introduction

The Air Force, in concert with the regulatory agencies, has evaluated remedial alternatives for Environmental Restoration Program (ERP) sites with groundwater contamination at Travis Air Force Base (AFB), California. Interim remedial actions for the groundwater sites have been specified in Groundwater Interim Records of Decision (IRODs) for the North, East, and West Industrial Operable Units (NEWIOU) (Travis AFB, 1997) and the West/Annexes/Basewide Operable Unit (WABOU) (Travis AFB, 1999). The selected interim remedial actions are under way.

In the IRODs, monitored natural attenuation (MNA) was selected as an interim remedy for one (1) ERP site (LF006) and as a potential remedy at all or portions of seven (7) other ERP sites (LF007, SS015, SS016, ST032, SD033, SD037, and DP039). Therefore, with the exception of sites SS016 and ST032, natural attenuation assessments were performed at all the sites over the interim period leading up to the Groundwater Record of Decision (ROD). Because groundwater contamination at ERP sites SS016 and ST032 was determined to be within the extent of hydraulic capture of the SS016 and SS029 groundwater extraction and treatment (GET) systems, these sites were not evaluated for natural attenuation as was specified in the NEWIOU Groundwater IROD.

The downgradient portions of two (2) adjacent sites, FT004 and SD031, were included for MNA evaluation over the interim period, although MNA evaluation was not specified for these sites in the NEWIOU Groundwater IROD. Although GET was specified for the source areas at FT004 and SD031, no interim remedial actions were specified for the downgradient portions of the plumes. However, the Air Force recognized that, to provide a comprehensive remedy at these sites, the groundwater that is not captured by the GET system needs to be addressed. Therefore, the portions of these sites not affected by the pumping remedial action also were evaluated for natural attenuation over the interim period.

In summary, over the interim period, natural attenuation assessments were performed at ERP sites FT004, LF006, LF007, SS015, SD031, SD033, SD037, and DP039. Sites SD033 and SD037 are located in the West Industrial Operable Unit (WIOU), where groundwater contamination from several sites has co-mingled, resulting in a large groundwater plume. The WIOU groundwater plume has been addressed holistically by interim remedial actions. The locations of these sites are shown on Figure ES-1 and the status of these sites is summarized in Table ES-1. The purpose of this natural attenuation assessment report (NAAR) is to determine whether MNA is an effective remedy at these sites, based on data collected to date.

ES.2 Definition of Natural Attenuation

MNA can be defined as follows (U.S. Environmental Protection Agency, 1998):

> The term "monitored natural attenuation" refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored clean-up approach) to achieve site-specific remedial objectives

within a time frame that is reasonable compared to other methods. The "natural attenuation processes" that are at work in such a remedial approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

ES.3 Background

Following the selection of MNA in the IRODs as a potential remedy for Travis AFB groundwater plumes or portions of plumes, the Air Force prepared the *Travis AFB Natural Attenuation Assessment Plan* (NAAP) (CH2M HILL, 1998). The NAAP is the guiding document for the evaluation of natural attenuation at Travis AFB and describes the overall approach that will be followed at each site being considered for natural attenuation. In accordance with the NAAP an initial assessment of natural attenuation was performed at Sites FT004, LF006, LF007, SD031, SD033, SD037, and DP039. Those initial natural attenuation assessments are documented in site-specific natural attenuation assessment workplans (NAAWs). The Site SS015 NAAW was not completed because the site was selected by the Air Force Center for Engineering and the Environment (AFCEE) for a treatability study to evaluate enhancement of in situ biodegradation of chlorinated solvents through the application of vegetable oil.

In addition to providing a site-specific initial assessment of natural attenuation, the NAAWs identified a monitoring network to assess the effectiveness of MNA at the site during the interim period leading up to the Groundwater ROD. The monitoring networks specified in the NAAWs have been sampled as part of the Groundwater Sampling and Analysis Program (GSAP) for 8 to 10 years, depending on the site. The objective of this historical monitoring during the interim period has been to assess plume stability; therefore, laboratory analyses have focused on chemicals of concern (COCs).

The NAAP specified that this NAAR would be prepared at the end of the interim period to summarize the collected data and draw conclusions regarding whether MNA has been effective at the sites identified for MNA assessment. In addition, the NAAR is intended to support the selection of permanent groundwater remedies in the upcoming basewide groundwater ROD.

As part of the preparation for this NAAR, geochemical parameters were collected at each of the MNA sites during the 4Q08 GSAP sampling event to support a screening for biodegradation potential. The screening evaluation involves scoring the site for biodegradation potential according to a procedure developed by AFCEE (Wiedemeier et al., 1996). After assigning points to the data, the points are summed and the following interpretations made:

- Zero (0) to five (5) points: *Inadequate* evidence for anaerobic biodegradation of chlorinated hydrocarbons
- Six (6) to fourteen (14) points: *Limited* evidence for biodegradation of chlorinated hydrocarbons

- Fifteen (15) to twenty (20) points: *Adequate* evidence for biodegradation of chlorinated hydrocarbons
- Greater than twenty (20) points: *Strong* evidence for biodegradation of chlorinated hydrocarbons

Sufficient data are now available to determine whether MNA is an effective remedy at these sites. The adjective *inadequate* as defined in the AFCEE scoring system means that the site conditions are not conducive to biodegradation of chlorinated solvents. Use of *inadequate* in the context of the AFCEE scoring system does not indicate a lack of data points or poor data quality.

ES.4 Objectives

The objectives of this NAAR are as follows:

- Provide a summary of existing data and determine whether MNA is an effective remedy at each of the sites.
- Modify the groundwater monitoring network to reflect current plume conditions and ensure protectiveness during the remainder of the interim period.

ES.5 MNA Assessment Conclusions

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has reduced in size. Over the interim period (8 to 10 years, depending on the site), the GSAP has monitored networks of wells at each site. At most sites, the plume has not only been stable, but has exhibited declining volatile organic compound (VOC) concentrations during the interim period, indicating that MNA is an effective remedy at the site.

In addition to monitoring for plume stability, a biological screening was performed to evaluate the dominant mechanism for natural attenuation at each site. At most sites, the evidence for biological degradation is *inadequate* to *limited*, based on the AFCEE scoring methodology. Aquifer conditions are generally aerobic, which is not conducive to biodegradation of parent chlorinated solvents such as trichloroethene (TCE) and tetrachloroethene (PCE). At several of these sites, GET is performed in the source area, which introduces oxygen into the aquifer. In addition, there are insufficient natural or anthropogenic carbon donors in most areas to impact geochemical conditions and result in reductive dechlorination. At some sites, the plume may have originally exhibited "mixed behavior," where anthropogenic carbon (such as total petroleum hydrocarbons [TPH]) may have been present in the source area (Type 1 behavior) but inadequate carbon was present in the downgradient portion of the plume to drive biodegradation (Type 3 behavior) (Wiedemeier et al., 1996).

At most sites, physical processes are currently the dominant mechanism for the attenuation observed at the site over the interim period. Physical processes include diffusion, dispersion, dilution, adsorption, and volatilization, and generally result in a reduction in the concentration, toxicity, or mobility of contaminants without reducing the overall mass or volume of the contaminant. However, the physical process of volatilization does result in a reduction in contaminant mass in groundwater, as the contaminant goes from liquid to vapor phase.

The conclusion of the MNA assessment for each site is presented in Table ES-2. The following subsections summarize the main conclusions for each of the sites.

ES.5.1 Sites FT004/SD031

- There is *inadequate* evidence for biodegradation of COCs at Sites FT004/SD031, based on the AFCEE scoring methodology. The upgradient GET system introduced oxygen into the groundwater, resulting in aerobic conditions. The GET system has since been shut down for a rebound study.
- There is substantial evidence for physical natural attenuation of COCs at Sites FT004/SD031.
- TCE and 1,1-dichloroethene (DCE) concentrations have declined over the interim period in most of the MNA wells. The maximum TCE and 1,1-DCE concentrations detected in MNA wells during 2008 were 14.4 micrograms per liter (µg/L) and 3.8 µg/L, respectively.
- There is no indication of plume migration. In fact, the TCE and 1,1-DCE plumes have reduced in size over time (Figure ES-2).
- Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for the distal portions of Sites FT004/SD031.

ES.5.2 Site LF006

- There is *inadequate* evidence for biodegradation of chlorinated COCs at Site LF006. However, the aerobic conditions at this site do support the biodegradation of total petroleum hydrocarbons as gasoline (TPH-G) and total petroleum hydrocarbons as diesel (TPH-D).
- There is substantial evidence for physical natural attenuation of COCs at Site LF006.
- There is no indication of plume migration and, in fact, TCE concentrations have declined over the interim period in most of the MNA wells. Currently, TCE exceeds the interim remediation goal (IRG) at only two (2) monitoring wells (MW208Dx06 and MW259x06). The maximum TCE concentration detected in 2008 was 8.8 µg/L.
- The TCE plume has reduced in size over time (see Figure ES-3).
- Detections of TPH-G are sporadic and low (typically less than 10 µg/L).
- TPH-D has been detected only once since 2004.
- 1,1-DCE concentrations are currently below the IRG.
- Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for Site LF006.

ES.5.3 Site LF007

- In the portion of the MNA assessment areas where COCs continue to exceed IRGs, there is *adequate* evidence for biodegradation of chlorinated solvents.
- In the portion of the MNA assessment areas where COCs are below IRGs, there is *inadequate to limited* evidence for biodegradation of chlorinated solvents. The plume may be exhibiting mixed behavior, with reducing, anaerobic conditions near the source area and aerobic conditions in the downgradient portion of the plume (Wiedemeier et al., 1996).
- Consistent 1,4-dichlorobenzene (DCB) detections have been restricted to monitoring wells MW261x07, MWBx07, and MWCx07.
- 1,4-DCB concentrations have declined over the interim period. Currently, 1,4-DCB exceeds the IRG at only one (1) monitoring well (MW261x07). The maximum 1,4-DCB concentration detected in 2008 was 27.3 µg/L.
- There is no indication of plume migration. In fact, the 1,4-DCB plume has reduced in size over time (see Figure ES-4).
- The only other site COC exceeding IRGs detected in Site LF007 MNA wells is benzene. Benzene detections are restricted to one (1) location, MW261x07. Benzene concentrations at this location are stable.
- Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for LF007B and LF007D.

ES.5.4 Site SS015

- In the source area well, there is *adequate* evidence for biodegradation of chlorinated solvents. Biodegradation potential in this area was enhanced by the vegetable oil injections performed in 2000-2001. The maximum concentration of TCE detected in the source area in 2008 was 376 µg/L.
- In the portion of the plume where COCs are near or below IRGs, there is *inadequate* to *limited* evidence for biodegradation of chlorinated solvents.
- TCE, PCE, and cis-1,2-DCE concentrations decreased in source area well MW216x15 from 2004 to 2007 but rebounded from 2007 to 2008. VC concentrations have increased from 2004 to 2008. These trends confirm that the vegetable oil injection enhanced biodegradation in the vicinity of MW216x15, but insufficient vegetable oil remains to complete the degradation process.
- After several years of stability, the plume appears to be migrating eastward (see Figure ES-5). The increase in COC concentrations at downgradient well MW625x15 and rebound in concentrations at source area well MW216x15 may indicate that the vegetable oil injected in 2000 and 2001 has been consumed and can no longer provide adequate substrate for micro-organisms.
- Four (4) additional monitoring wells are needed to monitor the Site SS015 plume. A shallow monitoring well adjacent to MW624x15 is needed because MW624x15

appears to be screened in bedrock. The extent of groundwater contamination in the saturated zone above the bedrock is unknown. In addition, a monitoring well is needed downgradient (eastward) of MW624x15 and MW625x15. The location of this monitoring well should be determined once sampling results are available from the shallow monitoring well near MW624x15 and the distribution of contaminants in the saturated zone is better understood. A third monitoring well, located to the southeast of MW625x15, is needed to better define the southeastern extent of the plume. One (1) additional monitoring well to the west of MW216x15 is needed to monitor the upgradient portion of the plume. Installation of these monitoring wells is planned for 2010.

- Based on the results of the natural attenuation assessment, MNA alone may not be a sufficient remedy at this site because recent data indicate that the plume may be migrating eastward. However, the vegetable oil injection study performed in 2000 and 2001 demonstrates that the biological component of natural attenuation can be effectively enhanced at this site. Therefore, enhanced MNA is a potential remedy for this site.

ES.5.5 West Industrial Operable Unit (Sites SD037 and SD033)

- There is *inadequate* evidence for biodegradation of chlorinated COCs in the southern WIOU, with the exception of the area that has been impacted by petroleum hydrocarbons associated with Site SS014. The upgradient GET system is introducing oxygen into the groundwater in the source area. Aerobic conditions found at this site are favorable for promoting degradation of TPH-G and TPH-D.
- There is substantial evidence of physical natural attenuation of COCs in the southern WIOU.
- There is no indication of plume migration. Over the interim period, TCE concentrations have been stable and low at all of the southern WIOU MNA wells. TCE has not been detected at most of these wells in several years. The maximum TCE concentration detected in these wells in 2008 was 16.2 µg/L.
- The extent of the WIOU plume has decreased over time (see Figure ES-6).
- The presence of petroleum hydrocarbons in the vicinity of MW05x14 enhances biodegradation of chlorinated solvents in this area. Thus, if the TCE plume were to migrate downgradient toward this well, the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume.
- Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for the downgradient portion of the WIOU.

ES.5.6 Site DP039

- There is *inadequate* evidence for biodegradation of COCs at Site DP039. A bioreactor was installed in the source area in 2008, which will enhance biodegradation in the source area.
- The evidence of physical natural attenuation of COCs at Site DP039 is mixed.

- Evidence for physical natural attenuation includes the decreasing COC trends at source area monitoring well MW751x39 and the stability of southern toe of the plume (remaining below IRGs). The maximum concentration of TCE detected at MW751x39 in 2008 was 1,400 µg/L; the historical maximum at this location was 3,800 µg/L.
- However, increasing COC trends are evident in well MW02x39, located in the central part of the plume. The maximum TCE concentration detected at this well in 2008 was 42.4 µg/L. In addition, the extent of the plume has not reduced in size as has been observed at most of the other MNA assessments sites (see Figure ES-7).
- Downgradient MNA wells MW758x39 and MW760x39 also display generally increasing TCE trends, although TCE concentrations have recently decreased in both wells and remain below IRGs.
- The stability of the eastern portion of the plume is uncertain because there is not a long monitoring history in this area. In 2007, it was discovered that the TCE plume extends further eastward than anticipated (MW785x39 is located in this portion of the plume). However, after an initial period of increasing concentrations, TCE concentrations appear to have stabilized at monitoring well MW785x39.
- Based on the results of the natural attenuation assessment, MNA may not be adequate to prevent plume migration. Consequently, the Air Force plans to implement enhanced natural attenuation by installing a biobarrier in the middle of the plume in addition to the bioreactor that has been installed in the source area. Enhanced MNA is the Air Force preferred remedy for DP039.

ES.6 Ongoing Monitoring

Groundwater monitoring will continue at all of these sites during the remainder of the interim period. The monitoring network will be modified as described in this report to reflect changed plume conditions. The focus of the monitoring will be to continue to assess plume stability in the portion of the site specified for MNA assessment over the interim period. Table ES-2 summarizes the monitoring networks for ongoing monitoring of plume stability. In addition to MNA, many of these sites have interim remedies of GET in the source area. Source area monitoring to support assessment of GET performance will continue to be performed as specified in the GSAP annual reports.

TABLE ES-1
Status of Natural Attenuation Sites
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Interim Remedy	Status of Interim Remedy
FT004	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
LF006	MNA for entire site	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
LF007	MNA assessment in Areas LF007B and LF007D	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SS015	MNA assessment for entire site	Ongoing monitoring to support enhanced natural attenuation evaluation
SD031	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SD033	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SD037	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
DP039	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation

Notes:

Distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment.

The Site SS015 NAAW was not completed because the site was selected by AFCEE for a vegetable oil injection treatability study.

TABLE ES-2
MNA Assessment Conclusions
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Interim Remedy	Has the Plume Been Stable over the Interim Period?	Dominant Natural Attenuation Mechanism	Conclusion of MNA Assessment
FT004	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
LF006	MNA for entire site	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the entire plume.
LF007B	MNA assessment for entire subarea	Yes, in fact, COCs are no longer detected in groundwater.	Physical	MNA is an appropriate remedy for the entire plume.
LF007D	MNA assessment for entire subarea	Yes, in fact, the plume has receded.	Biological in source area, physical in distal areas	MNA is an appropriate remedy for the entire plume.
SS015	MNA assessment for entire site	The plume was stable for several years but now appears to be migrating. The long period of plume stability is due to vegetable oil injection performed in 2000-2001 (enhanced MNA).	Biological (enhanced by vegetable oil injection)	Enhanced MNA is a potential remedy for the site.
SD031	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
SD033	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
SD037	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
DP039	MNA assessment in distal portion of plume	Uncertain. The southern toe of the plume has remained stable over the interim period. However, increasing COC trends at some areas within the plume suggest that MNA alone may not be sufficient to prevent plume migration.	Physical	Enhanced MNA is an appropriate remedy for the distal portion of the plume. Existing bioreactor will provide enhanced biodegradation of source area residuals. The planned biobarrier will enhance degradation in the central portion of the plume.

Note:

Distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment.

TABLE ES-3
Wells for Ongoing Monitoring of Plume Stability
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Well	Sampling Frequency	Analyses: VOCs (SW8260)	Analyses: TPH-G (SW8015B-P)	Analyses: TPH-D (SW8015B-E)
ERP Sites					
FT004/SD031 MNA	MW134X04	Annual	X		
	MW584X04	Annual	X		
	MW587x04	Annual	X		
	MW591X04	Annual	X		
	MW757X04	Annual	X		
	MW571X31	Annual	X		
	MW574X31	Annual	X		
LF006 MNA	MW208X06	Annual	X	X	X
	MW208DX06	Annual	X	X	X
	MW259X06	Annual	X	X	X
	MW1729X31	Annual	X	X	X
	MW1730x31	Annual	X	X	X
	MW1731X31	Annual	X	X	X
LF007 MNA	MWBX07	Annual	X		
	MWCX07	Annual	X		
	MW129X07	Annual	X		
	MW261X07	Annual	X		
	MW601X07	Annual	X		
	MW612X07	Annual	X		
	MW613X07	Annual	X		
SS015 MNA	MW104X15	Annual	X		
	MW105X15	Annual	X		
	MW216X15	Annual	X		
	MW306X15	Annual	X		
	MW624X15	Annual	X		
	MW625X15	Semiannual	X		
WIOU MNA	MW05X14	Annual	X	X	X
	MW116X37	Annual	X	X	X
	MW722X37	Annual	X	X	X
	MW723X37	Annual	X	X	X
	MW724X37	Annual	X	X	X
	MW1208X37	Annual	X	X	X
	MW1209X37	Annual	X	X	X

TABLE ES-3
Wells for Ongoing Monitoring of Plume Stability
Natural Attenuation Assessment Report, Travis Air Force Base, California

			Analyses		
Site	**Well**	**Sampling Frequency**	**VOCs (SW8260)**	**TPH-G (SW8015B-P)**	**TPH-D (SW8015B-E)**
DP039 MNA	MW02X39	Annual	X		
	MW758X39	Annual	X		
	MW759X39	Annual	X		
	MW760X39	Annual	X		
	MW761X39	Annual	X		
	MW762X39	Annual	X		
	MW785X39	Annual	X		

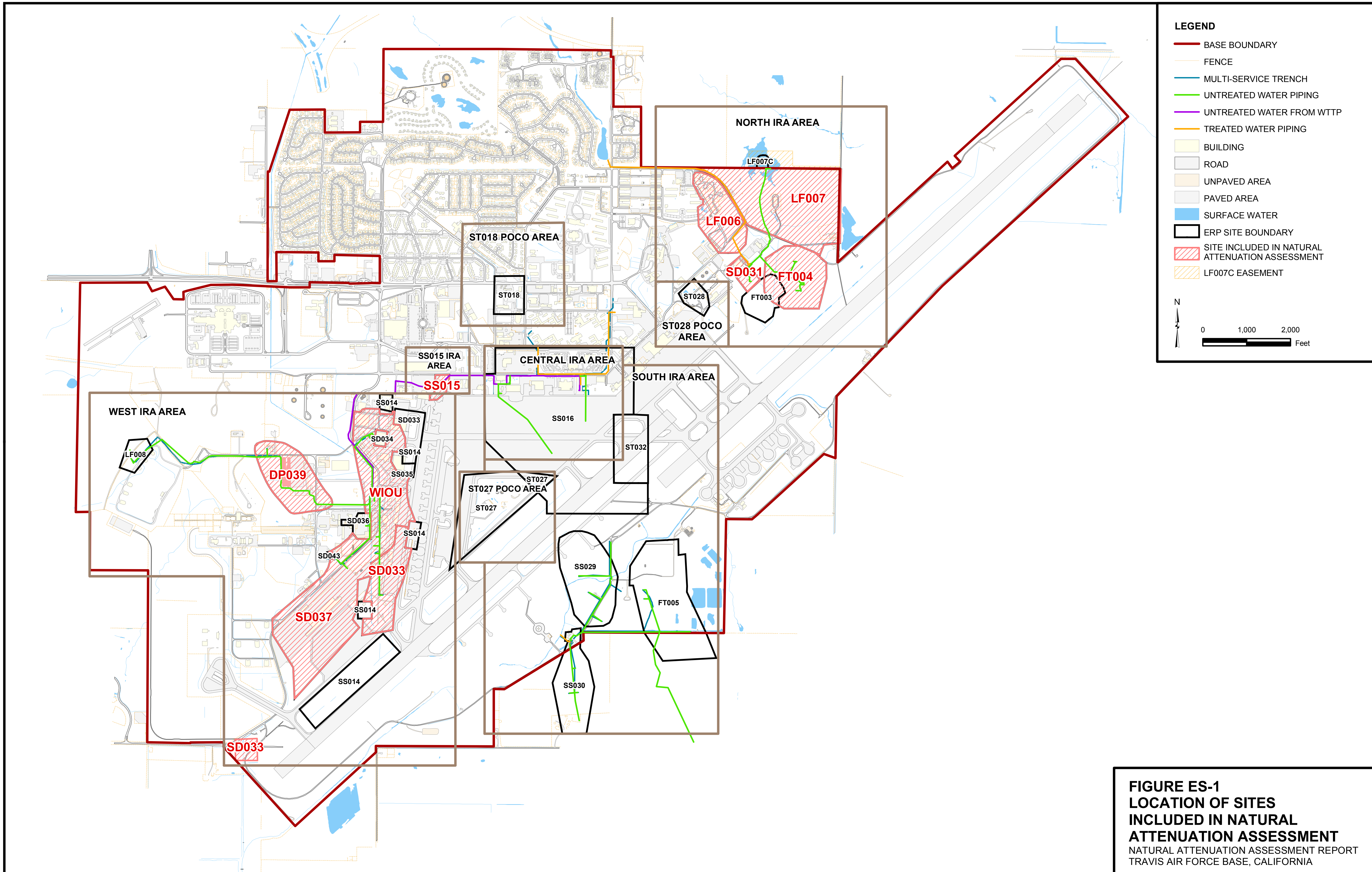

FIGURE ES-1
LOCATION OF SITES INCLUDED IN NATURAL ATTENUATION ASSESSMENT

NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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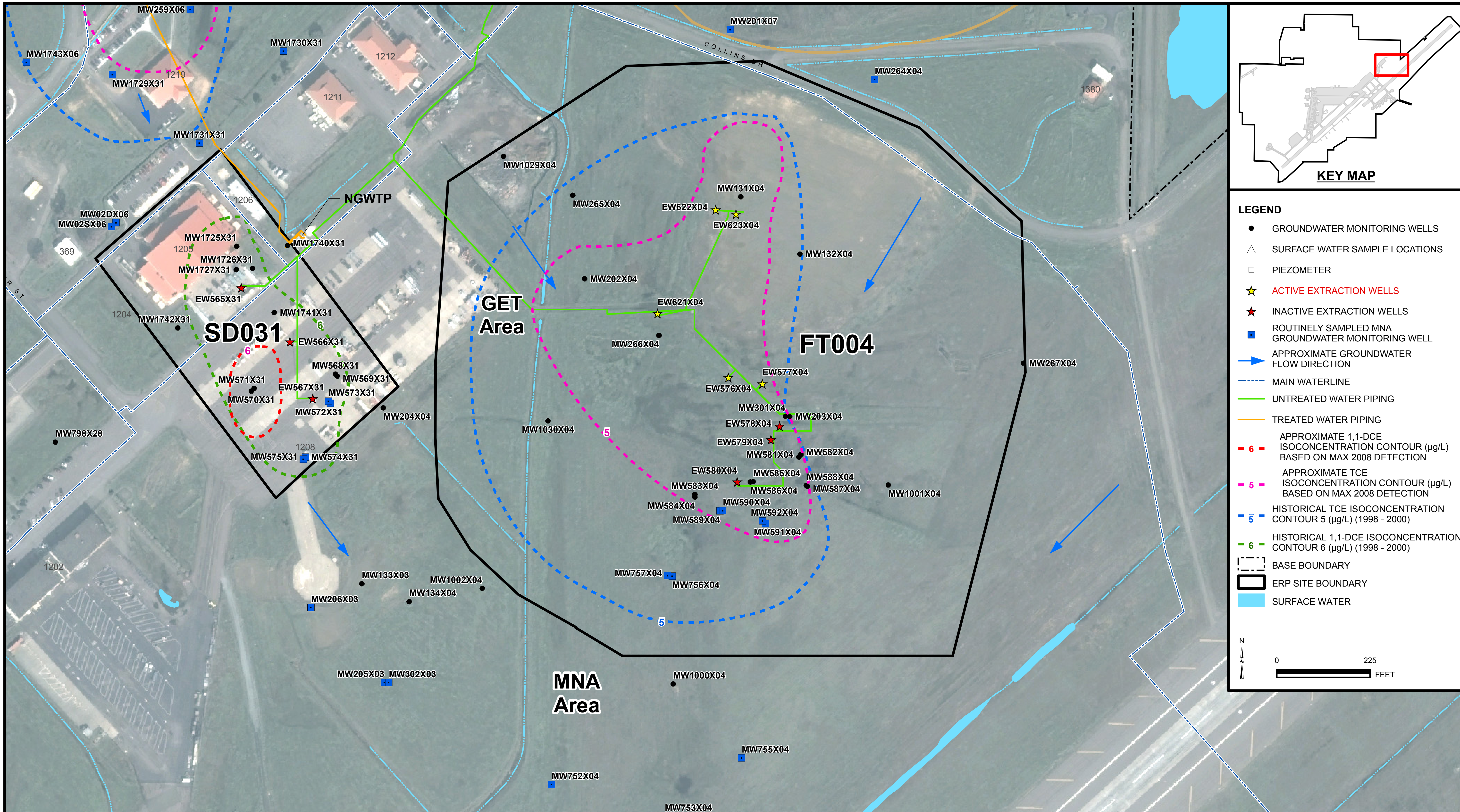

FIGURE ES-2
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT FT004/ SD031
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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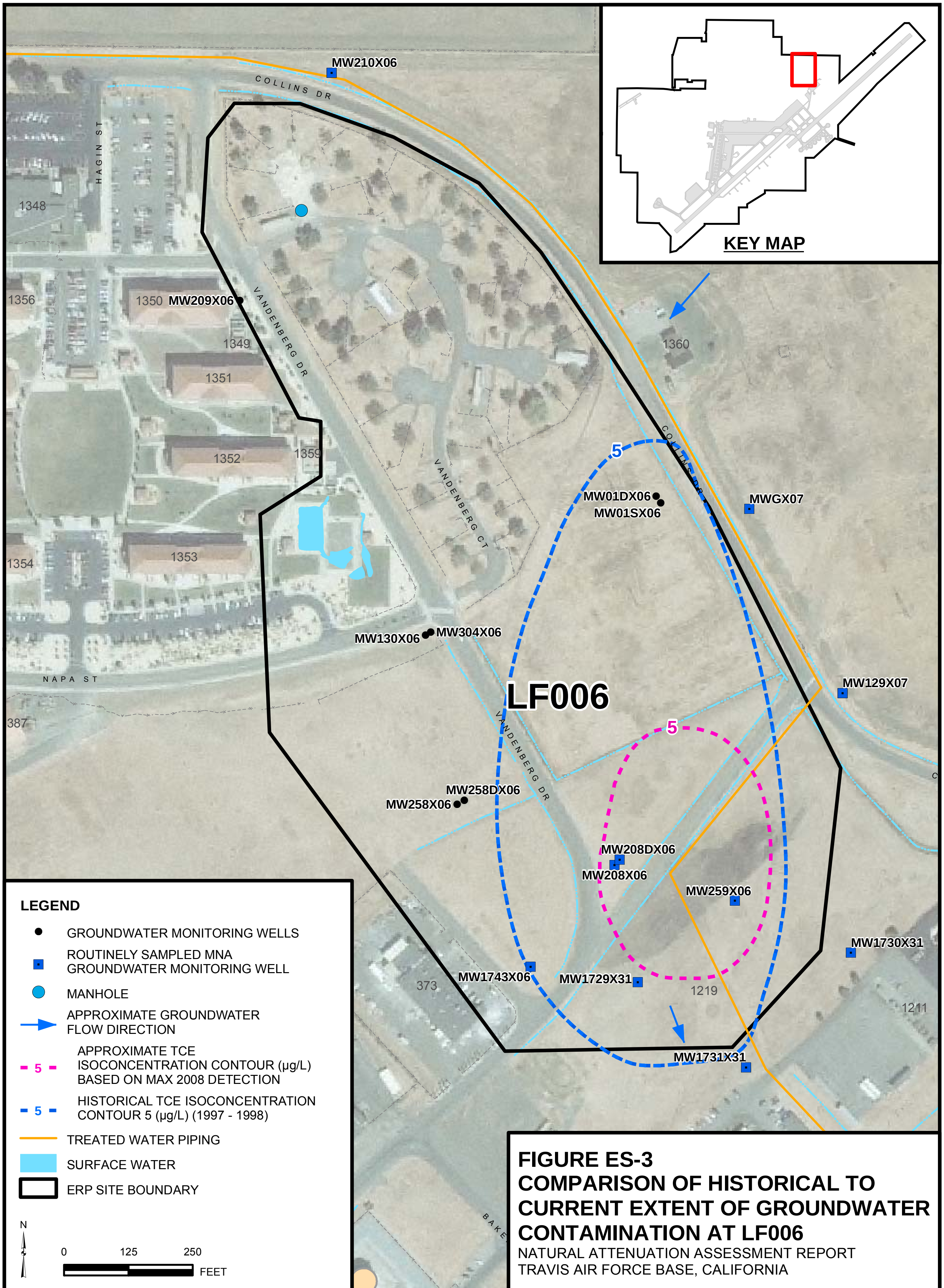

FIGURE ES-3
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT LF006
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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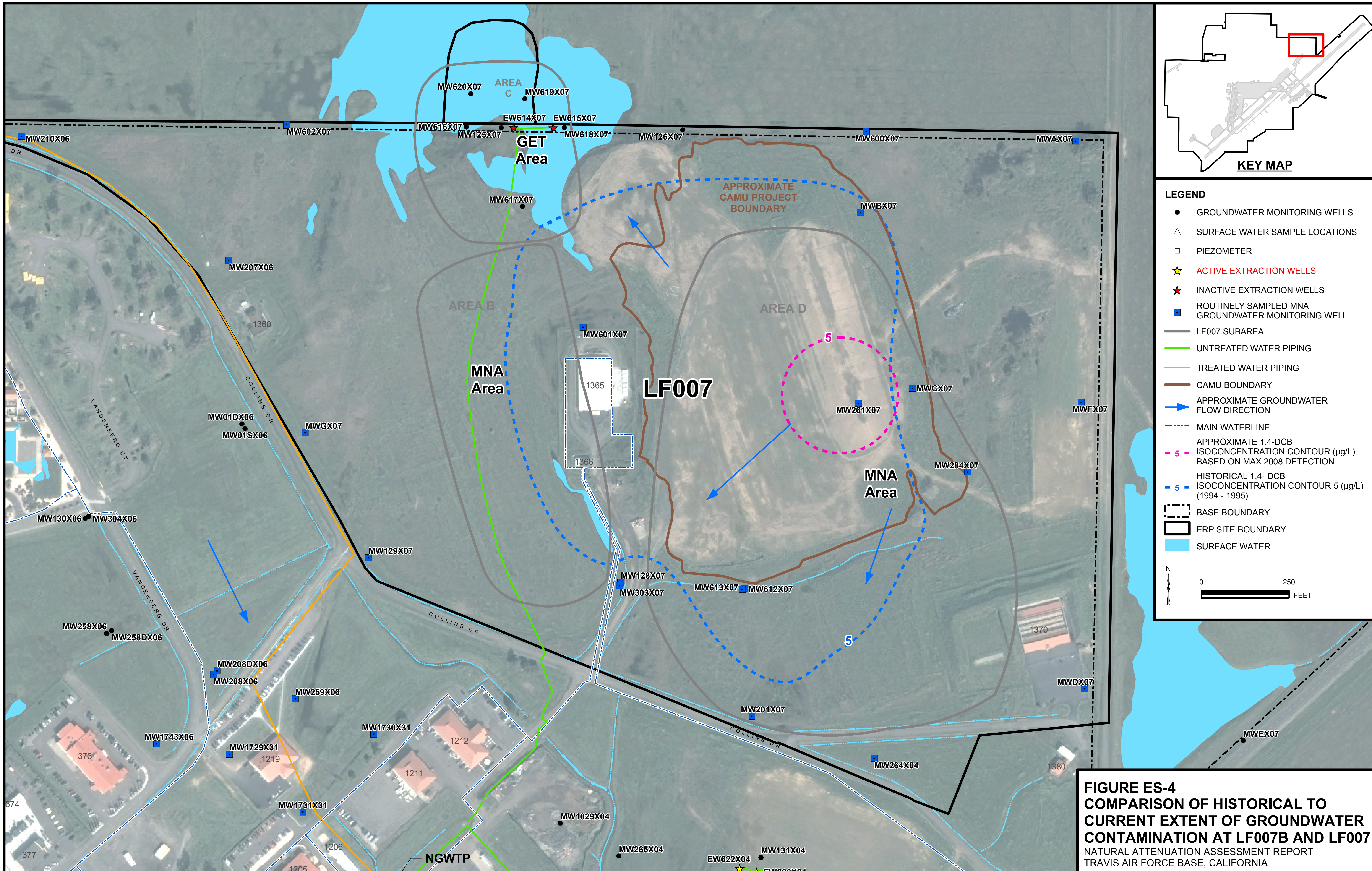

FIGURE ES-4
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT LF007B AND LF007D
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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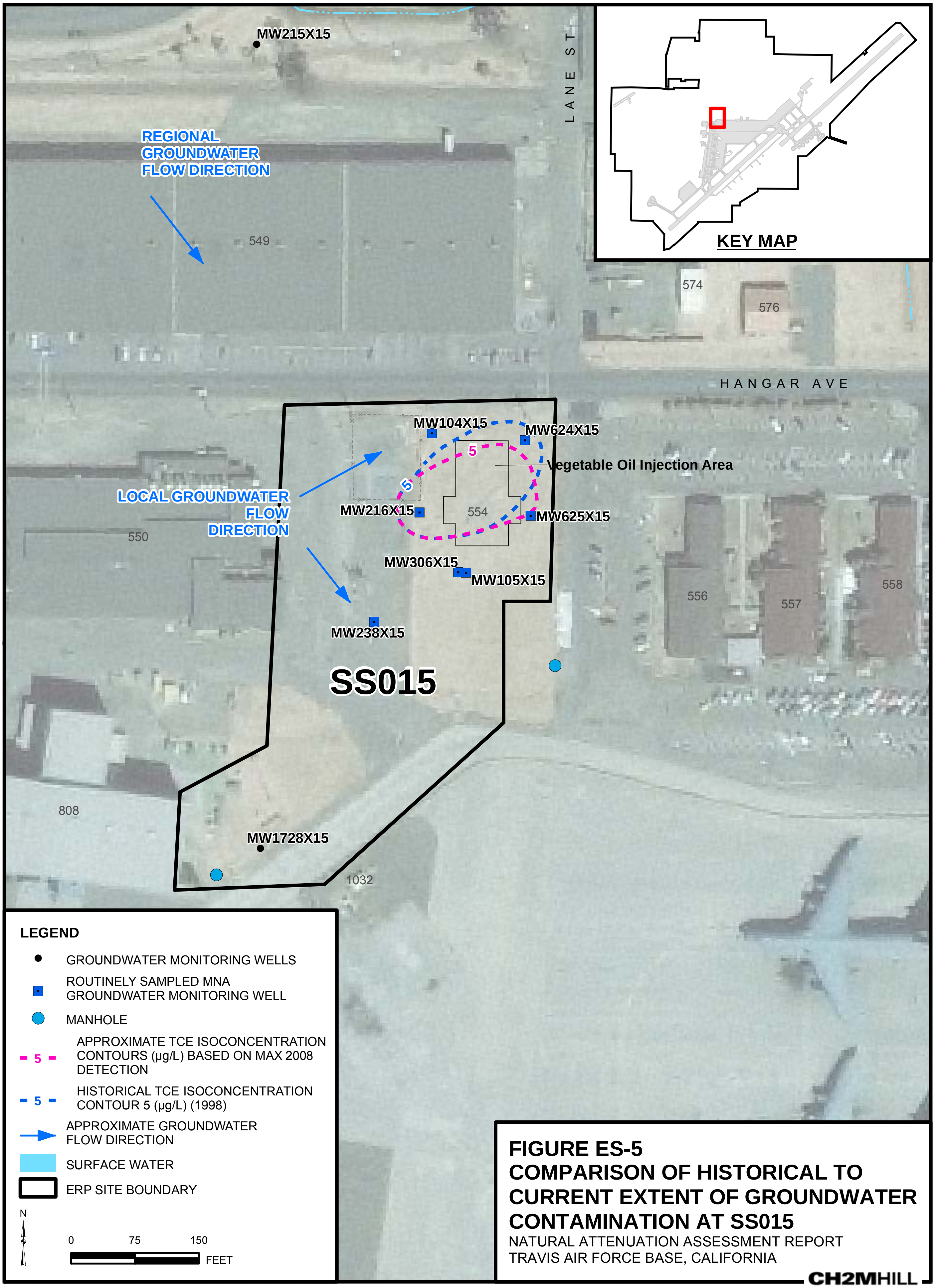

FIGURE ES-5
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT SS015
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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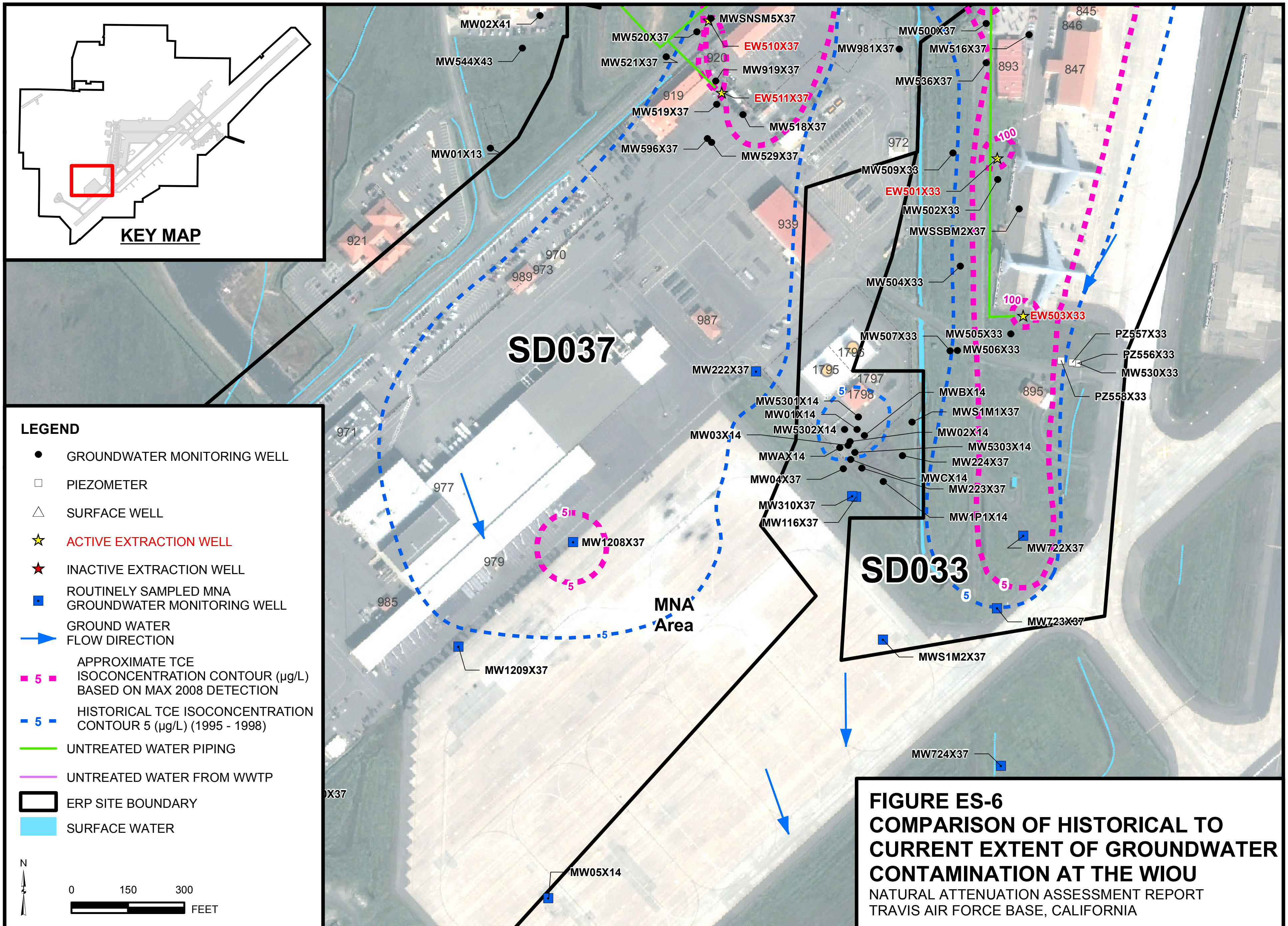

FIGURE ES-6
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT THE WIOU
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

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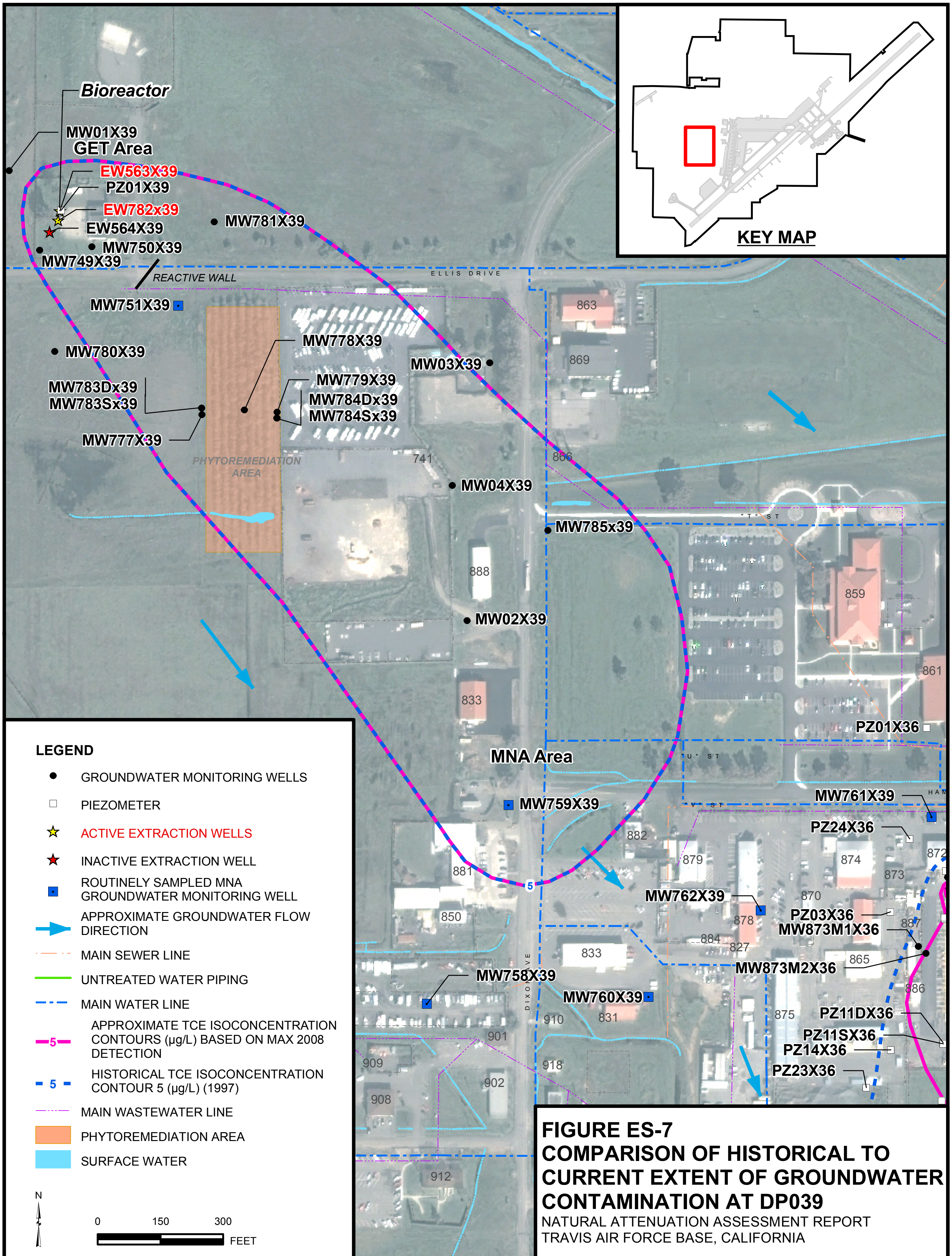

FIGURE ES-7
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT DP039
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SECTION 1
Introduction

The Air Force, in concert with the regulatory agencies, has evaluated remedial alternatives for Environmental Restoration Program (ERP) sites with groundwater contamination at Travis Air Force Base (AFB), California. Interim remedial actions for the groundwater sites have been specified in Groundwater Interim Records of Decision (IRODs) for the North, East, and West Industrial Operable Units (NEWIOU) (Travis AFB, 1997) and the West/Annexes/Basewide Operable Unit (WABOU) (Travis AFB, 1999). The selected interim remedial actions are under way.

In the IRODs, monitored natural attenuation (MNA) was selected as an interim remedy for one (1) ERP site (LF006) and as a potential remedy at all or portions of seven (7) other ERP sites (LF007, SS015, SS016, ST032, SD033, SD037, and DP039). Therefore, with the exception of sites SS016 and ST032, natural attenuation assessments were performed at all of these sites over the interim period leading up to the Groundwater Record of Decision (ROD). Because groundwater contamination at ERP sites SS016 and ST032 was determined to be within the extent of hydraulic capture of the SS016 and SS029 groundwater extraction and treatment (GET) systems, these sites were not evaluated for natural attenuation as was specified in the NEWIOU Groundwater IROD.

The downgradient portions of two (2) adjacent sites, FT004 and SD031, were included for MNA evaluation over the interim period, although MNA evaluation was not specified for these sites in the NEWIOU Groundwater IROD. Although GET was specified for the source areas at FT004 and SD031, no interim remedial actions were specified for the downgradient portions of the plumes. However, the Air Force recognized that, to provide a comprehensive remedy at these sites, the groundwater that is not captured by the GET system needs to be addressed. Therefore, the portions of these sites not affected by the pumping remedial action also were evaluated for natural attenuation over the interim period.

In summary, over the interim period, natural attenuation assessments were performed at ERP sites FT004, LF006, LF007, SS015, SD031, SD033, SD037, and DP039. The locations of these sites are shown on Figure 1-1 and the status of these sites is summarized in Table 1-1. The purpose of this natural attenuation assessment report (NAAR) is to determine whether MNA is an effective remedy at these sites, based on data collected to date.

1.1 Definition of Natural Attenuation

MNA can be defined as follows (U.S. Environmental Protection Agency, 1998):

> The term "monitored natural attenuation" refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored clean-up approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to other methods. The "natural attenuation processes" that are at work in such a remedial approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass,

toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

1.2 Background

Following the selection of MNA in the IRODs as a potential remedy for Travis AFB groundwater plumes or portions of plumes, the Air Force prepared the *Travis AFB Natural Attenuation Assessment Plan* (NAAP) (CH2M HILL, 1998). The NAAP is the guiding document for the evaluation of natural attenuation at Travis AFB and describes the overall approach that will be followed at each site being considered for natural attenuation. In accordance with the NAAP an initial assessment of natural attenuation was performed at Sites FT004, LF006, LF007, SD031, SD033, SD037, and DP039. Those initial natural attenuation assessments are documented in site-specific natural attenuation assessment workplans (NAAWs). The Site SS015 NAAW was not completed because the site was selected by the Air Force Center for Engineering and the Environment (AFCEE) for a treatability study to evaluate the application of vegetable oil to enhance in situ biodegradation of chlorinated solvents.

In addition to providing site-specific initial assessments of natural attenuation, the NAAWs identified monitoring networks to assess the effectiveness of MNA at the sites during the interim period leading up to the ROD. The monitoring networks specified in the NAAWs have been sampled as part of the Groundwater Sampling and Analysis Program (GSAP) for 8 to 10 years, depending on the site. The objective of this historical monitoring during the interim period has been to assess plume stability, so laboratory analyses have focused on chemicals of concern (COCs).

The NAAP specified that this NAAR would be prepared at the end of the interim period to summarize the collected data and draw conclusions regarding whether MNA has been effective at the sites identified for MNA assessment. In addition, the NAAR is intended to support the selection of permanent groundwater remedies in the upcoming basewide groundwater ROD.

1.3 Natural Attenuation Assessment Approach

Per the Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17 (1997), the Air Force believes the data collected to date at Travis AFB are of sufficient quality and duration to determine whether MNA is an effective remedy. Two lines of evidence were considered during the evaluation: (1) historical groundwater data that demonstrate plume attenuation and (2) hydrogeologic and geochemical data that indicate whether physical or biological attenuation processes are dominant at the site.

The first line of evidence, plume attenuation, includes the following:

- An assessment of COC concentration trends at individual wells
- Comparison of the historical to current extent of groundwater contamination at a site (whether or not the plume is stable, increasing, or decreasing in extent)

- An estimate of the distance the plume would be expected to have migrated over the interim monitoring period in the absence of natural attenuation mechanisms.
- Calculation of point attenuation rates and bulk attenuation rates and estimations of time to reach interim remediation goals (IRGs)

The second line of evidence was evaluated by collecting geochemical parameters at each of the MNA sites in the 4Q08 GSAP sampling event to support a screening for biodegradation potential of chlorinated COCs. The screening evaluation involves scoring the site for biodegradation potential according to a procedure developed by AFCEE (Wiedemeier et al., 1996). After assigning points to the data, the points are summed and the following interpretations made:

- Zero (0) to five (5) points: *Inadequate* evidence for biodegradation of chlorinated hydrocarbons
- Six (6) to fourteen (14) points: *Limited* evidence for biodegradation of chlorinated hydrocarbons
- Fifteen (15) to twenty (20) points: *Adequate* evidence for biodegradation of chlorinated hydrocarbons
- Greater than twenty (20) points: *Strong* evidence for biodegradation of chlorinated hydrocarbons

The adjective *inadequate* as defined in the AFCEE scoring system means that the site conditions are not conducive to biodegradation of chlorinated solvents. Use of *inadequate* in the context of the AFCEE scoring system does not indicate a lack of data points or poor data quality.

When evaluating the evidence for natural attenuation at each site, it is important to remember that there are two (2) mechanisms for natural attenuation: biological and physical. Biological attenuation occurs when microbial organisms destroy the contaminant by degrading or transforming it into another substance. Physical processes include diffusion, dispersion, dilution, adsorption, and volatilization, and generally result in a reduction in the concentration, toxicity, or mobility of contaminants without reducing the overall mass or volume of the contaminant. However, the physical process of volatilization does result in a reduction in contaminant mass in groundwater, as the contaminant goes from liquid to vapor phase.

Because the second line of evidence (screening evaluation of biodegradation potential) does not assess the effectiveness or contribution of physical attenuation mechanisms, it is important to evaluate the behavior of the plume over time. The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has reduced in size. In addition, achievement of Remedial Action Objectives (RAOs), which will be presented in the upcoming Basewide Groundwater Focused Feasibility Study, and estimated time to cleanup are important considerations for remedy selection.

1.4 Objectives

The objectives of this NAAR are as follows:

- Provide a summary of existing data and determine whether MNA is an effective remedy at each of the sites.
- Modify the groundwater monitoring network to reflect current plume conditions and ensure protectiveness during the remainder of the interim period.

1.5 Report Organization

The following sections are contained in this NAAR:

- **Section 1: Introduction** provides an introduction to this report.

Site-specific natural attenuation assessments are presented in Sections 2 through 7 as follows:

- **Section 2: Sites FT004/SD031** (combined because of site proximities and co-mingling of plumes)
- **Section 3: Site LF006**
- **Section 4: Site LF007**
- **Section 5: Site SS015**
- **Section 6**: **West Industrial Operable Unit (Sites SD037 and SD033)** (combined because of site proximities and co-mingling of plumes)
- **Section 7: Site DP039**
- **Section 8: Conclusions** provides a summary of the MNA assessment results.

Tables and figures are provided at the end of each section.

- Appendix A: Acronyms and Abbreviations
- Appendix B: References
- Appendix C: Field Parameters
- Appendix D: Concentration vs. Time Rate Constants
- Appendix E: Mann-Kendall Statistical Analysis
- Appendix F: Bulk Attenuation Rate Constants
- Appendix G: Response to Comments

TABLE 1-1
Status of Natural Attenuation Sites
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Interim Remedy	Status of Interim Remedy
FT004	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
LF006	MNA for entire site	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
LF007	MNA assessment in Areas LF007B and LF007D	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SS015	MNA assessment for entire site	Ongoing monitoring to support natural attenuation evaluation
SD031	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SD033	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
SD037	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation
DP039	MNA assessment in distal portion of plume	Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation

Notes:

Distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment.

The Site SS015 NAAW was not completed because the site was selected by AFCEE for a vegetable oil injection treatability study.

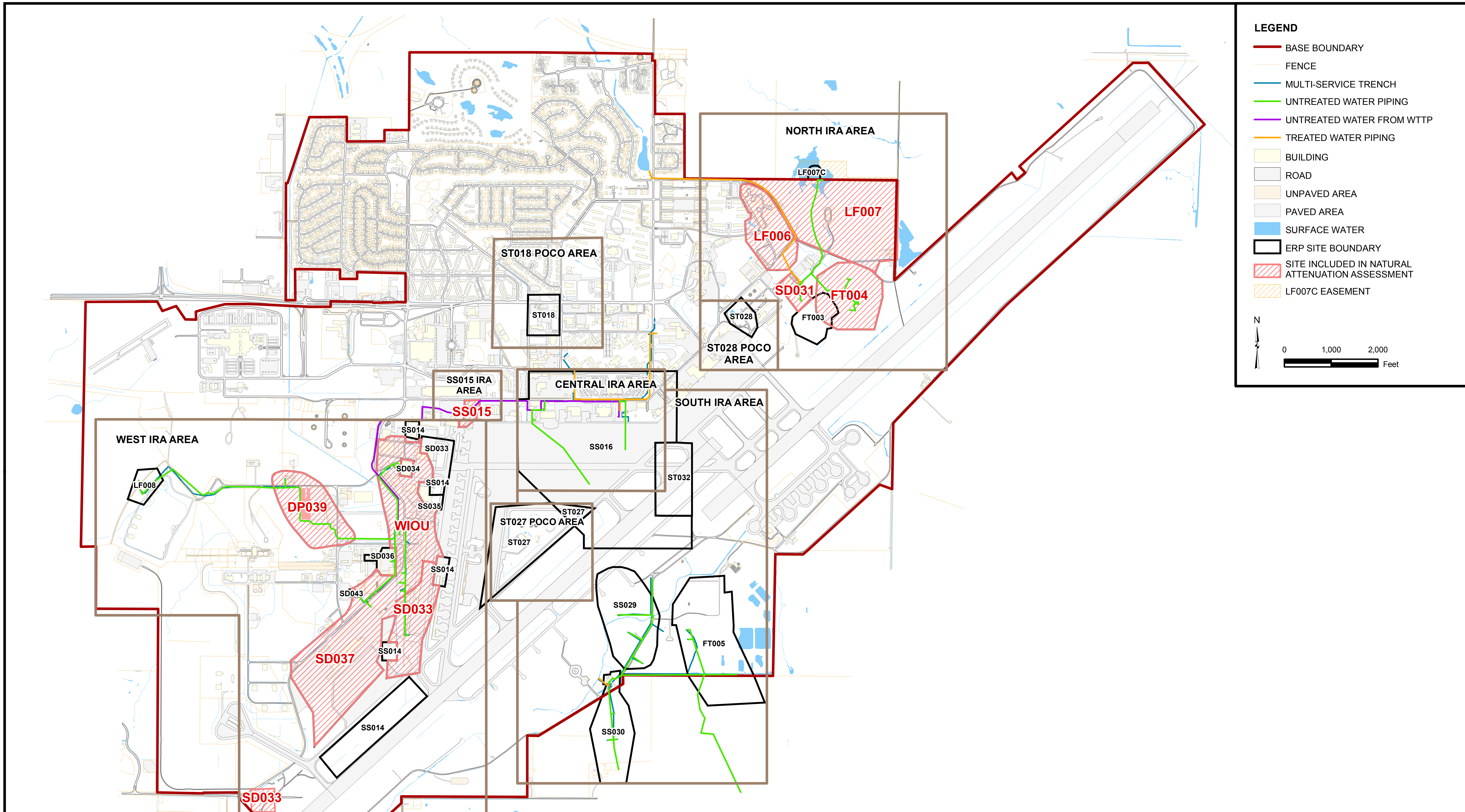

FIGURE 1-1
LOCATION OF SITES INCLUDED IN NATURAL ATTENUATION ASSESSMENT
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

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SECTION 2

Sites FT004/SD031

2.1 Site Background

Section 2 presents the natural attenuation assessment for Sites FT004 and SD031. These sites are presented together because the downgradient portions of the groundwater plumes at these sites are co-mingled and they share a common interim remedial approach. A detailed conceptual site model and preliminary natural attenuation assessment are presented in the *FT004/SD031 Natural Attenuation Assessment Workplan* (FT004/SD031 NAAW) (CH2M HILL, 2001a). This section focuses on data collected since the FT004/SD031 NAAW was submitted.

2.1.1 Site Description

Site FT004 covers approximately 30 acres in the northeastern portion of the East Industrial Operable Unit (EIOU) and is the former Fire Training Area No. 3 (FTA-3). The site was used for fire training exercises from 1953 to 1962. During these exercises, waste fuel, oils, and solvents were dumped onto frames or onto the ground and burned. Soil staining and stressed vegetation were observed during historical field investigations (Roy F. Weston, Inc., 1995). The site is currently an unused, open field (Figure 2-1).

Site SD031, west of Site FT004, covers approximately 5.5 acres and encompasses Facility 1205 in the northeastern part of the EIOU. Facility 1205 was constructed in 1957, and operations include the maintenance and repair of diesel-powered generators. Wastes generated at the facility include oils, antifreeze, and solvents. A wash rack, just south of the facility, is still used to clean diesel engine parts; it discharges to an oil/water separator (OWS). Accidental releases in the vicinity of this wash rack appear to be the source of groundwater contamination in the area. Since the discovery of the releases, proper material handling and process controls were implemented to prevent additional releases. Historical aerial photographs taken from 1958 to 1963 indicate that Facility 1205 may have been used as an aircraft maintenance hangar during that time.

2.1.2 Site COCs

The groundwater COCs and IRGs at the sites are as follows:

Site FT004:

COC	IRG (µg/L)	COC	IRG (µg/L)
1,1-dichloroethene (DCE)	6	cis-1,2-DCE	6
1,2-dichloroethane (DCA)	0.5	trichloroethene (TCE)	5
bis(2-ethylhexyl)phthalate	4	vinyl chloride (VC)	0.5
bromodichloromethane	100	nickel	100
chloroform	80		

Site SD031:

COC	IRG (µg/L)	COC	IRG (µg/L)
1,1-DCE	6	cis-1,2-DCE	6
1,2-DCA	0.5	TCE	5
benzene	1	VC	0.5
carbon tetrachloride	0.5	nickel	100
chloroform	80		

Currently, elevated nickel concentrations are restricted to the immediate vicinity of MW267x04 and are suspected to be naturally occurring.

2.1.3 Status of Interim Remedy

An interim remedial action (IRA) of GET has been implemented at Sites FT004 and SD031, as specified by the NEWIOU Groundwater IROD (Travis AFB, 1997). The interim remedial action objective (IRAO) of the FT004/SD031 IRA is source control. The GET was designed to capture those areas where volatile organic compound (VOC) contamination is present at concentrations greater than 100 micrograms per liter (µg/L). The Travis AFB Second Five-Year Review (CH2M HILL, 2008a) concluded that the Sites FT004 and SD031 GET systems are performing as designed.

The operation of the GET systems has greatly reduced the VOC plumes at both sites. VOC concentrations at Site SD031 have declined below 100 µg/L. At Site FT004, only a small area of the plume continues to exceed 100 µg/L. The Site SD031 extraction system and a portion of the Site FT004 extraction system were shut down for a 1-year rebound study in December 2007. The results of the rebound study are documented in the *2008 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2009a). The conclusion of the rebound evaluation was that VOC concentrations have not rebounded at these sites and that the plumes are stable. This report also recommended that all of the FT004 and SD031 extraction wells be shut down and that the rebound study continue through the interim period.

An interim action was not specifically identified in the IROD to remedy groundwater contamination beyond the source control target area. However, the Air Force recognized the need to conduct monitoring and evaluate natural attenuation to address contamination not captured by the extraction and treatment system in the southern (downgradient) portions of the plumes at Sites FT004 and SD031. Therefore, the Air Force has performed MNA assessment in the portions of the plumes downgradient from the 100-µg/L isopleths. The downgradient portions of Sites FT004 and SD031 underwent a combined natural attenuation assessment in 2000-2001, as documented in the FT004/SD031 NAAW (CH2M HILL, 2001a). Since 2001, seventeen (17) monitoring wells have been routinely sampled to support the ongoing MNA assessment: MW589x04, MW590x04, MW591x04, MW592x04, MW752x04, MW753x04, MW754x04, MW755x04, MW756x04, MW757x04, MW572x31, MW573x31, MW574x31, MW575x31, MW206x03, MW205x03, and MW302x03 (see Figure 2-1). These wells are located primarily in the downgradient and crossgradient portions of the sites, to monitor plume migration.

Eight (8) years of data collected from the MNA wells indicate that MNA is a viable remedy for the downgradient portions of the plumes. VOC concentrations have generally been stable or have decreased over time (CH2M HILL, 2008a).

In summary, the status of the IRAs at Sites FT004/SD031 is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
FT004 Source Area	Source Control	GET	GET has been shut down and the source area is undergoing a rebound study.
SD031 Source Area	Source Control	GET	GET has been shut down and the source area is undergoing a rebound study.
FT004/SD031 distal area (beyond GET)*	MNA Assessment	Groundwater monitoring	Ongoing groundwater monitoring.

*Although no IRA was specified in the IROD for the FT004/SD031 distal area, the Air Force is performing MNA assessment over the interim period.

2.2 Conceptual Site Model

2.2.1 Geology

Sites FT004 and SD031 are located on alluvium overlying an eroded bedrock valley. The alluvium is heterogeneous and consists primarily of silts and clays that are low in permeability and do not transmit groundwater readily. Bedrock in the valley is composed of Nortonville Shale. The valley is bounded on the east by a ridge of Markley Sandstone, which outcrops to the east of Site FT004. It is bounded on the west by a ridge of Domengine Sandstone that forms the hill on which the old Base Hospital is located. The bedrock formations all plunge to the southeast. Geologic cross sections through the Sites FT004 and SD031 groundwater plumes are presented on Figures 2-2 and 2-3, respectively.

2.2.2 Groundwater

As summarized in Table 2-1, depth to water at Sites FT004 and SD031 is approximately 7 to 15 feet below ground surface (bgs), and the saturated zone is approximately 20 to 35 feet thick. With the exception of a time period that coincided with the startup of the Site FT004 groundwater extraction system (2000 and 2001), groundwater elevations at Sites FT004 and SD031 have been stable, varying seasonally about 2 to 5 feet. During 2000 and 2001, the water table dropped from 5 to 10 feet lower than historical groundwater elevations in many Site FT004 wells.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 2-4, and are consistent with historical groundwater flow directions. Regional groundwater flow in the vicinity of Sites FT004 and SD031 is southeasterly, reflecting the impact of the ridge of Nortonville Shale to the west and the ridge of Markley Sandstone bedrock to the east. Groundwater flow directions and gradient vary across Sites FT004 and SD031, primarily affected by the groundwater extraction wells operating at these sites. During 2Q08, the Site SD031 extraction wells and a portion of the Site FT004 extraction wells were offline as part of a 1-year rebound study. Horizontal hydraulic gradients typically range from approximately 0.003 feet per foot (ft/ft) at Site SD031 and the southern portion of Site FT004 to 0.03 ft/ft in the northern portion of Site FT004 where the GET system is operational.

Vertical gradients (summarized in Table 2-2) vary at Sites FT004 and SD031. Of the fourteen (14) well pairs at these sites, only one (1) pair, MW589x04/MW590x04, shows significant vertical gradient (consistently greater than 0.01 ft/ft). The vertical gradient at this well pair is typically between 0.06 and 0.07 ft/ft upward. Vertical gradients at Site SD031 are typically slightly upward and are variable at Site FT004.

Several aquifer tests have been performed at Sites FT004 and SD031, and the results are summarized in Table 2-3. Hydraulic conductivities calculated from the aquifer tests ranged from 0.5 to 115 feet per day (ft/day), reflecting the heterogeneous nature of the sediments and the variation in the aquifer test methods utilized. The 115 ft/day value is an outlier that is not consistent with a clay or sandy clay. This value was derived from a slug test, rather than a pumping test, and the results appear to have been influenced by the higher permeability of the filter pack. If this outlier is removed, the average of the hydraulic conductivities calculated for these sites is approximately 20 ft/day.

The average linear flow of groundwater in the southern portion of Sites FT004 and SD031 (unaffected by the GET) may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.003 ft/ft, an average hydraulic conductivity of 20 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), the approximate groundwater velocity is about 0.3 ft/day or approximately 100 feet per year (ft/year).

Groundwater at Travis AFB is not used for human consumption and groundwater at Sites SD031/FT004 does not discharge to surface water. The Base boundary is approximately 2,000 feet from the leading edge of the plume. At the estimated groundwater velocity, it would take approximately 20 years for groundwater at Sites FT004/SD031 to reach the Base boundary. Because contaminants do not appear to be migrating in groundwater at this time, because ongoing monitoring will continue to evaluate whether contamination is migrating in the future, and because groundwater from Sites FT004/SD031 does not discharge to surface water, residual groundwater contamination at Sites FT004/SD031 should not pose a risk to receptors.

2.2.3 Current Distribution of Groundwater COCs

The monitoring wells selected to support the MNA assessment at Sites FT004 and SD031 over the interim period are MW589x04, MW590x04, MW591x04, MW592x04, MW752x04, MW753x04, MW754x04, MW755x04, MW756x04, MW757x04, MW572x31, MW573x31, MW574x31, MW575x31, MW206x03, MW205x03, and MW302x03, which are located in the downgradient portions of Sites FT004 and SD031. During the 2Q08 and 4Q08 sampling events, the only Site FT004/SD031 COC detected at concentrations exceeding interim remediation goals (IRGs) in the MNA wells was TCE. The current distribution of TCE at Sites FT004 and SD031 is depicted on Figure 2-5. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix.

TCE concentrations exceeded the IRG (5 µg/L) at only two (2) Site FT004 MNA wells (MW591x04 and MW590x04) and one (1) Site SD031 MNA well (MW574x31). The highest TCE concentration detected in an MNA well was 14.4 µg/L at well MW591x04. In 2008, TCE was not detected in eight (8) of the seventeen (17) MNA wells.

1,1-DCE is the primary COC at Site SD031. The current distribution of 1,1-DCE at Sites FT004 and SD031 is depicted on Figure 2-6. The 1,1-DCE concentration did not exceed the IRG (6 µg/L) at any MNA well. The highest 1,1-DCE concentration detected in an MNA well in 2008 was 3.8 µg/L at MW574x31. 1,1-DCE was not detected at any other MNA well during 2008.

A basewide vapor intrusion (VI) assessment is currently underway at Travis AFB. The purpose of the VI assessment is to evaluate potential for VI in buildings due to underlying VOC groundwater plumes. The VOC concentrations in the portion of the groundwater plume undergoing MNA assessment at Sites FT004/SD031 are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b). The groundwater VOC concentrations in the distal portion of the plume do not indicate potential for VI risk.

2.3 Natural Attenuation Assessment

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has reduced in size. Over the interim period, the GSAP has assessed plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 2.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 2.3.2.

2.3.1 Plume Attenuation

Chemical time-series plots of the primary COCs (TCE and 1,1-DCE) for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 2-7 and 2-8. Figure 2-7 illustrates the stable or decreasing TCE concentration trend observed in most of the Site FT004 and SD031 MNA monitoring wells (MW208x03, MW131x04, MW202x04, MW266x04, MW589x04, MW590x04, MW572x04, MW753x04, MW575x04, MW570x31, MW574x31, and MW575x31). TCE concentrations have recently increased slightly at MW134x04, where the maximum TCE concentration detected in 2008 was 0.67 µg/L and MW591x04, where the maximum TCE concentration detected in 2008 was 14.4 µg/L.

Figure 2-9 shows the current distribution of TCE exceeding its IRG (5 µg/L) and the historical extent of TCE contamination in groundwater exceeding its IRG at Site FT004. This figure illustrates the reduction in the extent of the FT004 TCE plume over time.

Figure 2-8 illustrates a similar decline in 1,1-DCE concentrations. 1,1-DCE concentrations have declined over time at wells MW206x03, MW131x04, MW202x04, MW266x04, MW589x04, MW572x31, MW573x31, MW572x31, and MW573x31. However, 1,1-DCE concentrations have recently increased at well pair MW570x31 and MW571x31. These wells are plume wells (rather than downgradient wells) and are the only monitoring wells at which 1,1-DCE continues to exceed the IRG. Figure 2-9, which illustrates the current distribution of 1,1-DCE exceeding the IRG and the historical maximum extent of 1,1-DCE exceeding the IRG, shows that the plume has greatly decreased in areal extent. Only a small area remains where 1,1-DCE concentrations exceed the IRG.

There is no indication of plume migration. The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of TCE at this site to approximately 0.8 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the portion of the plume beyond the capture of the GET system would be expected to have migrated approximately 600 feet (80 feet per year) over the 8 years of the MNA assessment period. However, the plume has receded, indicating that natural attenuation processes are occurring at the site.

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the seventeen (17) monitoring wells in the MNA assessment network, there are currently only three (3) monitoring wells at which COCs continue to exceed IRGs (maximum contaminant levels [MCLs]). A point attenuation rate constant was calculated for two (2) of these three (3) MNA wells: MW571x31 and MW590x04. An attenuation rate constant could not be calculated for well MW591x04, where TCE concentrations recently increased. At both monitoring wells MW571x31 and MW590x04, the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW574x31 is approximately 0.058 per year, and the attenuation rate constant calculated for well MW590x04 is approximately 0.58 per year (Appendix D). At these rates, TCE concentrations at well MW574x31 are expected to reach the IRG (5 μg/L) in 2021, and TCE concentrations at well MW590x04 would be expected to reach the IRG in 2007. TCE concentrations at well MW590x04 were below the IRG in 2007, but slightly exceeded the IRG of 5 μg/L in 2008 (TCE was detected at a concentration of 5.3 μg/L in 2008).

However, it should be noted that both wells MW571x31 and MW590x04 are located along the designed extent of hydraulic capture of the GET system. Therefore, attenuation rates at these wells were likely affected by the GET system. The rate of attenuation at these wells may decrease if groundwater extraction at the site ceases.

In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for MNA monitoring wells where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.

Bulk attenuation rates have not been calculated for FT004/SD031 at this time because, due to the recent GET IRA, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site.

2.3.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for Sites FT004/SD031. Table 2-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from monitoring wells at Sites FT004/SD031 during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), total organic carbon (TOC) (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and carbon dioxide (CO_2) (HACH field test). In addition, pH, temperature, dissolved oxygen (DO), oxidation reduction potential (ORP), conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Wells:** MW264x04 and MW1730x31
- **Source Wells:** MW131x04 and MW266x04 (no source area remains at SD031)
- **Plume Wells:** MW202x04, MW591x04, MW582x04, MW570x31, MW571x31, and MW574x41
- **Distal Wells:** MW134x04, MW752x04, MW753x04, and MW754x04

As shown in Table 2-5, no monitoring well included in the screening scored higher than five (5) points and there is inadequate evidence for biodegradation at Sites FT004/SD031. DO concentrations and ORP measurements across the site indicate aerobic rather than anaerobic conditions, which is not conducive to reductive dechlorination. The aerobic conditions result at least in part from the operation of the GET system, which causes aeration of the aquifer. In addition, there are insufficient natural or anthropogenic carbon donors in this area to impact geochemical conditions and result in reductive dechlorination.

A similar biodegradation screening was performed in 2000-2001, which is documented in the FT004/SD031 NAAW (CH2M HILL, 2001a). During the initial biodegradation screening, most monitoring wells scored between six (6) and eighteen (18) points (limited to adequate evidence of biodegradation). The initial screening was performed prior to the GET startup, and low DO measurements indicated reducing conditions.

2.4 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- There is currently inadequate evidence for biodegradation of COCs at Sites FT004/SD031, although a previous biodegradation screening indicated biodegradation may have historically occurred at these sites. There are insufficient natural or anthropogenic carbon donors in this area to impact geochemical conditions and result in reductive dechlorination. In addition, during the assessment, the upgradient GET system was introducing oxygen into the groundwater, resulting in aerobic conditions in the source area. The GET system has since been shut down for a rebound study.
- There is substantial evidence for physical natural attenuation of COCs at Sites FT004/SD031.
- TCE and 1,1-DCE concentrations have declined over the interim period in most of the MNA wells.
- The TCE and 1,1-DCE plumes have reduced in size over the 8 years since the MNA assessment began.
- There is no indication of plume migration. In fact, the toe of the plume has been receding.

Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for the distal portions of Sites FT004 and SD031.

2.5 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring in the distal portions of Sites FT004 and SD031. The distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells selected to monitor plume stability is presented on Figure 2-10 and will consist of MW571x31, MW574x31, MW134x04, MW584x04, MW587x04, MW757x04, and MW591x04. These wells will be sampled annually for VOCs. This network will continue to be monitored during the interim period or until such time as the remedy changes. Source area monitoring to support assessment of the FT004/SD031 GET performance will continue to be performed as specified in the GSAP annual reports.

TABLE 2-1

FT004/SD031 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: FT003									
MW133X03	10	30	49.02	29.02	61.70	9.05	52.65	10.61	51.09
MW205X03	5	20	54.44	39.44	61.98	10.19	51.79	11.79	50.19
MW206X03	5	20	53.74	38.74	61.24	8.85	52.39	10.23	51.01
MW302X03	43	53	16.62	6.62	62.22	10.29	51.93	12.13	50.09
Site: FT004									
EW576X04	5	30	54.57	29.57	59.57	NM	NM	NM	NM
EW577X04	5	30	54.94	29.94	59.94	NM	NM	NM	NM
EW578X04	5	55	54.81	4.81	59.81	NM	NM	NM	NM
EW579X04	5	55	53.94	3.94	58.94	NM	NM	NM	NM
EW580X04	5	55	54.05	4.05	59.05	NM	NM	NM	NM
EW621X04	8	28	51.9	31.9	57.37	NM	NM	NM	NM
EW622X04	8	28	52.9	32.9	58.43	NM	NM	NM	NM
EW623X04	8	28	52.8	32.8	58.39	NM	NM	NM	NM
MW131X04	10	30	49.2	29.2	62.63	14.82	47.81	17.98	44.65
MW132X04	11	31	48	28	62.94	11.68	51.26	14.43	48.51
MW134X04	11	31	48.29	28.29	61.98	9.48	52.5	11.32	50.66
MW202X04	4.5	19.5	53.41	38.41	62.01	8.14	53.87	11.04	50.97
MW203X04	5	20	52.52	37.52	62.13	10.47	51.66	14.07	48.06
MW204X04	5	20	53.73	38.73	61.36	NM	NM	9.49	51.87
MW264X04	15	25	49.4	39.4	68.59	8.84	59.75	12.2	56.39
MW265X04	6	16	52.9	42.9	63.06	8.19	54.87	11.3	51.76
MW266X04	6	16	51.8	41.8	62.27	10.23	52.04	14.81	47.46
MW267X04	4.5	14.5	57.2	47.2	66.18	7.64	58.54	11.13	55.05

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 2-1

FT004/SD031 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: FT004									
MW301X04	32	42	27.63	17.63	62.05	10.24	51.81	13.99	48.06
MW581X04	15	35	46.43	26.43	61.43	9.61	51.82	12.68	48.75
MW582X04	5	20	56.36	41.36	61.38	9.46	51.92	12.55	48.83
MW583X04	15	35	46.48	26.48	61.48	9.22	52.26	11.77	49.71
MW584X04	5	20	56.71	41.71	61.69	9.35	52.34	11.42	50.27
MW585X04	15	35	46.42	26.42	61.42	9.22	52.2	11.92	49.5
MW586X04	5	20	56.57	41.57	61.56	9.35	52.21	12.02	49.54
MW587X04	15	35	46.81	26.81	61.81	9.92	51.89	12.8	49.01
MW588X04	5	20	56.75	41.75	61.72	9.81	51.91	12.75	48.97
MW589X04	15	35	46.5	26.5	61.50	9.34	52.16	11.89	49.61
MW590X04	5	20	56.35	41.35	60.40	9.14	51.26	11.71	48.69
MW591X04	15	35	46.95	26.95	61.95	9.87	52.08	12.51	49.44
MW592X04	5	20	56.31	41.31	61.29	9.13	52.16	11.8	49.49
MW752X04	19	28	39.9	30.9	58.89	7.74	51.15	10.02	48.87
MW753X04	39	48	19.92	10.92	58.70	7.79	50.91	9.72	48.98
MW754X04	19	28	39.98	30.98	58.64	7.86	50.78	9.85	48.79
MW755X04	14	23	45.28	36.28	58.93	7.82	51.11	10	48.93
MW756X04	12	21	47.74	38.74	59.43	7.39	52.04	9.78	49.65
MW757X04	31	41	28.67	18.67	59.40	7.38	52.02	9.77	49.63
MW1000X04	6.5	16.5	51.47	41.47	62.36	NM	NM	12.98	49.38
MW1001X04	5.5	15.5	53.05	43.05	62.98	11.32	51.66	12.94	50.04
MW1002X04	7.2	17.2	51.04	41.04	62.71	10.22	52.49	12.18	50.53
MW1029X04	7.2	17.2	51.97	41.97	63.19	NM	NM	NM	NM

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 2-1

FT004/SD031 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: FT004									
MW1030X04	16.4	26.4	40.76	30.76	61.80	8.45	53.35	11	50.8
Site: LF006									
MW207X06	4.5	19.5	62.21	47.21	69.22	9.28	59.94	10.02	59.2
MW210X06	5.5	20.5	61.57	46.57	69.52	10.1	59.42	11.58	57.94
Site: SD031									
EW565X31	5	35	55.66	25.66	60.66	NM	NM	NM	NM
EW566X31	5	40	57.19	22.19	62.19	NM	NM	NM	NM
EW567X31	5	35	55.67	25.67	60.67	NM	NM	NM	NM
MW568X31	15	35	46.15	26.15	61.15	7.19	53.96	9.08	52.07
MW569X31	5	20	56.06	41.06	61.09	7.22	53.87	8.9	52.19
MW570X31	15	35	47.57	27.57	62.57	8.54	54.03	10.06	52.51
MW571X31	5	20	57.49	42.49	62.48	8.53	53.95	10.1	52.38
MW572X31	15	35	45.64	25.64	60.64	6.74	53.9	8.44	52.2
MW573X31	5	20	55.66	40.66	60.70	6.87	53.83	8.51	52.19
MW574X31	15	35	44.81	24.81	59.81	6.04	53.77	7.72	52.09
MW575X31	5	20	54.73	39.73	59.71	5.95	53.76	8.14	51.57
MW1725X31	6	16	52.86	42.86	63.73	8.86	54.87	10.42	53.31
MW1726X31	6	16	52.96	42.96	63.70	9	54.7	10.63	53.07
MW1727X31	5.5	15.5	53.42	43.42	60.39	NM	NM	NM	NM
MW1729X31	8	18	55.75	45.75	68.56	12.41	56.15	13.75	54.81
MW1730X31	6.5	16.5	53.36	43.36	63.92	7.51	56.41	9.4	54.52
MW1731X31	6	16	52.97	42.97	63.30	7.61	55.69	9.05	54.25
MW1740X31	12	17	45.98	40.98	62.39	NM	NM	9.21	53.18

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 2-1

FT004/SD031 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SD031									
MW1741X31	13.7	23.7	46.08	36.08	61.81	7.28	54.53	8.95	52.86
MW1742X31	13.8	23.8	43.43	33.43	60.59	NM	NM	7.5	53.09

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 2-2
FT004/SD031 Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base, California

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW302x03	MW205x03	-0.03	0.002	0.004	-0.003
MW301x04	MW203x04	-0.03	-0.03	0.006	0.000
MW581x04	MW582x04	-0.008	-0.007	-0.007	-0.006
MW583x04	MW584x04	-0.004	-0.002	-0.006	-0.008
MW585x04	MW586x04	-0.06	NA	-0.001	-0.003
MW587x04	MW588x04	0.006	0.01	-0.001	0.003
MW589x04	MW590x04	0.07	0.06	0.06	0.063
MW591x04	MW592x04	-0.003	-0.005	-0.006	-0.003
MW753x04	MW754x04	0.002	0.005	0.006	0.009
MW757x04	MW756x04	-0.002	0.001	-0.001	-0.001
MW568x31	MW569x31	-0.002	0.004	0.007	-0.01
MW570x31	MW571x31	0.008	0.006	0.006	0.01
MW572x31	MW573x31	0.002	0.003	0.006	0.001
MW574x31	MW575x31	0.002	0.009	0.001	0.043

Notes:

Minus sign indicates downward vertical gradient.

NA = Groundwater elevation was not measured and the vertical gradient could not be calculated.

TABLE 2-3
Aquifer Test Results for FT004/SD031
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
FT003	MW206x03	5–20	1988	Recovery	40	85% silty, clayey sand; 15% clay
FT004	MW203x04	5–20	1988	Gravity-injection	0.5	35% clayey sand; 65% silt
	MW264x04	15–25	9/11/91	Rising head slug Falling head slug	20 20	5% sandy clay; 95% shale
	MW265x04	6–6	9/13/91	Rising head slug	45	100% silty sand
	MW266x04	6–16	9/13/91	Rising head slug	45	75% silt with sand; 25% lean clay
	MW267x04	4.5–14.5	9/16/91	Rising head slug	115	25% clay; 50% clay with sand; 25% sandy clay
	MW131x04	10–30	10/14/98	Pumping	5	NA
	MW204x04	5–20	11/19/98	Pumping	3	NA
	MW1030x04	16.4–26.4	11/5/98	Pumping	15	NA
SD031	MW1727x31	5.5–15.5	10/16/98	Pumping	5	90% silty sand; 10% silt

Notes:

ft bgs = feet below ground surface
NA = data not available

Source: CH2M HILL, 2004.

TABLE 2-4

Summary of Analytes Detected in MNA Wells at FT004/SD031 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: FT003							
MW205X03							
	4/30/2008	SW8260	Freon 113	54		µg/L	1200
MW206X03							
	5/6/2008	SW8260	Freon 113	540		µg/L	1200
	5/6/2008	SW8260	Methylene chloride	2.7	J	µg/L	5
MW302X03							
	4/30/2008	SW8260	Acetone	2.6	J	µg/L	5110
Site: FT004							
MW131X04							
	4/28/2008	SW8260	1,2-DCA	0.34	J	µg/L	0.5
	4/28/2008	SW8260	Acetone	4.2	J	µg/L	5110
	4/28/2008	SW8260	Chloroform	0.2	J	µg/L	100
	4/28/2008	SW8260	Cis-1,2-DCE	5.3		µg/L	6
	4/28/2008	SW8260	Methylene chloride	0.37	J	µg/L	5
	4/28/2008	SW8260	TCE	**220**		µg/L	5
	4/28/2008	SW8260	trans-1,2-DCE	0.24	J	µg/L	
	12/3/2008	E310	Alkalinity	584		mg/L	
	12/3/2008	E300	Chloride	503		mg/L	
	12/3/2008	SM4500S2	No Analytes Detected				
	12/3/2008	A5310B	Total Organic Carbon	6.93		mg/L	
	12/3/2008	SW8260	Cis-1,2-DCE	3.4		µg/L	6
	12/3/2008	E300	Nitrate	0.016	J	mg/L	
	12/3/2008	RSK-175	No Analytes Detected				
	12/3/2008	E300	Sulfate	1150		mg/L	
	12/3/2008	SW8260	TCE	**131**		µg/L	5
MW134X04							
	5/6/2008	SW8260	Cis-1,2-DCE	0.17	J	µg/L	6
	5/6/2008	SW8260	Freon 113	180		µg/L	1200
	5/6/2008	SW8260	Methylene chloride	0.76	J	µg/L	5
	5/6/2008	SW8260	TCE	0.36	J	µg/L	5
	12/4/2008	E310	Alkalinity	458		mg/L	
	12/4/2008	E300	Chloride	228		mg/L	
	12/4/2008	SM4500S2	No Analytes Detected				
	12/4/2008	A5310B	Total Organic Carbon	2.08		mg/L	
	12/4/2008	RSK-175	No Analytes Detected				
	12/4/2008	SW8260	TCE	0.67		µg/L	5
	12/4/2008	E300	Nitrate	0.7		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 2-4

Summary of Analytes Detected in MNA Wells at FT004/SD031 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: FT004							
MW134X04							
	12/4/2008	E300	Sulfate	53.5		mg/L	
MW202X04							
	4/29/2008	SW8260	1,1-DCE	0.22	J	µg/L	6
	4/29/2008	SW8260	Cis-1,2-DCE	0.51		µg/L	6
	4/29/2008	SW8260	TCE	**45**		µg/L	5
	12/2/2008	E310	Alkalinity	468		mg/L	
	12/2/2008	E300	Chloride	226		mg/L	
	12/2/2008	SM4500S2	No Analytes Detected				
	12/2/2008	A5310B	Total Organic Carbon	2.85		mg/L	
	12/2/2008	E300	Nitrate	0.332		mg/L	
	12/2/2008	RSK-175	No Analytes Detected				
	12/2/2008	E300	Sulfate	617		mg/L	
	12/2/2008	SW8260	TCE	**58.3**		µg/L	5
MW264X04							
	5/2/2008	SW8260	Methylene chloride	0.57	J	µg/L	5
	11/21/2008	E310	Alkalinity	260		mg/L	
	11/21/2008	E300	Chloride	1590		mg/L	
	11/21/2008	SM4500S2	No Analytes Detected				
	11/21/2008	A5310B	Total Organic Carbon	2.29		mg/L	
	11/21/2008	E300	Nitrate	9.5		mg/L	
	11/21/2008	RSK-175	No Analytes Detected				
	11/21/2008	SW8260	No Analytes Detected				
	11/21/2008	E300	Sulfate	4770		mg/L	
MW266X04							
	4/29/2008	SW8260	Cis-1,2-DCE	1.1		µg/L	6
	4/29/2008	SW8260	TCE	**250**		µg/L	5
	12/2/2008	E310	Alkalinity	184		mg/L	
	12/2/2008	E300	Chloride	269		mg/L	
	12/2/2008	SM4500S2	No Analytes Detected				
	12/2/2008	A5310B	Total Organic Carbon	2.52		mg/L	
	12/2/2008	SW8260	Cis-1,2-DCE	1.1		µg/L	6
	12/2/2008	E300	Nitrate	0.761		mg/L	
	12/2/2008	RSK-175	No Analytes Detected				
	12/2/2008	E300	Sulfate	436		mg/L	
	12/2/2008	SW8260	TCE	**210**		µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: FT004							
MW582X04							
	4/25/2008	SW8260	Cis-1,2-DCE	3.4		µg/L	6
	4/25/2008	SW8260	TCE	**5.9**		µg/L	5
	4/25/2008	SW8260	Toluene	0.2	J	µg/L	150
	12/1/2008	E310	Alkalinity	393		mg/L	
	12/1/2008	E300	Chloride	458		mg/L	
	12/1/2008	SM4500S2	Sulfide	1.03		mg/L	
	12/1/2008	A5310B	Total Organic Carbon	11.6		mg/L	
	12/1/2008	SW8260	Cis-1,2-DCE	3.1		µg/L	6
	12/1/2008	E300	Nitrate	1.16		mg/L	
	12/1/2008	RSK-175	No Analytes Detected				
	12/1/2008	E300	Sulfate	701		mg/L	
	12/1/2008	SW8260	TCE	**6.5**		µg/L	5
MW589X04							
	4/25/2008	SW8260	Bromodichloromethane	0.24	J	µg/L	100
	4/25/2008	SW8260	Chloroform	0.87		µg/L	100
	4/25/2008	SW8260	TCE	3.5		µg/L	5
MW590X04							
	4/25/2008	SW8260	Bromodichloromethane	0.21	J	µg/L	100
	4/25/2008	SW8260	Chloroform	0.75		µg/L	100
	4/25/2008	SW8260	TCE	**5.3**		µg/L	5
MW591X04							
	4/24/2008	SW8260	TCE	**6.2**		µg/L	5
	12/1/2008	E310	Alkalinity	257		mg/L	
	12/1/2008	E300	Chloride	243		mg/L	
	12/1/2008	SM4500S2	Sulfide	1.03		mg/L	
	12/1/2008	A5310B	Total Organic Carbon	3.79		mg/L	
	12/1/2008	E300	Nitrate	0.896		mg/L	
	12/1/2008	RSK-175	No Analytes Detected				
	12/1/2008	E300	Sulfate	307		mg/L	
	12/1/2008	SW8260	TCE	**14.4**		µg/L	5
MW592X04							
	4/24/2008	SW8260	No Analytes Detected				
MW752X04							
	4/30/2008	SW8260	Freon 113	130		µg/L	1200
	4/30/2008	SW8260	PCE	0.57		µg/L	5
	4/30/2008	SW8260	TCE	0.63		µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte
[a] Bold values indicate result greater than IRGs

TABLE 2-4

Summary of Analytes Detected in MNA Wells at FT004/SD031 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: FT004							
MW752X04							
	12/3/2008	E310	Alkalinity	414		mg/L	
	12/3/2008	E300	Chloride	267		mg/L	
	12/3/2008	SM4500S2	No Analytes Detected				
	12/3/2008	A5310B	Total Organic Carbon	2.08		mg/L	
	12/3/2008	RSK-175	Methane	12.6		µg/L	
	12/3/2008	E300	Nitrate	0.848		mg/L	
	12/3/2008	SW8260	PCE	0.47	J	µg/L	5
	12/3/2008	E300	Sulfate	77.3		mg/L	
	12/3/2008	SW8260	TCE	0.65		µg/L	5
MW753X04							
	4/30/2008	SW8260	Acetone	2.4	J	µg/L	5110
	12/3/2008	E310	Alkalinity	263		mg/L	
	12/3/2008	E300	Chloride	201		mg/L	
	12/3/2008	SM4500S2	No Analytes Detected				
	12/3/2008	A5310B	Total Organic Carbon	1.68		mg/L	
	12/3/2008	RSK-175	Methane	228		µg/L	
	12/3/2008	E300	Nitrate	0.46		mg/L	
	12/3/2008	SW8260	No Analytes Detected				
	12/3/2008	E300	Sulfate	311		mg/L	
MW754X04							
	4/30/2008	SW8260	Acetone	2.7	J	µg/L	5110
	12/3/2008	E310	Alkalinity	328		mg/L	
	12/3/2008	E300	Chloride	202		mg/L	
	12/3/2008	E300	Nitrite	0.192		mg/L	
	12/3/2008	SM4500S2	No Analytes Detected				
	12/3/2008	A5310B	Total Organic Carbon	2.07		mg/L	
	12/3/2008	E300	Nitrate	1.11		mg/L	
	12/3/2008	RSK-175	No Analytes Detected				
	12/3/2008	SW8260	No Analytes Detected				
	12/3/2008	E300	Sulfate	241		mg/L	
MW755X04							
	4/30/2008	SW8260	Acetone	2.7	J	µg/L	5110
MW756X04							
	4/30/2008	SW8260	Acetone	2.2	J	µg/L	5110
	4/30/2008	SW8260	TCE	1		µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: FT004							
MW757X04							
	4/30/2008	SW8260	Acetone	2.2	J	µg/L	5110
	4/30/2008	SW8260	Cis-1,2-DCE	0.26	J	µg/L	6
	4/30/2008	SW8260	PCE	0.52		µg/L	5
	4/30/2008	SW8260	TCE	2.5		µg/L	5
Site: SD031							
MW570X31							
	4/28/2008	SW8260	1,1-DCA	0.34	J	µg/L	
	4/28/2008	SW8260	1,1-DCE	**7.3**	J	µg/L	6
	4/28/2008	SW8260	Freon 113	200		µg/L	1200
	4/28/2008	SW8260	PCE	0.52		µg/L	5
	12/9/2008	E310	Alkalinity	304		mg/L	
	12/9/2008	E300	Chloride	255		mg/L	
	12/9/2008	E300	Nitrite	0.18		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	5.32		mg/L	
	12/9/2008	SW8260	1,1-DCA	0.37	J	µg/L	
	12/9/2008	SW8260	1,1-DCE	**9.1**		µg/L	6
	12/9/2008	E300	Nitrate	0.734		mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8260	PCE	0.73		µg/L	5
	12/9/2008	E300	Sulfate	97.2		mg/L	
MW571X31							
	4/28/2008	SW8260	1,1,1-TCA	0.22	J	µg/L	0.5
	4/28/2008	SW8260	1,1-DCA	0.19	J	µg/L	
	4/28/2008	SW8260	1,1-DCE	**14**	J	µg/L	6
	4/28/2008	SW8260	Freon 113	590		µg/L	1200
	4/28/2008	SW8260	PCE	0.93		µg/L	5
	12/9/2008	E310	Alkalinity	460		mg/L	
	12/9/2008	E300	Chloride	196		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	11.4		mg/L	
	12/9/2008	SW8260	1,1-DCA	0.39	J	µg/L	
	12/9/2008	SW8260	1,1-DCE	**27.4**		µg/L	6
	12/9/2008	RSK-175	Methane	123		µg/L	
	12/9/2008	SW8260	PCE	1.8		µg/L	5
	12/9/2008	E300	Sulfate	92.3		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 2-4

Summary of Analytes Detected in MNA Wells at FT004/SD031 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD031							
MW572X31							
	4/28/2008	SW8260	Freon 113	300		µg/L	1200
	4/28/2008	SW8260	TCE	0.29	J	µg/L	5
MW573X31							
	4/28/2008	SW8260	1,2-DCB	0.34	J	µg/L	
	4/28/2008	SW8260	Freon 113	44		µg/L	1200
MW574X31							
	4/29/2008	SW8260	1,1-DCA	0.18	J	µg/L	
	4/29/2008	SW8260	Cis-1,2-DCE	0.73		µg/L	6
	4/29/2008	SW8260	Freon 113	210		µg/L	1200
	4/29/2008	SW8260	Methylene chloride	0.44	J	µg/L	5
	4/29/2008	SW8260	TCE	**9.4**		µg/L	5
	12/10/2008	E310	Alkalinity	397		mg/L	
	12/10/2008	E300	Chloride	318		mg/L	
	12/10/2008	SM4500S2	No Analytes Detected				
	12/10/2008	A5310B	Total Organic Carbon	4.74		mg/L	
	12/10/2008	SW8260	1,1-DCE	3.8		µg/L	6
	12/10/2008	SW8260	Cis-1,2-DCE	0.77	J	µg/L	6
	12/10/2008	E300	Nitrate	3.78		mg/L	
	12/10/2008	RSK-175	No Analytes Detected				
	12/10/2008	E300	Sulfate	50.7		mg/L	
	12/10/2008	SW8260	TCE	**10.7**		µg/L	5
MW575X31							
	4/29/2008	SW8260	Cis-1,2-DCE	0.48	J	µg/L	6
	4/29/2008	SW8260	Freon 113	130		µg/L	1200
	4/29/2008	SW8260	TCE	4		µg/L	5
MW1730X31							
	4/29/2008	SW8260	Acetone	2	J	µg/L	5110
	4/29/2008	SW8260	Methylene chloride	0.52	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	TPH-Gasoline	**6.2**	J	µg/L	5
	12/9/2008	E310	Alkalinity	357		mg/L	
	12/9/2008	E300	Chloride	160		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	6.7	J+	mg/L	
	12/9/2008	E300	Nitrate	1.03	J-	mg/L	
	12/9/2008	RSK-175	No Analytes Detected				

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 2-4

Summary of Analytes Detected in MNA Wells at FT004/SD031 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD031							
MW1730X31							
	12/9/2008	SW8260	No Analytes Detected				
	12/9/2008	E300	Sulfate	511		mg/L	

Qualifier Description
J = The analyte was positively identified, the quantitation is an estimate.
F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
B = The analyte was found in an associated blank, as well as in the sample.
M = A matrix effect was present.
none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 2-5
FT004/SD031 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

				Background		Source		Plume						Distal			
Analysis	**Criteria**	**Interpretation**	**Possible Value[a]**	**MW264x04**	**MW1730X31**	**MW131X04**	**MW266x04**	**MW202X04**	**MW591x04**	**MW582X04**	**MW570x31**	**MW571x31**	**MW574x31**	**MW134x04**	**MW752x04**	**MW753x04**	**MW754X04**
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	0	-3	0	0	0	0	0	0	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	2	2	2	2	0	2	2	0	2	2	2	2
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	3	3	0	0	0	0	0	0	0
Methane[b]	<0.5 mg/L	VC oxidizes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>0.5 mg/L	Ultimate reductive daughter product; VC accumulates	3														
ORP[b]	<50 mV	Reductive pathway possible	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
	<-100 mV	Reductive pathway likely	2														
pH[b]	5< pH <9	Optimal range for reductive pathway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5> pH >9	Outside optimal range for reductive pathway	-2														
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-5
FT004/SD031 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

				Background		Source		Plume						Distal			
Analysis	Criteria	Interpretation	Possible Value[a]	MW264x04	MW1730X31	MW131X04	MW266x04	MW202X04	MW591x04	MW582X04	MW570x31	MW571x31	MW574x31	MW134x04	MW752x04	MW753x04	MW754X04
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCE[b]		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCE[b]		Material released Daughter product of PCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DCE[b] (all isomers[d])		Materials released Daughter product of TCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VC		Material released Daughter product of DCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethene/ethane	>0.01 mg/L >0.1 mg/L	Daughter product of VC/ethane	2 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Sum[e]	**+3**	**+1**	**+4**	**+2**	**+2**	**+5**	**0**	**+4**	**+2**	**+1**	**+3**	**+2**	**+2**	**+2**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: Zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C= degree(s) Celsius
BTEX = benzene, toluene, ethylbenzene, and xylenes
mg/L = milligram(s) per liter
mV = millivolt(s)
NA = not analyzed
TCA = trichloroethane

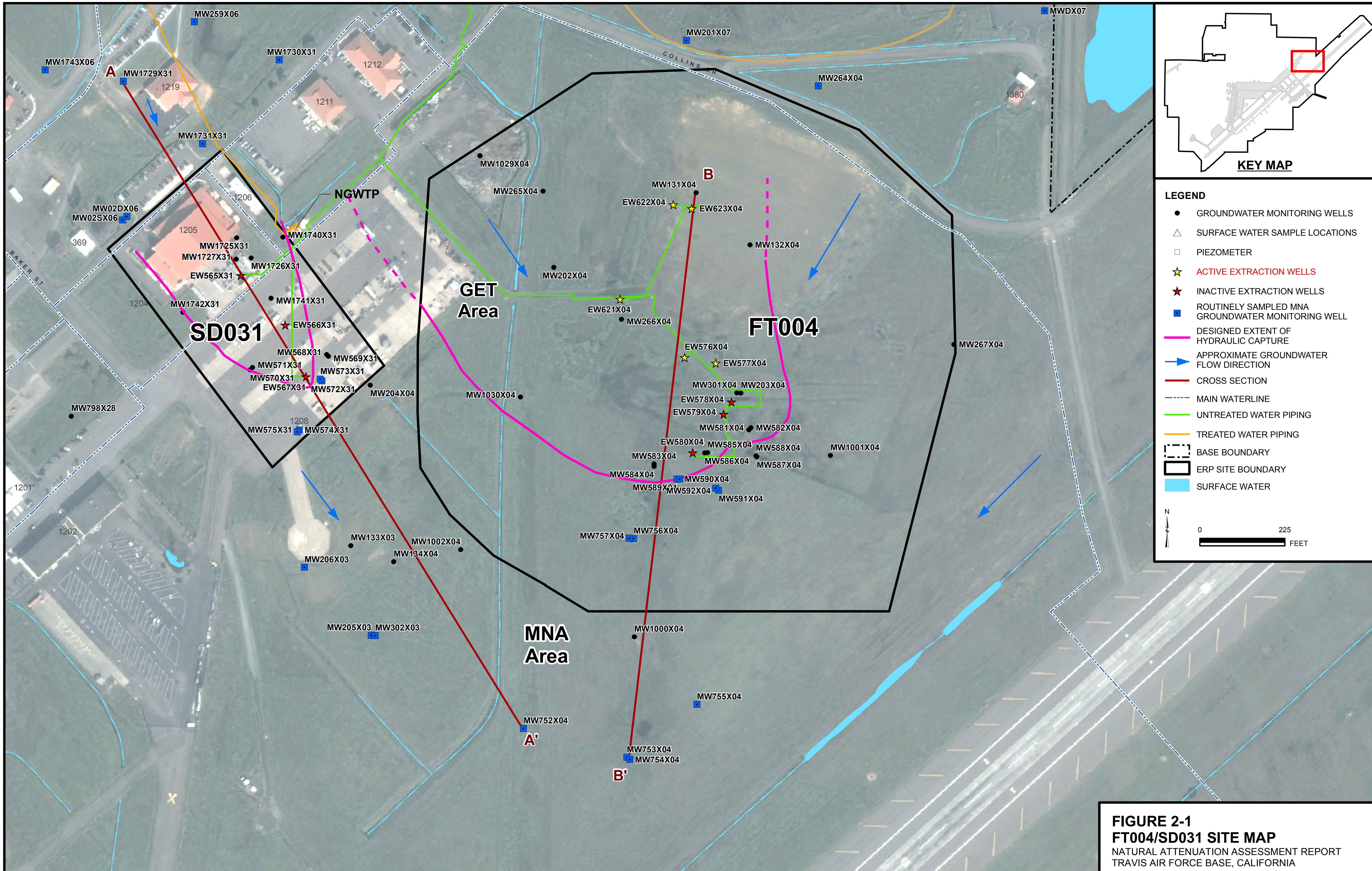
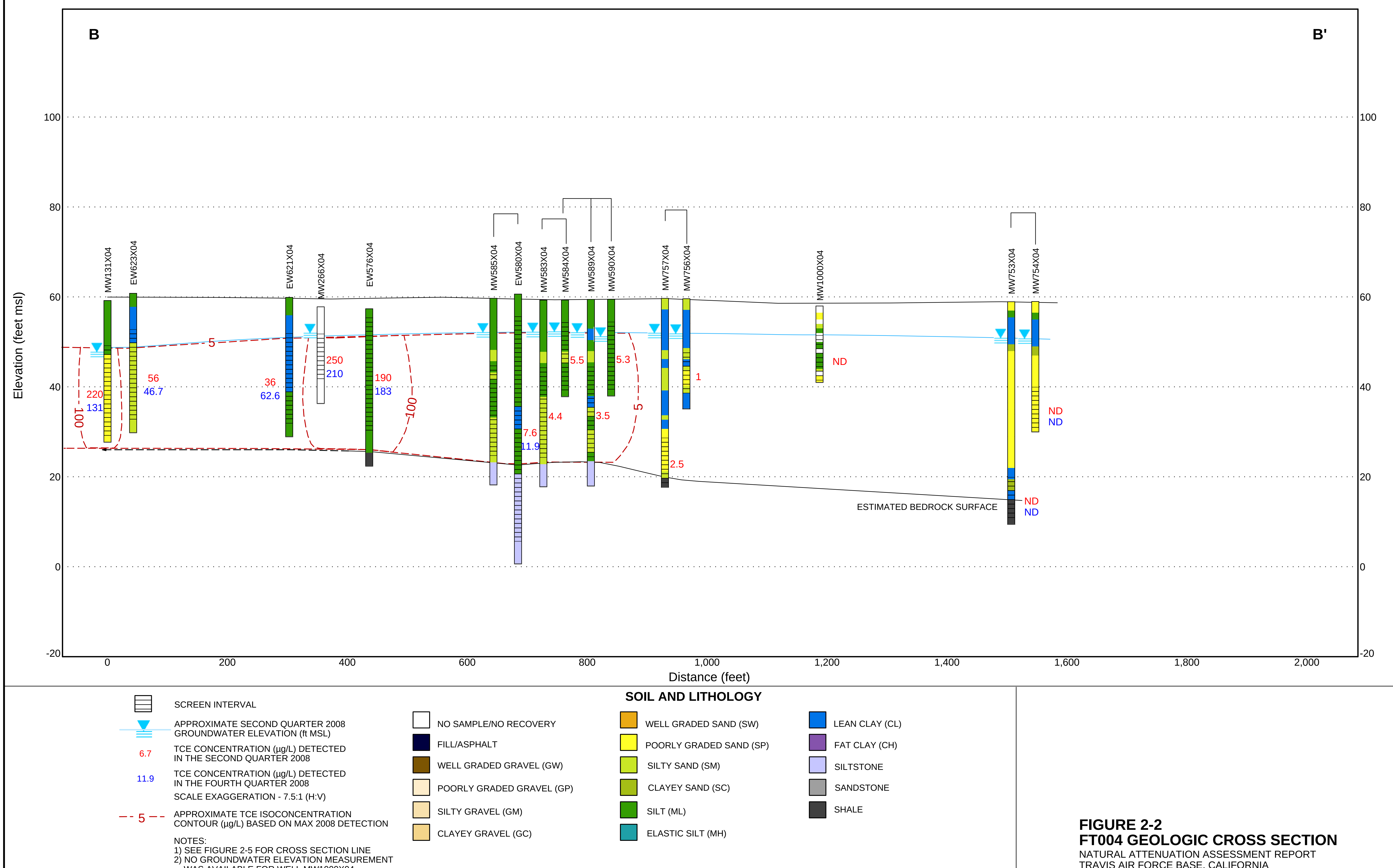


FIGURE 2-1
FT004/SD031 SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG2-1_FT004_SITE.MXD MCLAY1 1/22/2010

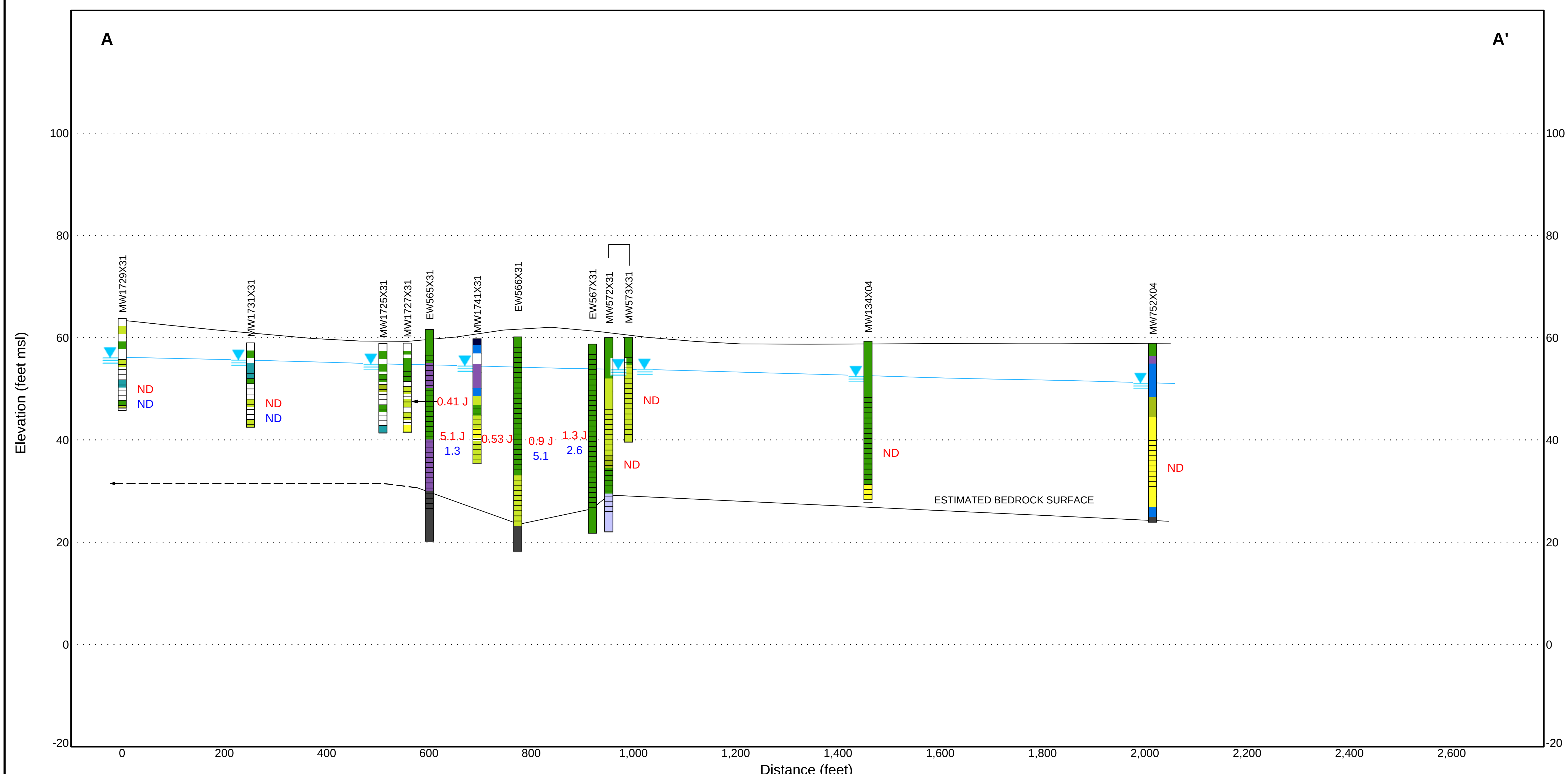


NOTES:
1) SEE FIGURE 2-5 FOR CROSS SECTION LINE
2) NO GROUNDWATER ELEVATION MEASUREMENT WAS AVAILABLE FOR WELL MW1000X04

FIGURE 2-2
FT004 GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;



SOIL AND LITHOLOGY

- SCREEN INTERVAL
- APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)
- 6.7 — 1,1 DCE CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008
- 1.3 — 1,1 DCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

SCALE EXAGGERATION - 10:1 (H:V)

NOTES:
1) SEE FIGURE 2-6 FOR CROSS SECTION LINE
2) NO GROUNDWATER ELEVATION MEASUREMENT WAS AVAILABLE FOR WELL MW1727X31

- NO SAMPLE/NO RECOVERY
- FILL/ASPHALT
- WELL GRADED GRAVEL (GW)
- POORLY GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- WELL GRADED SAND (SW)
- POORLY GRADED SAND (SP)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILT (ML)
- ELASTIC SILT (MH)
- LEAN CLAY (CL)
- FAT CLAY (CH)
- SILTSTONE
- SANDSTONE
- SHALE

FIGURE 2-3
SD031 GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

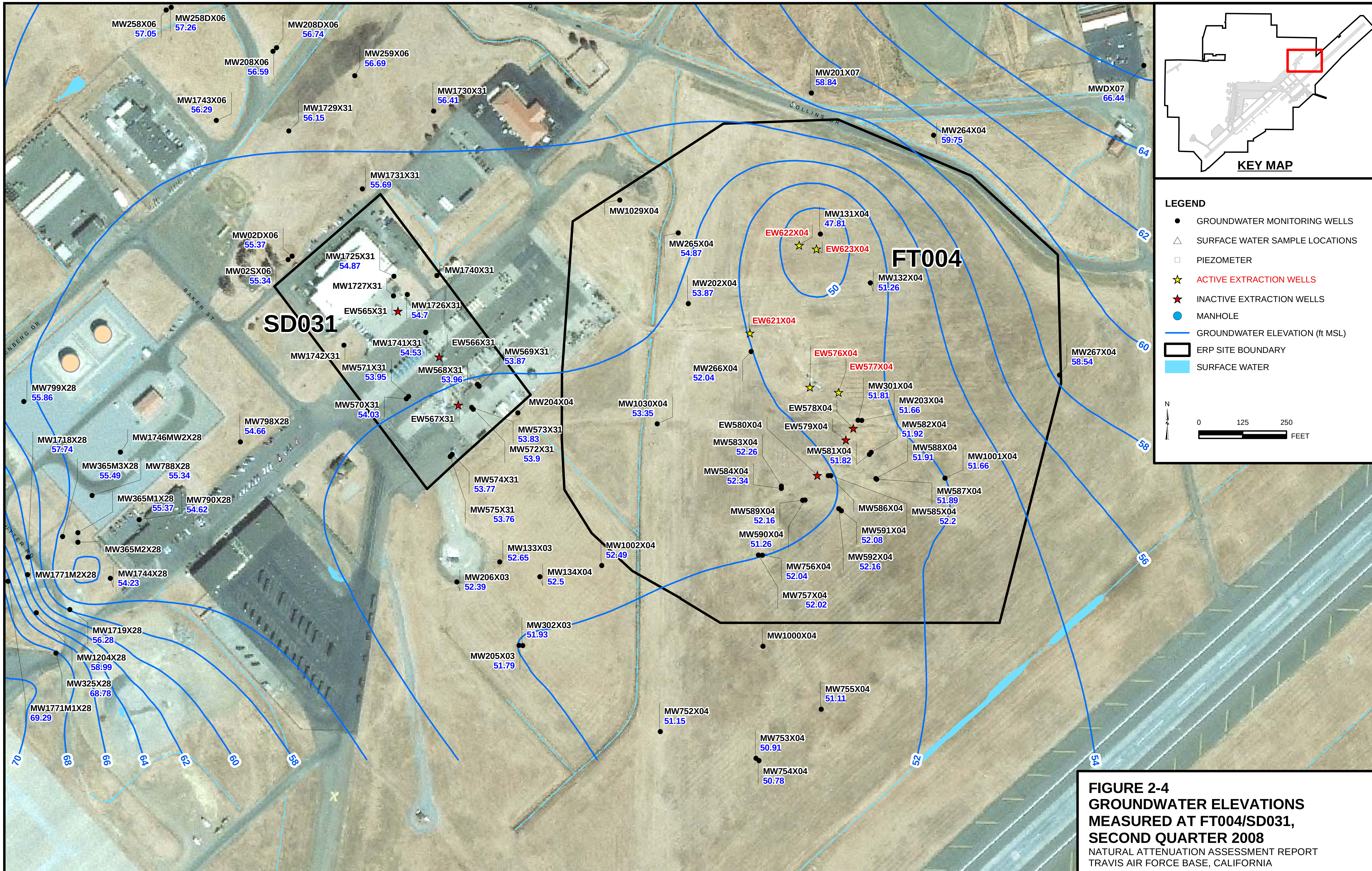


FIGURE 2-4
GROUNDWATER ELEVATIONS MEASURED AT FT004/SD031, SECOND QUARTER 2008

NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\FIG2-4_FT004_SD031_GW_2008.MXD MCLAY1 6/29/2009

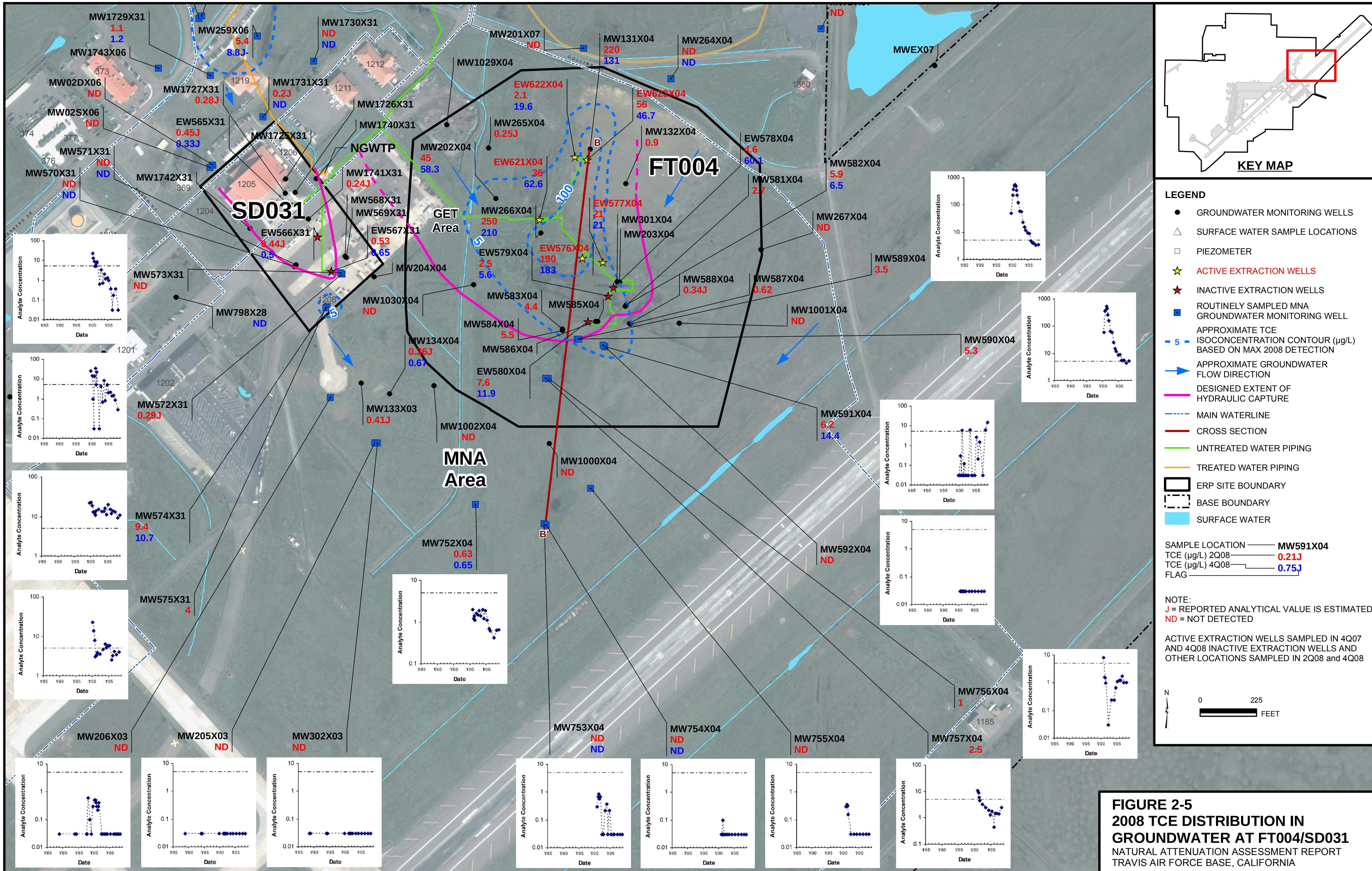


FIGURE 2-5
2008 TCE DISTRIBUTION IN GROUNDWATER AT FT004/SD031
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_MAY2010\FIG2-5_FT004_TCE.MXD JQUAN 6/2/2010 08:21:09

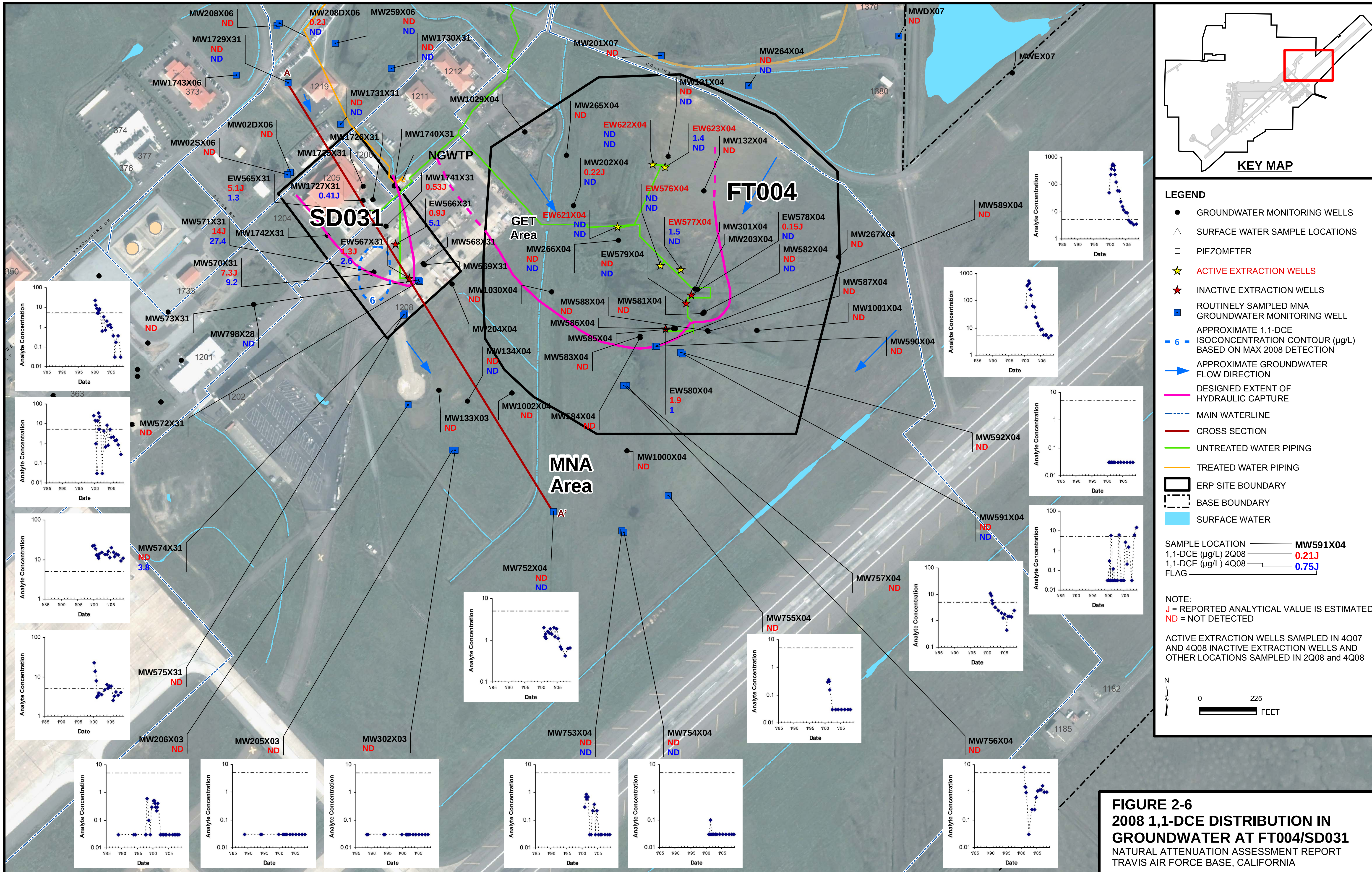
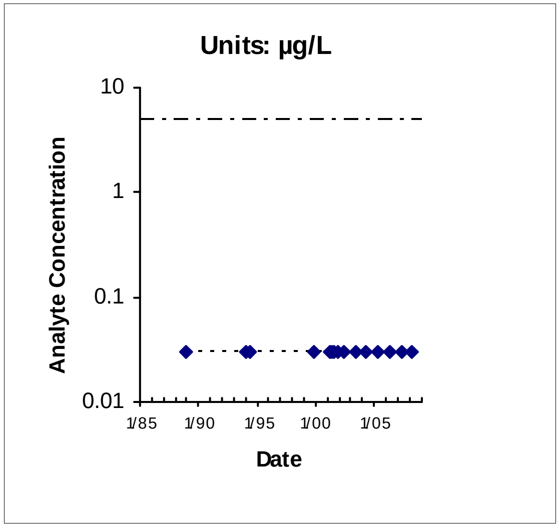
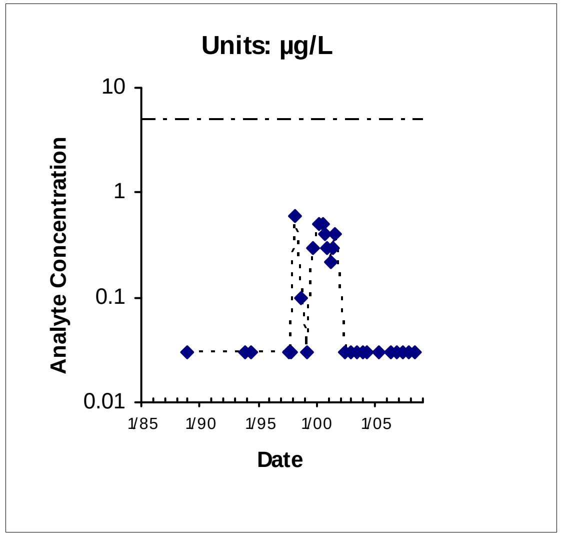


FIGURE 2-6
2008 1,1-DCE DISTRIBUTION IN GROUNDWATER AT FT004/SD031
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

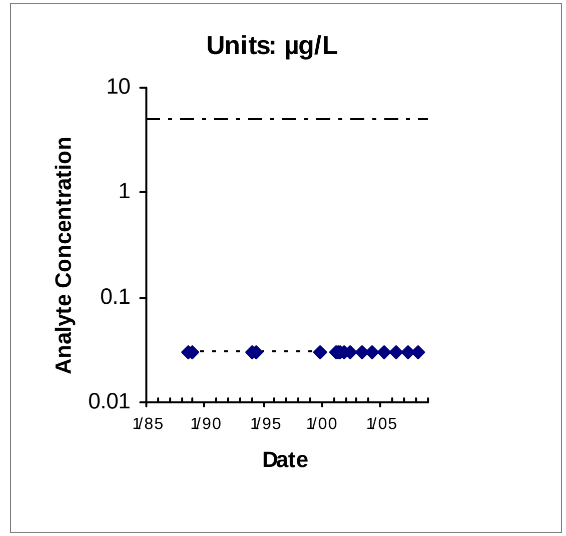
CH2MHILL



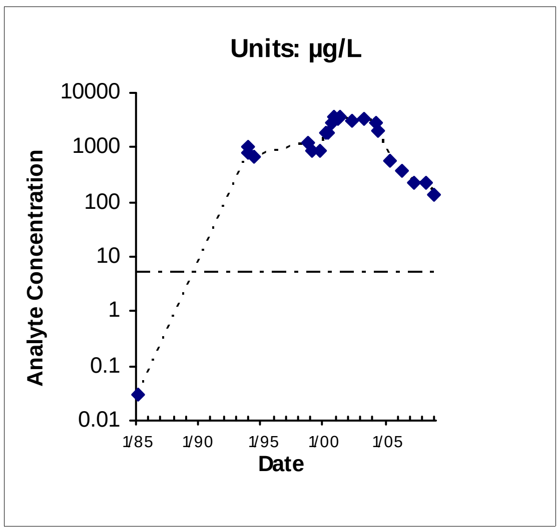
Location: MW205X03 Maximum: 0.03



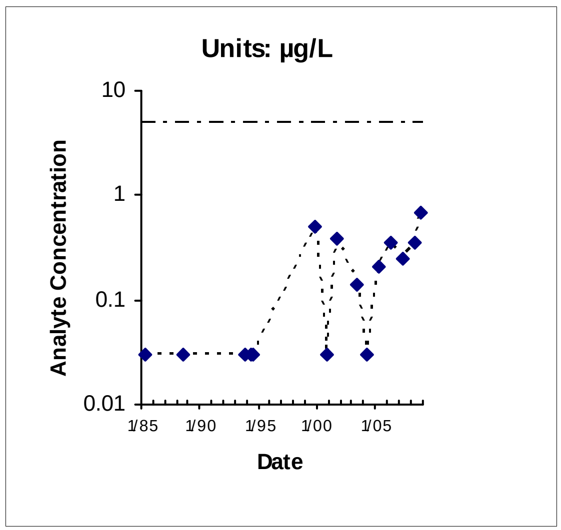
Location: MW206X03 Maximum: 0.6



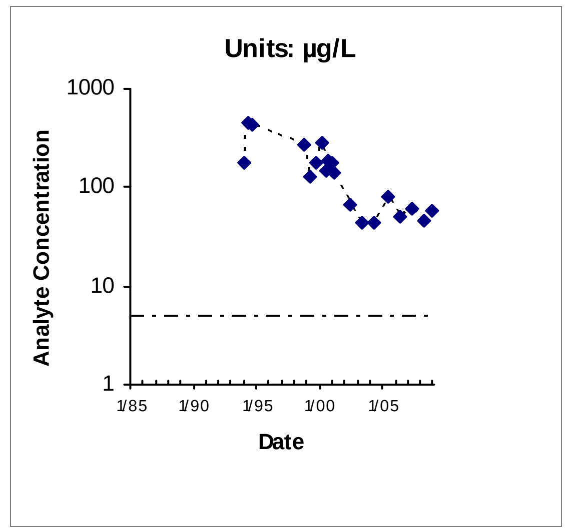
Location: MW302X03 Maximum: 0.03



Location: MW131X04 Maximum: 3600



Location: MW134X04 Maximum: 0.67



Location: MW202X04 Maximum: 460

— - — - — IRG (5 µg/L)

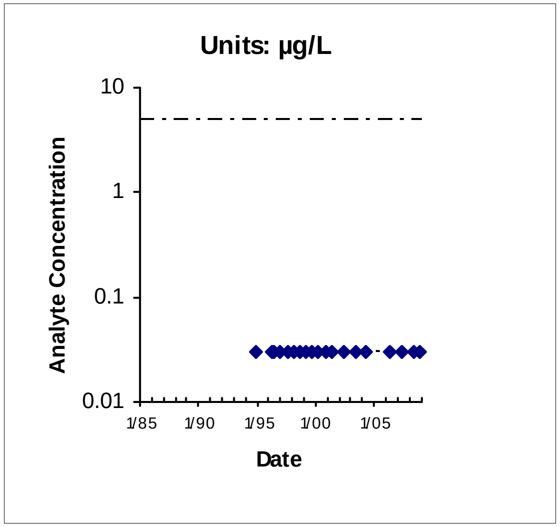
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 2-7

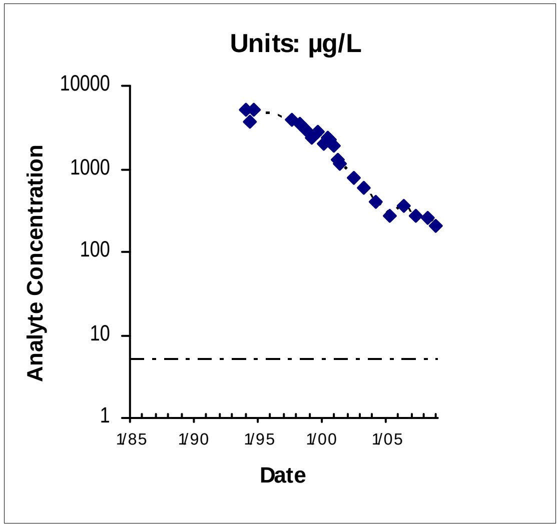
FT004/SD031 MNA Wells

TCE

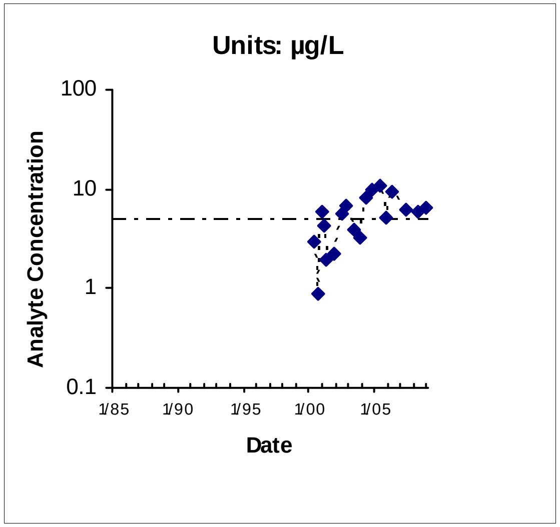
Chemical Time-series Plots



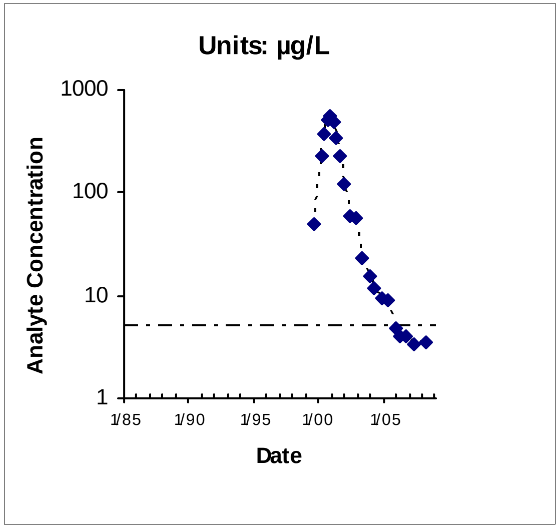
Location: MW264X04 Maximum: 0.03



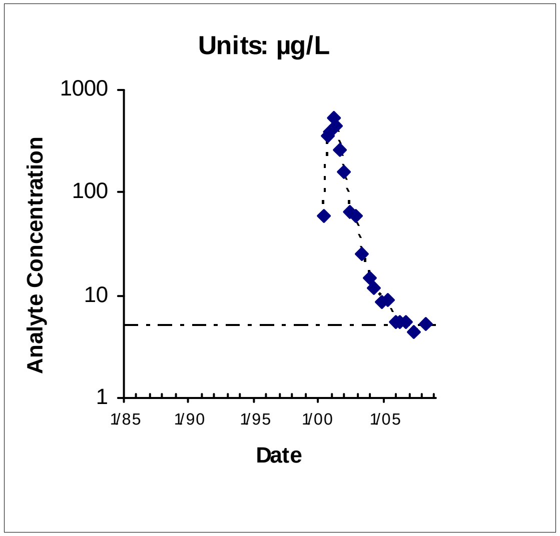
Location: MW266X04 Maximum: 5200



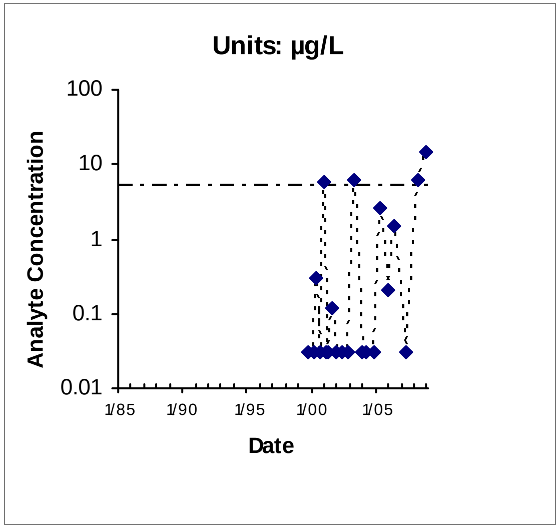
Location: MW582X04 Maximum: 11



Location: MW589X04 Maximum: 550



Location: MW590X04 Maximum: 530



Location: MW591X04 Maximum: 14.4

— - — - — IRG (5 µg/L)

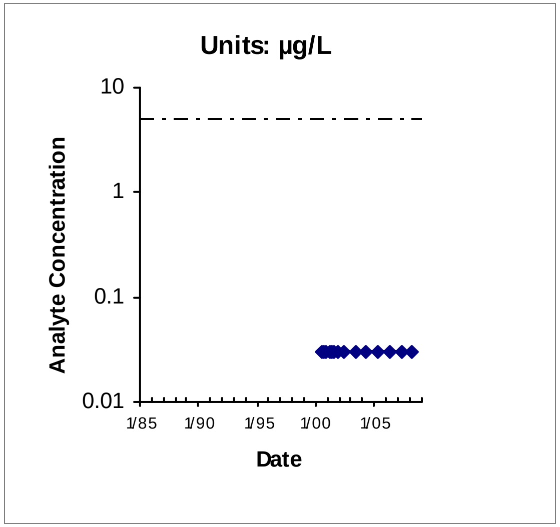
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 2-7

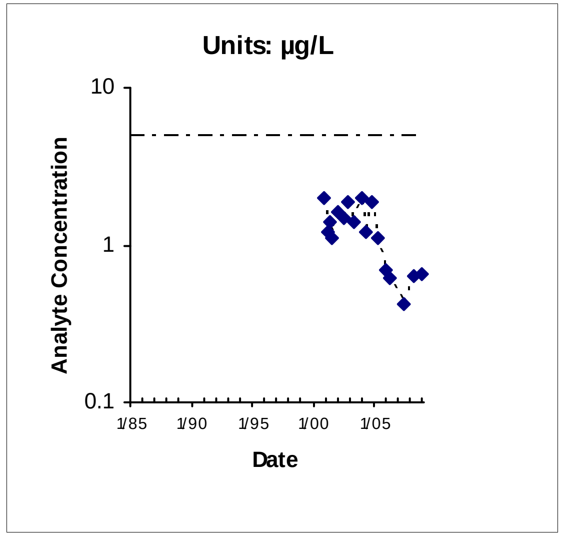
FT004/SD031 MNA Wells

TCE

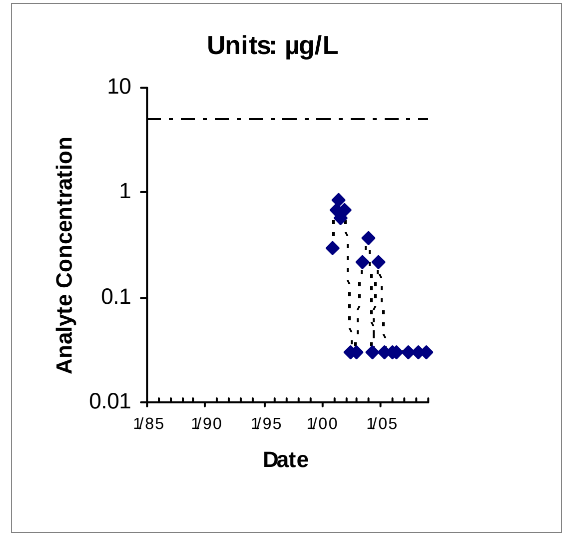
Chemical Time-series Plots



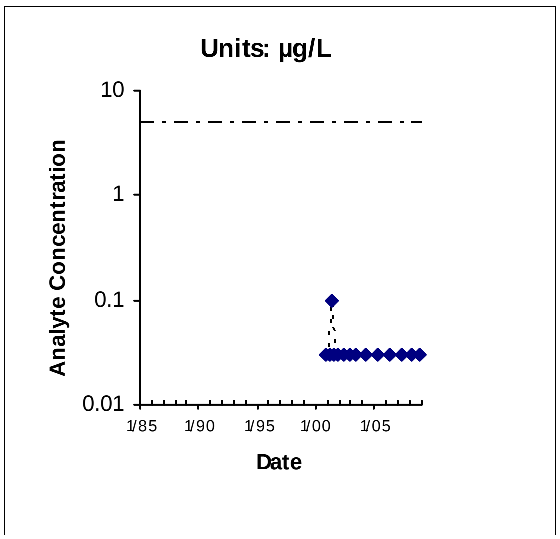
Location: MW592X04 Maximum: 0.03



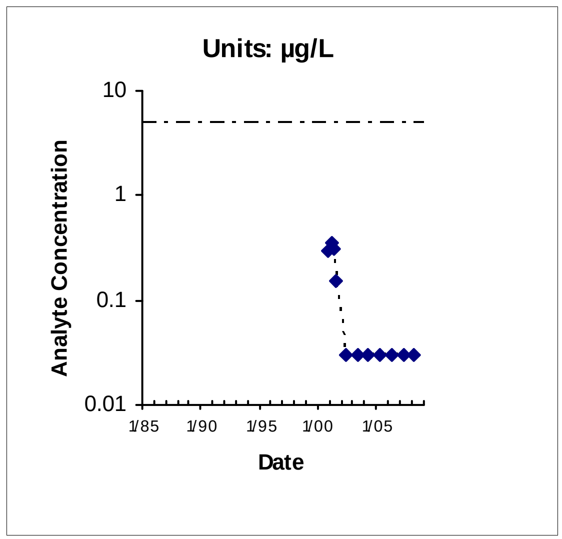
Location: MW752X04 Maximum: 2.01



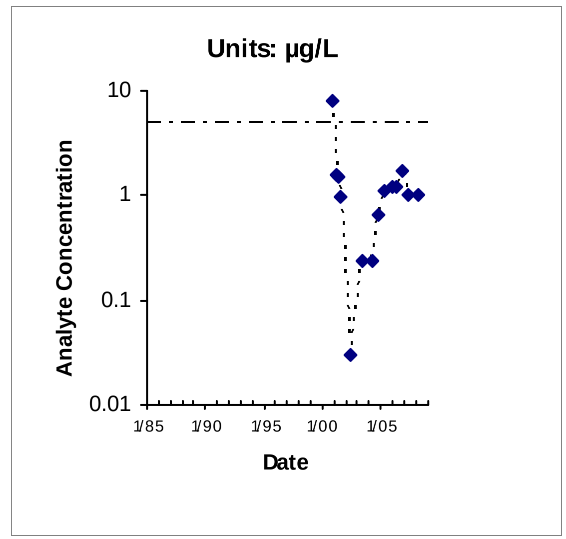
Location: MW753X04 Maximum: 0.85



Location: MW754X04 Maximum: 0.1



Location: MW755X04 Maximum: 0.35



Location: MW756X04 Maximum: 8

— - — - — IRG (5 µg/L)

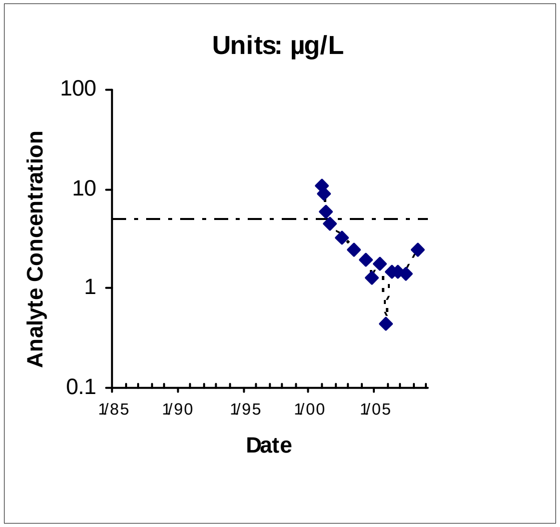
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 2-7

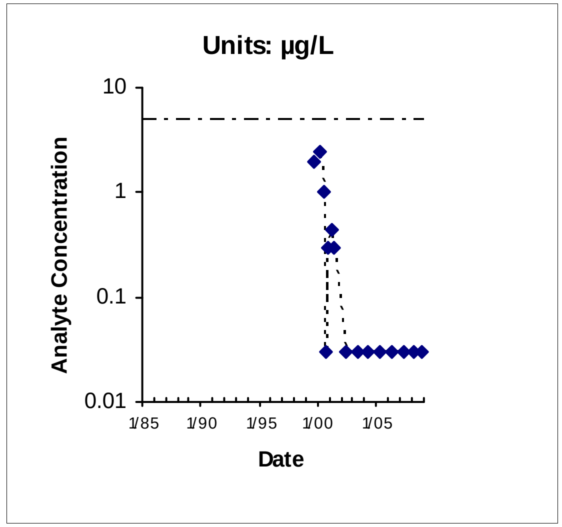
FT004/SD031 MNA Wells

TCE

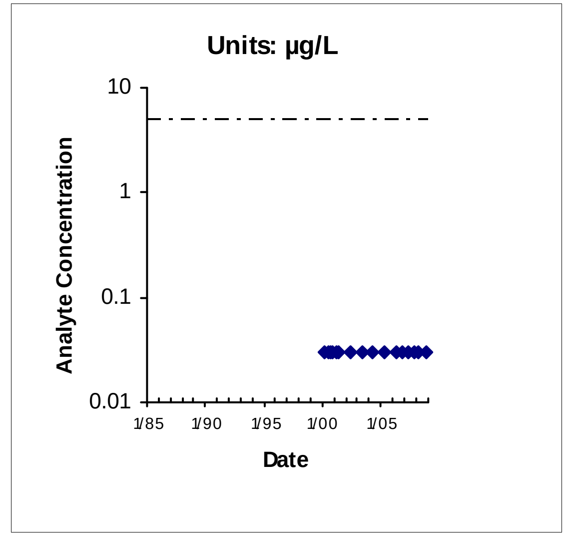
Chemical Time-series Plots



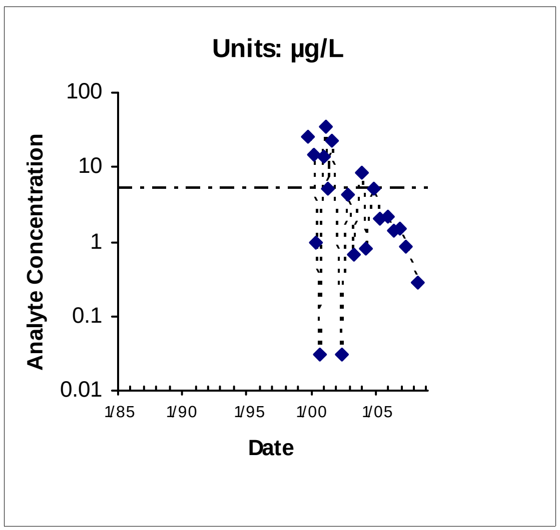
Location: MW757X04 Maximum: 11



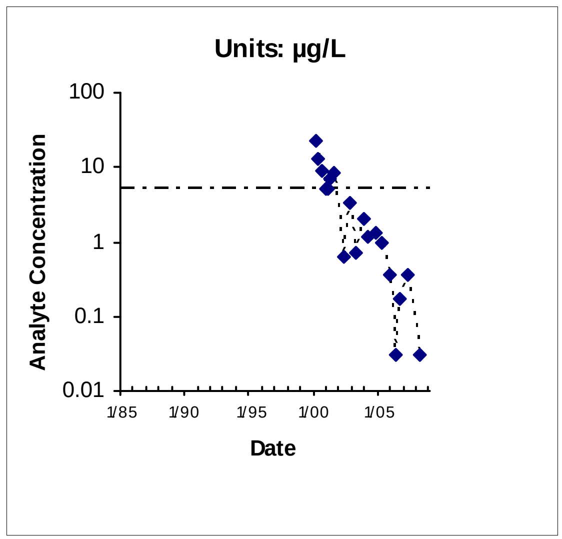
Location: MW570X31 Maximum: 2.4



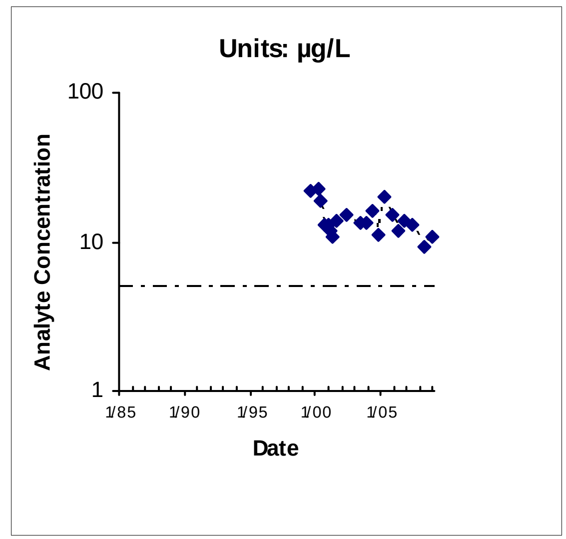
Location: MW571X31 Maximum: 0.03



Location: MW572X31 Maximum: 34



Location: MW573X31 Maximum: 23



Location: MW574X31 Maximum: 23

— - — - — IRG (5 µg/L)

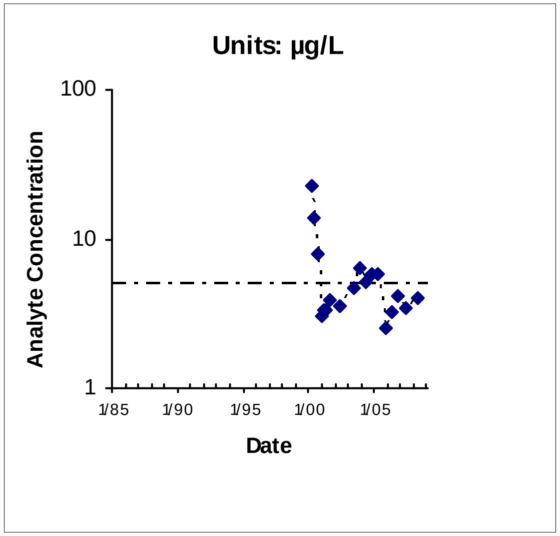
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 2-7

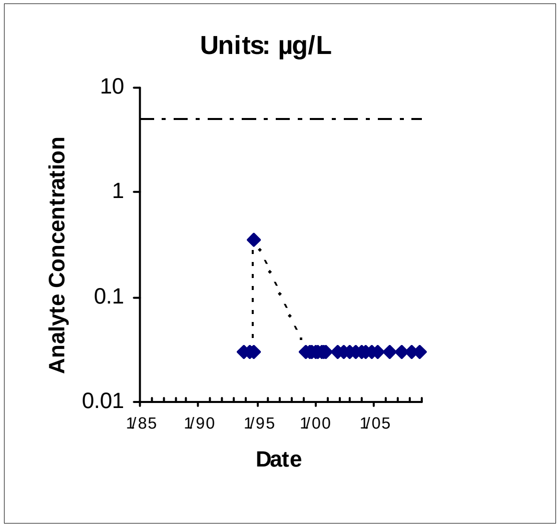
FT004/SD031 MNA Wells

TCE

Chemical Time-series Plots



Location: MW575X31 Maximum: 23



Location: MW1730X31 Maximum: 0.35

— - — - — IRG (5 µg/L)

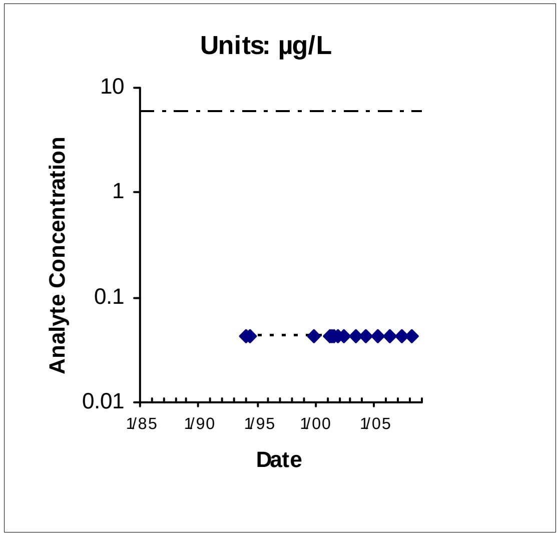
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 2-7

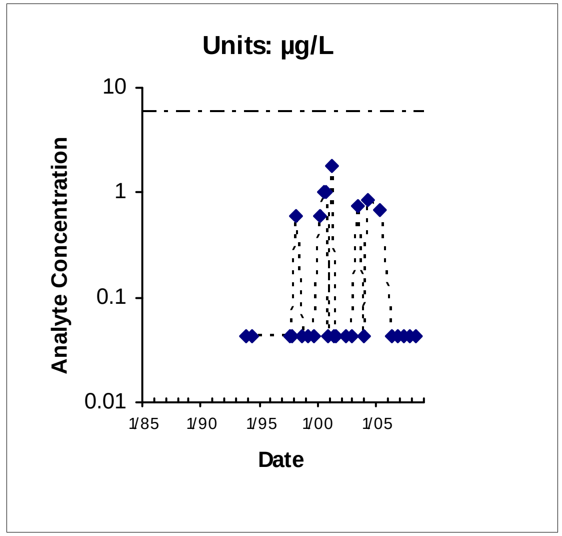
FT004/SD031 MNA Wells

TCE

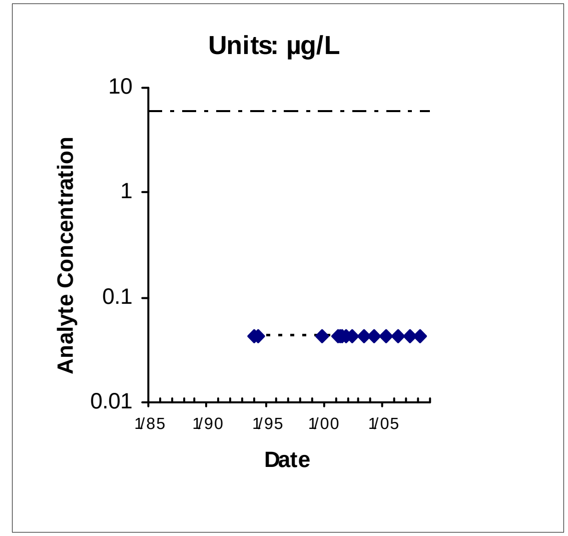
Chemical Time-series Plots



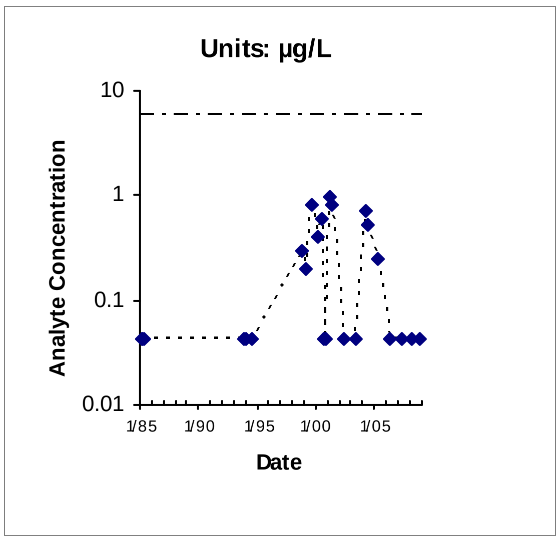
Location: MW205X03 Maximum: 0.0436



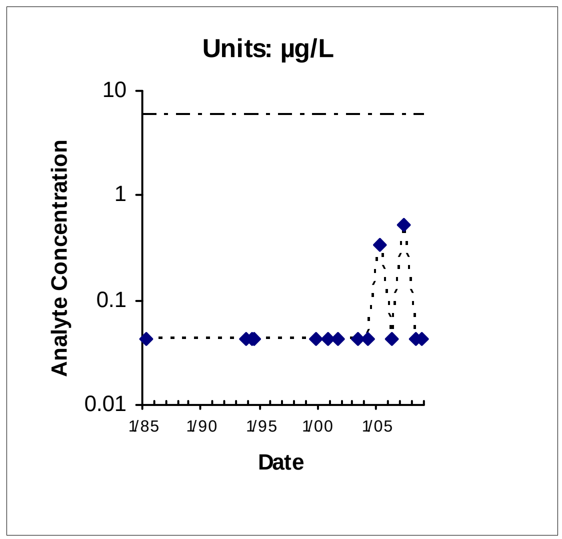
Location: MW206X03 Maximum: 1.8



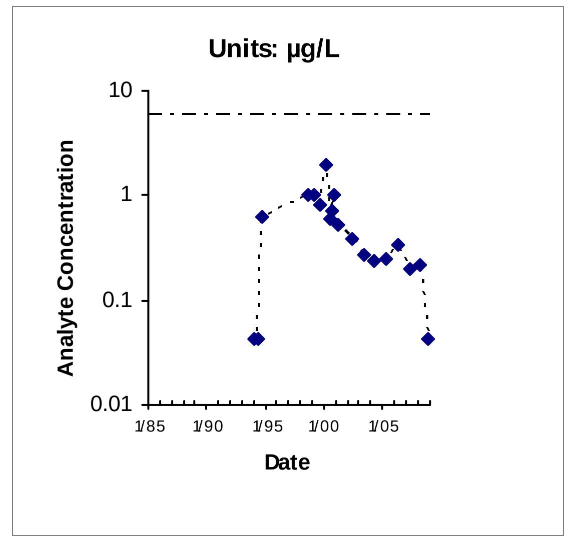
Location: MW302X03 Maximum: 0.0436



Location: MW131X04 Maximum: 0.98



Location: MW134X04 Maximum: 0.52



Location: MW202X04 Maximum: 2

— - - — - - — IRG (6 µg/L)

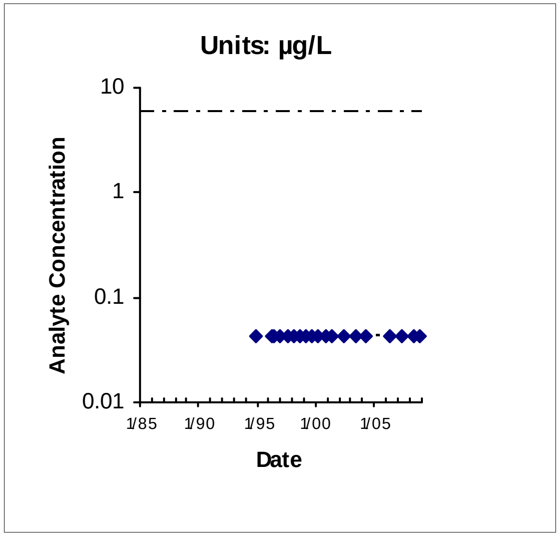
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 2-8

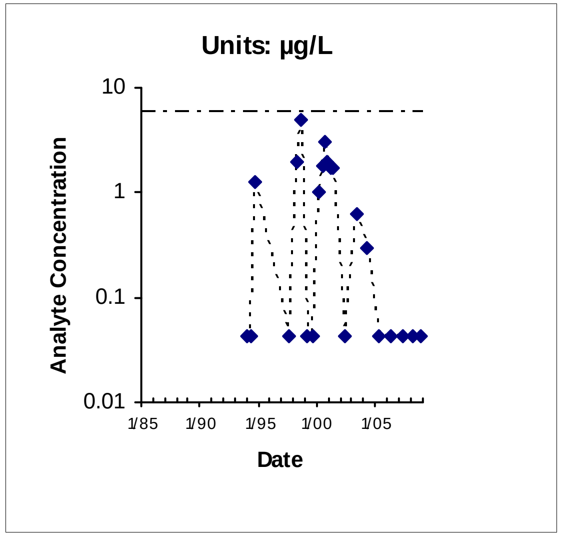
FT004/SD031 MNA Wells

1,1-DCE

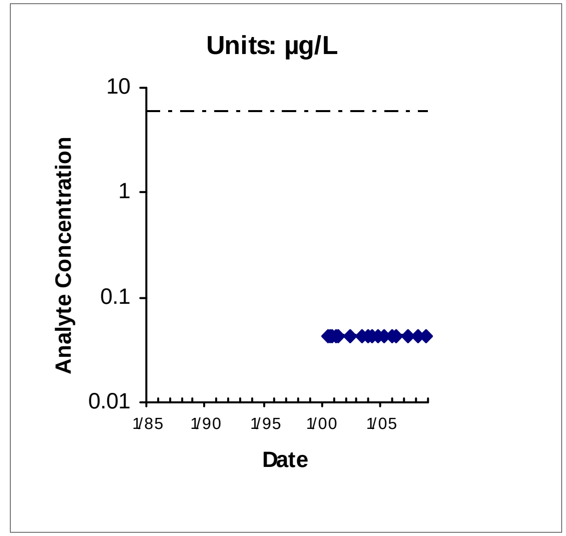
Chemical Time-series Plots



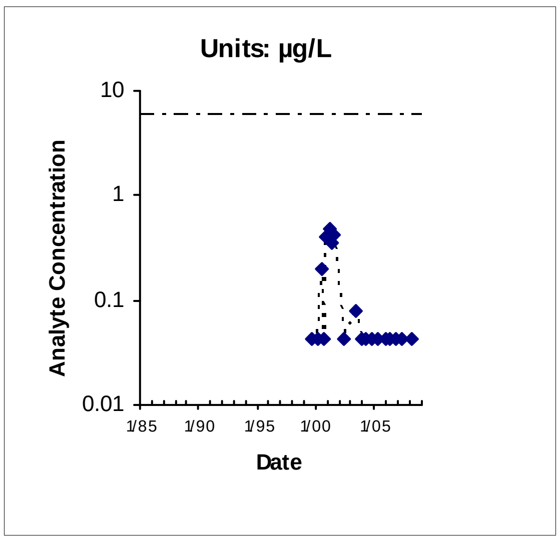
Location: MW264X04 Maximum: 0.0436



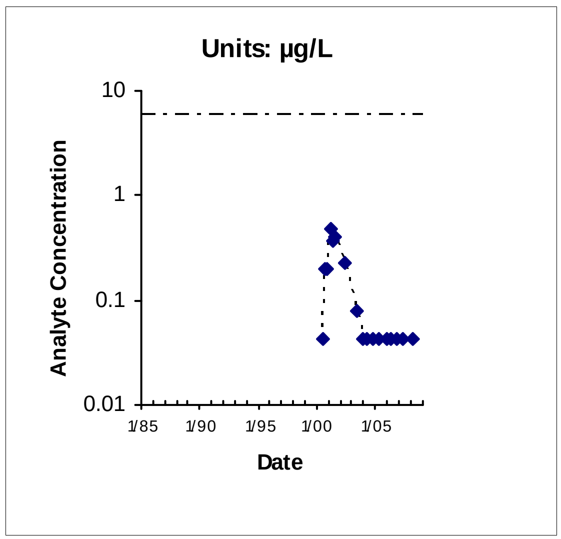
Location: MW266X04 Maximum: 5



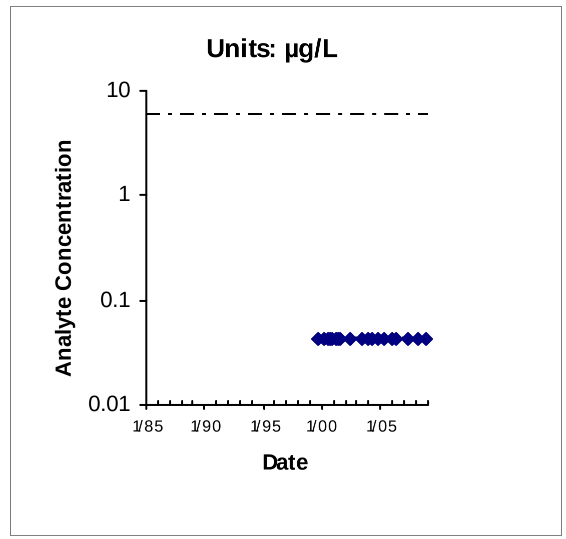
Location: MW582X04 Maximum: 0.0436



Location: MW589X04 Maximum: 0.48



Location: MW590X04 Maximum: 0.49



Location: MW591X04 Maximum: 0.0436

— - — - — IRG (6 µg/L)

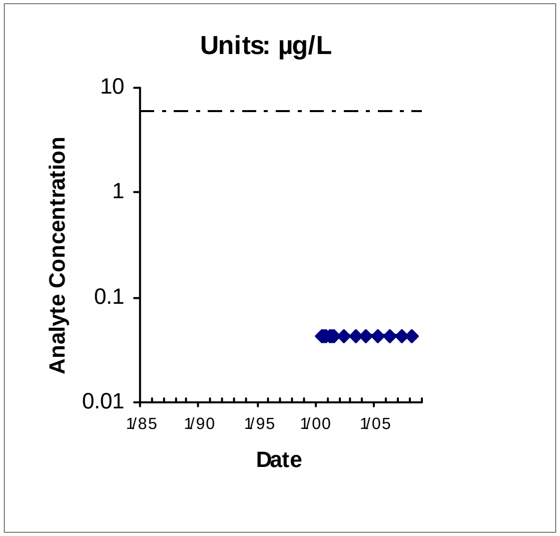
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 2-8

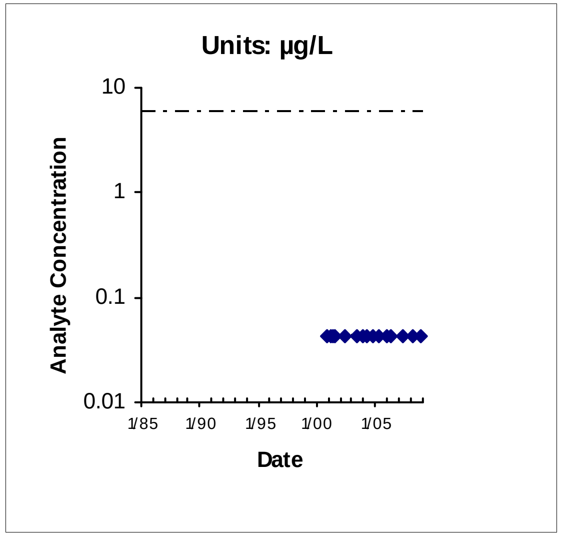
FT004/SD031 MNA Wells

1,1-DCE

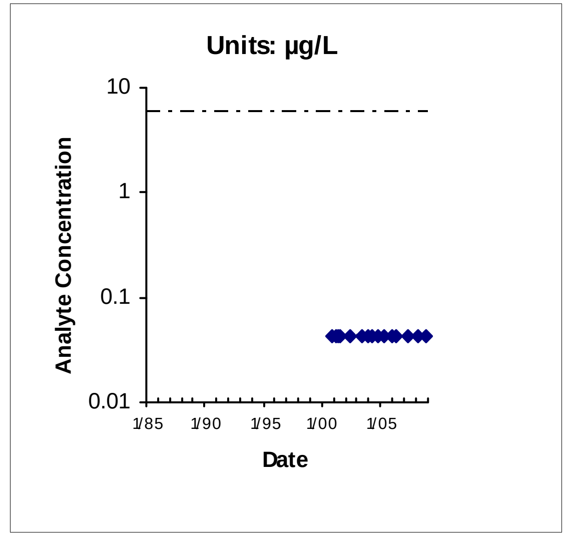
Chemical Time-series Plots



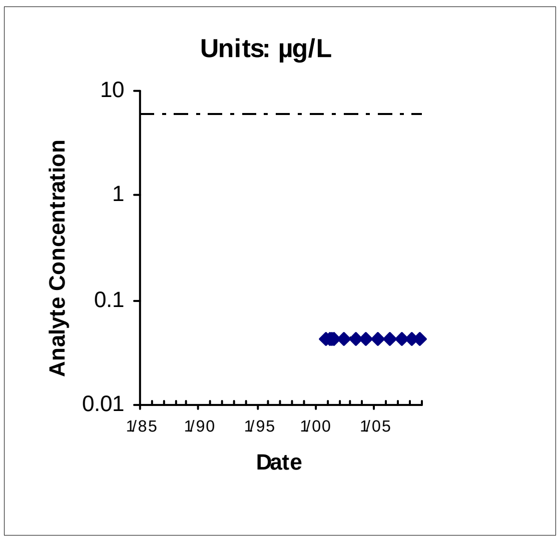
Location: MW592X04 Maximum: 0.0436



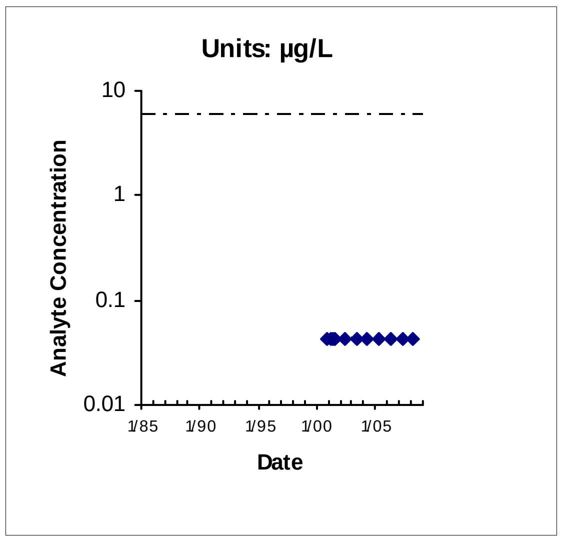
Location: MW752X04 Maximum: 0.0436



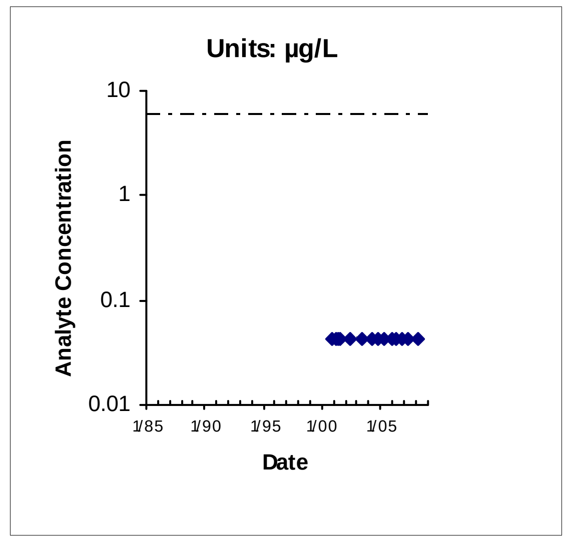
Location: MW753X04 Maximum: 0.0436



Location: MW754X04 Maximum: 0.0436



Location: MW755X04 Maximum: 0.0436



Location: MW756X04 Maximum: 0.0436

— - — - — IRG (6 µg/L)

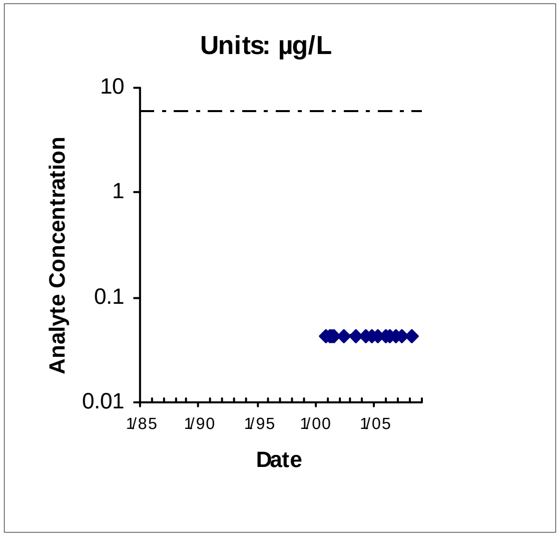
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 2-8

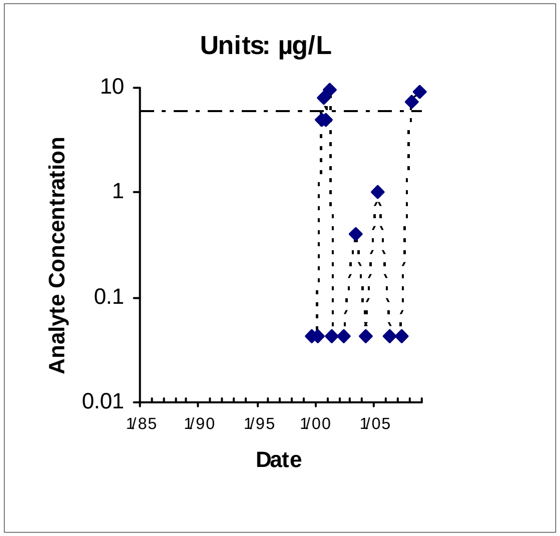
FT004/SD031 MNA Wells

1,1-DCE

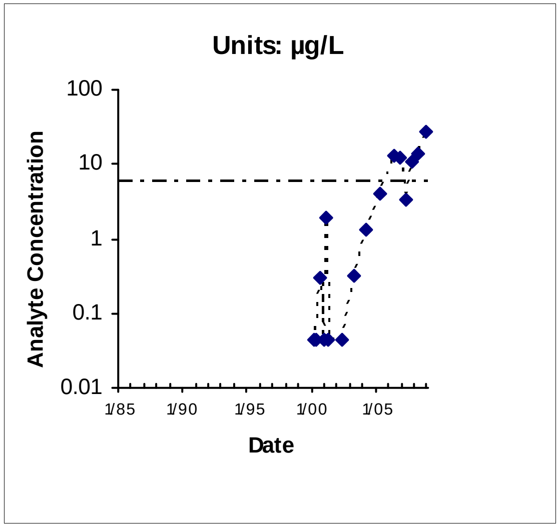
Chemical Time-series Plots



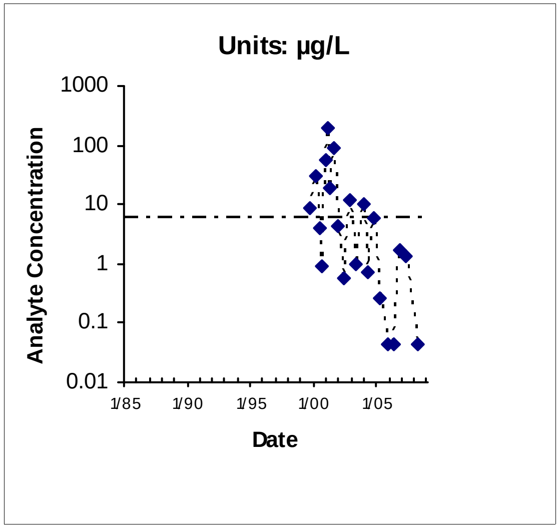
Location: MW757X04 Maximum: 0.0436



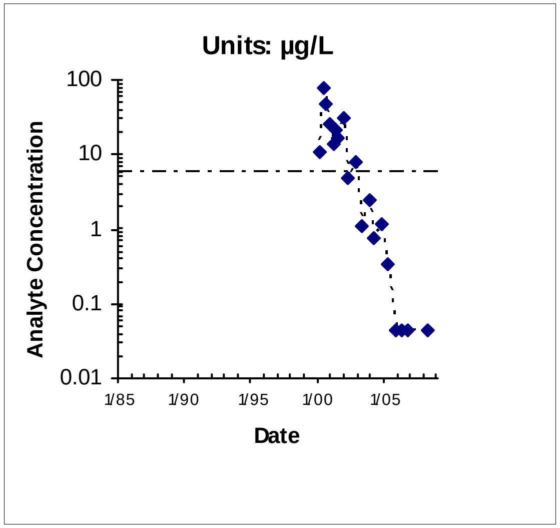
Location: MW570X31 Maximum: 9.4



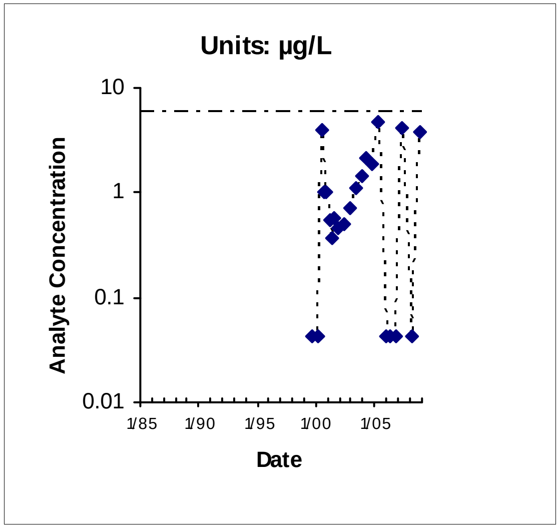
Location: MW571X31 Maximum: 27.4



Location: MW572X31 Maximum: 200



Location: MW573X31 Maximum: 76



Location: MW574X31 Maximum: 4.7

— - — - — IRG (6 µg/L)

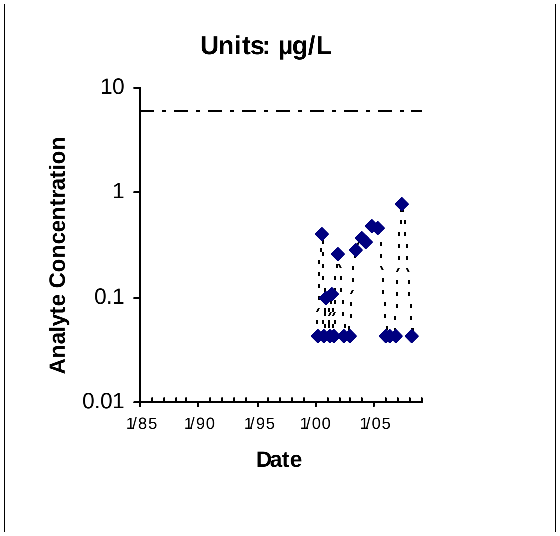
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 2-8

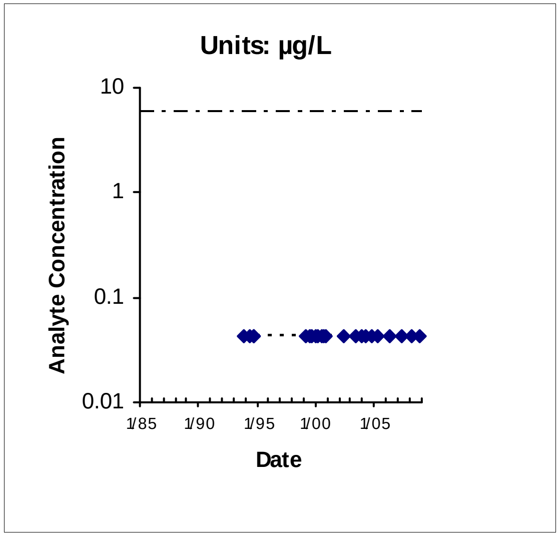
FT004/SD031 MNA Wells

1,1-DCE

Chemical Time-series Plots



Location: MW575X31 Maximum: 0.78



Location: MW1730X31 Maximum: 0.0436

— - — - — IRG (6 µg/L)

*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 2-8
FT004/SD031 MNA Wells
1,1-DCE
Chemical Time-series Plots

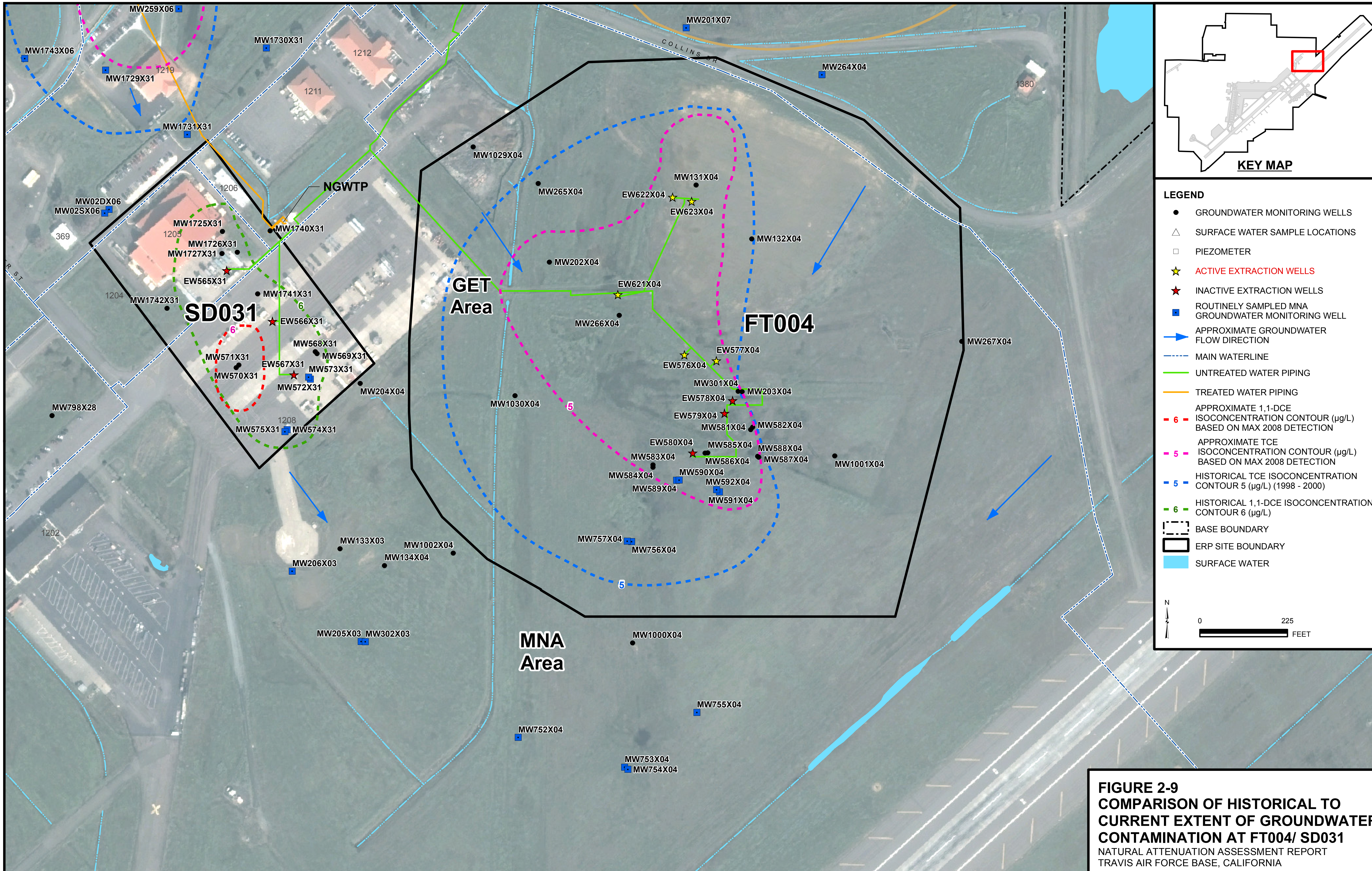


FIGURE 2-9
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT FT004/ SD031
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG2-9_FT004_SD031_SITES.MXD MCLAY1 1/14/2010

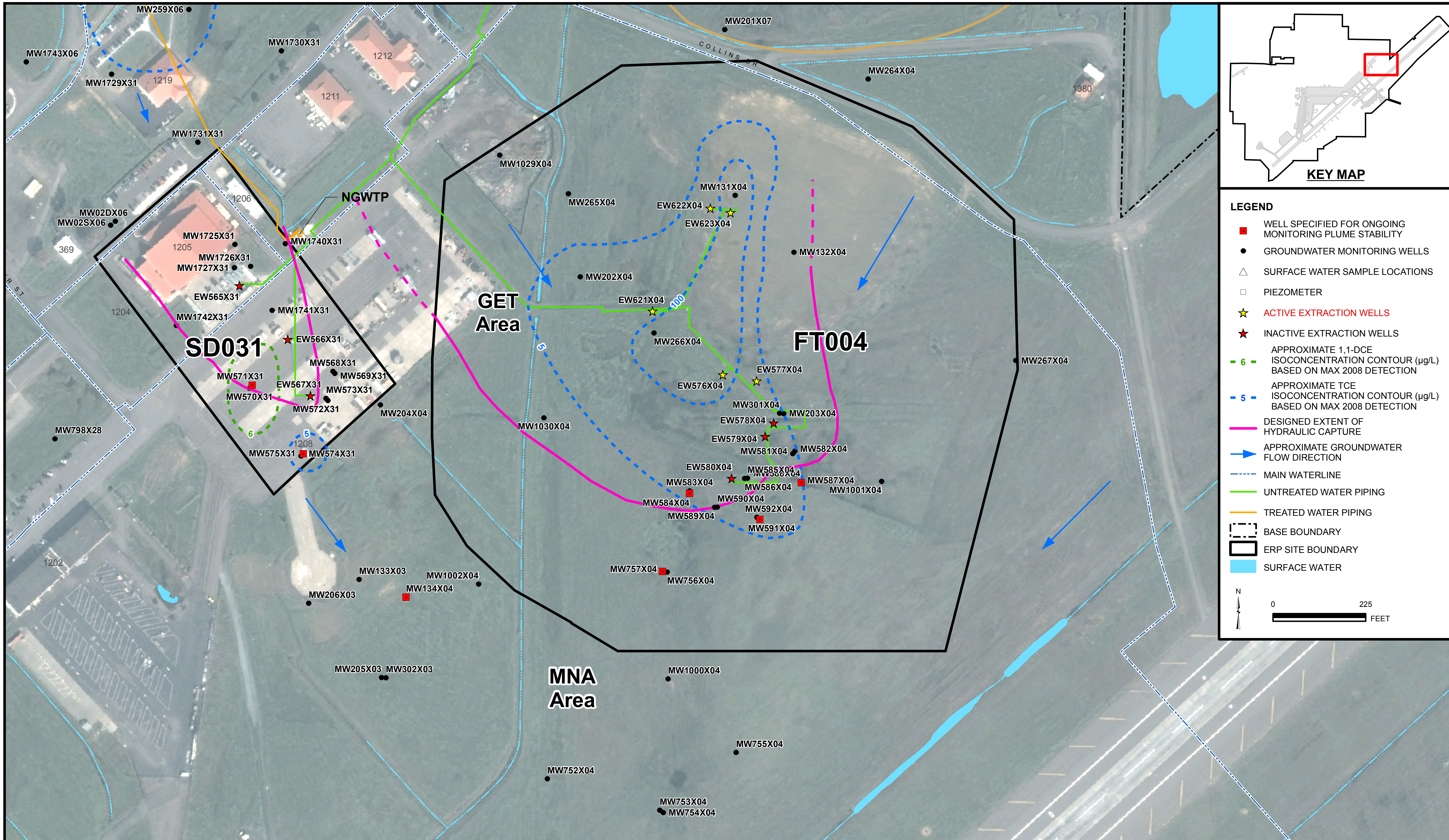


FIGURE 2-10
FT004/SD031 DISTAL MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG2-10_FT004_MONITORINGNETWORK.MXD MCLAY1 1/22/2010

SECTION 3

Site LF006

Section 3 presents the natural attenuation assessment for Site LF006. A detailed conceptual site model and preliminary natural attenuation assessment are presented in the *LF006 Natural Attenuation Assessment Workplan* (LF006 NAAW) (CH2M HILL, 1999a). This section focuses on data collected since the LF006 NAAW was submitted.

3.1 Site Background

3.1.1 Site Description

Site LF006 (Landfill 1) is a former burn-and-fill landfill that encompasses approximately 17 acres in the northeastern corner of Travis AFB. Site LF006 operated between 1943 and the early 1950s. Materials disposed of and burned at Site LF006 consisted primarily of wood, paper, glass, residential debris, and construction debris; industrial wastes were also reportedly disposed of at Site LF006 (Radian Corporation, 1996). Figure 3-1 presents a map of Site LF006.

3.1.2 Site COCs

The groundwater COCs and the IRGs at LF006 are as follows:

COC	IRG (µg/L)
1,1-DCE	6
TCE	5
total petroleum hydrocarbons as gasoline (TPH-G)	5
total petroleum hydrocarbons as diesel (TPH-D)	100

3.1.3 Status of Interim Remedy

Site LF006 was selected for MNA in the NEWIOU Groundwater IROD (Travis AFB, 1997). The site underwent a natural attenuation assessment in 1998-1999 as documented in the LF006 NAAW (CH2M HILL, 1999a). Since 1999, twelve (12) monitoring wells have been routinely sampled to support MNA: MW02Dx06, MW02Sx06, MW207x06, MW208x06, MW208Dx06, MW210x06, MW259x06, MW1743x06, MW129x07, MW1729x31, MW1730x31, and MW1731x31 (see Figure 3-1). These wells are located primarily in the downgradient and crossgradient portions of the site, to monitor plume migration.

Ten years of data collected from the MNA wells indicate MNA is a viable remedy for the Site LF006 groundwater plume. TCE concentrations have generally declined at the site. TPH-G and TPH-D detections have been sporadic and relatively low. The Second Five-Year Review (CH2M HILL, 2008a) concluded that MNA is an effective remedy for Site LF006.

In summary, the status of the IRA at Site LF006 is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
LF006	MNA	Groundwater monitoring	Ongoing groundwater monitoring

3.2 Conceptual Site Model

3.2.1 Geology

The natural near-surface geology in the vicinity of Site LF006 consists mainly of fine-grained lean clays and silts. More permeable sands and silts are typically encountered in deeper zones above the bedrock. The depth of the fine-grained materials ranges from 10 to 37 feet bgs. As expected in an alluvial setting, subsurface materials are heterogeneous, with sand stringers embedded within the silts and clays. The permeability of the embedded sand units varies, based on the proportions of silt and clay within the matrix. These unconsolidated materials are classified as Younger Alluvium at Travis AFB.

In the Site LF006 and Site LF007 area, surface soil and alluvium have been disturbed or removed during the placement of landfill and backfill material. At Site LF006, landfill and backfill material encountered in soil borings ranged between 2 and 13.5 feet (Radian Corporation, 1995).

Beneath the unconsolidated material, the bedrock surface consists of poorly indurated, dark-gray claystone and is identified as Nortonville Shale. The claystone has been encountered in soil borings at the site at depths ranging from 33 to 40 feet bgs. The upper surface of the bedrock is typically weathered, becoming increasingly competent with depth. Nortonville Shale was extensively eroded during the Pleistocene and forms a subsurface trough in the bedrock beneath Site LF006 that extends from northwest to southeast in this area. The trough is bounded by two bedrock ridges of Domengine Sandstone to the west and Markley Sandstone to the east, which form topographic ridges in the vicinity of Site LF006. A geologic cross section through the Site LF006 groundwater plume is presented on Figure 3-2.

3.2.2 Groundwater

As summarized in Table 3-1, the depth to water at Site LF006 is approximately 8 to 15 feet bgs, and the saturated zone is approximately 20 to 30 feet thick. Historically groundwater elevations have been stable at Site LF006, varying by approximately 2 to 5 feet per year, but with no long-term trends.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 3-3 and are consistent with historical groundwater flow directions. Groundwater in the vicinity of Site LF006 typically flows toward the southwest in the northern portion of the site, and changes direction toward the southeast in the southern portion of the site. A groundwater mound beneath Site LF007, east of Site LF006, causes the westward component of flow typically observed in the northern portion of Site LF006. Groundwater flow within the southern portion of Site LF006 is redirected ultimately toward the southeast by the ridge of Domengine Sandstone to the west of the site and the subsurface trough in the Nortonville Shale. Downgradient from Site LF006, groundwater flows toward Site SD031 to the southeast. The horizontal gradient at Site LF006 is approximately 0.003 ft/ft.

In general, vertical gradients at Site LF006 are negligible (less than 0.01 ft/ft). Of the four (4) well pairs at these sites, only one (1) pair, MW258x06/MW258Dx06, shows significant vertical gradient (consistently greater than 0.01 ft/ft). The vertical gradient for this well pair is typically between 0.01 and 0.03 ft/ft upward. Vertical gradients at Site LF006 are typically slightly upward (Table 3-2).

Several aquifer tests have been performed at Site LF006, and the results are summarized in Table 3-3. Hydraulic conductivities calculated from the aquifer tests ranged from 2 to 55 ft/day, reflecting the heterogeneous nature of the sediments and the variation in the aquifer test methods utilized. The average of the hydraulic conductivities calculated for the site is approximately 18 ft/day.

The average linear flow of groundwater at Site LF006 may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.003 ft/ft, an average hydraulic conductivity of 18 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), the approximate groundwater velocity is about 0.27 ft/day or approximately 100 ft/year.

Groundwater at Travis AFB is not used for human consumption and groundwater at Site LF006 does not discharge to surface water. The Base boundary is approximately 4,000 feet from the leading edge of the plume. At the estimated groundwater velocity, it would take approximately 40 years for groundwater at Site LF006 to reach the Base boundary. Because contaminants do not appear to be migrating in groundwater at this time, because ongoing monitoring will continue to evaluate whether contamination is migrating in the future, and because groundwater from Site LF006 does not discharge to surface water, residual groundwater contamination at Site LF006 should not pose a risk to receptors.

3.2.3 Current Distribution of Groundwater Contamination

The monitoring wells selected to support MNA at Site LF006 are MW02Dx06, MW02Sx06, MW207x06, MW208x06, MW208Dx06, MW210x06, MW259x06, MW1743x06, MW129x07, MW1729x31, MW1730x31, and MW1731x31. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix. During the 2Q08 and 4Q08 sampling events, the only Site LF006 COCs detected at concentrations exceeding IRGs were TCE, TPH-G, and TPH-D. TPH-D was detected at only one (1) location, MW208Dx06, where it was detected at a concentration of 120 µg/L, slightly exceeding the IRG of 100 µg/L. This has been the only TPH-D detection at the site since 2004.

TCE and TPH-G are the only site COCs detected at concentrations exceeding the IRGs at multiple locations. The current distributions of TCE and TPH-G at Site LF006 are depicted on Figures 3-4 and 3-5, respectively. TCE was detected at concentrations exceeding the IRG at only two (2) monitoring wells: MW208Dx06 and MW259x06. The maximum TCE concentration detected in 2008 was 8.8 J- µg/L at well MW259x06.

TPH-G was detected at several Site LF006 monitoring wells at concentrations slightly exceeding the IRG (5 µg/L) in 2Q08. The maximum concentration detected was 10 J µg/L at MW02Sx06 in the downgradient portion of the plume. Several wells were also analyzed for TPH-G in 4Q08 (MW01Sx06, MW01Dx06, MW208Dx06, MW210x06, and MW259x06) and TPH-G was not detected in any of them.

A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site LF006 groundwater plume are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b). The groundwater VOC concentrations at Site LF006 do not indicate potential for VI risk

3.3 Natural Attenuation Assessment

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has reduced in size. During the interim period, the GSAP has monitored several wells to evaluate plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 3.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 3.3.2.

3.3.1 Plume Attenuation

Chemical time-series plots of the primary COCs (TCE, TPH-G, and TPH-D) for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 3-6 through 3-8. Figure 3-6 illustrates the decreasing TCE concentration trend observed at the Site LF006 monitoring wells. Only two (2) monitoring wells continue to exceed the TCE IRG: MW208Dx06 and MW259x06. TCE concentrations are declining at MW208Dx06 and are stable (approximately 10 µg/L) at well MW259x06.

Figure 3-9 shows the current distribution of TCE exceeding the IRG and the historical extent of TCE contamination exceeding the IRG in groundwater at Site LF006. This figure illustrates the reduction in the extent of the Site LF006 TCE plume over time.

Figure 3-7 illustrates that TPH-G detections at Site LF006 have been sporadic and low (less than 50 µg/L). Figure 3-8 shows that TPH-D has not been detected at the site for several years, with the exception of a detection at MW208Dx06 in 2008 of 120 µg/L.

There is no indication of plume migration. The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of TCE at this site to approximately 0.8 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the plume would be expected to have migrated approximately 800 feet (approximately 80 feet per year) over the 10 years of the MNA assessment period. However, the plume has receded, indicating that natural attenuation processes are occurring at this site.

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the twelve (12) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring wells at which COCs continue to exceed IRGs (MCLs). A point attenuation rate constant was calculated for these two (2) MNA wells: MW208Dx06 and MW259x06. At both monitoring wells, the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW208Dx06 is approximately 0.061 per year, and the attenuation rate constant calculated for well MW259x06 is approximately 0.035 per year (Appendix D). At these rates, TCE concentrations at well MW208Dx06 would be expected to reach the IRG (5 μg/L) in 2009, and TCE concentrations at well MW259x06 would be expected to reach the IRG in 2014. Little change in aquifer conditions between 1999 (when the initial MNA assessment was performed) and 2008 is evident. The aquifer remains aerobic and available carbon is low; physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. These mechanisms are not anticipated to change in the near future and thus the attenuation rates calculated provide reasonable estimates of time to reach IRGs.

In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for MNA monitoring wells where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.

A bulk attenuation rate constant of approximately 0.75 per year was calculated for TCE at Site LF006, based on the 2008 distribution of TCE in groundwater at the site (Appendix F). The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring. The maximum TCE concentration detected at Site LF006 in 2008 was 8.8 J- μg/L, and no TCE source area remains at the site. The travel time for TCE to reach the IRG (5 μg/L) once it leaves the portion of the plume with the highest TCE concentrations (8.8 J- μg/L) is estimated to be approximately 0.75 year. The plume (exceeding the IRG) should extend approximately 63 feet from the portion of the plume with the highest TCE concentrations.

3.3.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for Site LF006. Table 3-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from monitoring wells at Site LF006 during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), TOC (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and CO_2 (HACH field test). In addition, pH, temperature, DO, ORP, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Well:** MW210x06
- **Source Wells:** MW01Sx06 and MW01Dx06
- **Plume Wells:** MW208Dx06 and MW259x06
- **Distal Wells:** MW1729x06, MW1731x31, and MW1730x31

As shown in Table 3-5, no monitoring well included in the screening scored higher than five (5) points, and there is inadequate evidence for biodegradation of chlorinated solvents at Site LF006. DO concentrations and ORP measurements across the site indicate aerobic rather than anaerobic conditions. Aerobic conditions are not conducive to biodegradation of TCE but are conducive to the biodegradation of TPH-G and TPH-D.

A similar biodegradation screening was performed in 1998-1999, which is documented in the LF006 NAAW (CH2M HILL, 1999a). During the initial biodegradation screening, most monitoring wells scored between zero (0) and five (5) points (inadequate evidence of biodegradation). The highest score was nine (9) at plume monitoring well MW259x06 (limited evidence of biodegradation).

3.4 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- There is inadequate evidence for biodegradation of chlorinated COCs at Site LF006. However, the aerobic conditions at the site do support the biodegradation of TPH-G and TPH-D.
- There is substantial evidence of physical natural attenuation of COCs at Site LF006.
- TCE concentrations have declined over the interim period in most of the MNA wells. Currently, TCE exceeds the IRG at only two (2) monitoring wells (MW208Dx06 and MW259x06).
- The TCE plume has reduced in size over the 10 years since the MNA assessment began.
- Detections of TPH-G are sporadic and low (typically less than 10 µg/L).
- TPH-D has been detected at the site only once in the last several years (since 2004).
- 1,1-DCE concentrations are currently below the IRG.
- There is no indication of plume migration. In fact, the plume has been receding.

Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for Site LF006.

3.5 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring at Site LF006. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells to monitor plume stability is presented on Figure 3-10 and will consist of MW208x06, MW208Dx06, MW259x06, MW1729x31, MW1730x31, and MW1731x31. These wells will be sampled annually for VOCs, TPH-G, and TPH-D. This network will continue to be monitored during the interim period or until such time as the remedy changes.

TABLE 3-1

LF006 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: LF006									
MW01DX06	27	37	40	30	67.91	8.45	59.46	11.17	56.74
MW01SX06	12	22	67.9	57.9	67.87	8.45	59.42	11.17	56.7
MW02DX06	22	32	41	31	64.02	8.65	55.37	9.62	54.4
MW02SX06	6	16	57	47	64.01	8.67	55.34	9.62	54.39
MW130X06	10	30	53.76	33.76	66.02	NM	NM	9.58	56.44
MW207X06	4.5	19.5	62.21	47.21	69.22	9.28	59.94	10.02	59.2
MW208DX06	25	35	40	30	66.73	9.99	56.74	11.46	55.27
MW208X06	5	20	58.47	43.47	66.00	9.41	56.59	10.85	55.15
MW209X06	5	20	61.64	46.64	69.05	NM	NM	11.44	57.61
MW210X06	5.5	20.5	61.57	46.57	69.52	10.1	59.42	11.58	57.94
MW258X06	7	17	58.14	48.14	67.28	10.23	57.05	11.73	55.55
MW258DX06	22	32	44	34	67.30	10.04	57.26	11.56	55.74
MW259X06	7	17	56	46	65.33	8.64	56.69	10.43	54.9
MW304X06	55	65	8.73	-1.27	66.35	NM	NM	9.7	56.65
MW1743X06	12	22	53.52	43.52	69.98	13.69	56.29	14.92	55.06
Site: LF007									
MW129X07	10	30	53.98	33.98	66.37	7.83	58.54	10.73	55.64
Site: SD031									
MW1729X31	8	18	55.75	45.75	68.56	12.41	56.15	13.75	54.81
MW1730X31	6.5	16.5	53.36	43.36	63.92	7.51	56.41	9.4	54.52
MW1731X31	6	16	52.97	42.97	63.30	7.61	55.69	9.05	54.25

Note: Grouped by Site and sorted by Location.
btoc = below top of casing
NM = not measured
bgs = below ground surface
msl = mean sea level

TABLE 3-2
LF006 Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base, California

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW01Dx06	MW01Sx06	0.004	-0.001	0.003	0.003
MW02Dx06	MW02Sx06	0.002	0.005	0.005	0.002
MW208Dx06	MW208x06	0.03	0.008	0.009	0.007
MW258Dx06	MW258x06	0.02	0.02	0.02	0.013

Note:

Minus sign indicates downward vertical gradient.

TABLE 3-3
Aquifer Test Results for LF006
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
LF006	MW130x06	10–20	1988	Gravity-injection	2	100% silty clay
	MW258x06	7–17	9/11/91	Rising head slug	55	20% silt; 20% sandy clay; 60% sandy silt
	MW259x06	7–17	9/11/91	Rising head slug	20	15% sill with sand; 83% clay with sand; 2% silty sand
	MW02Dx06	22–32	8/5/98	Pumping	20	100% poorly graded sand with some clay
	MW02Sx06	6–16	8/6/98	Pumping	4	50% clay; 50% sand with clay
	MW208x06	5–20	8/12/98	Pumping	2	75% sandy clay; 25% sand with clay
	MW208Dx06	25–35	8/18/98	Pumping	20	100% sandy clay

Notes:
ft bgs = feet below ground surface
Source: CH2M HILL, 2004.

TABLE 3-4

Summary of Analytes Detected in MNA Wells at LF006 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: LF006							
MW01DX06							
	12/10/2008	E310	Alkalinity	346		mg/L	
	12/10/2008	E300	Chloride	68.7		mg/L	
	12/10/2008	E300	Nitrite	0.0752	J	mg/L	
	12/10/2008	SM4500S2	No Analytes Detected				
	12/10/2008	A5310B	Total Organic Carbon	5.87		mg/L	
	12/10/2008	E300	Nitrate	0.267		mg/L	
	12/10/2008	RSK-175	No Analytes Detected				
	12/10/2008	SW8015-E	No Analytes Detected				
	12/10/2008	SW8015-P	No Analytes Detected				
	12/10/2008	SW8260	No Analytes Detected				
	12/10/2008	E300	Sulfate	276		mg/L	
MW01SX06							
	12/15/2008	E310	Alkalinity	372		mg/L	
	12/15/2008	E300	Chloride	92.7		mg/L	
	12/15/2008	E300	Nitrite	0.117		mg/L	
	12/15/2008	SM4500S2	No Analytes Detected				
	12/15/2008	A5310B	Total Organic Carbon	3.16		mg/L	
	12/15/2008	E300	Nitrate	0.601		mg/L	
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	SW8015-E	No Analytes Detected				
	12/15/2008	SW8015-P	No Analytes Detected				
	12/15/2008	E300	Sulfate	298		mg/L	
	12/15/2008	SW8260	TCE	2.3		µg/L	5
MW02DX06							
	4/28/2008	SW8260	Acetone	3.4	J	µg/L	5110
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8015-P	TPH-Gasoline	**9**	J	µg/L	5
MW02SX06							
	4/28/2008	SW8260	Acetone	3.1	J	µg/L	5110
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8015-P	TPH-Gasoline	**10**	J	µg/L	5
MW207X06							
	4/28/2008	SW8260	Acetone	3.8	J	µg/L	5110
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8015-P	TPH-Gasoline	**8.3**	J	µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Summary of Analytes Detected in MNA Wells at LF006 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF006							
MW207X06							
	11/21/2008	E310	Alkalinity	278		mg/L	
	11/21/2008	E300	Chloride	94.3		mg/L	
	11/21/2008	SM4500S2	No Analytes Detected				
	11/21/2008	A5310B	Total Organic Carbon	2.23		mg/L	
	11/21/2008	E300	Nitrate	0.809		mg/L	
	11/21/2008	RSK-175	No Analytes Detected				
	11/21/2008	SW8260	No Analytes Detected				
	11/21/2008	E300	Sulfate	512		mg/L	
MW208DX06							
	4/28/2008	SW8260	1,1-DCE	0.2	J	µg/L	6
	4/28/2008	SW8260	Acetone	2.3	J	µg/L	5110
	4/28/2008	SW8260	Cis-1,2-DCE	0.93		µg/L	6
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8260	TCE	**5.9**		µg/L	5
	4/28/2008	SW8015-P	TPH-Gasoline	**9**	J	µg/L	5
	12/10/2008	E310	Alkalinity	279		mg/L	
	12/10/2008	E300	Chloride	201		mg/L	
	12/10/2008	SM4500S2	No Analytes Detected				
	12/10/2008	A5310B	Total Organic Carbon	4.86		mg/L	
	12/10/2008	SW8260	Cis-1,2-DCE	0.91	J	µg/L	6
	12/10/2008	E300	Nitrate	0.5		mg/L	
	12/10/2008	RSK-175	No Analytes Detected				
	12/10/2008	SW8015-P	No Analytes Detected				
	12/10/2008	E300	Sulfate	130		mg/L	
	12/10/2008	SW8260	TCE	**6**		µg/L	5
	12/10/2008	SW8015-E	TPH-Diesel	**120**		µg/L	100
MW208X06							
	4/28/2008	SW8260	Acetone	3.2	J	µg/L	5110
	4/28/2008	SW8260	Cis-1,2-DCE	0.27	J	µg/L	6
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8260	TCE	2.4		µg/L	5
	4/28/2008	SW8015-P	TPH-Gasoline	**7.4**	J	µg/L	5
MW210X06							
	4/28/2008	SW8260	Acetone	2.6	J	µg/L	5110
	4/28/2008	SW8015-E	No Analytes Detected				
	4/28/2008	SW8015-P	TPH-Gasoline	**9.1**	J	µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 3-4

Summary of Analytes Detected in MNA Wells at LF006 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF006							
MW210X06							
	12/16/2008	E310	Alkalinity	274		mg/L	
	12/16/2008	E300	Chloride	314		mg/L	
	12/16/2008	SM4500S2	No Analytes Detected				
	12/16/2008	A5310B	Total Organic Carbon	3.73		mg/L	
	12/16/2008	E300	Nitrate	4.09		mg/L	
	12/16/2008	RSK-175	No Analytes Detected				
	12/16/2008	SW8015-E	No Analytes Detected				
	12/16/2008	SW8015-P	No Analytes Detected				
	12/16/2008	SW8260	No Analytes Detected				
	12/16/2008	E300	Sulfate	65.3		mg/L	
MW259X06							
	4/29/2008	SW8260	Acetone	2.7	J	µg/L	5110
	4/29/2008	SW8260	Cis-1,2-DCE	0.82		µg/L	6
	4/29/2008	SW8260	Methylene chloride	0.56	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8260	TCE	**5.4**		µg/L	5
	4/29/2008	SW8015-P	TPH-Gasoline	**6.2**	J	µg/L	5
	12/10/2008	E310	Alkalinity	303		mg/L	
	12/10/2008	E300	Chloride	222		mg/L	
	12/10/2008	SM4500S2	No Analytes Detected				
	12/10/2008	A5310B	Total Organic Carbon	7.67		mg/L	
	12/10/2008	SW8260	Cis-1,2-DCE	1.2	J-	µg/L	6
	12/10/2008	RSK-175	No Analytes Detected				
	12/10/2008	SW8015-E	No Analytes Detected				
	12/10/2008	SW8015-P	No Analytes Detected				
	12/10/2008	E300	Sulfate	239		mg/L	
	12/10/2008	SW8260	TCE	**8.8**	J-	µg/L	5
Site: LF007							
MW129X07							
	5/2/2008	SW8260	Methylene chloride	0.48	J	µg/L	5
	5/2/2008	SW8015-E	No Analytes Detected				
	5/2/2008	SW8015-P	TPH-Gasoline	**5.1**	J	µg/L	5
	12/4/2008	E310	Alkalinity	381		mg/L	
	12/4/2008	E300	Chloride	136		mg/L	
	12/4/2008	SM4500S2	No Analytes Detected				
	12/4/2008	A5310B	Total Organic Carbon	2.56		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 3-4

Summary of Analytes Detected in MNA Wells at LF006 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF007							
MW129X07							
	12/4/2008	RSK-175	No Analytes Detected				
	12/4/2008	SW8260	No Analytes Detected				
	12/4/2008	E300	Nitrate	1.96		mg/L	
	12/4/2008	E300	Sulfate	336		mg/L	
Site: SD031							
MW1729X31							
	4/29/2008	SW8260	Acetone	2.2	J	µg/L	5110
	4/29/2008	SW8260	Methylene chloride	0.49	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8260	TCE	1.1		µg/L	5
	4/29/2008	SW8015-P	TPH-Gasoline	**5.6**	J	µg/L	5
	12/9/2008	E310	Alkalinity	129		mg/L	
	12/9/2008	E300	Chloride	77.8		mg/L	
	12/9/2008	E300	Nitrite	0.175	J	mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	5.78		mg/L	
	12/9/2008	E300	Nitrate	14		mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8015-E	No Analytes Detected				
	12/9/2008	SW8015-P	No Analytes Detected				
	12/9/2008	E300	Sulfate	83.9		mg/L	
	12/9/2008	SW8260	TCE	1.2		µg/L	5
MW1730X31							
	4/29/2008	SW8260	Acetone	2	J	µg/L	5110
	4/29/2008	SW8260	Methylene chloride	0.52	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	TPH-Gasoline	**6.2**	J	µg/L	5
	12/9/2008	E310	Alkalinity	357		mg/L	
	12/9/2008	E300	Chloride	160		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	6.7	J+	mg/L	
	12/9/2008	E300	Nitrate	1.03	J-	mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8260	No Analytes Detected				
	12/9/2008	E300	Sulfate	511		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 3-4

Summary of Analytes Detected in MNA Wells at LF006 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD031							
MW1731X31							
	4/29/2008	SW8260	Acetone	2.3	J	µg/L	5110
	4/29/2008	SW8260	Methylene chloride	0.53	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8260	TCE	0.2	J	µg/L	5
	4/29/2008	SW8015-P	TPH-Gasoline	**9.5**	J	µg/L	5
	12/9/2008	E310	Alkalinity	270		mg/L	
	12/9/2008	E300	Chloride	197		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	5.25		mg/L	
	12/9/2008	E300	Nitrate	0.0855	J	mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8015-E	No Analytes Detected				
	12/9/2008	SW8015-P	No Analytes Detected				
	12/9/2008	SW8260	No Analytes Detected				
	12/9/2008	E300	Sulfate	188		mg/L	

Qualifier Description

J = The analyte was positively identified, the quantitation is an estimate.

F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).

B = The analyte was found in an associated blank, as well as in the sample.

M = A matrix effect was present.

none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 3-5
LF006 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source		Plume		Downgradient		
				MW210x06	MW01Sx06	MW01Dx06	MW208Dx06	MW259x06	MW1729x31	MW1731x31	MW1730x31
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	0	0	0	0	0	0	0	0
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	-3	0	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	0	2	2	2	2	0	2	0
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	0	0	0	0	0	0
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0
Methane[b]	<0.5 mg/L >0.5 mg/L	VC oxidizes Ultimate reductive daughter product; VC accumulates	0 3	0	0	0	0	0	0	0	0
ORP[b]	<50 mV <-100 mV	Reductive pathway possible Reductive pathway likely	1 2	0	0	0	1	1	0	1	1
pH[b]	5< pH <9 5> pH >9	Optimal range for reductive pathway Outside optimal range for reductive pathway	0 -2	0	0	0	0	0	0	0	0
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	0	0	0	0	0	0	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	0	0	0	0	0	0	0	0
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	0	0	0	0	0	0	0	0
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	0	0	0	0	0	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	0	0	0	0	0	0	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA	NA	NA	NA	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0	0	0	0	0
PCE[b]		Material released	0	0	0	0	0	0	0	0	0
TCE[b]		Material released Daughter product of PCE	0 2[c]	0	0	0	0	0	0	0	0
DCE[b] (all isomers[d])		Materials released Daughter product of TCE	0 2[c]	2	2	2	2	2	2	2	2
VC		Material released Daughter product of DCE	0 2[c]	0	0	0	0	0	0	0	0

TABLE 3-5
LF006 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source		Plume		Downgradient		
				MW210x06	MW01Sx06	MW01Dx06	MW208Dx06	MW259x06	MW1729x31	MW1731x31	MW1730x31
Ethene/ethane	>0.01 mg/L	Daughter product of VC/ethane	2	0	0	0	0	0	0	0	0
	>0.1 mg/L		3								
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	0	0	0	0	0	0	0
			Sum[e]	**+2**	**+4**	**+4**	**+5**	**+5**	**-1**	**+5**	**+3**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C = degree(s) Celsius
mg/L = milligram(s) per liter
mV = millivolt(s)
NA = not analyzed
TCA = trichloroethane

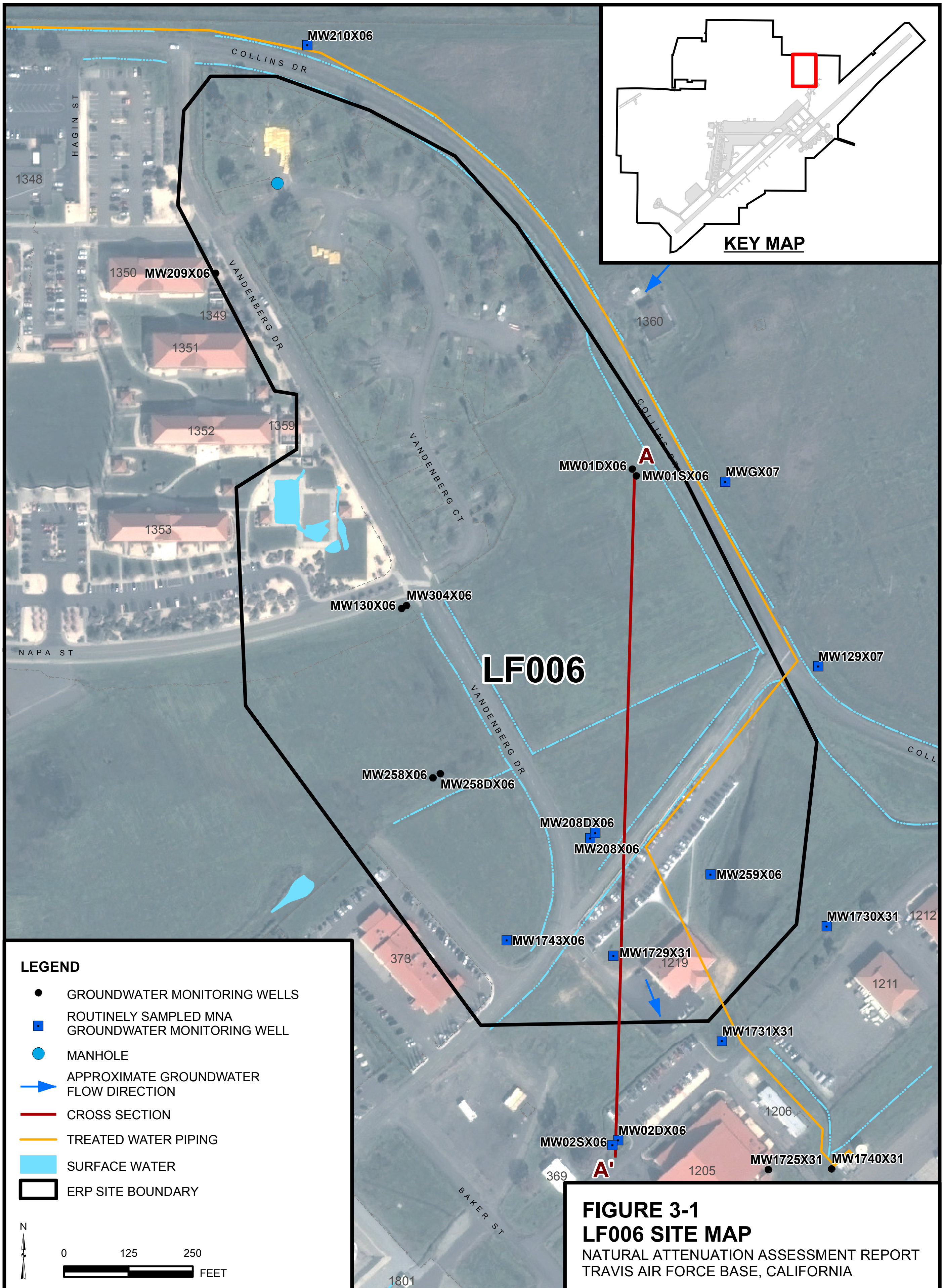
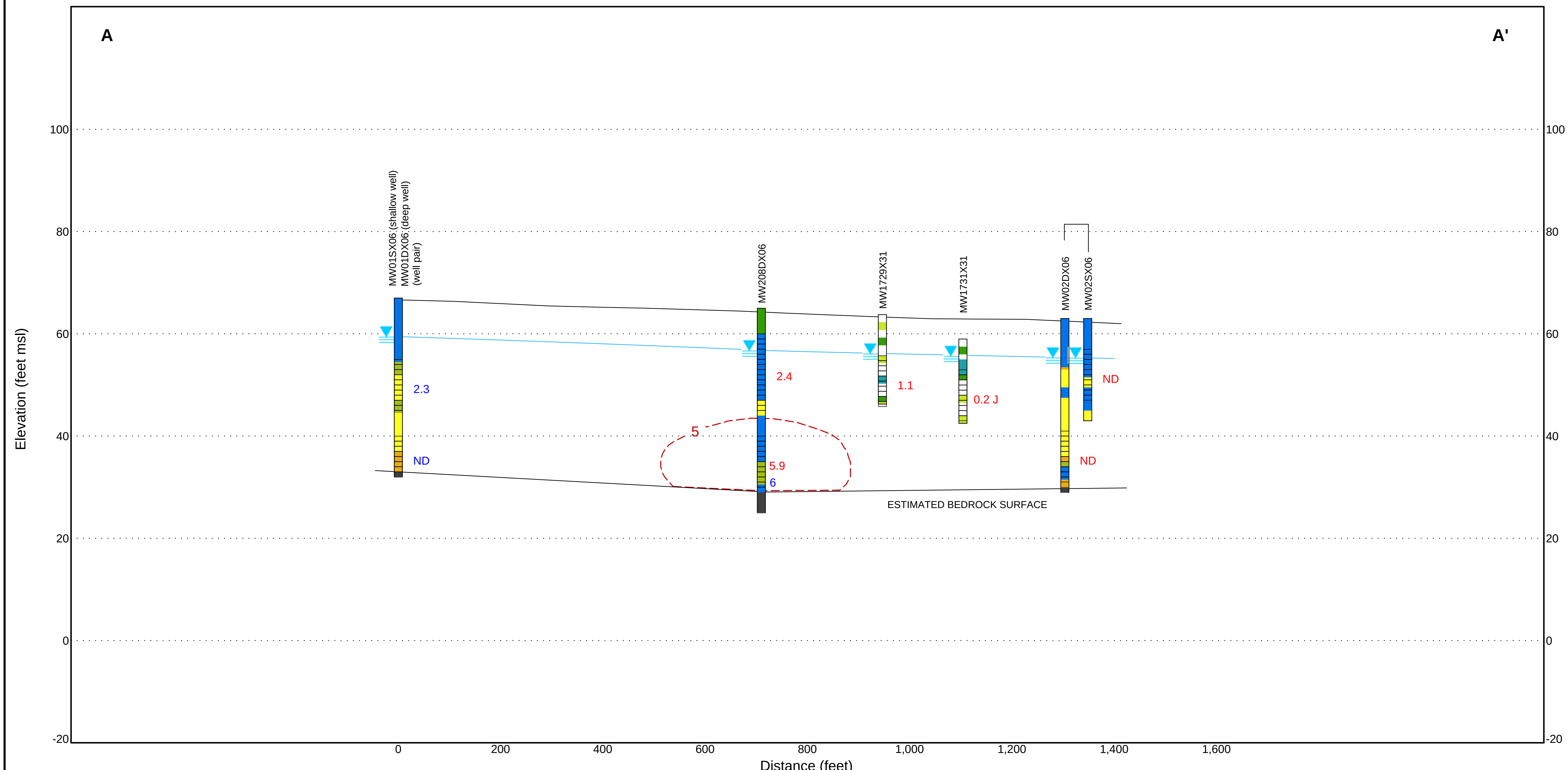


FIGURE 3-1
LF006 SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG3-1_LF006_SITE.MXD MCLAY1 1/14/2010



SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6 TCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

— — 5 — — APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L) BASED ON MAX 2008 DETECTION

SCALE EXAGGERATION - 10:1 (H:V)

NOTE: SEE FIGURE 3-4 FOR CROSS SECTION LINE

SOIL AND LITHOLOGY

- NO SAMPLE/NO RECOVERY
- FILL/ASPHALT
- WELL GRADED GRAVEL (GW)
- POORLY GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- WELL GRADED SAND (SW)
- POORLY GRADED SAND (SP)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILT (ML)
- ELASTIC SILT (MH)
- LEAN CLAY (CL)
- FAT CLAY (CH)
- SILTSTONE
- SANDSTONE
- SHALE

FIGURE 3-2
LF006 GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

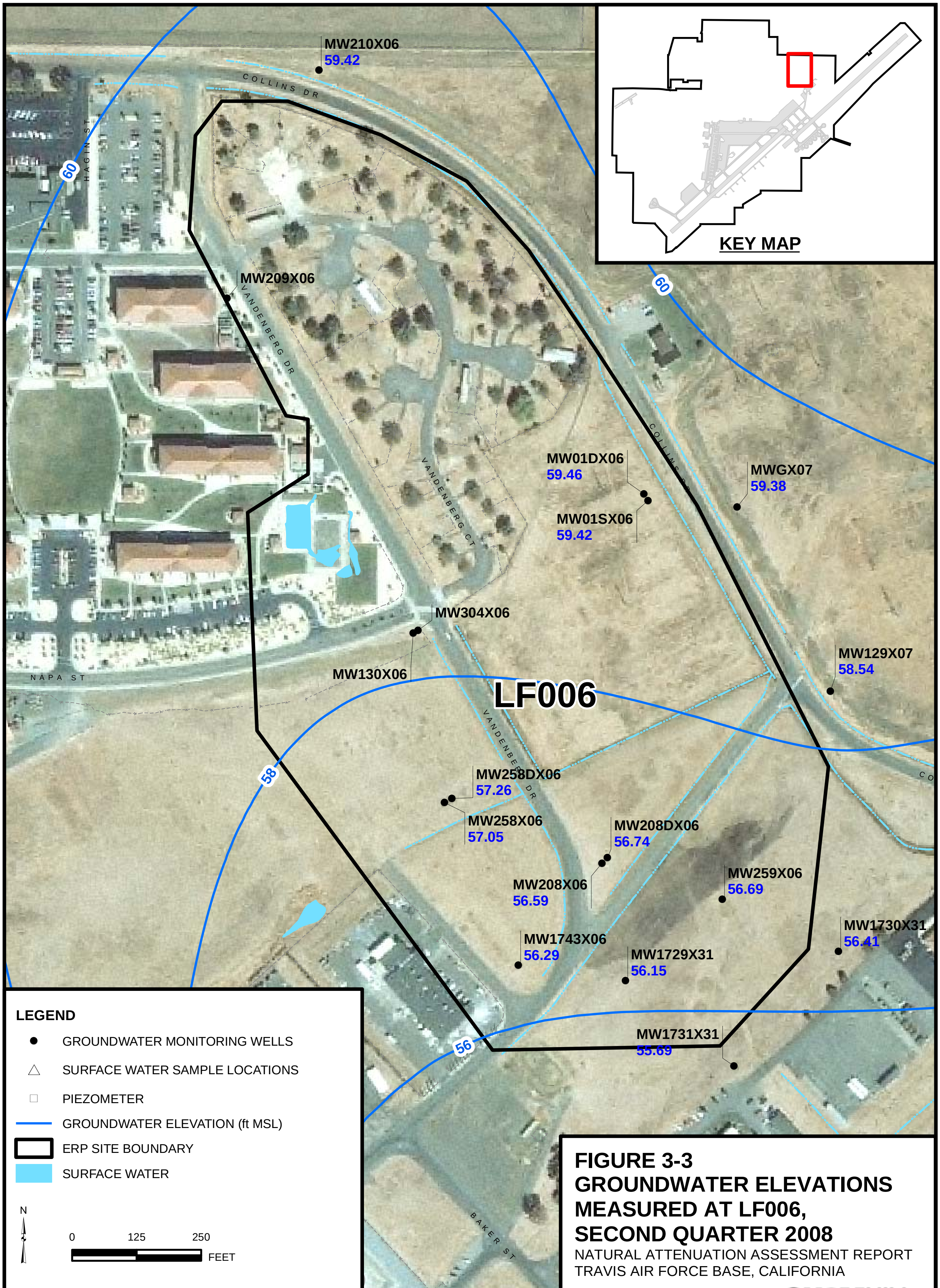


FIGURE 3-3
GROUNDWATER ELEVATIONS MEASURED AT LF006, SECOND QUARTER 2008
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\FIG3-3_LF006_GW_2008.MXD MCLAY1 6/30/2009

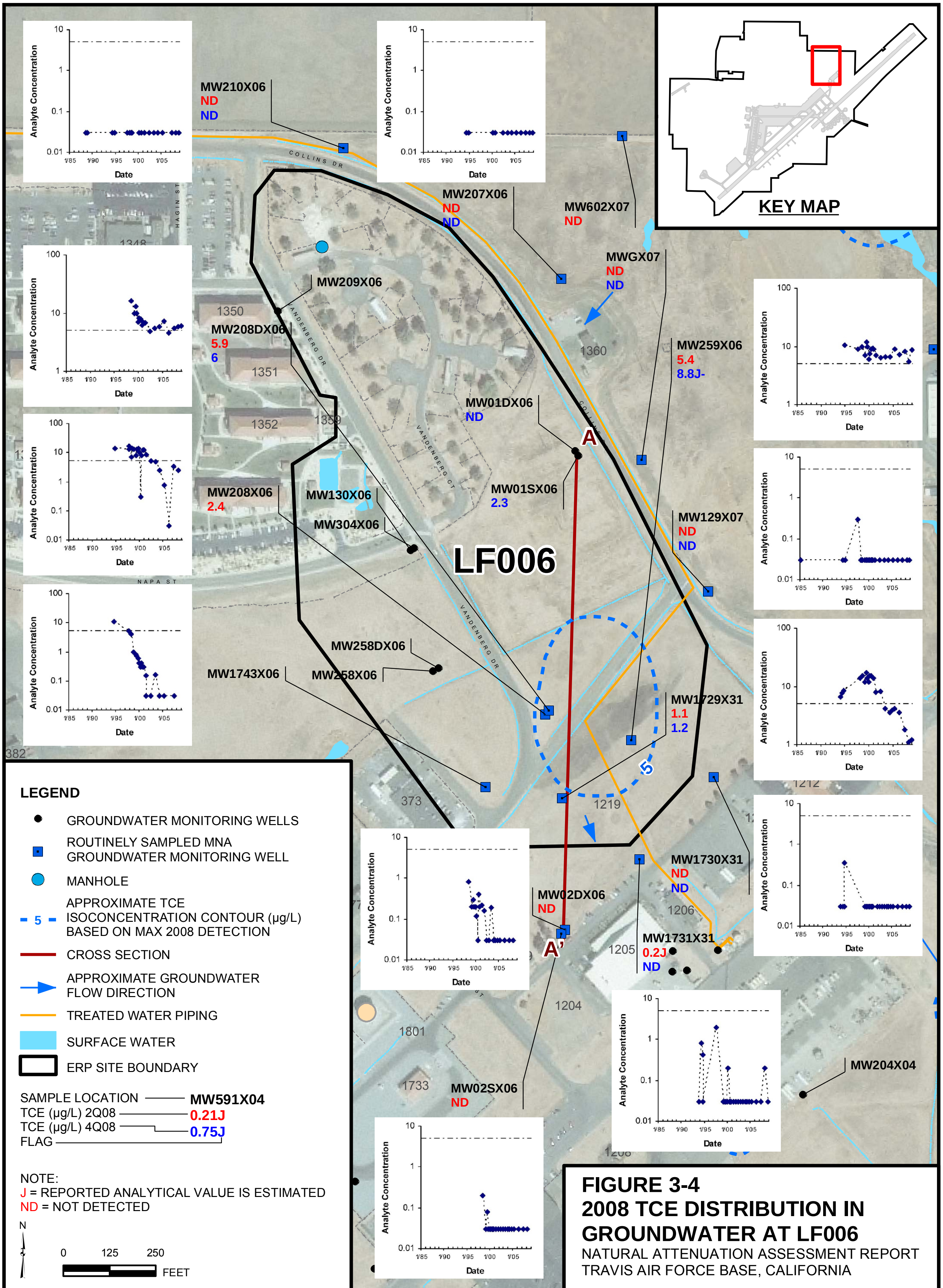


FIGURE 3-4
2008 TCE DISTRIBUTION IN GROUNDWATER AT LF006
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

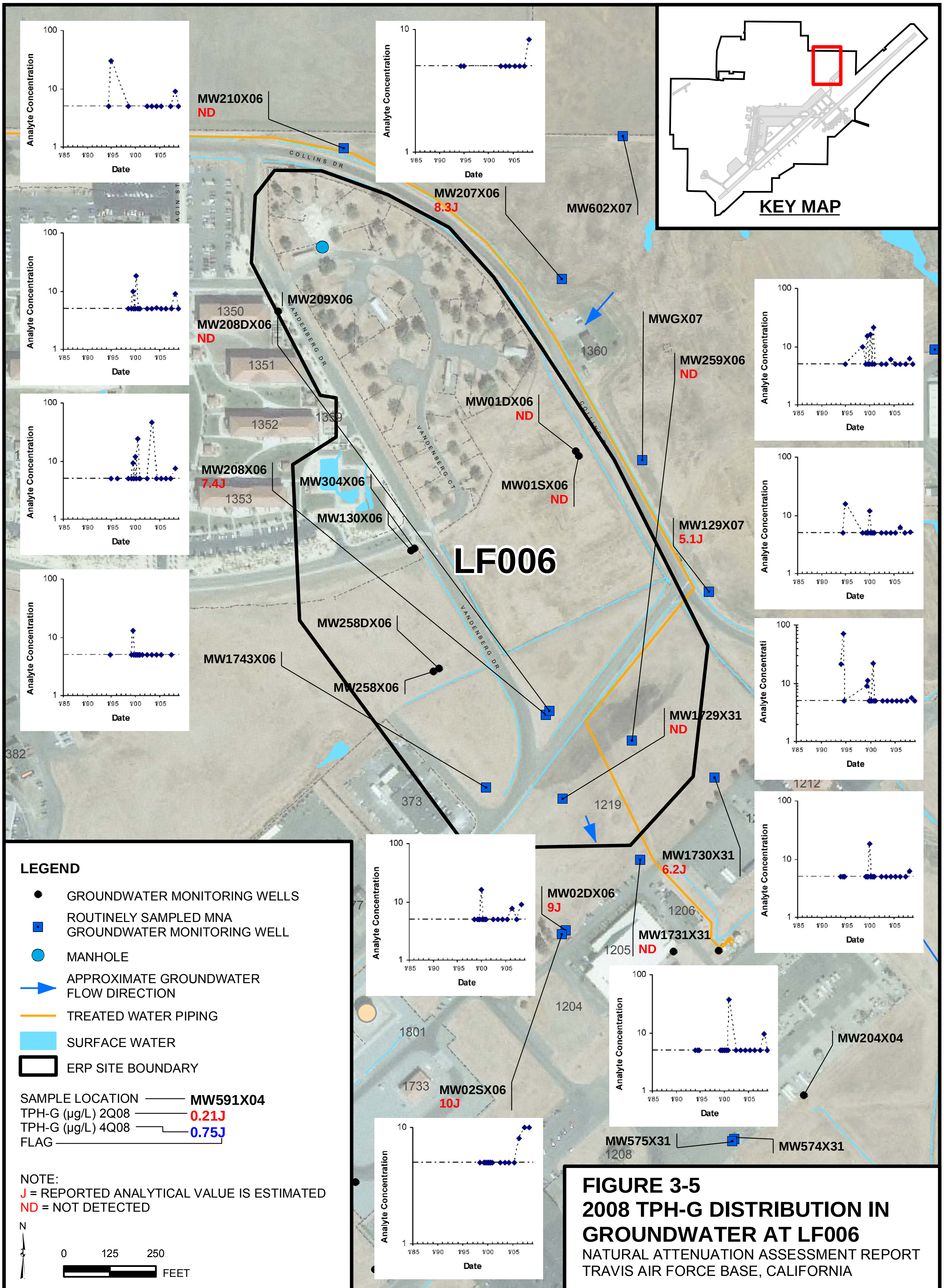
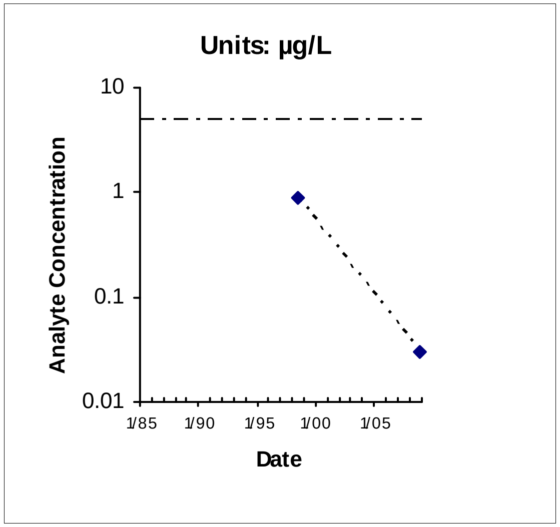


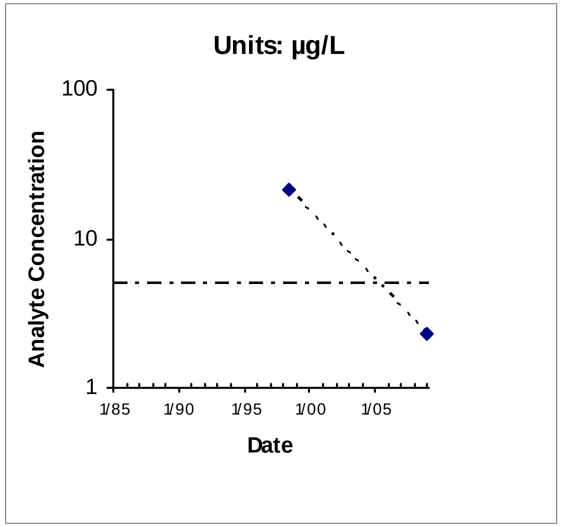
FIGURE 3-5
2008 TPH-G DISTRIBUTION IN GROUNDWATER AT LF006
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

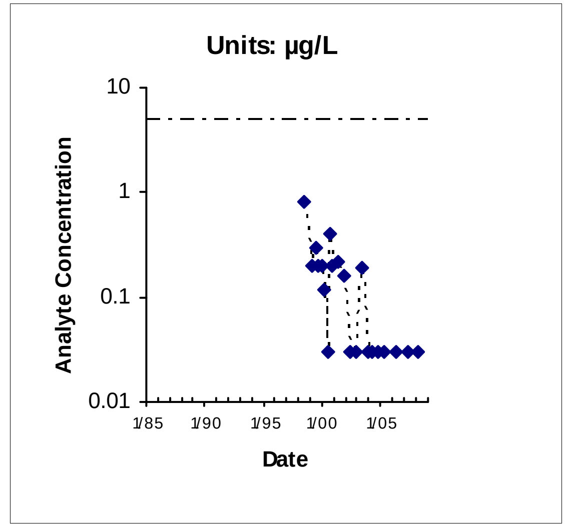
RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_MAY2010\FIG3-5_LF006_TPH-G.MXD JQUAN 5/28/2010 09:41:59



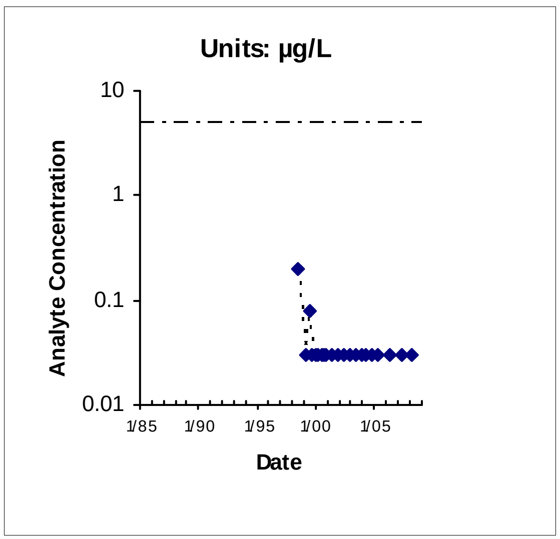
Location: MW01DX06 Maximum: 0.9



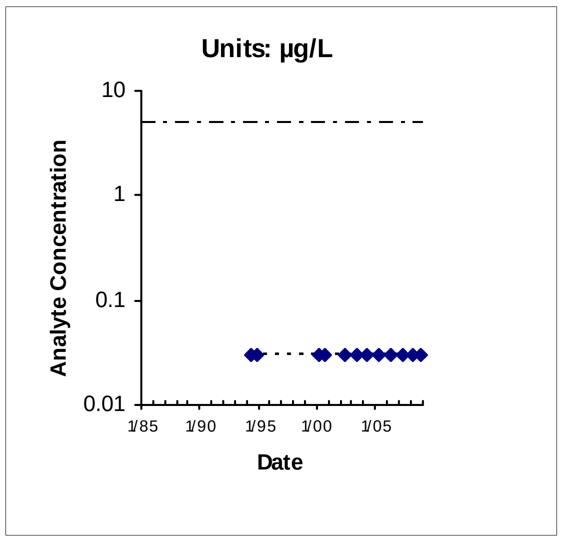
Location: MW01SX06 Maximum: 21



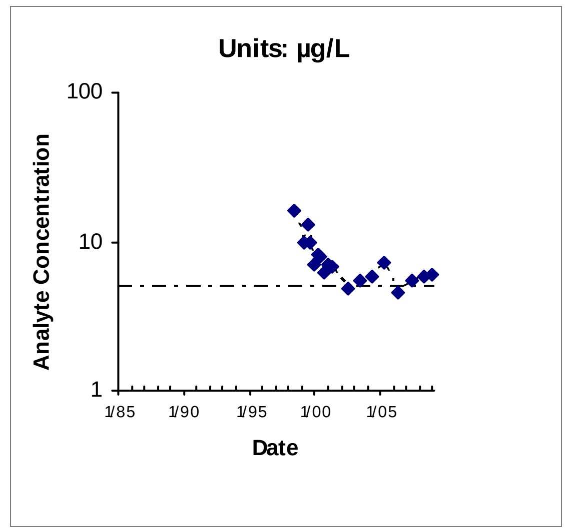
Location: MW02DX06 Maximum: 0.8



Location: MW02SX06 Maximum: 0.2



Location: MW207X06 Maximum: 0.03



Location: MW208DX06 Maximum: 16

— - — - — IRG (5 µg/L)

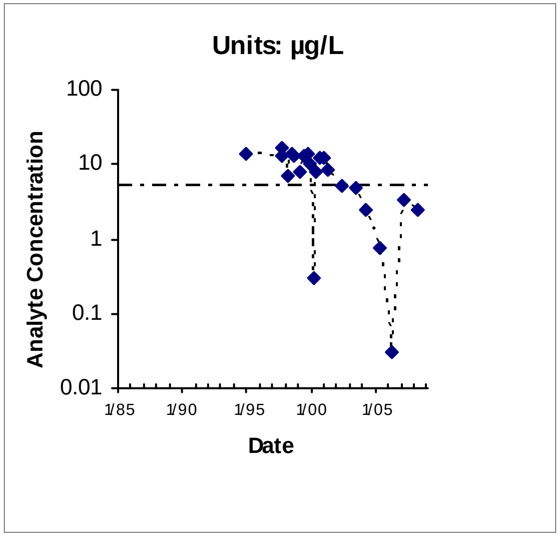
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 3-6

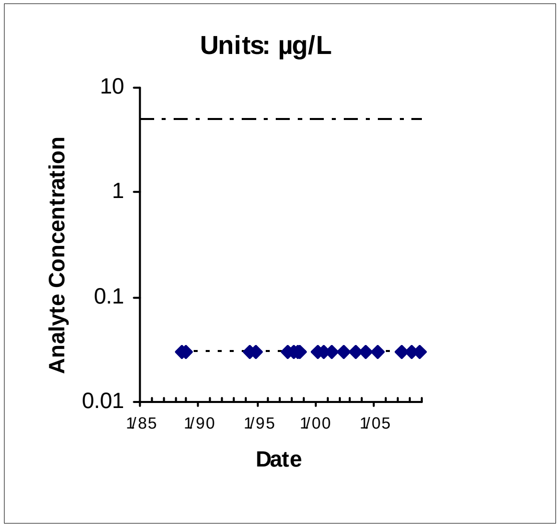
LF006 MNA Wells

TCE

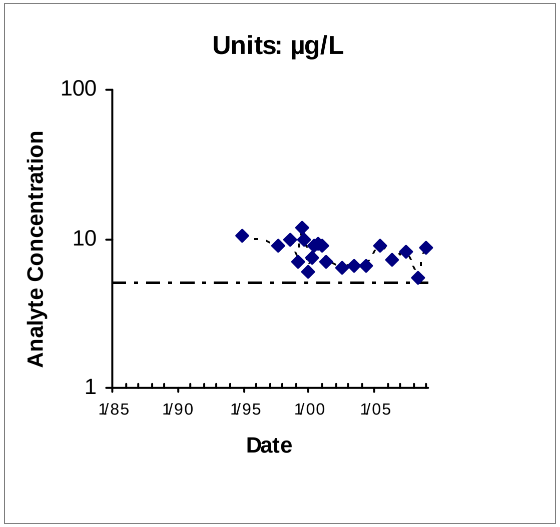
Chemical Time-series Plots



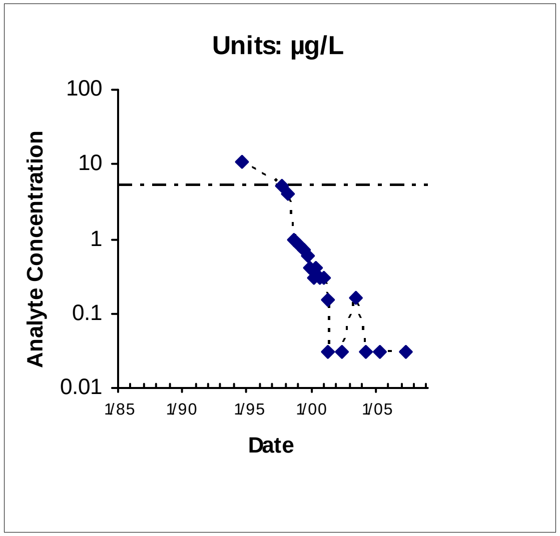
Location: MW208X06 Maximum: 17



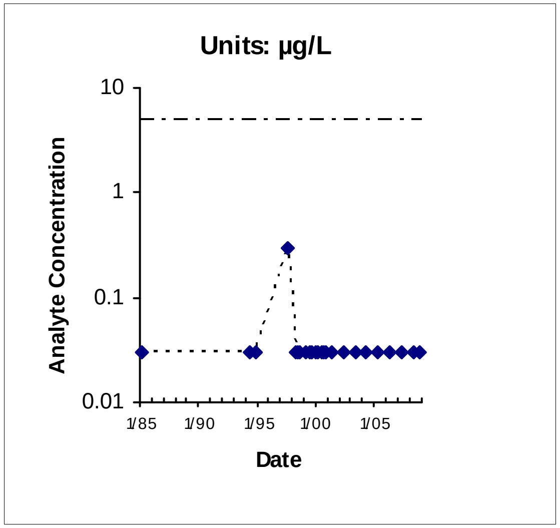
Location: MW210X06 Maximum: 0.03



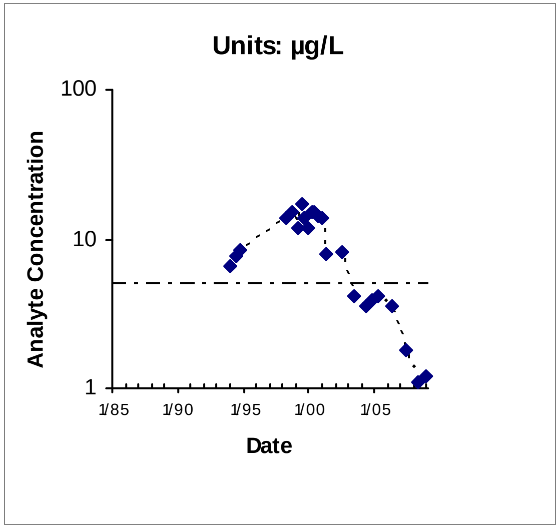
Location: MW259X06 Maximum: 12



Location: MW1743X06 Maximum: 10.6



Location: MW129X07 Maximum: 0.3



Location: MW1729X31 Maximum: 17

— - — - — IRG (5 µg/L)

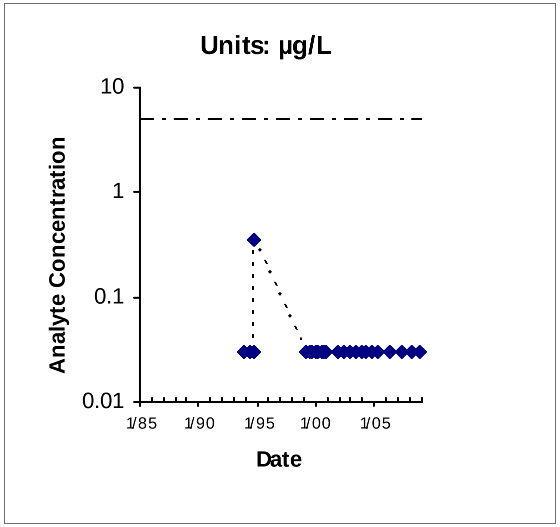
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 3-6

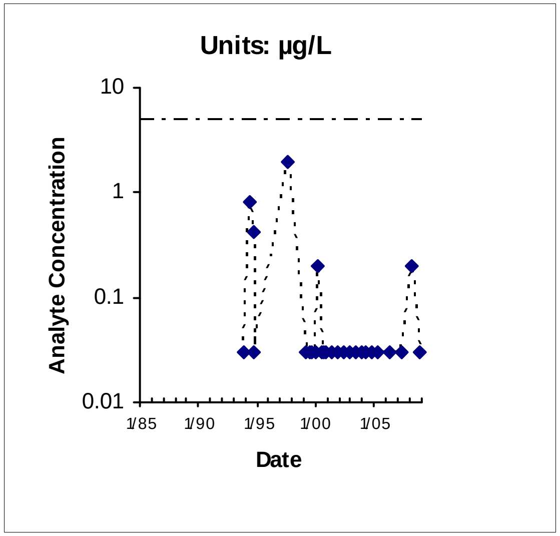
LF006 MNA Wells

TCE

Chemical Time-series Plots



Location: MW1730X31 Maximum: 0.35



Location: MW1731X31 Maximum: 2

— - — - — IRG (5 µg/L)

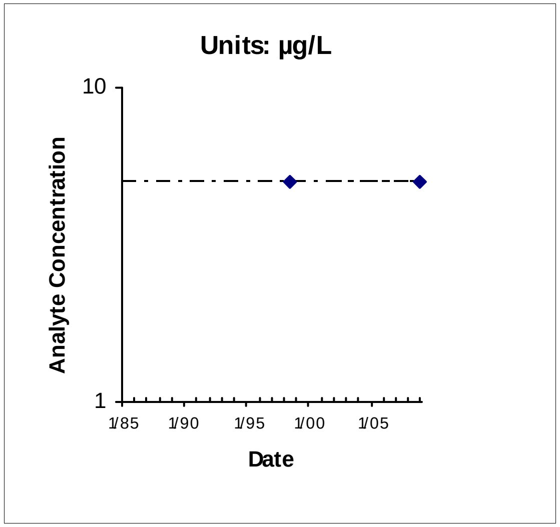
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 3-6

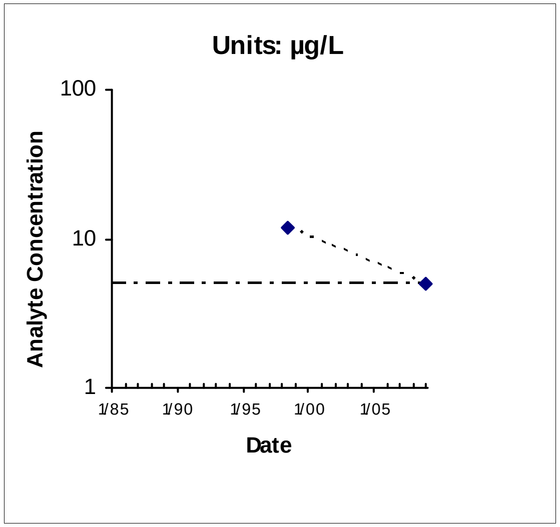
LF006 MNA Wells

TCE

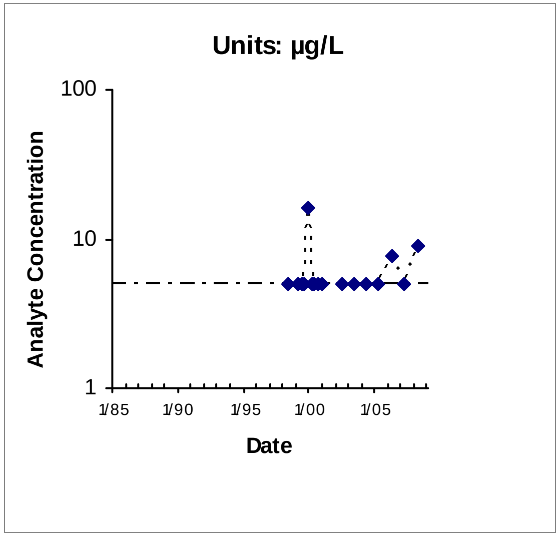
Chemical Time-series Plots



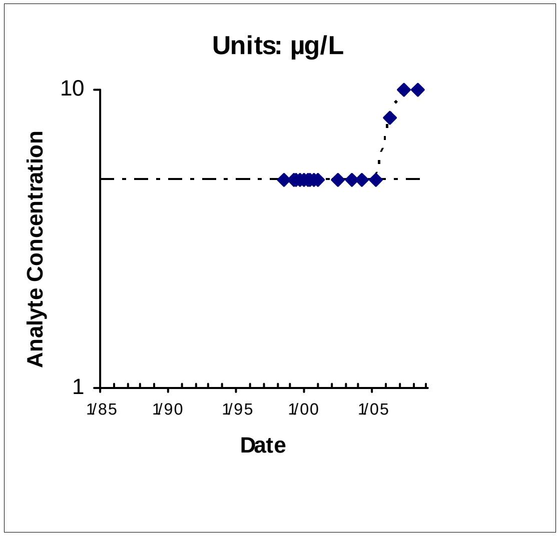
Location: MW01DX06 Maximum: 5



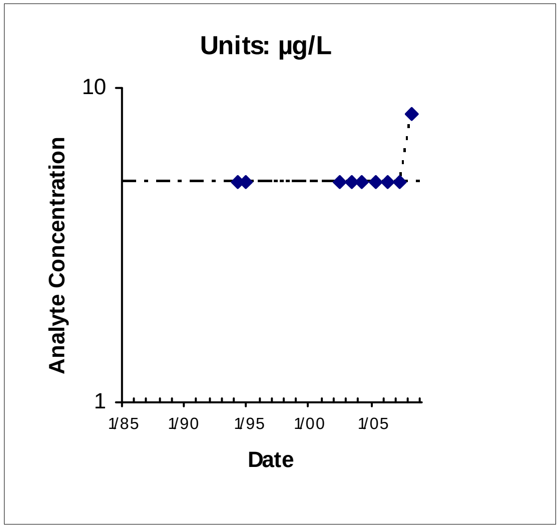
Location: MW01SX06 Maximum: 12



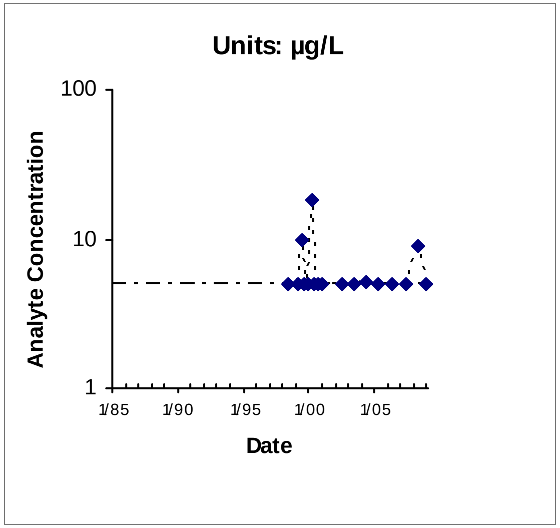
Location: MW02DX06 Maximum: 16



Location: MW02SX06 Maximum: 10



Location: MW207X06 Maximum: 8.3



Location: MW208DX06 Maximum: 18

— - — - — IRG (5 µg/L)

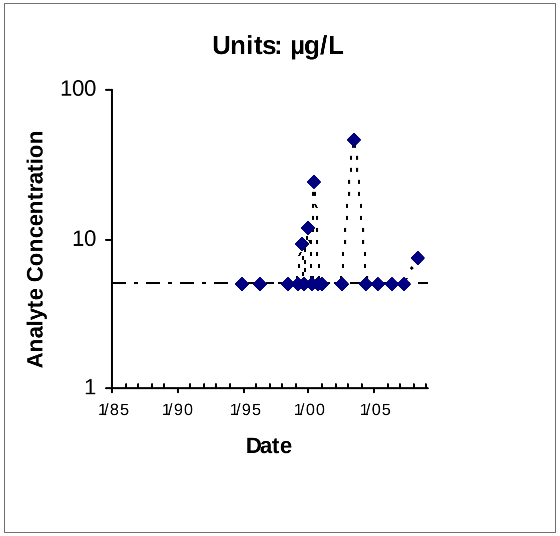
*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 3-7

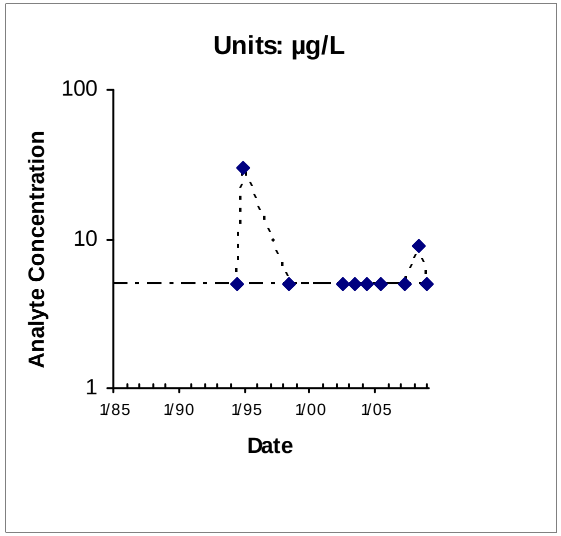
LF006 MNA Wells

TPH-Gasoline

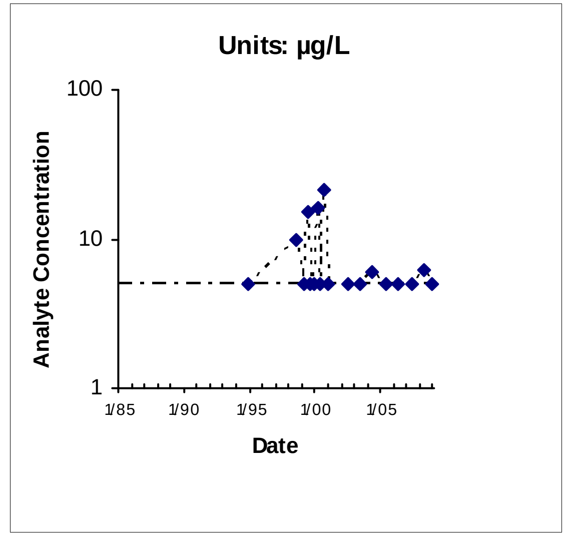
Chemical Time-series Plots



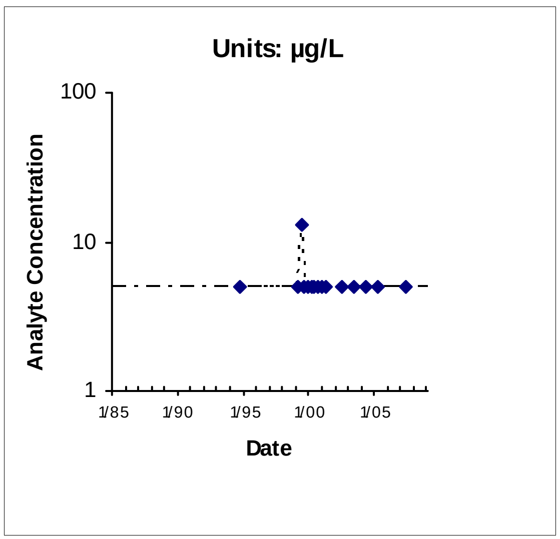
Location: MW208X06 Maximum: 46.2



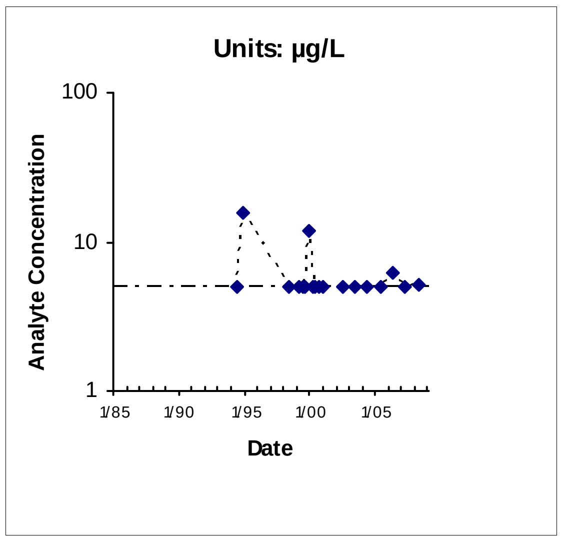
Location: MW210X06 Maximum: 30.3



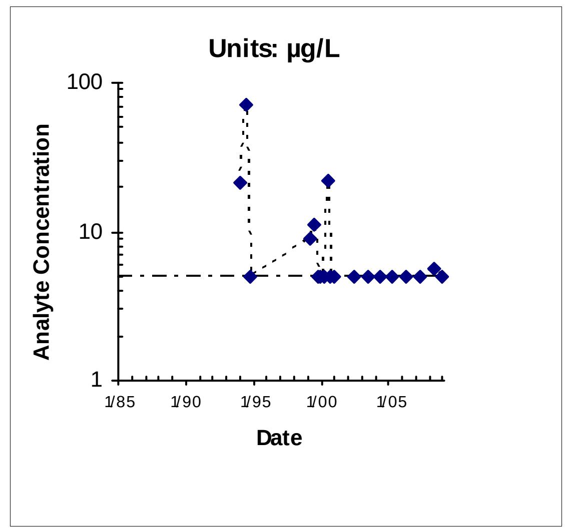
Location: MW259X06 Maximum: 21



Location: MW1743X06 Maximum: 13



Location: MW129X07 Maximum: 15.5



Location: MW1729X31 Maximum: 71

— - — - — IRG (5 µg/L)

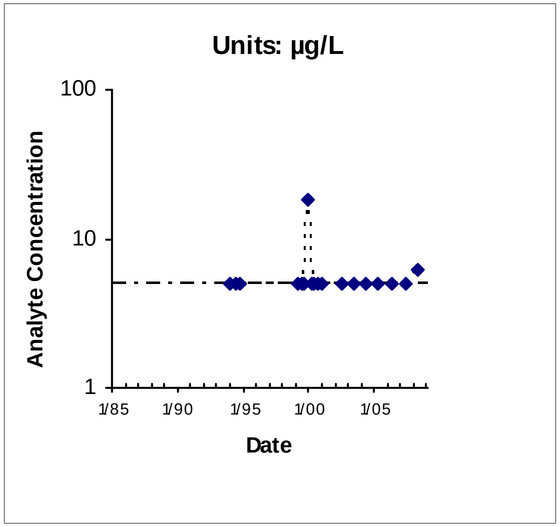
*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 3-7

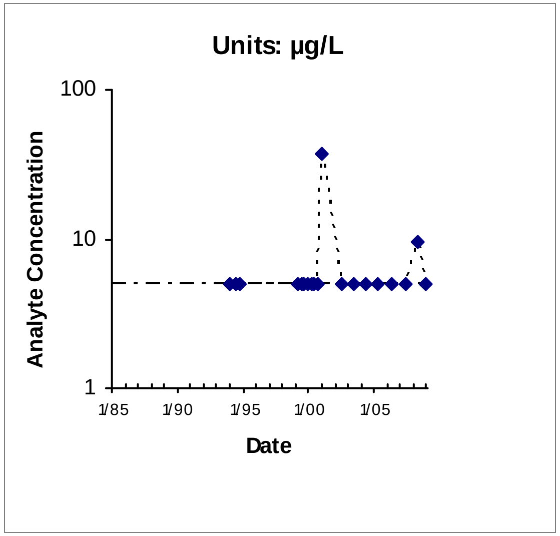
LF006 MNA Wells

TPH-Gasoline

Chemical Time-series Plots



Location: MW1730X31 Maximum: 18



Location: MW1731X31 Maximum: 37

— - — - — IRG (5 µg/L)

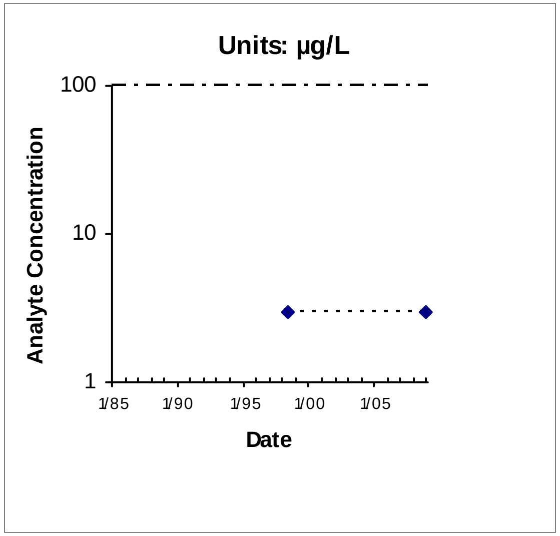
*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 3-7

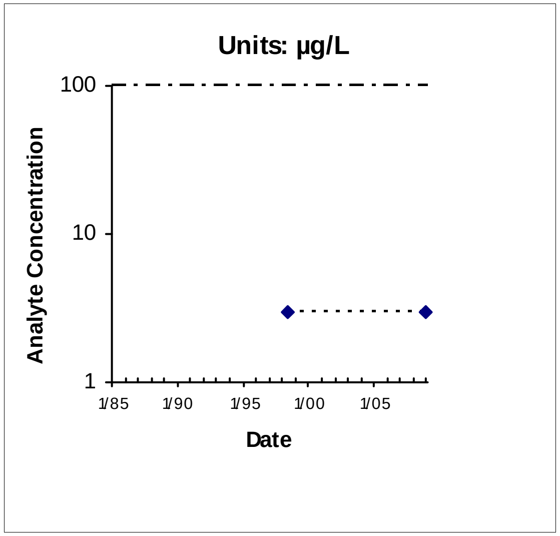
LF006 MNA Wells

TPH-Gasoline

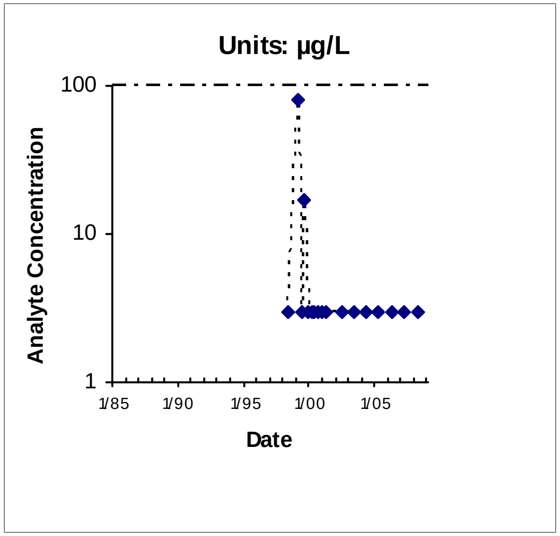
Chemical Time-series Plots



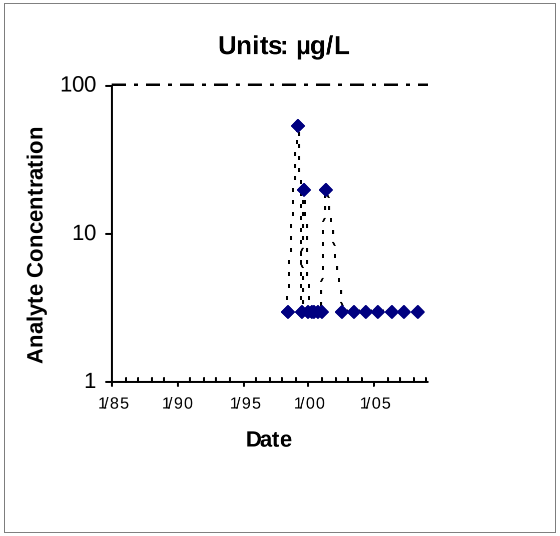
Location: MW01DX06 Maximum: 3



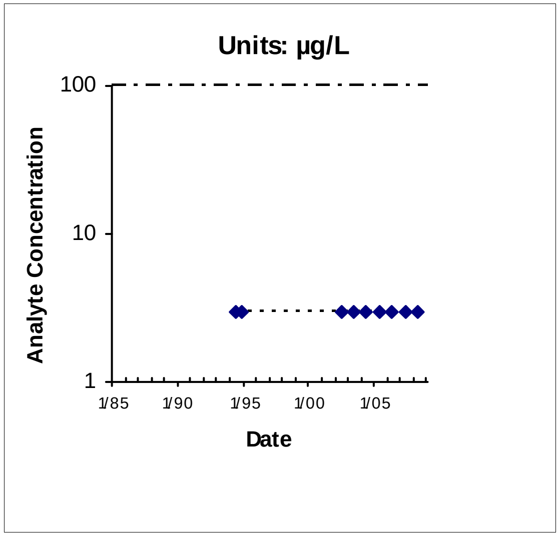
Location: MW01SX06 Maximum: 3



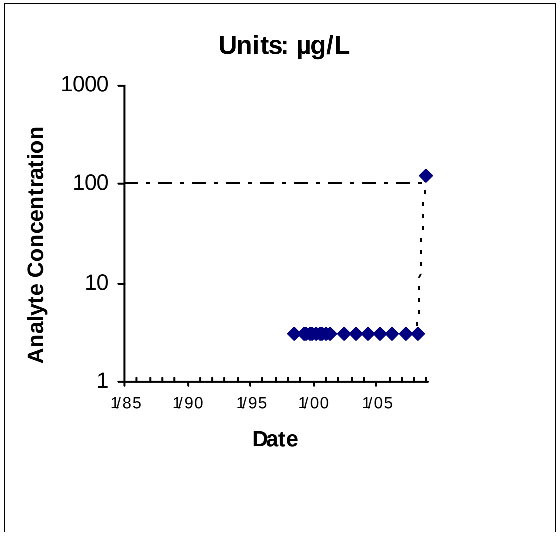
Location: MW02DX06 Maximum: 81



Location: MW02SX06 Maximum: 53



Location: MW207X06 Maximum: 3



Location: MW208DX06 Maximum: 120

— - — - — IRG (100 µg/L)

*Nondetects shown as the Method Detection Limit (3 µg/L)

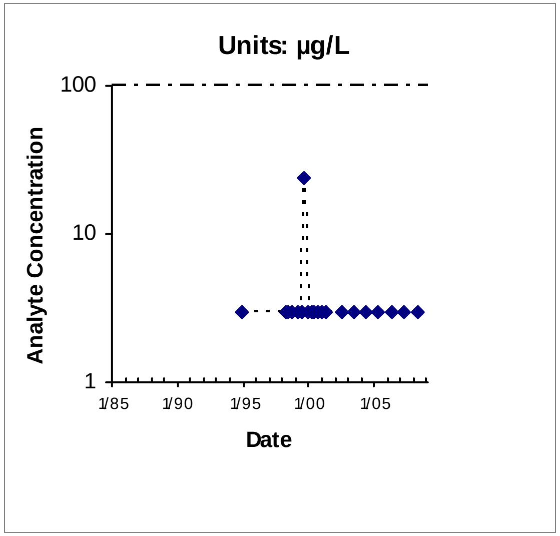
FIGURE 3-8

LF006 MNA Wells

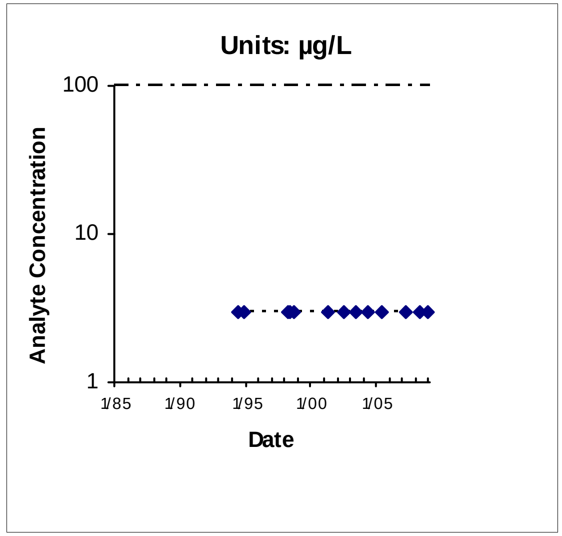
TPH-Diesel

Chemical Time-series Plots

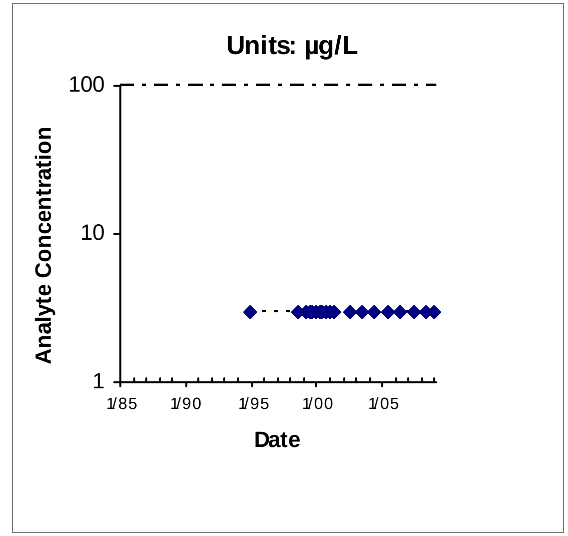
Page 1 of 3



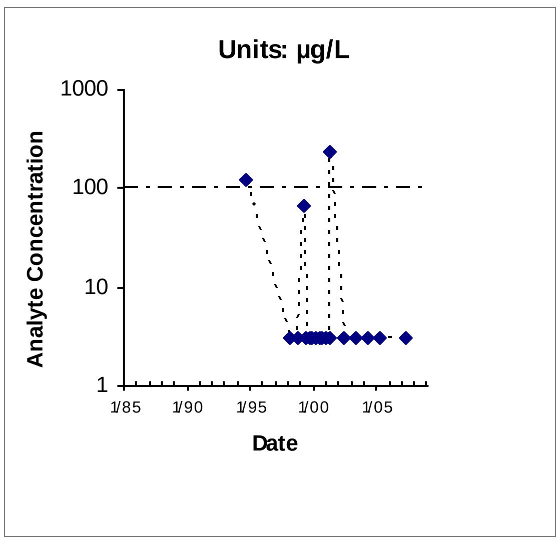
Location: MW208X06 Maximum: 24



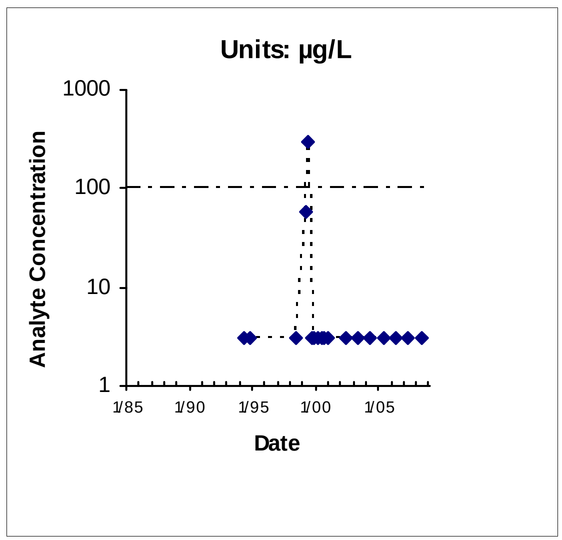
Location: MW210X06 Maximum: 3



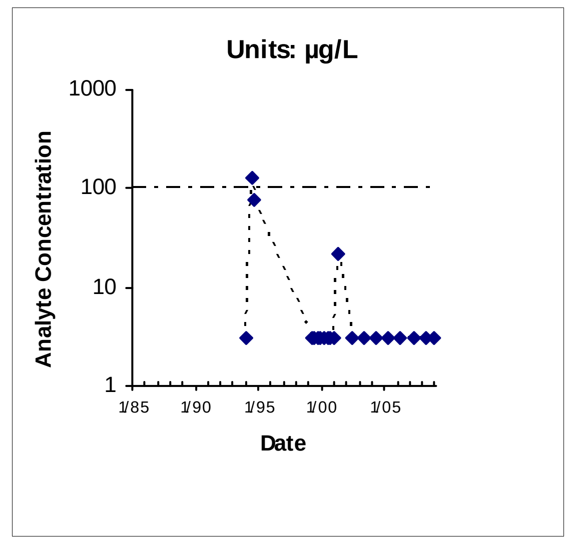
Location: MW259X06 Maximum: 3



Location: MW1743X06 Maximum: 240



Location: MW129X07 Maximum: 300



Location: MW1729X31 Maximum: 130

— - — - — IRG (100 µg/L)

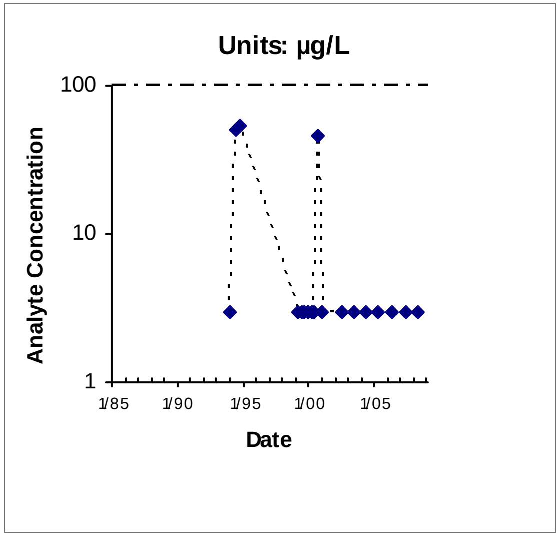
*Nondetects shown as the Method Detection Limit (3 µg/L)

FIGURE 3-8

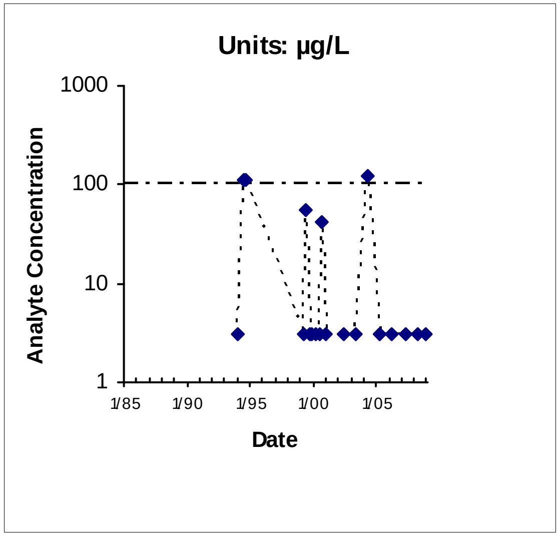
LF006 MNA Wells

TPH-Diesel

Chemical Time-series Plots



Location: MW1730X31 Maximum: 54



Location: MW1731X31 Maximum: 120

— - — - — IRG (100 µg/L)

*Nondetects shown as the Method Detection Limit (3 µg/L)

FIGURE 3-8

LF006 MNA Wells

TPH-Diesel

Chemical Time-series Plots

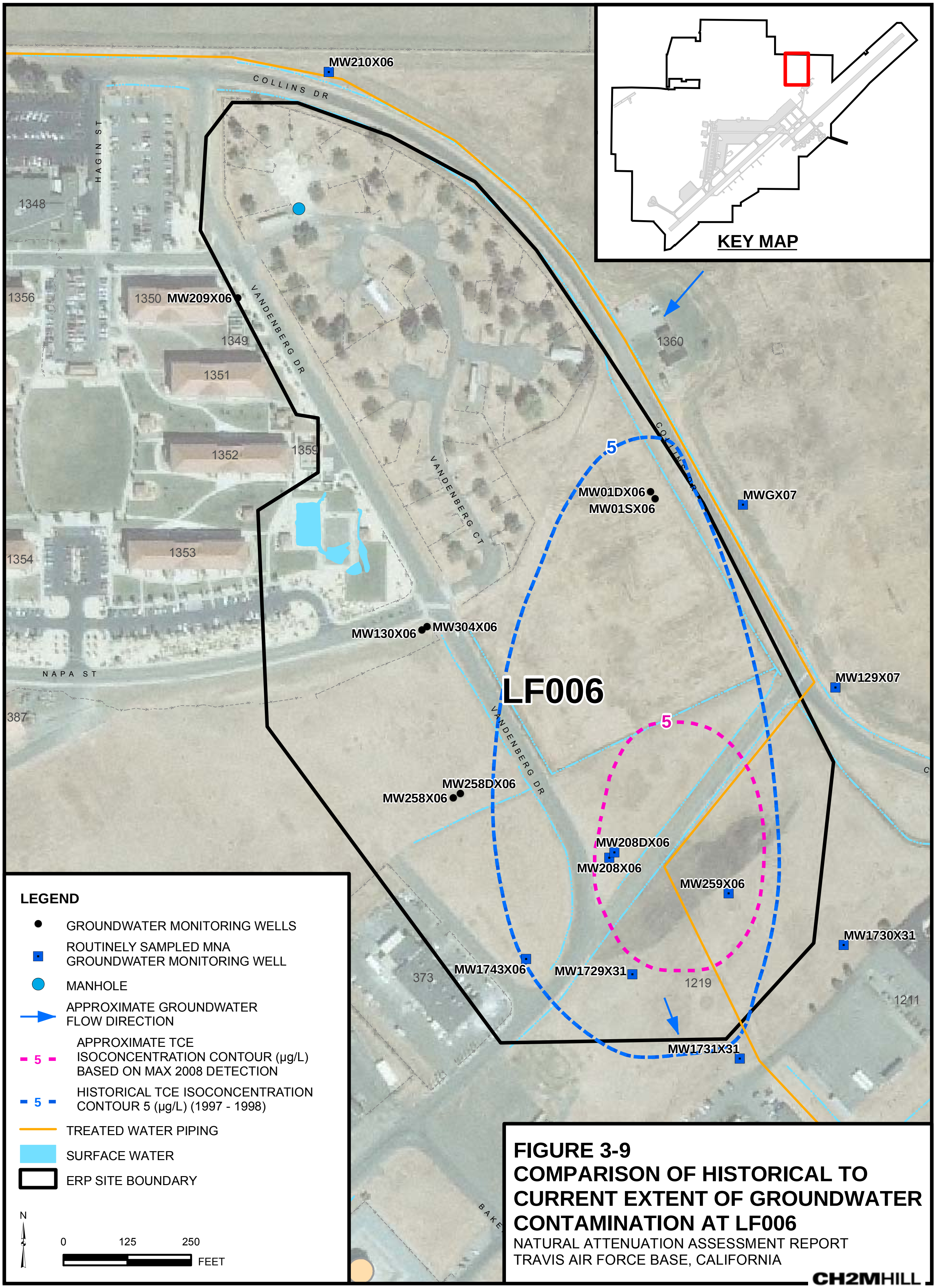


FIGURE 3-9
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT LF006
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\334892_2008ANNUALGSAP\MAPFILES\HISTORICAL_MAX_PLUMES\NAAR_MAPS\FIG3-9_LF006_SITE.MXD MCLAY1 6/30/2009

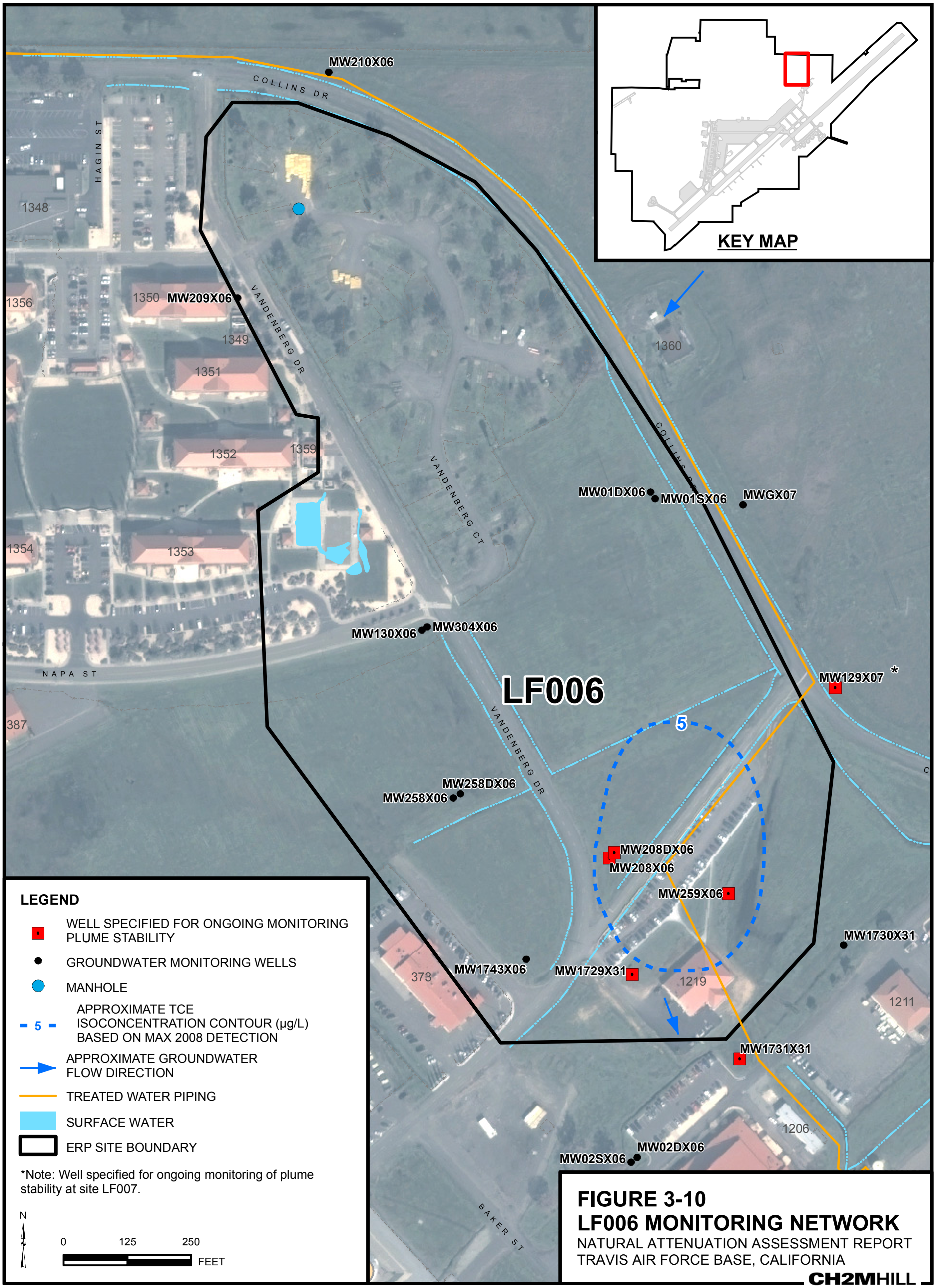


FIGURE 3-10
LF006 MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG3-10_LF006_MONITORINGNETWORK.MXD MCLAY1 1/14/2010

SECTION 4

Site LF007

Section 4 presents the natural attenuation assessment for Site LF007. A detailed conceptual site model and preliminary natural attenuation assessment are presented in the *Natural Attenuation Assessment Workplan* (LF007 NAAW) (Radian Corporation, 1999). This section focuses on data collected since the LF007 NAAW was submitted.

4.1 Site Background

4.1.1 Site Description

Site LF007 is former Landfill 2 in the North Operable Unit (NOU); it encompasses approximately 73 acres. The landfill was operated using trench-and-cover methods beginning in the early 1950s, following the closure of Landfill 1 (Site LF006). The landfill was used primarily for the disposal of general refuse, such as wood, glass, and construction debris. Small amounts of industrial wastes and fuel sludge from tank-cleaning operations also were reported to have been disposed of at Landfill 2. Use of Landfill 2 ceased in 1974 (Radian Corporation, 1995).

From the early 1950s until 1964, a portion of the eastern part of the landfill was used by the Defense Reutilization and Marketing Office (DRMO) to store excess waste materials, including oils, hydraulic fluid, and solvents, for resale or disposal. As determined by aerial photographs, a skeet range also was located at the site around 1953; however, the exact dates of operation are not known (Radian Corporation, 1995). During the NOU remedial investigation (RI), Site LF007 was divided into three (3) study areas designated as LF007B, LF007C, and LF007D (see Figure 4-1).

In addition to the Base Corrective Action Management Unit (CAMU), current Site LF007 operations include the operations at the Affiliate Radio System, the permitted hazardous waste storage facility, and a small arms firing range. Several large vernal pools are within the site boundaries; some extend north across the Base boundary. The land north of Site LF007, beyond the Base boundary, is privately owned and used for pasture.

4.1.2 Site COCs

The groundwater COCs and IRGs at Site LF007 are as follows:

LF007B:

COC	IRG (µg/L)	COC	IRG (µg/L)
1,4-dichlorobenzene (1,4-DCB)	5	polychlorinated biphenyls (PCBs)	0.5
2,3,7,8-tetrachlorodibenzo-p-dioxin	0.00003	benzene	1
bis(2-ethylhexyl)phthalate	4	chlorobenzene	70

LF007C:

COC	IRG (µg/L)	COC	IRG (µg/L)
1,1-DCE	6	TCE	5
1,2-DCA	0.5	VC	0.5
1,2-dichloropropane	5		

LF007D:

COC	IRG (µg/L)	COC	IRG (µg/L)
1,1-DCE	6	bis(2-ethylhexyl)phthalate	4
1,4-DCB	5	chlorobenzene	70
2,3,7,8-tetrachlorodibenzo-p-dioxin	0.00003	PCBs	0.5
benzene	1	VC	0.5

4.1.3 Status of the Interim Remedy

An IRA of groundwater GET has been implemented at LF007C, as specified by the NEWIOU Groundwater IROD (Travis AFB, 1997). Because the LF007C area is addressed by GET, this area is not included in the natural attenuation assessment.

Areas LF007B and LF007D were selected for MNA assessment in the NEWIOU Groundwater IROD (Travis AFB, 1997). Areas LF007B and LF007D underwent a natural attenuation assessment in 1997-1999 as documented in the LF007 NAAW *(*Radian Corporation, 1999). Since 1999, twenty (20) monitoring wells have been routinely sampled to support the ongoing MNA assessment: MW264x04, MW207x06, MW210x06, MW128x07, MW129x07, MW201x07, MW261x07, MW284x07, MW303x07, MW600x07, MW601x07, MW602x07, MW612x07, MW613x07, MWAx07, MWBx07, MWCx07, MWDx07, MWFx07, and MWGx07 (see Figure 4-1). These wells are located primarily in the downgradient and crossgradient portions of Areas LF007B and LF007D, to monitor plume migration.

Ten (10) years of data collected from the MNA wells indicate that MNA is a viable remedy for LF007B and LF007D. Very few site monitoring wells have VOC detections. Most VOC detections are below IRGs, and VOC concentrations are stable or declining. The Second Five-Year Review (CH2M HILL, 2008a) concluded that MNA is an effective remedy for LF007B and LF007D.

In summary, the status of the IRAs at Areas LF007B, LF007C, and LF007D is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
LF007B	MNA Assessment	Groundwater monitoring	Ongoing groundwater monitoring
LF007C	Migration Control and Offbase Remediation	GET	Ongoing GET
LF007D	MNA Assessment	Groundwater monitoring	Ongoing groundwater monitoring

4.2 Conceptual Site Model

4.2.1 Geology

The natural near-surface geology in the vicinity of Site LF007 consists mainly of fine-grained alluvium overlying bedrock. The alluvium consists primarily of silts and clays that are low in permeability and do not transmit groundwater readily. More permeable units, such as sands and gravels, tend to occur as discrete lenses rather than continuous beds that may be correlated from place to place. Bedrock in the vicinity of Site LF007 consists of undifferentiated Tertiary sandstone, siltstone, and shale. On the eastern edge of Site LF007 lies a north-south trending subsurface ridge of Markley Sandstone, resulting in a thinning of the saturated zone toward the east. Geologic cross sections through the LF007B and LF007D areas are presented on Figures 4-2 and 4-3.

The stratigraphy at Site LF007 also consists of fill material (municipal waste) and backfill material. The fill material and municipal waste that overlie the alluvium at Site LF007 consist of sands and gravels interbedded with clay, organic matter, glass, metal, plastic, rubber, construction debris, and small amounts of industrial wastes and fuel sludge. The thickness of the fill material and municipal waste ranges from a few feet to more than 20 feet. Backfill consisting of clayey silt, sand and gravel, and organic matter overlies the fill and is about 1 to 5 feet thick. On the eastern portion of the landfill, the fill and wastes settled unevenly, which resulted in north-south trending depressions in LF007D. The depressions were eliminated in 2002 during regrading for the CAMU. The surface at LF007B and the western half of the landfill have not been affected by differential settling.

4.2.2 Groundwater

As summarized in Table 4-1, depth to water at Site LF007 is approximately 5 to 25 feet bgs, and the saturated zone is approximately 5 to 50 feet thick. The large variation in saturated thickness is due to the ridge of Markley Sandstone in the eastern portion of the site. Groundwater elevations at Site LF007 have a larger seasonal variation than that which has been observed for the rest of the Base. For example, MWEx07 typically varies by as much as 20 feet in 1 year. Other Site LF007 monitoring wells, such as MWDx07 and MWFx07, typically vary by 10 feet in a year. These fluctuations are related to the seasonal presence of vernal pools and surface water ponding that recharges the groundwater system during the winter.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 4-4 and are consistent with historical groundwater flow directions. While the regional groundwater flow direction at Travis AFB is generally toward the south, the groundwater flow system in the vicinity of Site LF007 is influenced by the near-surface bedrock beneath the relatively thin alluvium. A groundwater mound exists in the eastern portion of the site, resulting in radial groundwater flow away from the mound. Groundwater elevation data indicate that groundwater along the Base boundary in the Site LF007C and LF007D areas flows northwesterly off-base for some distance before moving southerly with the regional gradient. However, the precise nature of the off-base groundwater flow direction is uncertain because of the relatively flat gradients in this area and limited number of off-base data points. The horizontal gradient in the western portion of Site LF007, away from the Site LF007 groundwater mound, is approximately 0.003 ft/ft. The horizontal gradients near the groundwater mound are approximately 0.02 ft/ft.

In general, vertical gradients at Site LF007 are negligible (less than 0.01 ft/ft). In 2008, vertical gradients ranged from -0.03 ft/ft downward to 0.005 ft/ft upward (Table 4-2). While the vertical gradients are typically less than 0.01 ft/ft at Site LF007, a downward vertical gradient of -0.03 ft/ft was measured at well pair MW128x07/MW303x07 in 2Q08. Downward vertical gradients at this site are due to the presence of shallow bedrock and an adjacent basin. It is a recharge zone.

Two (2) aquifer tests have been performed at Site LF007, and the results are summarized in Table 4-3. Hydraulic conductivities calculated from the aquifer tests ranged from 1 to 7 ft/day, reflecting the low permeability of the sediments. The average of the hydraulic conductivities calculated for the site is approximately 4 ft/day.

The average linear flow of groundwater at Site LF007 may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.02 ft/ft, an average hydraulic conductivity of 4 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), approximate groundwater velocity is about 0.4 ft/day or approximately 150 ft/year.

Groundwater at Travis AFB is not used for human consumption and groundwater in Area LF007B does not discharge to surface water. Groundwater in Area LF007D does have the potential to discharge to surface water in the vicinity of Area LF007C (where seasonal vernal pools are present); however, groundwater at Area LF007C is addressed by a GET IRA. The nearest domestic wells are approximately 2,500 feet from the leading edge of the LF007D plume (COC concentrations are below IRGs in Area LF007B). At the estimated groundwater velocity, it would take approximately 16 years for groundwater at Area LF007D to reach the domestic wells, assuming groundwater flow is consistently northward beyond the Base boundary. However, the northward groundwater flow direction observed in the vicinity of Area LF007D is expected to curve southward to rejoin the regional flow (which is to the south toward the Base). Because contaminants do not appear to be migrating in groundwater at this time, because ongoing monitoring will continue to evaluate whether contamination is migrating in the future, and because groundwater from Areas LF007B and LF007D does not impact surface water, residual groundwater contamination at Areas LF007B and LF007D should not pose a risk to receptors.

4.2.3 Current Distribution of Groundwater Contamination

The monitoring wells selected to support the MNA assessment in the LF007B and LF007D areas over the interim period are MW264x04, MW207x06, MW210x06, MW128x07, MW129x07, MW201x07, MW261x07, MW284x07, MW303x07, MW600x07, MW601x07, MW602x07, MW612x07, MW613x07, MWAx07, MWBx07, MWCx07, MWDx07, MWFx07, and MWGx07.

During the 2Q08 and 4Q08 sampling events, the only Site LF007 COCs detected at concentrations exceeding IRGs in MNA wells were 1,4-DCB and benzene. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix.

1,4-DCB and benzene concentrations exceeded IRGs at only one (1) location, MW261x07 (LF007D area). Figure 4-5 illustrates the current distribution of 1,4-DCB at Site LF007. The maximum 1,4-DCB concentration detected at MW261x07 in 2008 was 27.3 µg/L (the IRG is 5 µg/L). 1,4-DCB was detected at a low (1.3 µg/L) concentration in nearby well MWCx07. 1,4-DCB was not detected at any other Site LF007 monitoring well during 2008. Benzene was only detected in one (1) well, MW261x07. The concentration detected in 2008 was 2.7 µg/L (the IRG is 1 µg/L).

A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site LF007 groundwater plumes are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b). The groundwater VOC concentrations at Site LF007 do not indicate potential for VI risk.

4.3 Natural Attenuation Assessment

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has been reduced in size. Over the interim period, the GSAP has been monitoring several wells to evaluate plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 4.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 4.3.2.

4.3.1 Plume Attenuation

Chemical time-series plots of the primary COCs (1,4-DCB and benzene) for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 4-6 and 4-7

Consistent 1,4-DCB detections have been restricted to monitoring wells MW261x07, MWBx07, and MWCx07. 1,4-DCB concentrations continue to exceed the IRG at MW261x07. 1,4-DCB concentrations have declined slightly over time at this monitoring well. The historical maximum concentration detected is 39 µg/L, and in 2008, the concentrations detected ranged from 23 to 27.3 µg/L. 1,4-DCB concentrations have declined at MWBx07; 1,4-DCB has not been detected at this monitoring well since 2006. 1,4-DCB concentrations have also declined slightly at MWCx07. The historical maximum detection at MWCx07 was 2.6 µg/L, and it was detected at a maximum concentration of 1.3 µg/L in 2008.

Figure 4-8 shows the current distribution of 1,4-DCB exceeding the IRG and the historical extent of 1,4-DCB contamination in groundwater exceeding the IRG at Site LF007. The historical extent of contamination is based on in situ and monitoring well data collected during the 1994-1995 RI (Radian, 1996). This figure illustrates the reduction in the extent of the Site LF007 1,4-DCB plume over time.

Benzene is only consistently detected at one (1) well, MW261x07. The historical maximum detection is 4 µg/L; benzene detections in 2008 ranged from 2.2 to 2.7 µg/L. Benzene concentrations remain stable at this well.

There is no indication of plume migration. The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of 1,4-DCB at this site to approximately 0.6 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the plume would be expected to have migrated approximately 900 feet (90 feet per year) over the 10 years of the MNA assessment period. However, the plume has receded, indicating that natural attenuation processes are occurring at the site.

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the twenty (20) monitoring wells in the MNA assessment network, there is currently only one (1) monitoring well at which COCs continue to exceed IRGs (MCLs). Point attenuation rate constants were calculated for the one (1) MNA well at which COCs continue to exceed IRGs: MW261x07. At this monitoring well, two COCs continue to exceed IRGs: 1,4-DCB and benzene. Attenuation rate constants were calculated for both COCs. The attenuation rate constant calculated for 1,4-DCB at well MW261x07 is approximately 0.054 per year. At this attenuation rate, the 1,4-DCB concentrations would be expected to reach the IRG (5 μg/L) in 2029.

Benzene concentrations have declined very slightly over the last 10 years; an attenuation rate constant of approximately 0.0039 per year was calculated (Appendix D). At this attenuation rate, benzene concentrations would be expected to continue to exceed the MCL (1 μg/L) for over 100 years at this location.

Although the current anaerobic conditions in the immediate vicinity of well MW261x07 (evident in monitoring data collected at this well from the initial MNA assessment in 1999 through 2008) are conducive to biodegradation of chlorinated solvents (such as 1,4-DCB), aerobic conditions are more favorable for biodegradation of benzene. Once the degradation of 1,4-DCB is complete, conditions near well MW261x07 are expected to gradually become aerobic, like the rest of the site, and more conducive to benzene degradation. The benzene concentrations detected at this well only slightly exceed the MCL (ranging from 2.2 to 2.7 μg/L in 2008) and are restricted to the immediate vicinity of this well. In addition, this well is located in a capped landfill and there are no receptors.

In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for the MNA monitoring well where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.

A bulk attenuation rate was calculated only for 1,4-DCB because it is the only chemical that was detected at more than 1 monitoring well at the site during 2008. A bulk attenuation constant could only be calculated for the LF007D area. Because no chemicals were detected in the LF007B area monitoring wells, a bulk attenuation rate constant could not be calculated for this area. A bulk attenuation rate constant of approximately 1.8 per year was calculated for 1,4-DCB at Site LF007D, based on the 2008 distribution of 1,4-DCB in groundwater at the site (Appendix F). The data set is limited to the two monitoring wells (MW261x07 and MWCx07) where 1,4-DCB is currently detected. The positive bulk attenuation rate constant indicates that attenuation of 1,4-DCB is occurring. The travel time for 1,4-DCB to reach the IRG (5 µg/L) once it leaves the source area (near well MW261x07) is estimated to be approximately 0.96 year. The plume (exceeding the IRG) should extend approximately 85 feet from the source area.

4.3.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for Site LF007. Table 4-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from monitoring wells at Site LF007 during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), TOC (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and CO_2 (HACH field test). In addition, pH, temperature, DO, ORP, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Well:** MWAx07
- **Source Well:** MW261x07
- **Plume Well:** MWCx07
- **Distal Wells:** MW207x06, MW129x07, MW612x07, MW613x07, MWFx07, MW600x07, and MW601x07

As shown in Table 4-5, source area well MW261x07 received a score of eighteen (18), indicating adequate evidence for biodegradation of chlorinated solvents. This is the only monitoring well in Areas LF007B and LF007D that has COCs at concentrations exceeding IRGs (1,4-DCB and benzene). In the portions of Areas LF007B and LF007D where COCs are below IRGs, there was limited to inadequate evidence of biodegradation (scoring nine [9] points or less).

A similar biodegradation screening was performed in 1997-1999 as documented in the LF007 NAAW (Radian Corporation, 1999). During the initial biodegradation screening, most monitoring wells scored between five (5) and fourteen (14) points (inadequate to limited evidence of biodegradation). The only monitoring well scoring higher than fourteen (14) points was source monitoring well MW261x06. The scores for this well ranged from nine (9) to twenty-one (21) points in 1997 and 1998.

4.4 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- At Area LF007B, no COCs are currently detected in groundwater.
- In the portion of Area LF007D where COCs continue to exceed IRGs, there is adequate evidence for biodegradation of chlorinated solvents (1,4-DCB).
- In the portion of Area LF007D where COCs are below IRGs, there is inadequate to limited evidence for biodegradation of chlorinated solvents. The plume may be exhibiting mixed behavior, with reducing, anaerobic conditions near the source area and aerobic conditions in the downgradient portion of the plume (Wiedemeier et al., 1996).
- Consistent 1,4-DCB detections have been restricted to monitoring wells MW261x07, MWBx07, and MWCx07 in Area LF007D.
- 1,4-DCB concentrations have declined over the interim period. Currently, 1,4-DCB exceeds the IRG at only one (1) monitoring well (MW261x07).
- The 1,4-DCB plume has reduced in size over the 10 years since the MNA assessment began.
- The only other site COC exceeding IRGs detected at Area LF007D wells is benzene. Benzene detections are restricted to one (1) location, MW261x07. Benzene concentrations at this location are stable.
- There is no indication of plume migration. In fact, the plume has receded.

Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for LF007B and LF007D.

4.5 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring at LF007B and LF007D. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells to monitor plume stability is presented on Figure 4-9 and will consist of MWBx07, MWCx07, MW129x07, MW261x07, MW601x07, MW612x07, and MW613x07. These wells will be sampled annually for VOCs. This network will continue to be monitored during the interim period or until such time as the remedy changes. Monitoring to support assessment of the LF007C GET performance will continue to be performed as specified in the GSAP annual reports.

TABLE 4-1

LF007 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: LF007									
EW614X07	15	50	51.8	16.8	69.13	7.57	61.56	NM	NM
EW615X07	15	50	51.1	16.1	68.47	6.84	61.63	NM	NM
MW125X07	17	37	49.21	29.21	68.95	7.15	61.8	11.97	56.98
MW126X07	8	28	57.38	37.38	68.08	6.09	61.99	10.65	57.43
MW128X07	6	26	56.12	36.12	64.45	6.26	58.19	10.24	54.21
MW129X07	10	30	53.98	33.98	66.37	7.83	58.54	10.73	55.64
MW201X07	5	20	58.46	43.46	65.95	7.11	58.84	10.63	55.32
MW261X07	8.5	18.5	84.8	74.8	95.82	24.85	70.97	26.89	68.93
MW284X07	6.9	16.9	70.81	60.81	79.85	8.77	71.08	13.22	66.63
MW303X07	54.8	64.8	7.53	-2.47	64.87	6.87	58	10.56	54.31
MW600X07	5.5	25.5	67.5	47.5	72.46	7.45	65.01	13.24	59.22
MW601X07	5	25	62	42	66.77	5.28	61.49	10.01	56.76
MW602X07	5.5	20	65.5	51	69.94	9.34	60.6	12.58	57.36
MW612X07	10	20	56.4	46.4	68.92	7.81	61.11	11.74	57.18
MW613X07	50	60	16.6	6.6	68.88	7.57	61.31	11.72	57.16
MW616X07	15	50	50.9	15.9	67.92	6.32	61.6	10.91	57.01
MW617X07	15	50	52.5	17.5	69.91	7.8	62.11	13.8	56.11
MW618X07	15	50	53.1	18.1	68.13	6.22	61.91	11.34	56.79
MW619X07	10	40	55.69	25.69	68.45	7.01	61.44	11.5	56.95
MW620X07	10	35	55.98	30.98	68.34	7.35	60.99	11.5	56.84
MWAX07	12	27	57.14	42.14	69.14	10.27	58.87	18.01	51.13
MWBX07	6	16	67.54	57.54	73.54	6.11	67.43	10.49	63.05
MWCX07	7.1	17.1	68.9	58.9	76.00	8.95	67.05	12.88	63.12

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 4-1

LF007 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: LF007									
MWDX07	16.5	26.5	59.6	49.6	76.85	10.41	66.44	16.14	60.71
MWEX07	17	32	56.42	41.42	73.42	NM	NM	24.01	49.41
MWFX07	18	28	60.68	50.68	78.68	13.31	65.37	22.74	55.94
MWGX07	6.9	16.9	59.62	49.62	66.52	7.14	59.38	10.2	56.32

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 4-2
LF007 Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base, California

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW303x07	MW128x07	-0.005	0.002	-0.03	0.002
MW613x07	MW612x07	-0.002	-0.001	0.005	-0.001

Note:

Minus sign indicates downward vertical gradient.

TABLE 4-3
Aquifer Test Results for LF007
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
LF007	MW128x07	6–26	1988	Gravity-injection	1	70% silty, clayey sand; 30% clay
	MW125x07	17–37	9/7/01	Pumping	7	NA

Notes:

ft bgs = feet below ground surface
NA = data not available

Source: CH2M HILL, 2004.

TABLE 4-4

Summary of Analytes Detected in MNA Wells at LF007 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: LF007							
MW128X07							
	5/2/2008	SW8260	Methylene chloride	0.53	J	µg/L	5
MW129X07							
	5/2/2008	SW8260	Methylene chloride	0.48	J	µg/L	5
	5/2/2008	SW8015-E	No Analytes Detected				
	5/2/2008	SW8015-P	TPH-Gasoline	**5.1**	J	µg/L	5
	12/4/2008	E310	Alkalinity	381		mg/L	
	12/4/2008	E300	Chloride	136		mg/L	
	12/4/2008	SM4500S2	No Analytes Detected				
	12/4/2008	A5310B	Total Organic Carbon	2.56		mg/L	
	12/4/2008	RSK-175	No Analytes Detected				
	12/4/2008	SW8260	No Analytes Detected				
	12/4/2008	E300	Nitrate	1.96		mg/L	
	12/4/2008	E300	Sulfate	336		mg/L	
MW201X07							
	5/5/2008	SW8260	Acetone	2.3	J	µg/L	5110
	5/5/2008	SW8260	Methylene chloride	0.58	J	µg/L	5
MW261X07							
	5/5/2008	SW8260	1,2-DCB	4.3		µg/L	
	5/5/2008	SW8260	1,3-DCB	0.43	J	µg/L	
	5/5/2008	SW8260	1,4-DCB	**23**		µg/L	5
	5/5/2008	SW8260	Acetone	18		µg/L	5110
	5/5/2008	SW8260	Benzene	**2.2**		µg/L	1
	5/5/2008	SW8260	Chlorobenzene	32		µg/L	70
	5/5/2008	SW8260	Ethylbenzene	0.25	J	µg/L	700
	5/5/2008	SW8260	m,p-Xylene	1.4		µg/L	1750
	5/5/2008	SW8260	Methyl tert-butyl ether (MTBE)	0.32	J	µg/L	13
	5/5/2008	SW8260	o-Xylene	0.64		µg/L	1750
	5/5/2008	SW8260	Styrene	0.18	J	µg/L	
	5/5/2008	SW8260	Toluene	0.76		µg/L	150
	11/24/2008	E310	Alkalinity	1500		mg/L	
	11/24/2008	E300	Chloride	1630		mg/L	
	11/24/2008	SM4500S2	No Analytes Detected				
	11/24/2008	A5310B	Total Organic Carbon	211		mg/L	
	11/24/2008	SW8260	1,2-DCB	5.1		µg/L	
	11/24/2008	SW8260	1,3-DCB	0.62		µg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 4-4

Summary of Analytes Detected in MNA Wells at LF007 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF007							
MW261X07							
	11/24/2008	SW8260	1,4-DCB	**27.3**		µg/L	5
	11/24/2008	SW8260	Acetone	12.1		µg/L	5110
	11/24/2008	SW8260	Benzene	**2.7**		µg/L	1
	11/24/2008	SW8260	Chlorobenzene	36		µg/L	70
	11/24/2008	RSK-175	Ethane	0.27	J	µg/L	
	11/24/2008	SW8260	m,p-Xylene	2		µg/L	1750
	11/24/2008	RSK-175	Methane	3020		µg/L	
	11/24/2008	SW8260	o-Xylene	0.77		µg/L	1750
	11/24/2008	E300	Sulfate	0.395	J	mg/L	
	11/24/2008	SW8260	Toluene	0.56		µg/L	150
MW284X07							
	5/5/2008	SW8260	Acetone	2.2	J	µg/L	5110
MW303X07							
	5/2/2008	SW8260	Methylene chloride	0.53	J	µg/L	5
MW600X07							
	5/6/2008	SW8260	Methylene chloride	0.34	J	µg/L	5
	5/6/2008	SW8260	TCE	0.3	J	µg/L	5
	12/10/2008	E310	Alkalinity	359		mg/L	
	12/10/2008	E300	Chloride	924		mg/L	
	12/10/2008	SM4500S2	No Analytes Detected				
	12/10/2008	A5310B	Total Organic Carbon	5.63		mg/L	
	12/10/2008	RSK-175	Methane	40.4		µg/L	
	12/10/2008	E300	Nitrate	0.182		mg/L	
	12/10/2008	SW8260	No Analytes Detected				
	12/10/2008	E300	Sulfate	34.1		mg/L	
MW601X07							
	5/1/2008	SW8260	No Analytes Detected				
	12/9/2008	E310	Alkalinity	500		mg/L	
	12/9/2008	E300	Chloride	377		mg/L	
	12/9/2008	SM4500S2	No Analytes Detected				
	12/9/2008	A5310B	Total Organic Carbon	10.8		mg/L	
	12/9/2008	E300	Nitrate	1.03		mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8260	No Analytes Detected				
	12/9/2008	E300	Sulfate	1210		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 4-4

Summary of Analytes Detected in MNA Wells at LF007 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF007							
MW602X07							
	5/1/2008	SW8260	No Analytes Detected				
MW612X07							
	6/20/2008	SW8260	1,2-Dichloropropane	0.14	J	µg/L	5
	6/20/2008	SW8260	Acetone	2.6	J	µg/L	5110
	6/20/2008	SW8270	Bis (2-ethylhexyl) phthalate	2.3	J	µg/L	4
	6/20/2008	SW8260	Methylene chloride	0.45	J	µg/L	5
	6/20/2008	SW8082	No Analytes Detected				
	12/4/2008	E310	Alkalinity	453		mg/L	
	12/4/2008	E300	Chloride	822		mg/L	
	12/4/2008	SM4500S2	No Analytes Detected				
	12/4/2008	A5310B	Total Organic Carbon	9		mg/L	
	12/4/2008	RSK-175	No Analytes Detected				
	12/4/2008	SW8260	No Analytes Detected				
	12/4/2008	SW8270	Diethyl phthalate	7.4	J	µg/L	
	12/4/2008	E300	Nitrate	0.244		mg/L	
	12/4/2008	SW8082	No Analytes Detected				
	12/4/2008	E300	Sulfate	2330		mg/L	
MW613X07							
	6/20/2008	SW8260	Acetone	2.4	J	µg/L	5110
	6/20/2008	SW8270	Bis (2-ethylhexyl) phthalate	2.2	J	µg/L	4
	6/20/2008	SW8082	No Analytes Detected				
	12/4/2008	E310	Alkalinity	404		mg/L	
	12/4/2008	E300	Chloride	412		mg/L	
	12/4/2008	SM4500S2	No Analytes Detected				
	12/4/2008	A5310B	Total Organic Carbon	2.41		mg/L	
	12/4/2008	SW8260	Acetone	4.9	J	µg/L	5110
	12/4/2008	RSK-175	No Analytes Detected				
	12/4/2008	SW8270	Diethyl phthalate	9.5	J	µg/L	
	12/4/2008	E300	Nitrate	0.285		mg/L	
	12/4/2008	SW8082	No Analytes Detected				
	12/4/2008	E300	Sulfate	2780		mg/L	
MWAX07							
	5/1/2008	SW8260	No Analytes Detected				
	12/9/2008	E310	Alkalinity	512		mg/L	
	12/9/2008	E300	Chloride	346		mg/L	
	12/9/2008	SM4500S2	Sulfide	0.582	J	mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF007							
MWAX07							
	12/9/2008	A5310B	Total Organic Carbon	25.7		mg/L	
	12/9/2008	E300	Nitrate	22.6		mg/L	
	12/9/2008	RSK-175	No Analytes Detected				
	12/9/2008	SW8260	No Analytes Detected				
	12/9/2008	E300	Sulfate	698		mg/L	
MWBX07							
	5/1/2008	SW8260	Chlorobenzene	0.19	J	µg/L	70
MWCX07							
	5/5/2008	SW8260	1,4-DCB	0.21	J	µg/L	5
	5/5/2008	SW8260	Acetone	4.1	J	µg/L	5110
	5/5/2008	SW8260	Dichlorodifluoromethane	0.37	J	µg/L	
	5/5/2008	SW8260	Methylene chloride	0.55	J	µg/L	5
	11/24/2008	E310	Alkalinity	949		mg/L	
	11/24/2008	E300	Chloride	725		mg/L	
	11/24/2008	SM4500S2	No Analytes Detected				
	11/24/2008	A5310B	Total Organic Carbon	20.2		mg/L	
	11/24/2008	SW8260	1,4-DCB	1.3		µg/L	5
	11/24/2008	RSK-175	Methane	25.7		µg/L	
	11/24/2008	E300	Sulfate	31.5		mg/L	
MWDX07							
	5/6/2008	SW8260	Methylene chloride	0.38	J	µg/L	5
MWFX07							
	5/5/2008	SW8260	No Analytes Detected				
	11/24/2008	E310	Alkalinity	229		mg/L	
	11/24/2008	E300	Chloride	293		mg/L	
	11/24/2008	SM4500S2	No Analytes Detected				
	11/24/2008	A5310B	Total Organic Carbon	8.42		mg/L	
	11/24/2008	E300	Nitrate	17.8	J-	mg/L	
	11/24/2008	RSK-175	No Analytes Detected				
	11/24/2008	SW8260	No Analytes Detected				
	11/24/2008	E300	Sulfate	230		mg/L	
MWGX07							
	5/2/2008	SW8260	Methylene chloride	0.33	J	µg/L	5
	11/21/2008	E310	Alkalinity	377		mg/L	
	11/21/2008	E300	Chloride	193		mg/L	
	11/21/2008	SM4500S2	No Analytes Detected				

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 4-4

Summary of Analytes Detected in MNA Wells at LF007 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: LF007							
MWGX07							
	11/21/2008	A5310B	Total Organic Carbon	3.9		mg/L	
	11/21/2008	E300	Nitrate	0.459		mg/L	
	11/21/2008	RSK-175	No Analytes Detected				
	11/21/2008	SW8260	No Analytes Detected				
	11/21/2008	E300	Sulfate	348		mg/L	

Qualifier Description
J = The analyte was positively identified, the quantitation is an estimate.
F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
B = The analyte was found in an associated blank, as well as in the sample.
M = A matrix effect was present.
none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 4-5
LF007 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Plume	Distal						
				MWAx07	MW261x07	MWCx07	MW207x06	MWGx07	MW129x07	MW612x07	MW613x07	MWFx07	MW600x07	MW601x07
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	0	0	0	3	3	0	0	0	0	0	0
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	0	0	0	0	0	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	0	2	2	2	2	0	2	2	0	2	0
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	3	0	3	0	0	0	3	0	0	0
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	0	2	0	0	0	0	0	0	0	0	0
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methane[b]	<0.5 mg/L >0.5 mg/L	VC oxidizes Ultimate reductive daughter product; VC accumulates	0 3	0	3	0	0	0	0	0	0	0	0	0
ORP[b]	<50 mV <-100 mV	Reductive pathway possible Reductive pathway likely	1 2	0	2	1	1	1	0	0	1	0	0	0
pH[b]	5< pH <9 5> pH >9	Optimal range for reductive pathway Outside optimal range for reductive pathway	0 -2	0	0	0	0	0	0	0	0	0	0	0
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	2	2	2	0	0	0	0	0	0	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	0	1	1	0	0	0	0	0	0	0	0
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	1	0	0	0	0	0	0	0	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	2	2	0	0	0	2	0	0	2	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0	0	0	0	0	0	0	0
PCE[b]		Material released	0	0	0	0	0	0	0	0	0	0	0	0
TCE[b]		Material released Daughter product of PCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0
DCE[b] (all isomers[d])		Materials released Daughter product of TCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0
VC		Material released Daughter product of DCE	0 2[c]	0	0	0	0	0	0	0	0	0	0	0

TABLE 4-5
LF007 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Plume	Distal							
				MWAx07	MW261x07	MWCx07	MW207x06	MWGx07	MW129x07	MW612x07	MW613x07	MWFx07	MW600x07	MW601x07
Ethene/ethane	>0.01 mg/L	Daughter product of VC/ethane	2	0	0	0	0	0	0	0	0	0	0	0
	>0.1 mg/L		3											
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	0	0	0	0	0	0	0	0	0	0
			Sum[e]	**+2**	**+18**	**+8**	**+9**	**+6**	**0**	**+4**	**+6**	**0**	**+4**	**0**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C = degree(s) Celsius
mg/L = milligram(s) per liter
mV = millivolt(s)
NA = not analyzed
TCA = trichloroethane

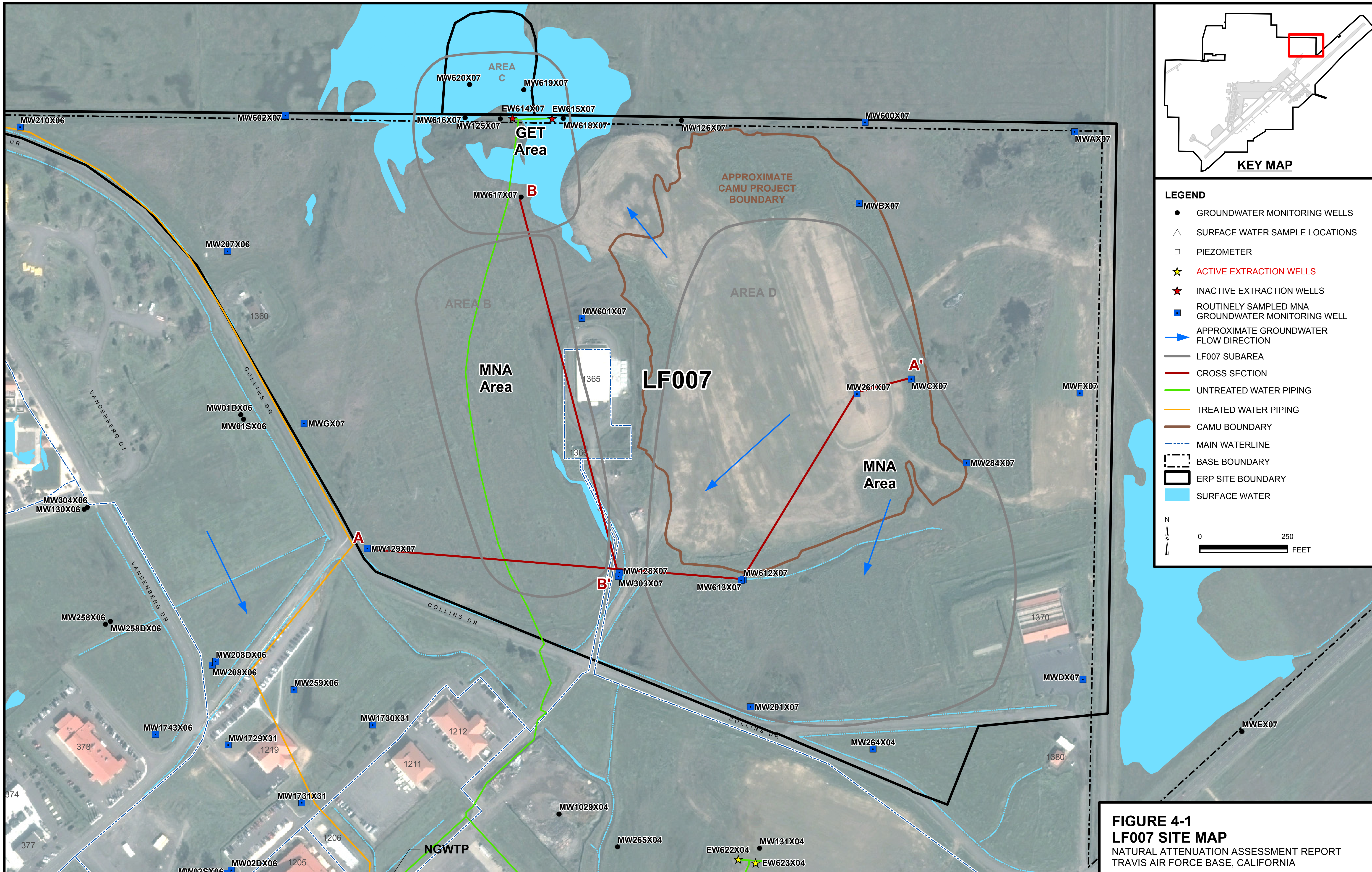
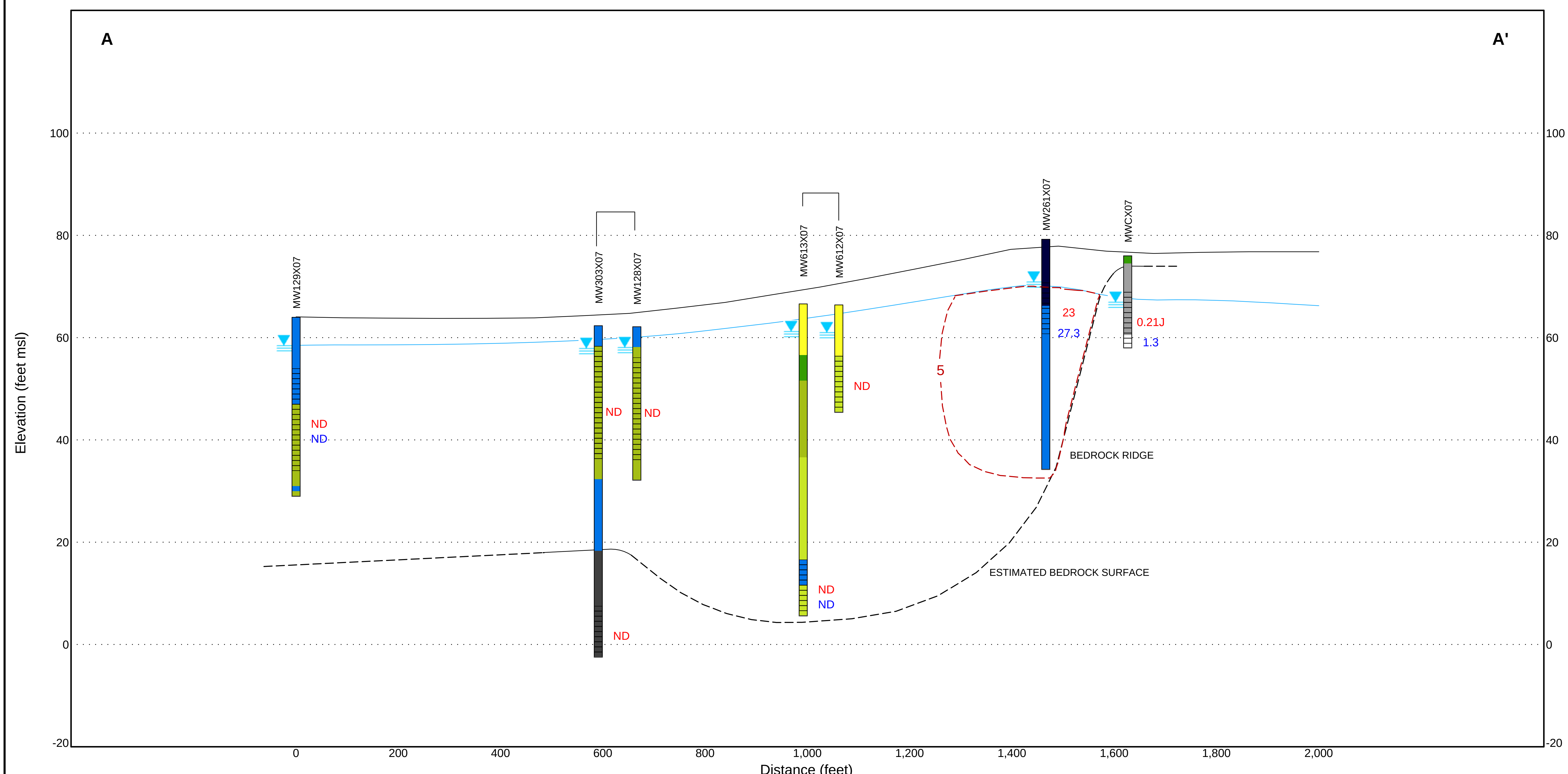


FIGURE 4-1
LF007 SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG4-1_LF007_SITE.MXD MCLAY1 1/13/2010



SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

6.7 1-4-DCB CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6.7 1,4-DCB CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

– – 5 – – APPROXIMATE 1-4-DCB ISOCONCENTRATION CONTOUR (µg/L) BASED ON MAX 2008 DETECTION

SCALE EXAGGERATION - 10:1 (H:V)

NOTE: SEE FIGURE 4-6 FOR CROSS SECTION LINE

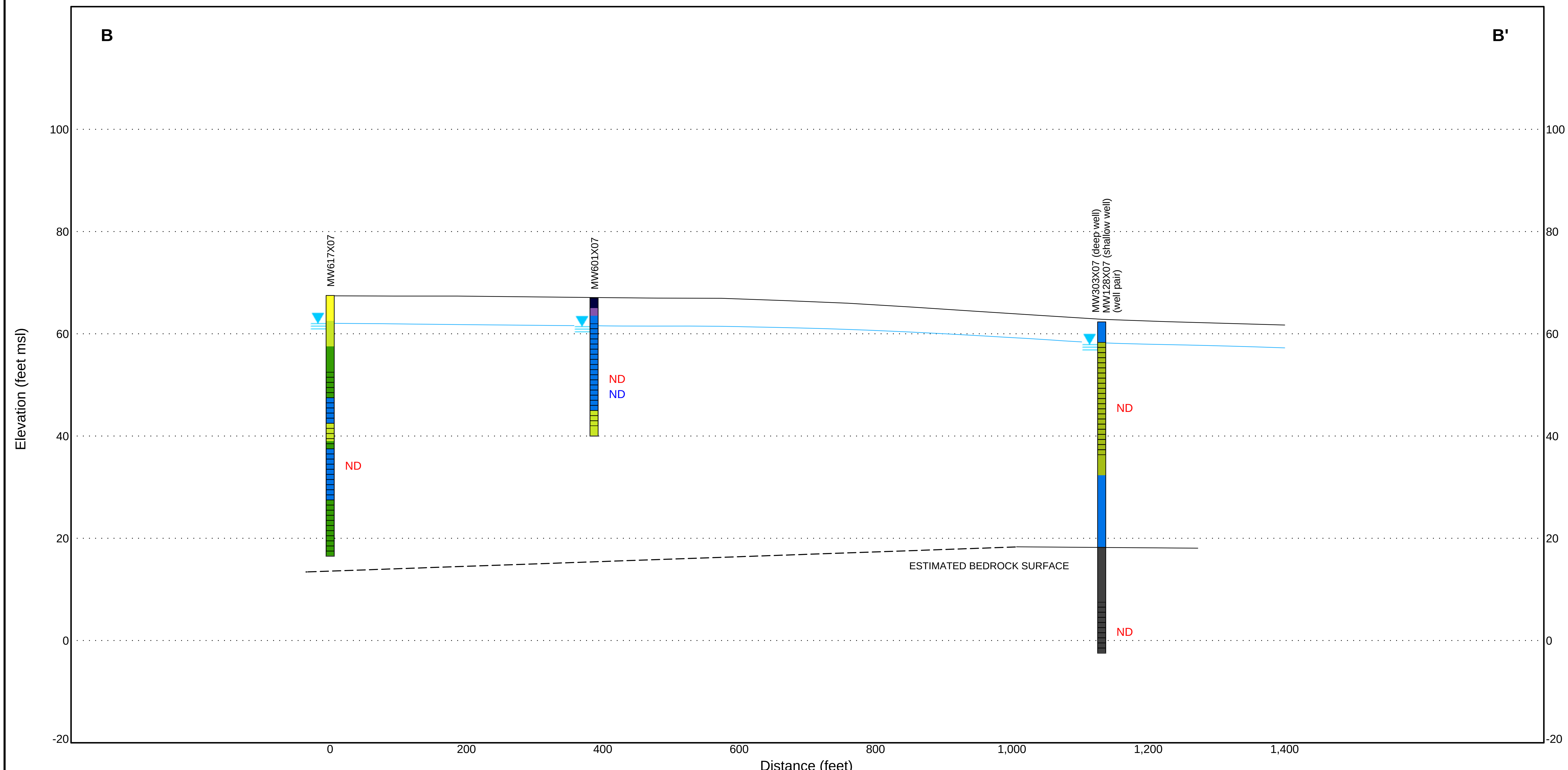
SOIL AND LITHOLOGY

NO SAMPLE/NO RECOVERY
FILL/ASPHALT
WELL GRADED GRAVEL (GW)
POORLY GRADED GRAVEL (GP)
SILTY GRAVEL (GM)
CLAYEY GRAVEL (GC)
WELL GRADED SAND (SW)
POORLY GRADED SAND (SP)
SILTY SAND (SM)
CLAYEY SAND (SC)
SILT (ML)
ELASTIC SILT (MH)
LEAN CLAY (CL)
FAT CLAY (CH)
SILTSTONE
SANDSTONE
SHALE

FIGURE 4-2
LF007D GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;



SOIL AND LITHOLOGY

SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

ND 1,4-DCB CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

SCALE EXAGGERATION - 7.5:1 (H:V)

NOTE: SEE FIGURE 4-5 FOR CROSS SECTION LINE

NO SAMPLE/NO RECOVERY
FILL/ASPHALT
WELL GRADED GRAVEL (GW)
POORLY GRADED GRAVEL (GP)
SILTY GRAVEL (GM)
CLAYEY GRAVEL (GC)
WELL GRADED SAND (SW)
POORLY GRADED SAND (SP)
SILTY SAND (SM)
CLAYEY SAND (SC)
SILT (ML)
ELASTIC SILT (MH)
LEAN CLAY (CL)
FAT CLAY (CH)
SILTSTONE
SANDSTONE
SHALE

FIGURE 4-3
LF007B GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

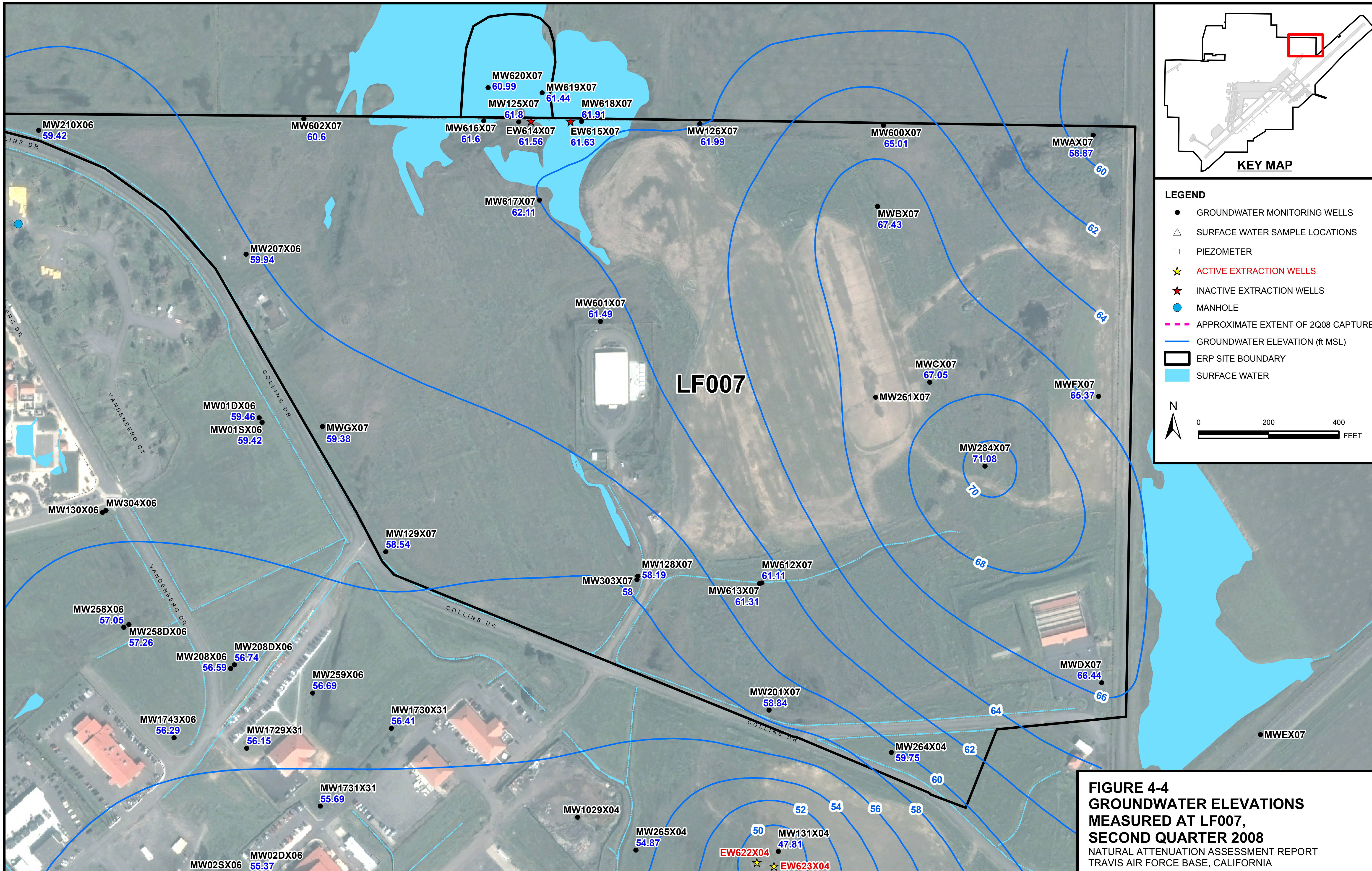


FIGURE 4-4
GROUNDWATER ELEVATIONS MEASURED AT LF007, SECOND QUARTER 2008

NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG4-4_FT004_SD031_LF007_GW_2008.MXD MCLAY1 1/11/2010

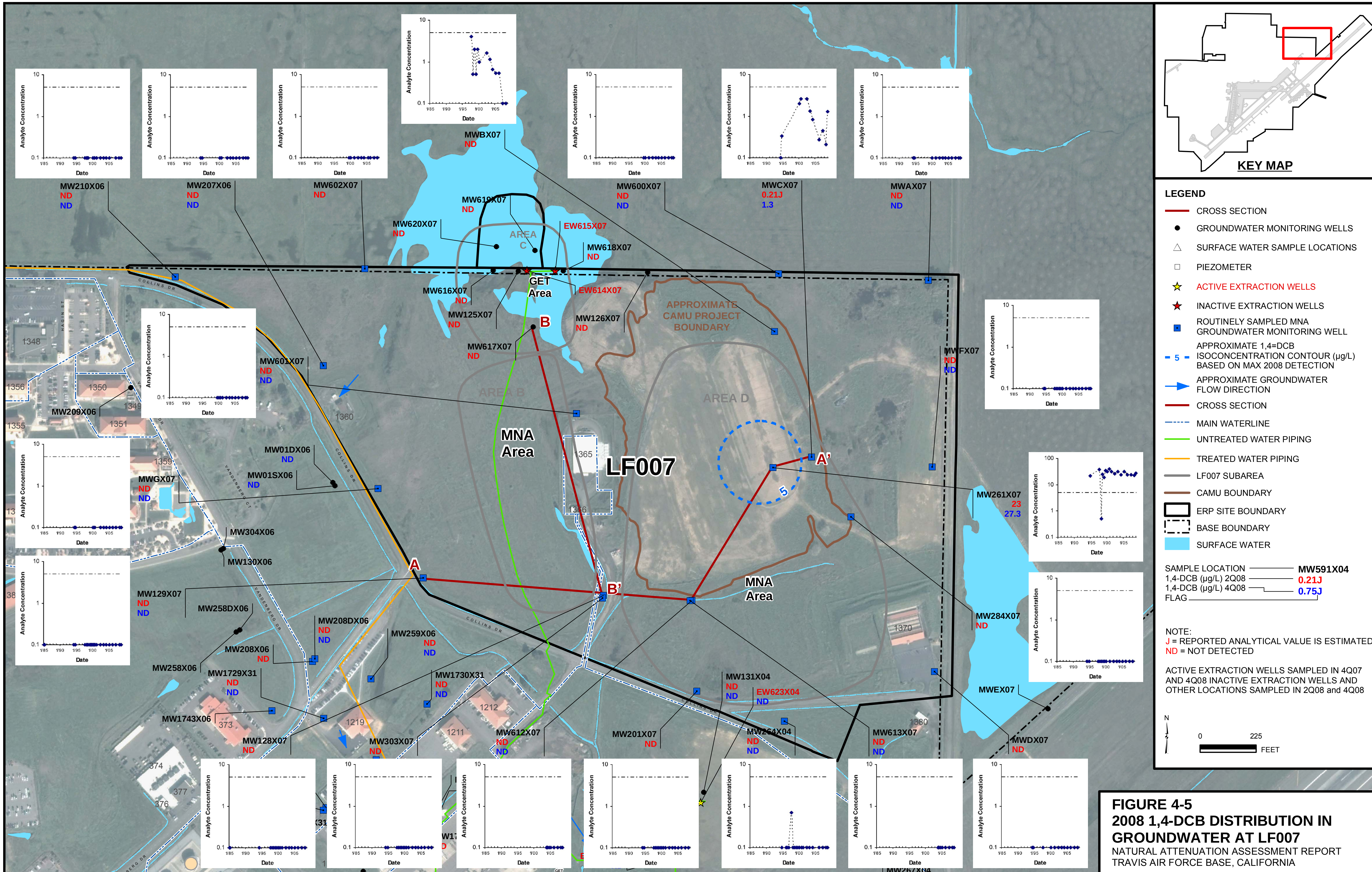
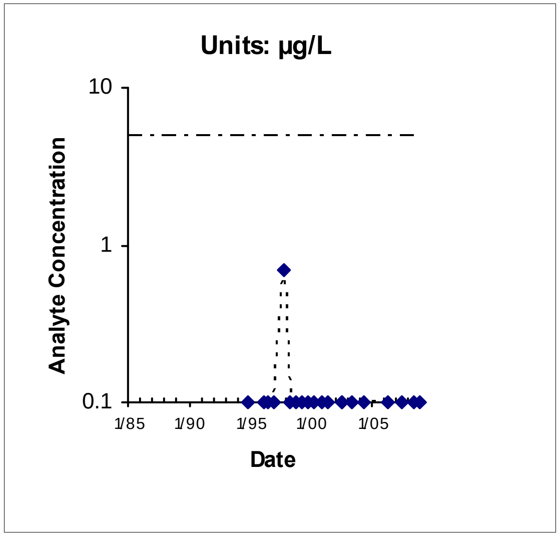
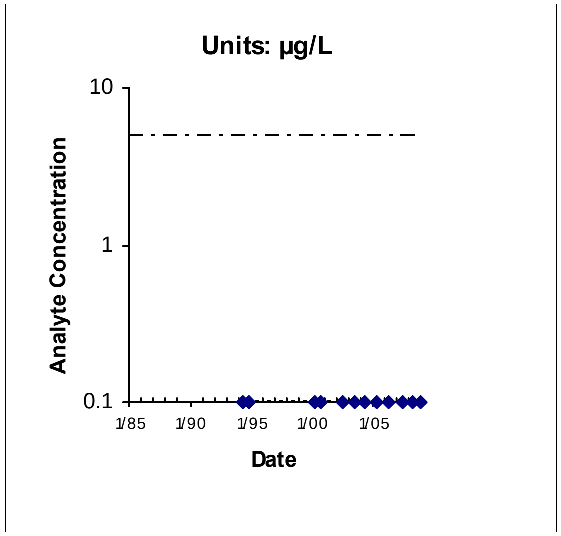


FIGURE 4-5
2008 1,4-DCB DISTRIBUTION IN GROUNDWATER AT LF007
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

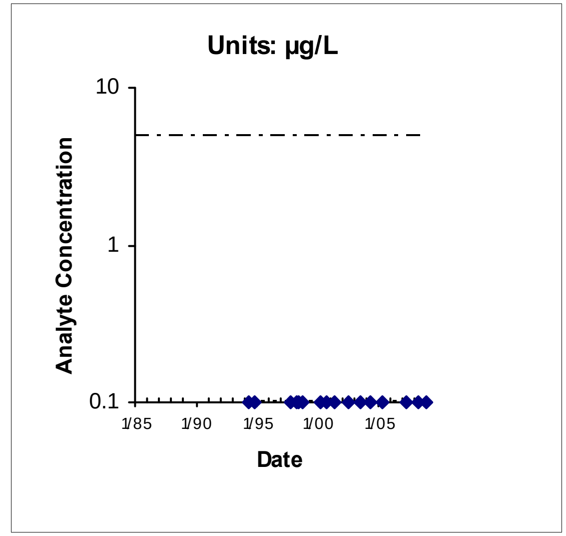
CH2MHILL



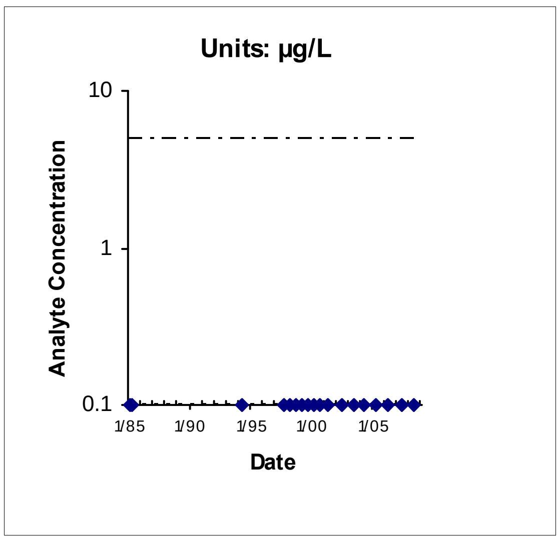
Location: MW264X04 Maximum: 0.7



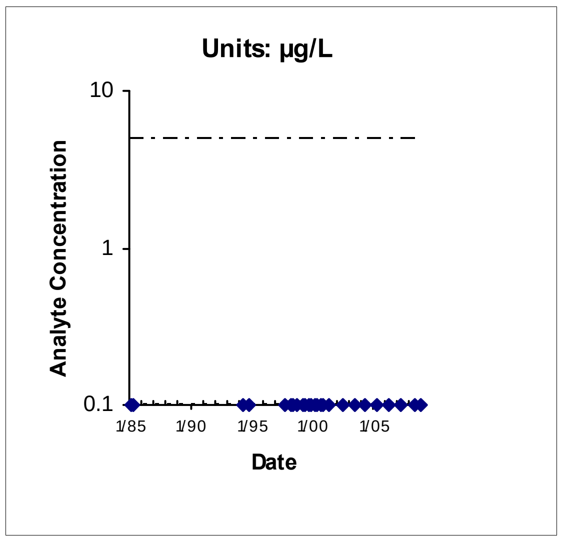
Location: MW207X06 Maximum: 0.1



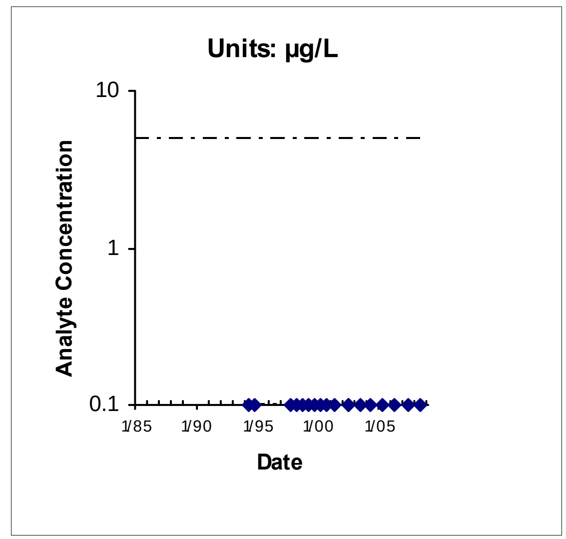
Location: MW210X06 Maximum: 0.1



Location: MW128X07 Maximum: 0.1



Location: MW129X07 Maximum: 0.1



Location: MW201X07 Maximum: 0.1

— - — - — IRG (5 µg/L)

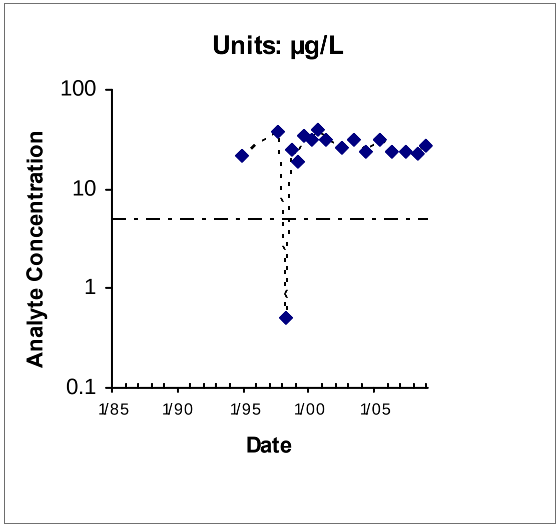
*Nondetects shown as the Method Detection Limit (0.1 µg/L)

FIGURE 4-6

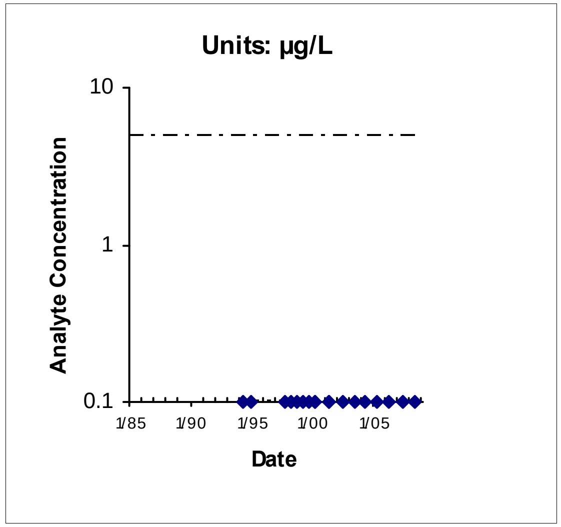
LF007 MNA Wells

1,4-DCB

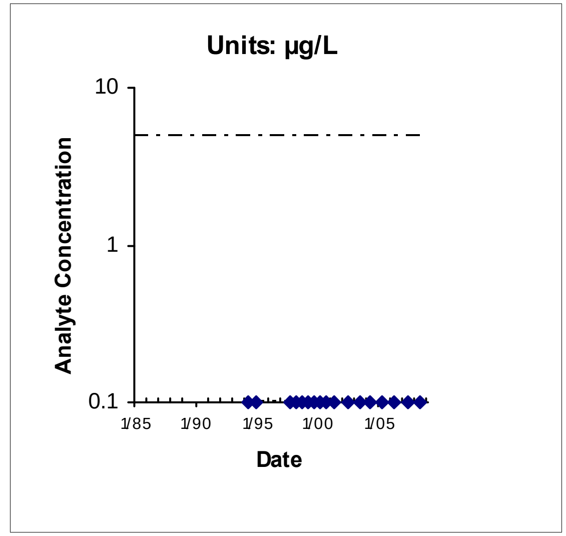
Chemical Time-series Plots



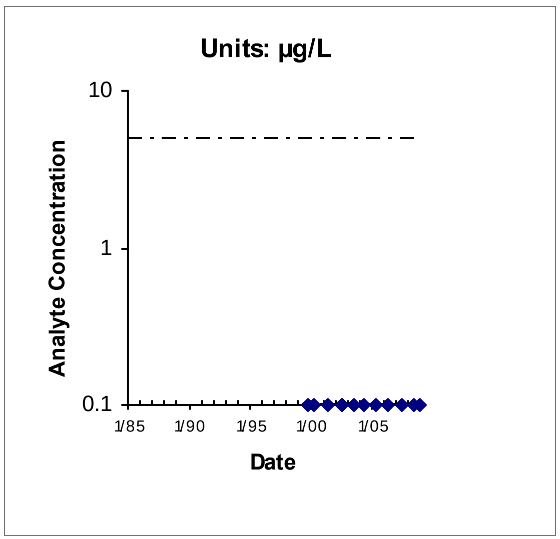
Location: MW261X07 Maximum: 39



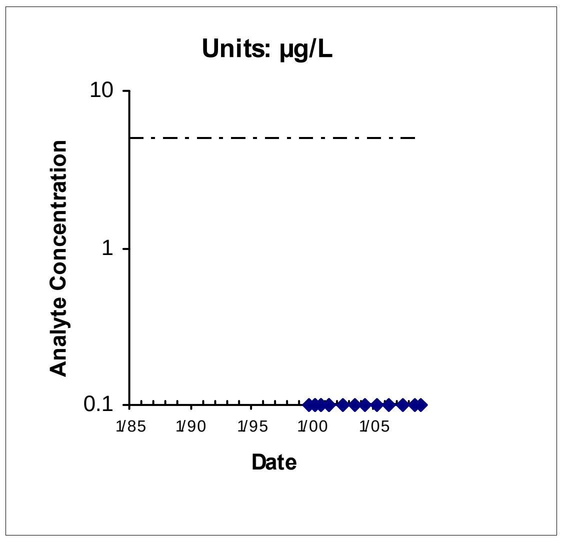
Location: MW284X07 Maximum: 0.1



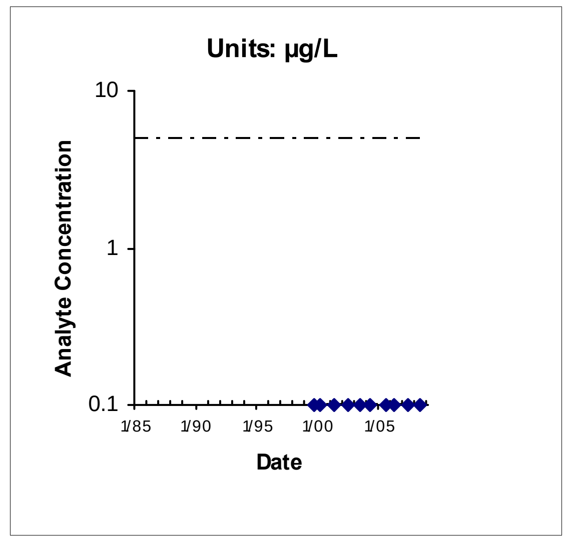
Location: MW303X07 Maximum: 0.1



Location: MW600X07 Maximum: 0.1



Location: MW601X07 Maximum: 0.1

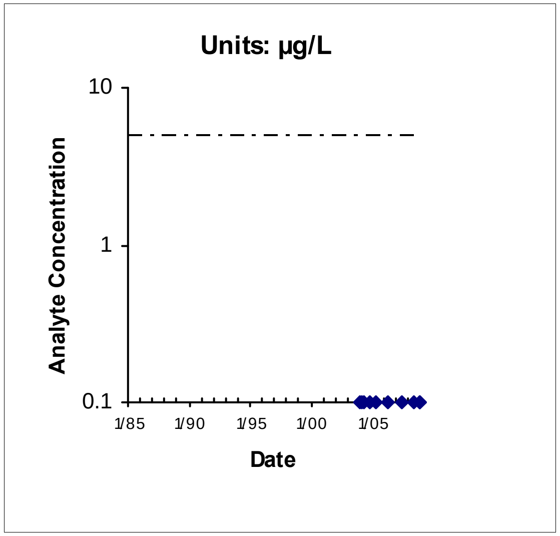


Location: MW602X07 Maximum: 0.1

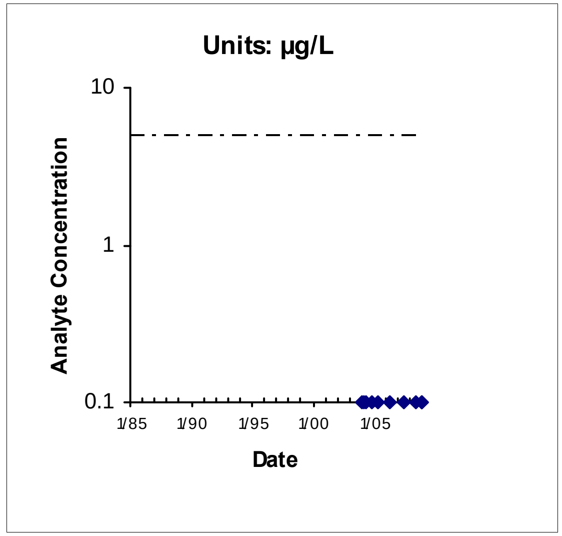
— - — - — IRG (5 µg/L)

*Nondetects shown as the Method Detection Limit (0.1 µg/L)

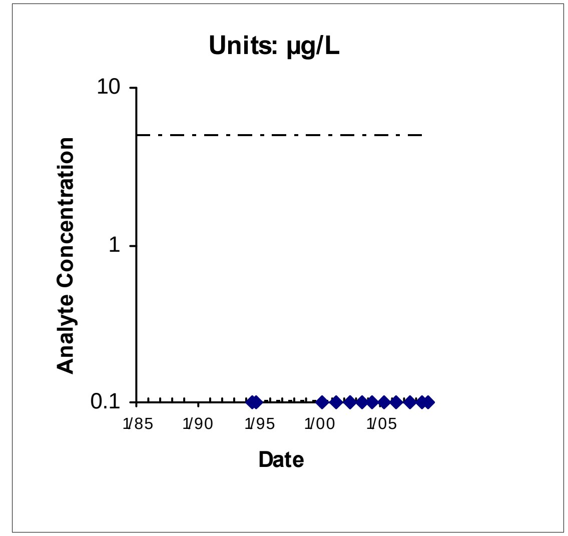
FIGURE 4-6
LF007 MNA Wells
1,4-DCB
Chemical Time-series Plots



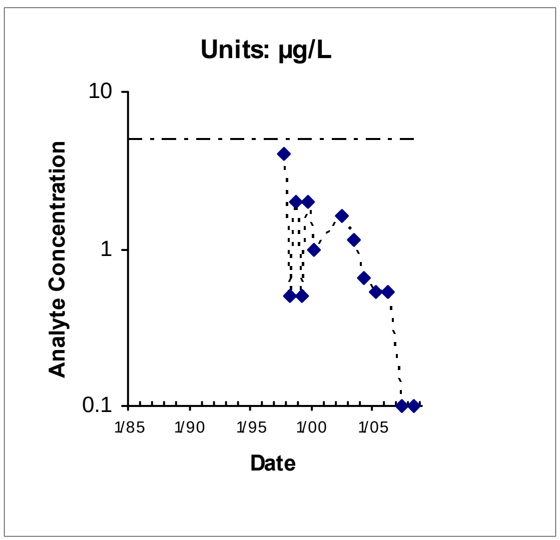
Location: MW612X07 Maximum: 0.1



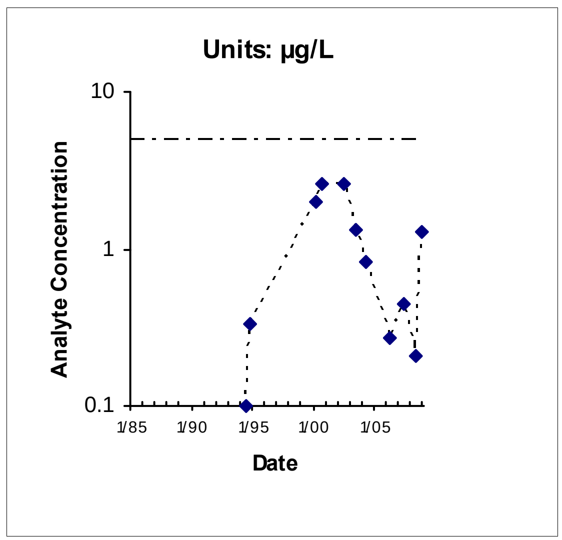
Location: MW613X07 Maximum: 0.1



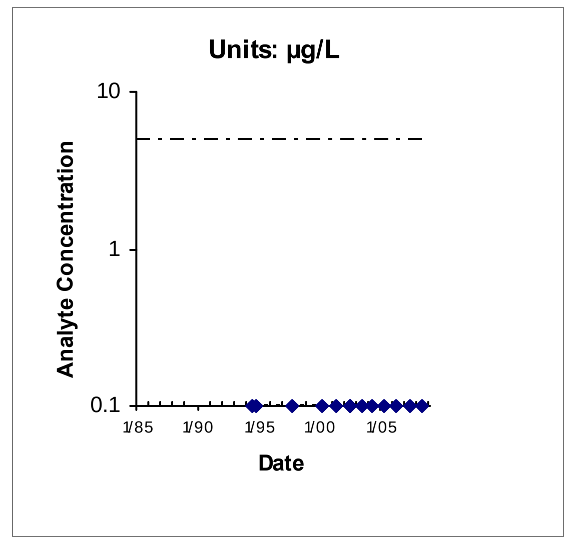
Location: MWAX07 Maximum: 0.1



Location: MWBX07 Maximum: 4



Location: MWCX07 Maximum: 2.6



Location: MWDX07 Maximum: 0.1

— - — - — IRG (5 µg/L)

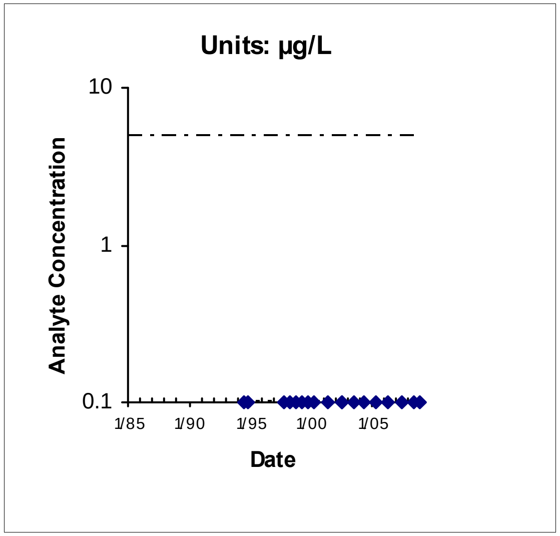
*Nondetects shown as the Method Detection Limit (0.1 µg/L)

FIGURE 4-6

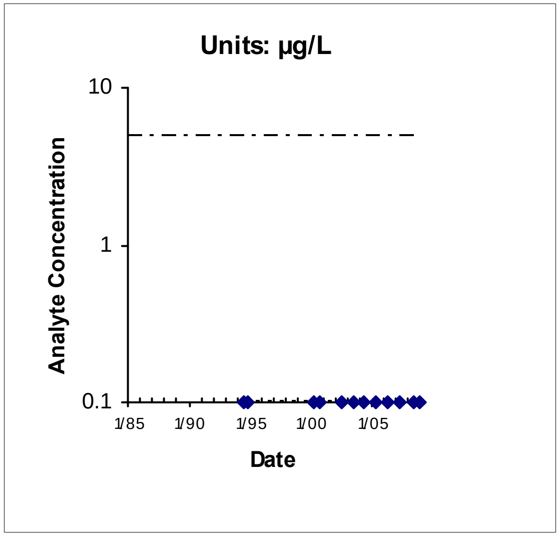
LF007 MNA Wells

1,4-DCB

Chemical Time-series Plots



Location: MWFX07 Maximum: 0.1



Location: MWGX07 Maximum: 0.1

— - — - — IRG (5 µg/L)

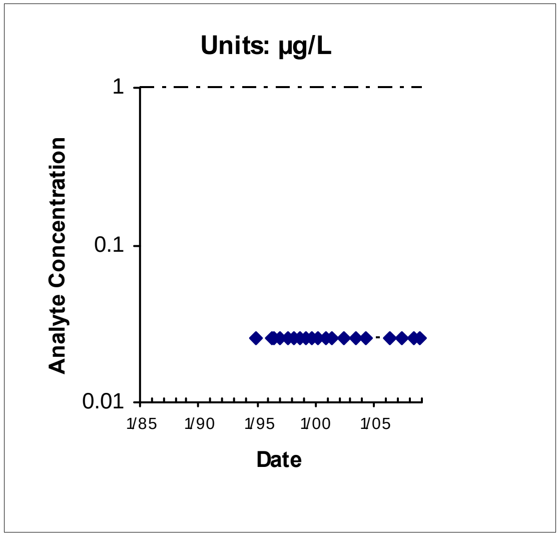
*Nondetects shown as the Method Detection Limit (0.1 µg/L)

FIGURE 4-6

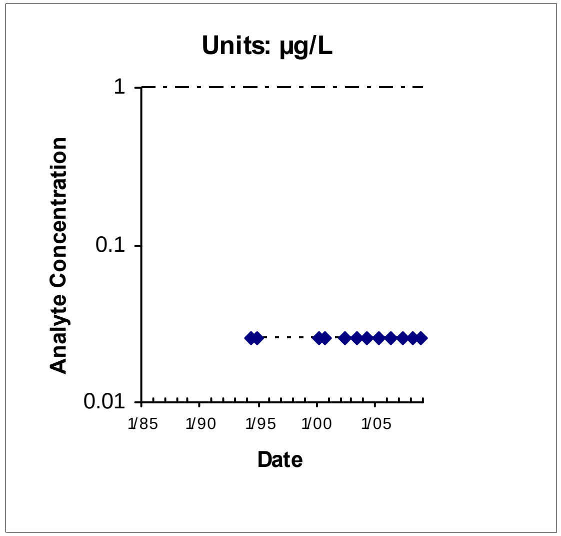
LF007 MNA Wells

1,4-DCB

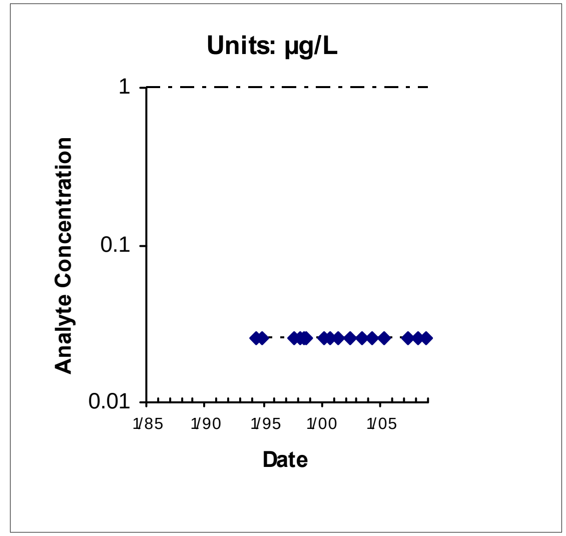
Chemical Time-series Plots



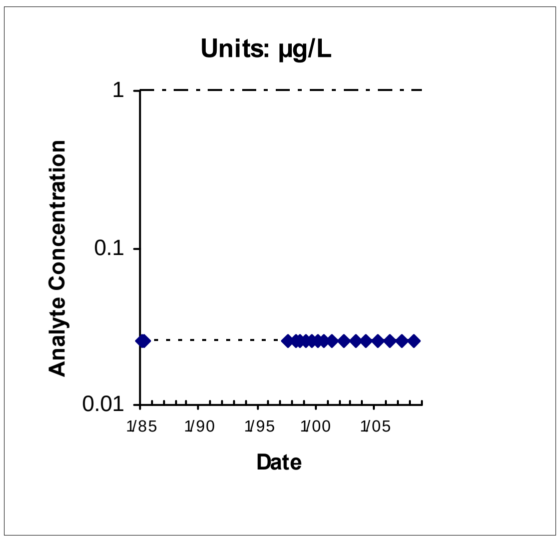
Location: MW264X04 Maximum: 0.0257



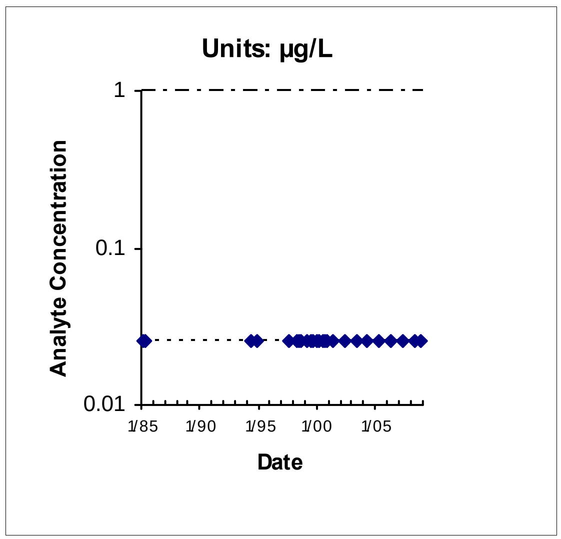
Location: MW207X06 Maximum: 0.0257



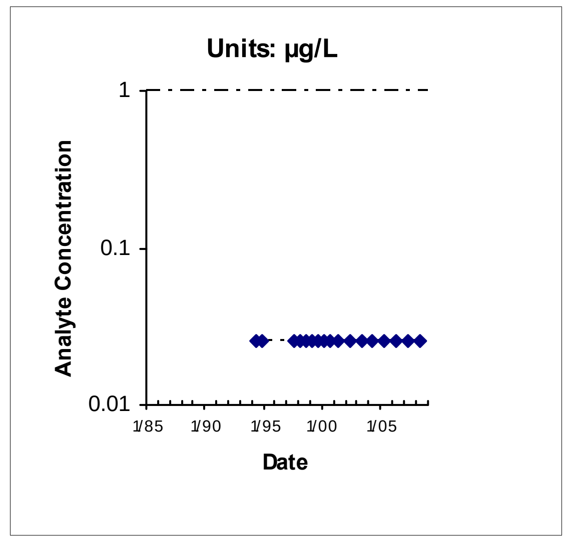
Location: MW210X06 Maximum: 0.0257



Location: MW128X07 Maximum: 0.0257



Location: MW129X07 Maximum: 0.0257



Location: MW201X07 Maximum: 0.0257

— - — - — IRG (1 µg/L)

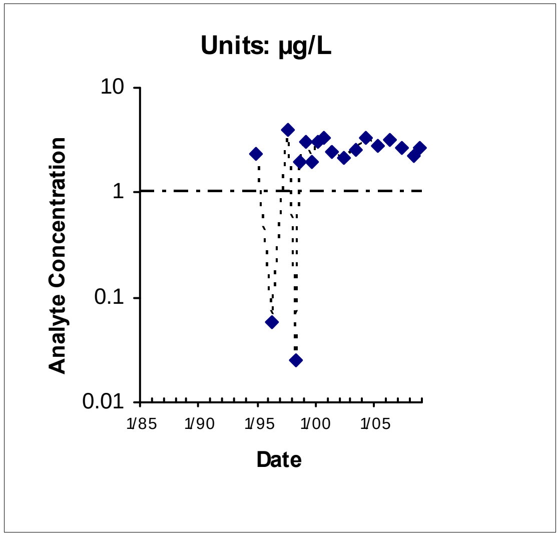
*Nondetects shown as the Method Detection Limit (0.0257 µg/L)

FIGURE 4-7

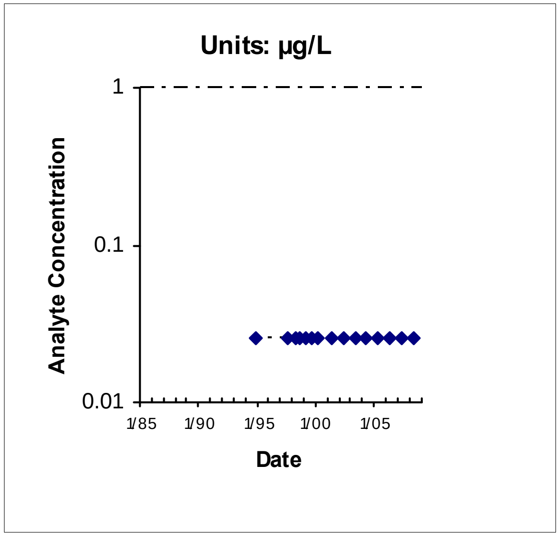
LF007 MNA Wells

Benzene

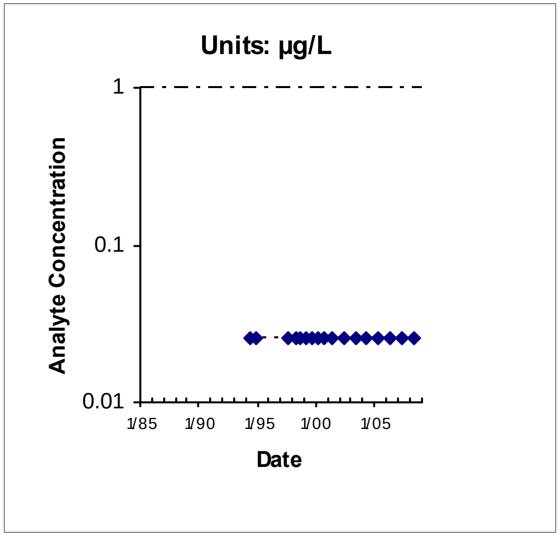
Chemical Time-series Plots



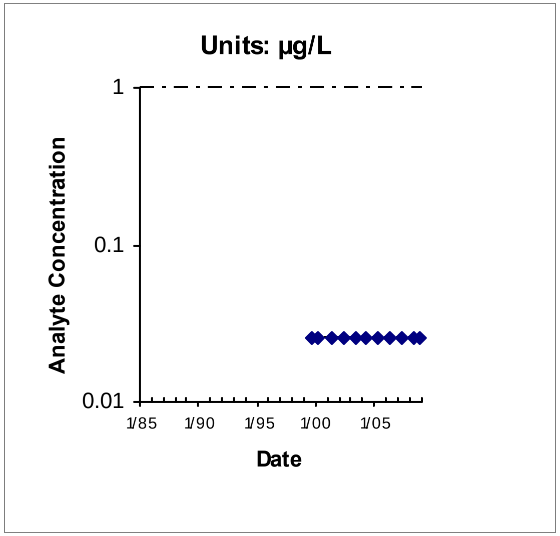
Location: MW261X07 Maximum: 4



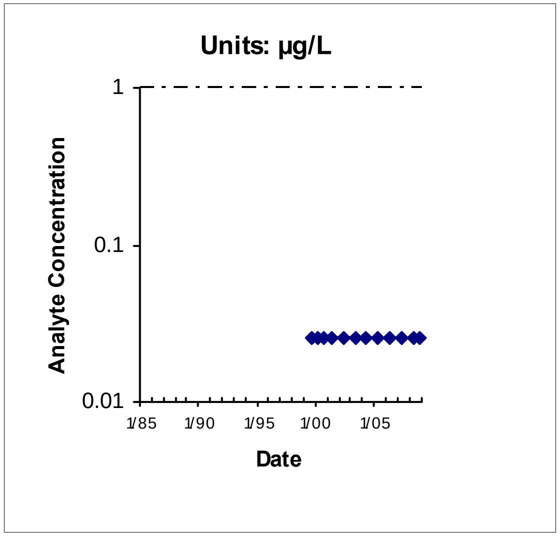
Location: MW284X07 Maximum: 0.0257



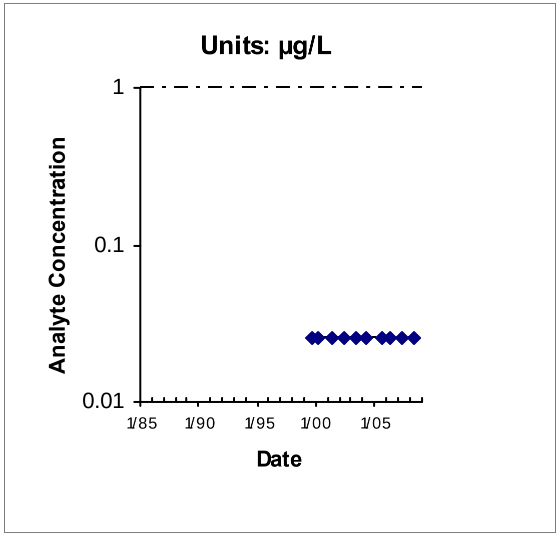
Location: MW303X07 Maximum: 0.0257



Location: MW600X07 Maximum: 0.0257



Location: MW601X07 Maximum: 0.0257



Location: MW602X07 Maximum: 0.0257

— - — - — IRG (1 µg/L)

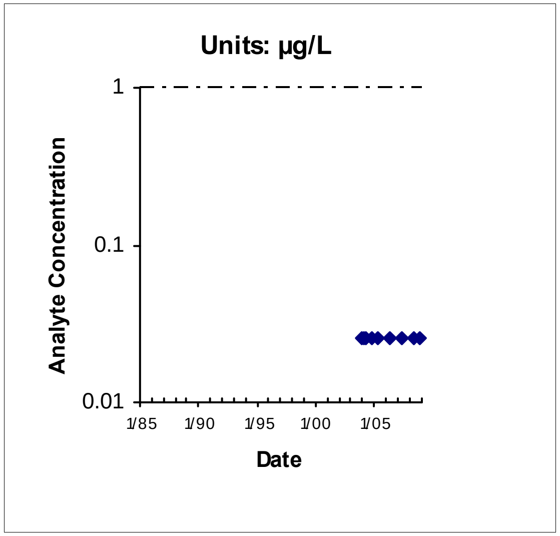
*Nondetects shown as the Method Detection Limit (0.0257 µg/L)

FIGURE 4-7

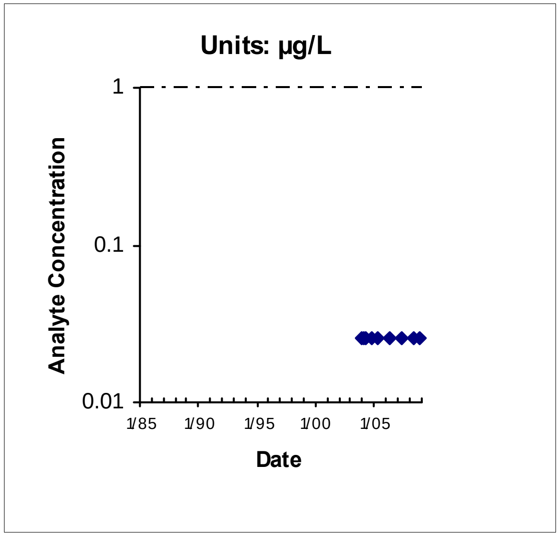
LF007 MNA Wells

Benzene

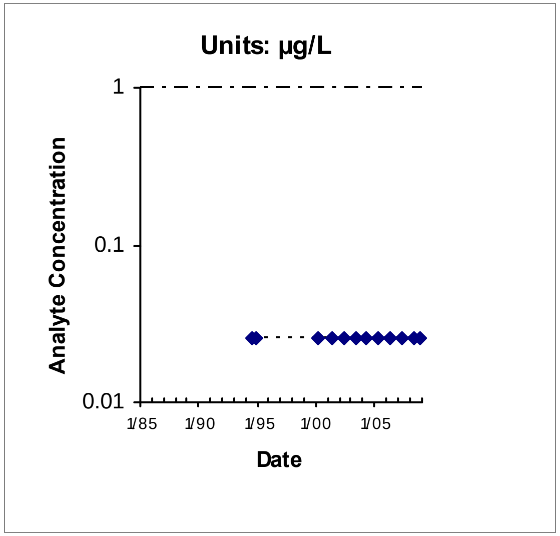
Chemical Time-series Plots



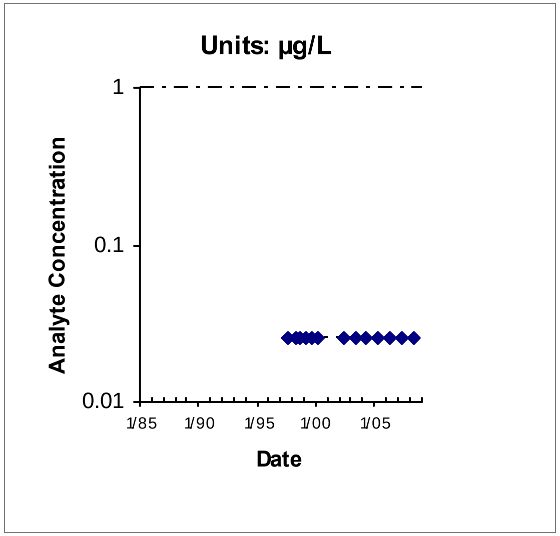
Location: MW612X07 Maximum: 0.0257



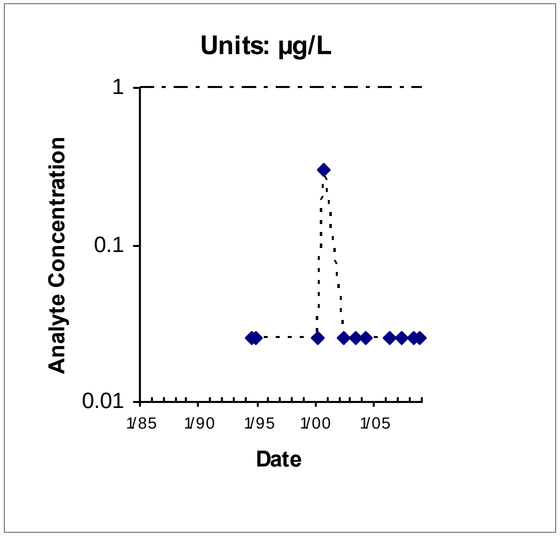
Location: MW613X07 Maximum: 0.0257



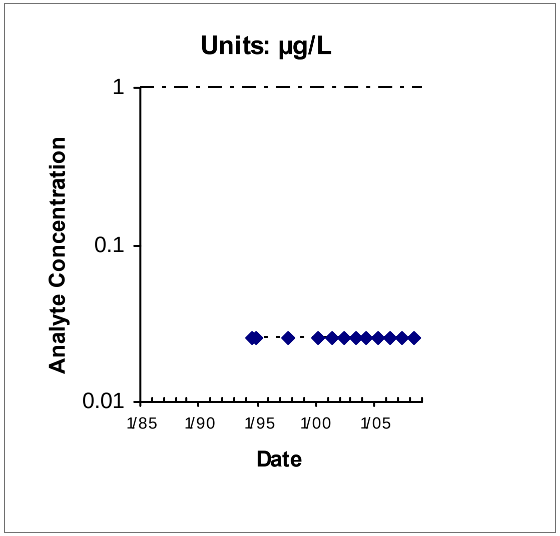
Location: MWAX07 Maximum: 0.0257



Location: MWBX07 Maximum: 0.0257



Location: MWCX07 Maximum: 0.3



Location: MWDX07 Maximum: 0.0257

— - — - — IRG (1 µg/L)

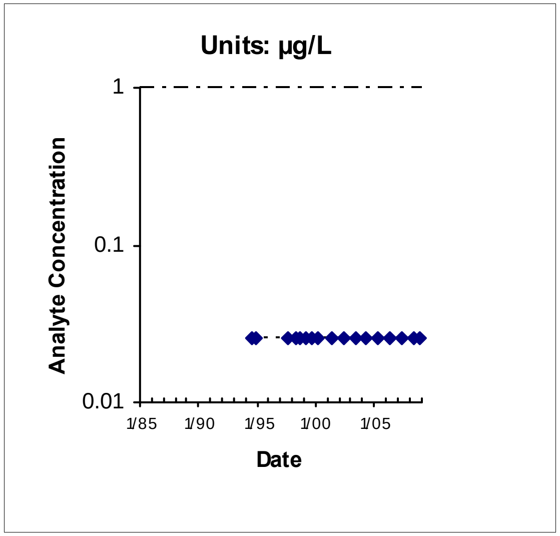
*Nondetects shown as the Method Detection Limit (0.0257 µg/L)

FIGURE 4-7

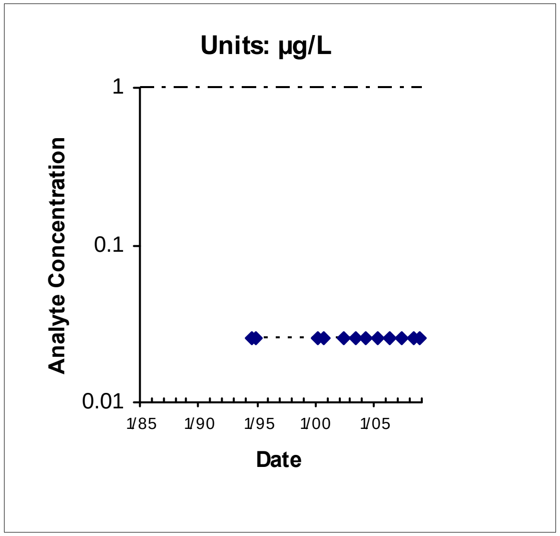
LF007 MNA Wells

Benzene

Chemical Time-series Plots



Location: MWFX07 Maximum: 0.0257



Location: MWGX07 Maximum: 0.0257

— - — - — IRG (1 µg/L)

*Nondetects shown as the Method Detection Limit (0.0257 µg/L)

FIGURE 4-7

LF007 MNA Wells

Benzene

Chemical Time-series Plots

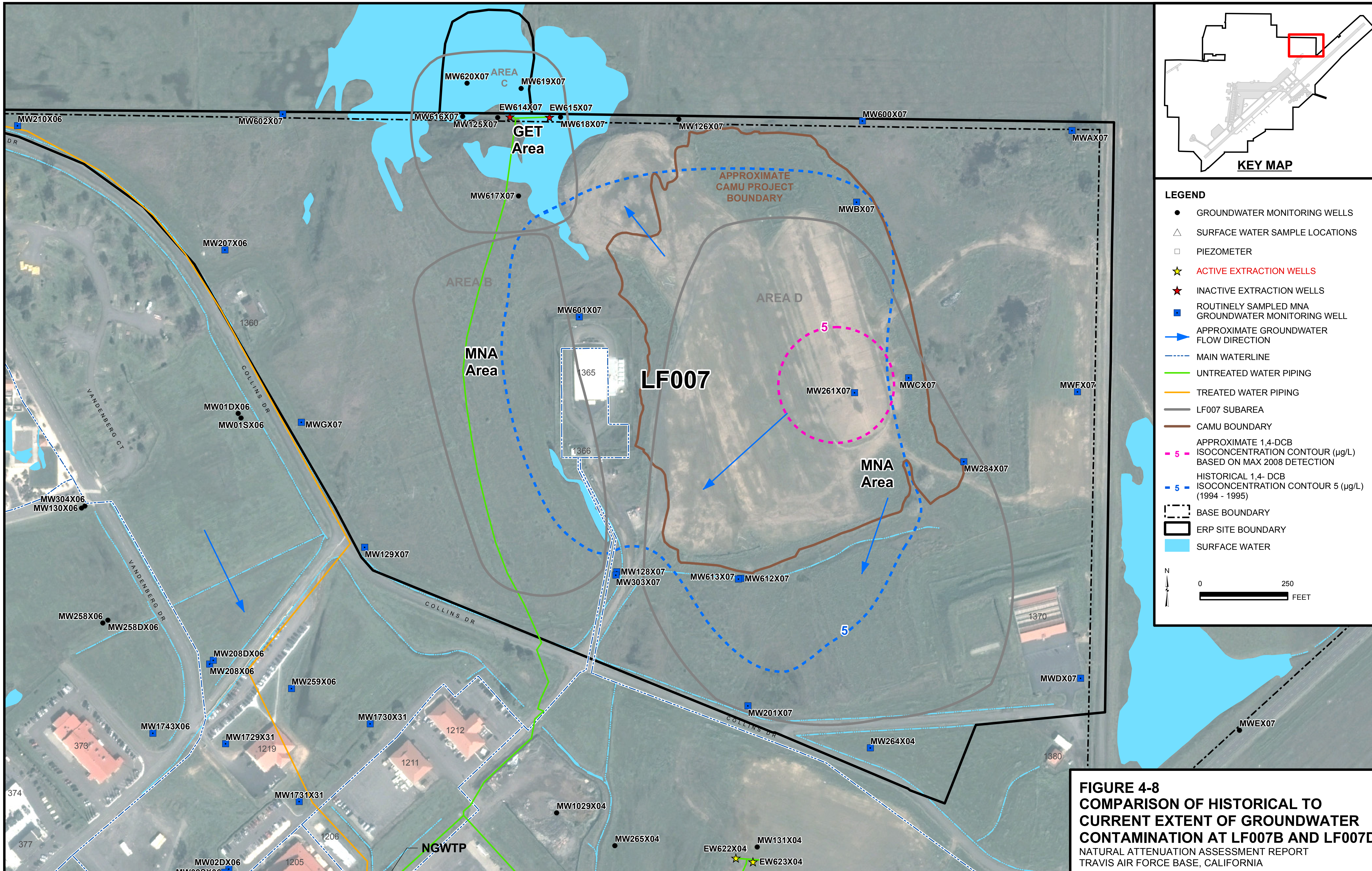


FIGURE 4-8
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT LF007B AND LF007D
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG4-8_LF007B_LF007D_SITES.MXD MCLAY1 1/13/2010

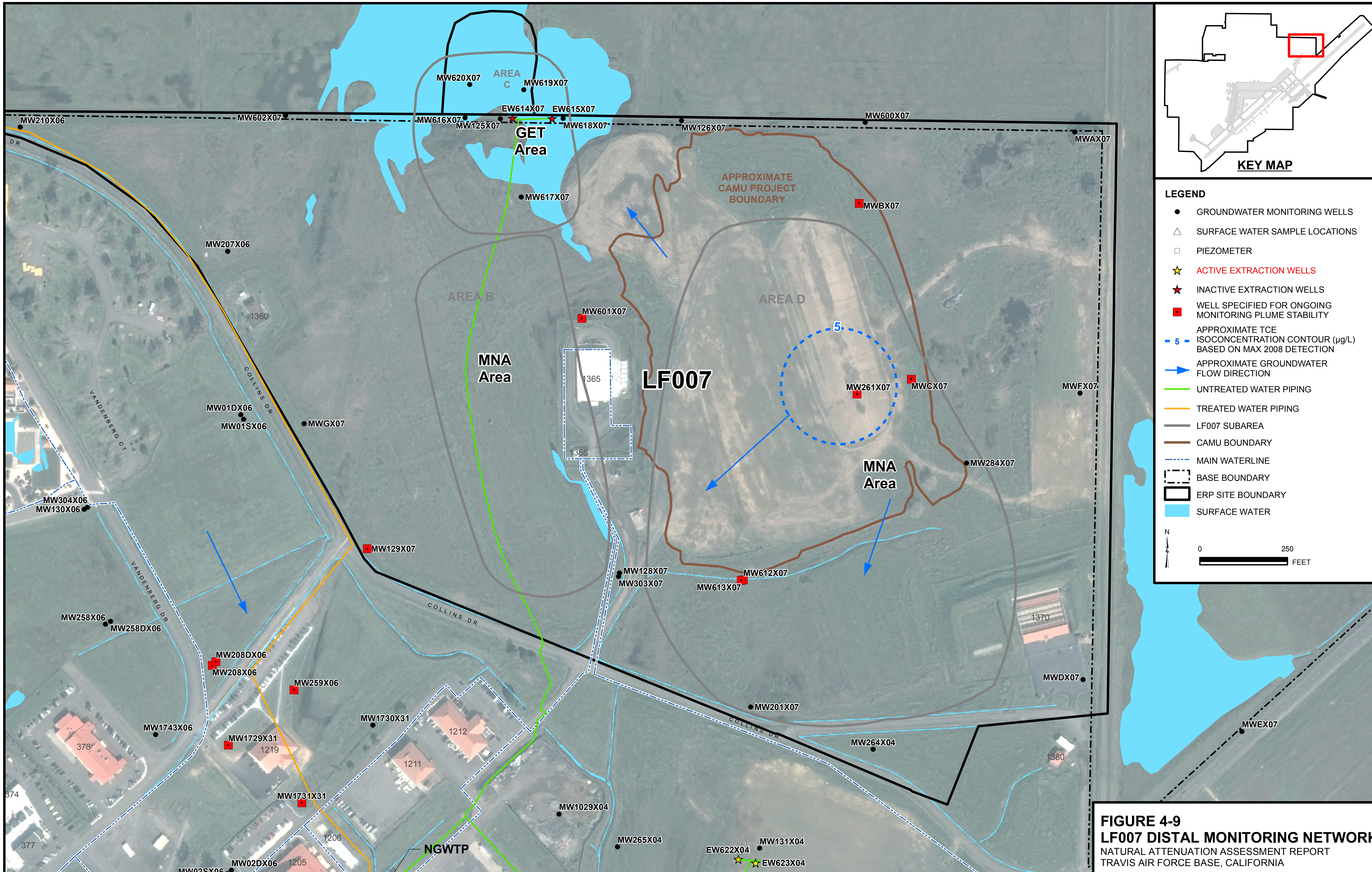


FIGURE 4-9
LF007 DISTAL MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG4-9_LF007_MONITORINGNETWORK.MXD MCLAY1 1/13/2010

SECTION 5

Site SS015

Section 5 presents the natural attenuation assessment for Site SS015. In 1998, an investigation was performed at Site SS015 to support a natural attenuation assessment. The purpose of the investigation was to define the extent of contamination and derive the groundwater flow direction. The results of this investigation are presented in the Summary of the Site SS015 Site Investigation, Travis AFB, CA Technical Memorandum (CH2M HILL, 1999b). However, the initial natural attenuation assessment for Site SS015 was delayed because the site was selected by AFCEE for a treatability study to evaluate the application of vegetable oil to enhance in situ biodegradation of chlorinated solvents. In 2000 and 2001, vegetable oil was injected into the groundwater at the site to support the treatability study. The results of the study are documented in the *Phase II Field Feasibility Test for In-Situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection at Site SS015* (Parsons, 2002). This section focuses on data collected since the 1998 field investigation and 2000 field test were performed.

5.1 Site Background

5.1.1 Site Description

Site SS015 occupies 3.5 acres in the central portion of Travis AFB. Three (3) potential sources of groundwater contamination have been identified at Site SS015: former Facility 550, former Facility 552 (including the area at Facility 1832), and the Solvent Spill Area (SSA) east of Facility 550. Figure 5-1 presents a map of Site SS015.

Former Facility 550 was south of Hangar Avenue. Beginning in 1952, the facility housed a corrosion control shop, metals processing shop, and fiberglass shop. Paints, paint thinners, methyl ethyl ketone, acids, and stripping wastes were used or generated at the facility. A floor drain connected to the sanitary sewer was used to discharge wastes from the corrosion control shop.

Former Facility 552 was a fenced, bermed concrete pad south of Hangar Avenue and immediately east of Facility 550. Most recently, the facility was used as a hazardous waste collection area. Paint, chromic acid, and waste solvents generated during aircraft maintenance activities at Facility 550 were stored at Facility 552. From 1954 to 1980, radomes were stripped of paint in an area adjacent to Facility 552 (Roy F. Weston, Inc., 1995). Facility 1832 is a 15,000-gallon OWS that received liquids generated at a wash rack on the aircraft-parking apron. In 1992, a new hazardous waste accumulation facility was constructed at the site.

The SSA occupied 1.4 acres east of Facility 550. Paint was stripped from aircraft in the area for an undocumented period of time. Accidental releases included an estimated 100 to 150 gallons per month of methyl ethyl ketone, toluene, or tetraethylene glycol dimethyl ether from work trays used to collect stripping wastes. Soil is visibly stained in the SSA in aerial photographs taken before 1970 (Roy F. Weston, Inc., 1995).

In 2004, Facilities 550 and 552 were demolished to construct a petroleum, oil, and lubricants (POL) military compound consisting of an office building, a fuel truck maintenance facility, and a large concrete truck parking area. The POL building (Building 554) was constructed with a vapor barrier and passive vent system to protect the building from potential vapor intrusion from the underlying groundwater plume.

5.1.2 Site COCs

The groundwater COCs and IRGs at Site SS015 are as follows:

COC	IRG (µg/L)	COC	IRG (µg/L)
TCE	5	bis(2-ethylhexyl)phthalate	4
PCE	5	VC	0.5
cis-1,2-DCE	6	nickel	100
1,2-DCA	0.5		

Bis(2-ethylhexyl)phthalate, a suspected lab contaminant, has not been analyzed as part of the GSAP since 1997. Historical detections of bis(2-ethylhexyl)phthalate in Site SS015 groundwater samples are at or below the level of laboratory contamination; 6.68 µg/L is the maximum concentration detected.

Elevated nickel concentrations detected at the site were demonstrated to have resulted from corrosion of stainless steel well screens (CH2M HILL, 1999c). Nickel is no longer monitored by the GSAP at this site.

5.1.3 Status of Interim Remedy

Site SS015 was selected for MNA assessment in the NEWIOU Groundwater IROD (Travis AFB, 1997). The site underwent a pre-design investigation to support a natural attenuation assessment in 1998 (CH2M HILL, 1999b). However, the initial natural attenuation assessment for Site SS015 was delayed because the site was selected for a treatability study of enhanced MNA through vegetable oil injection, which was performed in 2000 and 2001 (Parsons, 2002). The purpose of this treatability study was to demonstrate that it was possible to initiate reductive dechlorination under site-specific conditions by injecting an organic carbon source into the subsurface. Over the course of the treatability study, approximately 227 gallons of vegetable oil were injected. The treatability study was limited in extent and not designed to be an enhanced MNA remedy. The vegetable oil injection has been completed and the monitoring/injection points used during the project have been decommissioned. In 2004, Building 554, the POL building, was constructed over a portion of the vegetable oil injection area. Two (2) monitoring wells, MW624x15 and MW625x15, were constructed on the east side of the building to monitor the downgradient extent of the plume.

Routine monitoring through the GSAP has been ongoing at the site. Seven (7) monitoring wells have been routinely sampled to support the ongoing MNA assessment: MW104x15, MW105x15, MW216x15, MW238x15, MW306x15, MW624x15, and MW625x15 (see Figure 5-1).

The Second Five-Year Review (CH2M HILL, 2008a) concluded that MNA is a viable remedy for Site SS015, based on 10 years of data collected from the MNA wells. While VOC concentrations (both parent and daughter products) have been increasing in source area well MW216x15, until the 4Q08 event, only trace concentrations had been detected in downgradient wells. However, in 4Q08, VOCs were detected in one (1) downgradient well at concentrations exceeding IRGs.

In summary, the status of the IRA at Site SS015 is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
SS015	MNA Assessment	Groundwater monitoring Treatability study of enhanced MNA was performed at the site in 2000-2001	Ongoing groundwater monitoring

5.2 Conceptual Site Model

5.2.1 Geology

Approximately 20 feet of unconsolidated Older Alluvium covers sedimentary bedrock (Markley Sandstone) in the vicinity of Site SS015. The alluvium is composed of discontinuous lenses of sand, silt, and clay. The bedrock underlying the alluvium at Site SS015 consists of shale and sandstone. A submerged sandstone ridge strikes across Site SS015 from the northwest to the southeast, which influences the groundwater flow directions at the site. A geologic cross section through the Site SS015 groundwater plume is presented on Figure 5-2.

5.2.2 Groundwater

As summarized in Table 5-1, depth to water at Site SS015 is approximately 7 to 12 feet bgs, and the saturated zone is approximately 10 feet thick. Groundwater elevations are relatively stable at Site SS015, varying seasonally by approximately 2 to 4 feet.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 5-3. The regional groundwater flow direction in the vicinity of Site SS015 is toward the southeast. However, the site investigation conducted in 1999 indicated that the local flow direction at Site SS015 is toward the northeast (CH2M HILL, 1999b). The local northeastern flow direction was confirmed by the subsequent vegetable oil treatability study performed in 2000 and 2001. Both the 1999 investigation and subsequent 2000-2001 study included the installation of several piezometers, which have since been decommissioned. However, an eastern-northeastern gradient away from the source area near MW216x15 is evident in groundwater elevation data collected from the current site monitoring wells. An eastern-northeastern groundwater flow direction is also consistent with the observed distribution of groundwater contamination, which extends to the east-northeast from monitoring well MW216x15. In the southern portion of the site, the groundwater flow directions are more southeasterly, although previous site investigations (CH2M HILL, 1999b and Parsons, 2002) found that the groundwater contamination had not migrated in this direction. The somewhat radial groundwater flow directions reflect the presence of a subsurface bedrock ridge at the site, which diverts groundwater toward the northeast. The horizontal gradient to the east-northeast at Site SS015 is approximately 0.007 ft/ft.

Only one (1) well pair is available at Site SS015 to evaluate vertical gradients (MW105x15/ MW306x15). The vertical gradient has been variable at this site. The vertical gradient for well pair MW105x15/MW306x15 ranged from 0.02 ft/ft upward to -0.006 ft/ft downward in 2008 (Table 5-2).

Four (4) aquifer tests have been performed at Site SS015, and the results are summarized in Table 5-3. Hydraulic conductivities calculated from the aquifer tests ranged from 1 to 45 ft/day, reflecting the heterogeneous nature of the sediments and shallow bedrock and the variation the aquifer test methods utilized. The average of the hydraulic conductivities calculated for the site is approximately 27 ft/day.

The average linear flow of groundwater at Site SS015 may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.007 ft/ft, an average hydraulic conductivity of 27 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), the approximate groundwater velocity is about 0.9 ft/day or 300 ft/year.

Groundwater at Travis AFB is not used for human consumption and groundwater at Site SS015 does not discharge to surface water. The Base boundary is approximately 7,000 feet from the leading edge of the plume. At the estimated groundwater velocity, it would take approximately 23 years for groundwater at Site SS015 to reach the Base boundary. Groundwater contamination at Site SS015 does not currently pose a risk to receptors. Ongoing monitoring will continue to evaluate whether contamination is migrating away from the site.

5.2.3 Current Distribution of Groundwater Contamination

The monitoring wells selected to support MNA assessment over the interim period at Site SS015 are MW104x15, MW105x15, MW216x15, MW238x15, MW306x15, MW624x15, and MW625x15. During the 2Q08 and 4Q08 sampling events, the Site SS015 COCs detected at concentrations exceeding IRGs were TCE; cis-1,2-DCE; PCE; and VC. PCE concentrations exceeded the IRG in only source area well MW216x15; the maximum concentration detected in 2008 was 83.4 µg/L. TCE; cis-1,2-DCE; and VC exceeded IRGs at both the source area well MW216x15 and downgradient well MW625x15. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix.

Figure 5-4 illustrates the current distribution of TCE at Site SS015. There is currently no monitoring well directly upgradient of source area well MW216x15; therefore, recent analytical data upgradient of the source area are not available. In 2008, TCE concentrations exceeded the IRG at source area well, MW216x15 (376 µg/L) and downgradient well MW625x15 (5.3 µg/L). The TCE concentrations detected in source area well MW216x15 are typical for this monitoring well; however, the TCE concentration detected at downgradient well MW625x15 in the 4Q08 event was higher than historically detected and exceeded the IRG for the first time. A confirmation sample was collected from this well in February 2009, and the TCE concentration detected (6.9 µg/L) was similar to the 4Q08 result.

The current extent of COCs to the northeast of the site is uncertain because the furthest downgradient monitoring well in this area (MW624x15) is relatively deep (45 to 55 feet bgs) and appears to be screened in bedrock (although no lithologic log is available for this monitoring well, depth to bedrock is approximately 20 feet at this site). No site COCs have been detected in this well; however, it is possible that VOCs are present in the saturated zone above the bedrock in the vicinity of this well.

Cis-1,2-DCE and VC also exceeded IRGs in both the source area well and downgradient well MW625x15. The maximum 2008 concentration of cis-1,2-DCE detected in the source area well was 2,180 µg/L (the IRG is 6 µg/L). Cis-1,2-DCE was detected at a concentration of 30.7 µg/L at downgradient well MW625x15 during 4Q08 and exceeded the IRG for the first time. A similar result (26 µg/L) was detected in the February 2009 confirmation sample from this well. VC was detected in the source area well at a maximum concentration of 1,480 µg/L (the IRG is 0.5 µg/L). VC was detected at a concentration of 9.6 µg/L in downgradient well MW625x15 during 4Q08, which was the first time it was detected at this well. VC was not detected in the February 2009 confirmation sample from this well.

A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site SS015 groundwater plume exceed the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b), indicating potential for VI. However, the Air Force constructed Building 554 at Site SS015 with a vapor barrier and passive vent system to protect the building from potential VI from the underlying groundwater plume.

5.3 Natural Attenuation Assessment

There is evidence that the limited vegetable oil injections completed in 2001 have enhanced the reductive dechlorination of TCE and PCE in the source area and in downgradient groundwater. The impact of enhanced biodegradation is now being observed at well MW625x15 at the distal end of the plume.

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has been reduced in size. Over the interim period, the GSAP has been monitoring several wells to evaluate plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 5.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 5.3.2.

5.3.1 Plume Attenuation

Chemical time-series plots of the primary COCs (TCE; PCE; cis-1,2-DCE; and VC) for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 5-5 through 5-8. These figures show that from 2004 to 2007, starting approximately 3 years after the vegetable oil injection was performed, TCE; PCE; and cis-1,2-DCE concentrations decreased in source area well MW216x15.

In 2004, VC concentrations began to increase in this well and continued to increase through 2008. The vegetable oil injection took place in multiple injection points in an area approximately 20 feet downgradient of MW216x15 (Figure 5-1). Approximately 227 gallons of vegetable oil were injected during the treatability study. The decline in TCE; PCE; and cis-1,2-DCE concentrations and increase in VC concentrations observed over this time period at MW216x15 is due to the vegetable oil injection. The delay between the injection and observed decline in VOC concentrations could be attributed to the location of the injection site, which was just downgradient of MW216x15.

Since 2007, PCE and TCE concentrations have rebounded in this source area well to concentrations similar to historical concentrations. However, concentrations of cis-1,2-DCE and VC, biodegradation products of PCE and TCE, continue to increase, and have exceeded historical maximum concentrations. In addition, cis-1,2-DCE and VC concentrations exceed PCE and TCE concentrations by an order of magnitude—strong evidence for the effectiveness of enhanced biodegradation.

Beyond the source area, COCs have recently been detected in downgradient well MW625x15. In 4Q08, TCE was detected at a concentration of 5.3 µg/L, slightly exceeding the IRG. Because this result was higher than expected, a confirmation sample was collected in February 2009. TCE was detected in the confirmation sample at 6.9 µg/L, confirming that TCE concentrations exceed the IRG at this location. As previously discussed, daughter products VC and cis-1,2-DCE also exceeded IRGs at this well in 4Q08, although the 4Q08 VC exceedance was not confirmed by the February 2009 sample. The relatively rapid increase in COC concentrations at this downgradient well might indicate that the vegetable oil injected upgradient of this well has been consumed.

Figure 5-9 shows the current distribution of TCE and the historical extent of TCE contamination in groundwater at Site SS015. This figure shows that the extent of the plume to the northeast may have been slightly reduced over time. However, the extent of the plume in this area is uncertain because there are no monitoring wells screened in the saturated zone above the bedrock in this area (MW624x15 is screened in bedrock). The plume has recently expanded slightly to the east (in the vicinity of MW625x15).

The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of TCE at this site to approximately 0.8 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the plume would be expected to have migrated approximately 2,400 feet (240 feet per year) over the 10 years of the MNA assessment period. However, available data indicate the plume has only recently begun to migrate slightly (migration beneath Building 554 is difficult to assess because no wells exist between MW216x15 and MW625x15, and the downgradient edge of the plume is not adequately defined).

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the seven (7) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring wells at which COCs continue to exceed IRGs (MCLs). However, a point attenuation rate constant could not be calculated for these Site SS015 wells (MW216x15 and MW625x15) because COC concentrations have recently been increasing at both of these wells.

In addition to concentration vs. time attenuation (or point attenuation) rates (which could not be calculated at Site SS015), a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.

Bulk attenuation rate constants for TCE, cis-1,2-DCE, and vinyl chloride (COCs detected at multiple wells at the site) were calculated for Site SS015 (Appendix F). The data set for this analysis was limited to the two wells at which site COCs were detected (MW216x15 and MW625x15). Bulk attenuation rate constants of approximately 8.3 per year (TCE), 9.9 per year (cis-1,2-DCE), and 12 per year (vinyl chloride) were calculated at Site SS015, based on the 2008 distribution of COCs in groundwater at the site. The positive bulk attenuation rate constants indicate that attenuation of TCE and daughter products cis-1,2-DCE and vinyl chloride is occurring at the site. The travel times for COCs to reach IRGs upon leaving the source area are estimated to be approximately 0.52 year (TCE), 0.6 year (cis-1,2-DCE), and 0.68 year (vinyl chloride). Based on the travel times for the various COCs, the VOC plume (exceeding IRGs) should extend approximately 205 feet from the source area at Site SS015.

5.3.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for Site SS015. Table 5-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from monitoring wells at Site SS015 during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), TOC (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and CO_2 (HACH field test). In addition, pH, temperature, DO, ORP, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Well:** MW238x15
- **Source Well:** MW216x15
- **Distal Wells:** MW624x15 and MW625x15

As shown in Table 5-5, source area well MW216x15 received a score of nineteen (19), indicating adequate evidence for biodegradation of chlorinated solvents. The potential for biodegradation was enhanced by the vegetable oil injection performed downgradient of this well in 2000-2001. The only other monitoring well at the site at which site COCs were detected at concentrations exceeding IRGs (MW625x15) received a score of ten (10), indicating limited evidence for biodegradation of chlorinated solvents. This well has a negative ORP and high dissolved iron, both indicators that groundwater passing through this area originated in the highly anaerobic zone created by the vegetable oil injection. Background well MW238x15 received a score of six (6), also indicating limited evidence for biodegradation. Well MW624x15, where no site COCs were detected, received a score of zero (0).

5.4 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- In the source area well, there is adequate evidence for biodegradation of chlorinated solvents. Biodegradation potential in this area was enhanced by the treatability study vegetable oil injections performed in 2000-2001.
- In the portion of the MNA assessment areas where COCs are near or below IRGs, there is inadequate to limited evidence for biodegradation of chlorinated solvents.
- TCE; PCE; and cis-1,2-DCE concentrations decreased in source area well MW216x15 from 2004 to 2007 but rebounded from 2007 to 2008. VC concentrations have continuously increased from 2004 to 2008.
- The elevated concentrations of breakdown products (cis-1,2-DCE and VC) relative to the concentration of parent compounds (PCE and TCE) in the source area confirm that the vegetable oil injection enhanced biodegradation, but insufficient vegetable oil remains to complete the degradation process. The concentrations of daughter products are currently an order of magnitude higher than the concentrations of the parent compounds.
- After several years of stability, the plume appears to be migrating eastward. The increase in COC concentrations at downgradient well MW625x15 and rebound in concentrations at source area well MW216x15 may indicate that the vegetable oil injected in 2000-2001 has been consumed and can no longer provide adequate substrate for micro-organisms.
- Four (4) additional monitoring wells are needed to monitor the Site SS015 plume (see Figure 5-10). Previous investigations (CH2M HILL, 1999b and Parsons, 2002) found that the groundwater contamination at the site is distributed to the northeast of well MW216x15. However, the extent of contamination toward the northeast has not been adequately defined. A shallow monitoring well adjacent to MW624x15 is needed because MW624x15 appears to be screened in bedrock and the extent of groundwater contamination in the saturated zone above the bedrock is unknown. In addition, a monitoring well is needed downgradient (eastward) of MW624x15 and MW625x15. The location of this monitoring well should be determined once sampling results are

available from the shallow monitoring well near MW624x15 and the distribution of contaminants in the saturated zone is better understood. A third monitoring well, located to the southeast of MW625x15, is needed to better define the southeastern extent of the plume. One (1) additional monitoring well to the west of MW216x15 is needed to monitor the upgradient portion of the plume. Installation of these monitoring wells is planned for 2010.

Based on the results of the natural attenuation assessment, MNA alone may not be a sufficient remedy at this site because recent data indicate the plume may be migrating eastward. However, the vegetable oil injection study performed in 2000 and 2001 demonstrates that the biological component of natural attenuation can be effectively enhanced at this site. Therefore, enhanced MNA is a potential remedy for this site.

5.5 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring at Site SS015. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells to monitor plume stability is presented on Figure 5-10 and will consist of MW216x15, MW104x15, MW624x15, MW625x15, MW105x15, and MW306x15. These wells will be sampled annually for VOCs. Well MW625x15, a downgradient well that recently exhibited increasing COC trends, will be sampled semiannually for VOCs. Any additional monitoring wells installed at the site will be sampled semiannually for 2 years until COC trends have been established. This network will continue to be monitored during the interim period or until such time as the remedy changes.

TABLE 5-1

SS015 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SS015									
MW104X15	20	40	37.4	17.4	60.42	9.31	51.11	9.49	50.93
MW105X15	10	30	48.4	28.4	62.35	11.55	50.8	11.5	50.85
MW215X15	5	20	54.3	39.3	62.86	NM	NM	7.41	55.45
MW216X15	7	22	51.02	36.02	61.69	9.21	52.48	9.15	52.54
MW238X15	7	17	50.3	40.3	58.73	7.69	51.04	7.68	51.05
MW306X15	48	58	10.52	0.52	62.09	10.76	51.33	11.45	50.64
MW624X15	45	55	16.8	6.8	60.00	9.78	50.22	9.63	50.37
MW625X15	10	30	51.94	31.94	61.00	10.55	50.45	10.44	50.56
MW1728X15	7.5	17.5	48.9	38.9	60.86	NM	NM	9.9	50.96

Note: Grouped by Site and sorted by Location.
btoc = below top of casing
NM = not measured
bgs = below ground surface
msl = mean sea level

TABLE 5-2
SS015 Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base, California

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW306x15	MW105x15	-0.003	0.04	0.02	-0.006

Note:

Minus sign indicates downward vertical gradient.

TABLE 5-3
Aquifer Test Results for SS015
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
SS015	MW104x15	20–40	1988	Gravity-injection	1	<5% silty sand; 35% clay; 60 % shale and siltstone
	MW315x15	45–55	9/18/91	Rising head slug Falling head slug	35 30	100% shale
	MW237x15	7–17	9/18/91	Rising head slug	45	75% silty sand; 10% clay; 15% fill
	MW238x15	7–17	9/18/91	Rising head slug	25	10% silt with sand; 90% clay

Note:

Source: CH2M HILL, 2004.

TABLE 5-4

Summary of Analytes Detected in MNA Wells at SS015 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: SS015							
MW104X15							
	4/30/2008	SW8260	Methylene chloride	0.49	J	µg/L	5
MW105X15							
	4/29/2008	SW8260	Methyl tert-butyl ether (MTBE)	5.5		µg/L	13
	4/29/2008	SW8260	Methylene chloride	0.33	J	µg/L	5
MW216X15							
	4/30/2008	SW8260	1,1-DCA	0.63		µg/L	
	4/30/2008	SW8260	1,1-DCE	2.3		µg/L	6
	4/30/2008	SW8260	Benzene	**3.1**		µg/L	1
	4/30/2008	SW8260	Chlorobenzene	27		µg/L	70
	4/30/2008	SW8260	Cis-1,2-DCE	**790**		µg/L	6
	4/30/2008	SW8260	Methyl tert-butyl ether (MTBE)	**27**		µg/L	13
	4/30/2008	SW8260	PCE	**39**		µg/L	5
	4/30/2008	SW8260	TCE	**330**		µg/L	5
	4/30/2008	SW8260	Toluene	0.48	J	µg/L	150
	4/30/2008	SW8260	trans-1,2-DCE	29		µg/L	
	4/30/2008	SW8260	Vinyl chloride	**310**		µg/L	0.5
	12/22/2008	E310	Alkalinity	1060		mg/L	
	12/22/2008	E300	Chloride	483		mg/L	
	12/22/2008	SM4500S2	No Analytes Detected				
	12/22/2008	A5310B	Total Organic Carbon	20.5		mg/L	
	12/22/2008	SW8260	1,1-DCA	2.3	J	µg/L	
	12/22/2008	SW8260	1,1-DCE	**7.1**		µg/L	6
	12/22/2008	SW8260	Benzene	**16.4**		µg/L	1
	12/22/2008	SW8260	Chlorobenzene	**114**		µg/L	70
	12/22/2008	SW8260	Cis-1,2-DCE	**2180**		µg/L	6
	12/22/2008	RSK-175	Ethane	0.29	J	µg/L	
	12/22/2008	RSK-175	Ethene	2.6		µg/L	
	12/22/2008	RSK-175	Methane	681	J+	µg/L	
	12/22/2008	SW8260	Methyl tert-butyl ether (MTBE)	**24.4**	J	µg/L	13
	12/22/2008	SW8260	PCE	**83.4**		µg/L	5
	12/22/2008	E300	Sulfate	3150		mg/L	
	12/22/2008	SW8260	TCE	**376**		µg/L	5
	12/22/2008	SW8260	Toluene	2.4	J	µg/L	150
	12/22/2008	SW8260	trans-1,2-DCE	112		µg/L	
	12/22/2008	SW8260	Vinyl chloride	**1480**		µg/L	0.5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 5-4

Summary of Analytes Detected in MNA Wells at SS015 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SS015							
MW238X15							
	4/30/2008	SW8260	No Analytes Detected				
	1/12/2009	E310	Alkalinity	513		mg/L	
	1/12/2009	E300	Chloride	191		mg/L	
	1/12/2009	SM4500S2	No Analytes Detected				
	1/12/2009	A5310B	Total Organic Carbon	6.73		mg/L	
	1/12/2009	E300	Nitrate	0.131		mg/L	
	1/12/2009	RSK-175	No Analytes Detected				
	1/12/2009	SW8260	No Analytes Detected				
	1/12/2009	E300	Sulfate	2240		mg/L	
MW306X15							
	4/30/2008	SW8260	No Analytes Detected				
MW624X15							
	4/29/2008	SW8260	Methylene chloride	0.33	J	µg/L	5
	12/22/2008	E310	Alkalinity	232		mg/L	
	12/22/2008	E300	Chloride	329		mg/L	
	12/22/2008	SM4500S2	No Analytes Detected				
	12/22/2008	A5310B	Total Organic Carbon	4.27		mg/L	
	12/22/2008	E300	Nitrate	1.01	J-	mg/L	
	12/22/2008	RSK-175	No Analytes Detected				
	12/22/2008	SW8260	No Analytes Detected				
	12/22/2008	E300	Sulfate	2170		mg/L	
MW625X15							
	4/29/2008	SW8260	Cis-1,2-DCE	1.6		µg/L	6
	4/29/2008	SW8260	Methyl tert-butyl ether (MTBE)	1.5		µg/L	13
	4/29/2008	SW8260	Methylene chloride	0.33	J	µg/L	5
	4/29/2008	SW8260	TCE	0.7		µg/L	5
	12/22/2008	E310	Alkalinity	381		mg/L	
	12/22/2008	E300	Chloride	297		mg/L	
	12/22/2008	SM4500S2	Sulfide	0.576	J-	mg/L	
	12/22/2008	A5310B	Total Organic Carbon	6.82		mg/L	
	12/22/2008	SW8260	Cis-1,2-DCE	**30.7**		µg/L	6
	12/22/2008	RSK-175	Ethene	0.58	J	µg/L	
	12/22/2008	RSK-175	Methane	11.6		µg/L	
	12/22/2008	SW8260	Methyl tert-butyl ether (MTBE)	4.3	J	µg/L	13
	12/22/2008	E300	Nitrate	0.0157	J-	mg/L	
	12/22/2008	SW8260	PCE	0.42	J	µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 5-4

Summary of Analytes Detected in MNA Wells at SS015 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SS015							
MW625X15							
	12/22/2008	E300	Sulfate	1960		mg/L	
	12/22/2008	SW8260	TCE	**5.3**		µg/L	5
	12/22/2008	SW8260	Toluene	1.6		µg/L	150
	12/22/2008	SW8260	trans-1,2-DCE	1.8		µg/L	
	12/22/2008	SW8260	Vinyl chloride	**9.6**		µg/L	0.5
	2/17/2009	SW8260	Cis-1,2-DCE	**26**		µg/L	6
	2/17/2009	SW8260	Methyl tert-butyl ether (MTBE)	1.8		µg/L	13
	2/17/2009	SW8260	PCE	0.91		µg/L	5
	2/17/2009	SW8260	TCE	**6.9**		µg/L	5
	2/17/2009	SW8260	trans-1,2-DCE	1.6		µg/L	

Qualifier Description
J = The analyte was positively identified, the quantitation is an estimate.
F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
B = The analyte was found in an associated blank, as well as in the sample.
M = A matrix effect was present.
none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 5-5
SS015 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Distal	
				MW238x15	MW216x15	MW624x15	MW625x15
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	3	0	0	0
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	2	2	0	2
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	3
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	0	0
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0
Methane[b]	<0.5 mg/L	VC oxidizes	0	0	3	0	0
	>0.5 mg/L	Ultimate reductive daughter product; VC accumulates	3				
ORP[b]	<50 mV	Reductive pathway possible	1	0	1	0	1
	<-100 mV	Reductive pathway likely	2				
pH[b]	5< pH <9	Optimal range for reductive pathway	0	0	0	0	0
	5> pH >9	Outside optimal range for reductive pathway	-2				
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	0	2	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	1	1	0	0
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	0	1	0	0
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	1	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	2	0	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA

TABLE 5-5
SS015 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Distal	
				MW238x15	MW216x15	MW624x15	MW625x15
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0
PCE[b]		Material released	0	0	0	0	0
TCE[b]		Material released Daughter product of PCE	0 2[c]	0	0	0	0
DCE[b] (all isomers[d])		Materials released Daughter product of TCE	0 2[c]	0	2	0	2
VC		Material released Daughter product of DCE	0 2[c]	0	2	0	2
Ethene/ethane	>0.01 mg/L >0.1 mg/L	Daughter product of VC/ethane	2 3	0	0	0	0
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	2	0	0
			Sum[e]	**+6**	**+19**	**0**	**+10**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C = degree(s) Celsius
mg/L = milligram(s) per liter
NA = not analyzed
TCA = trichloroethane

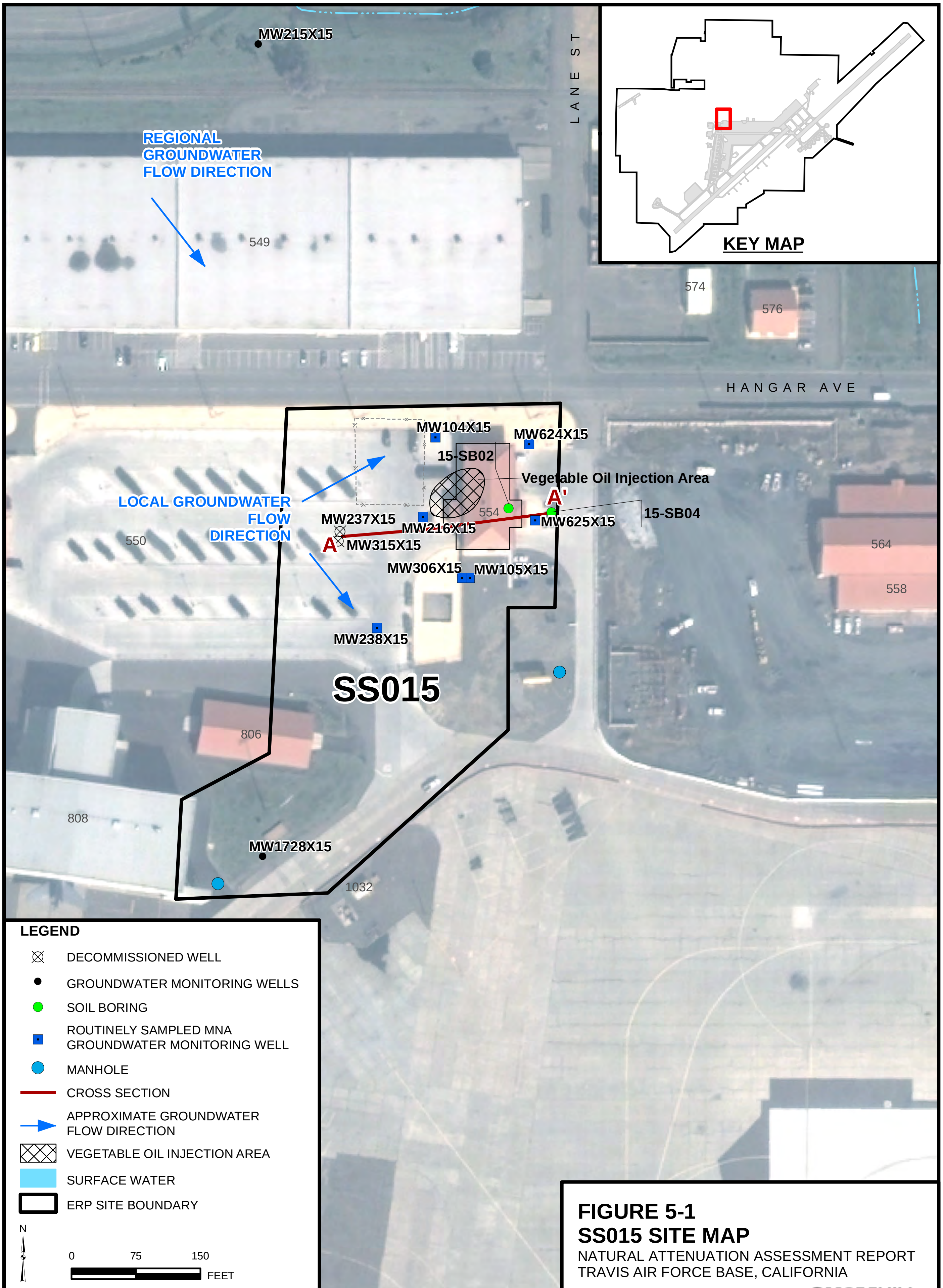
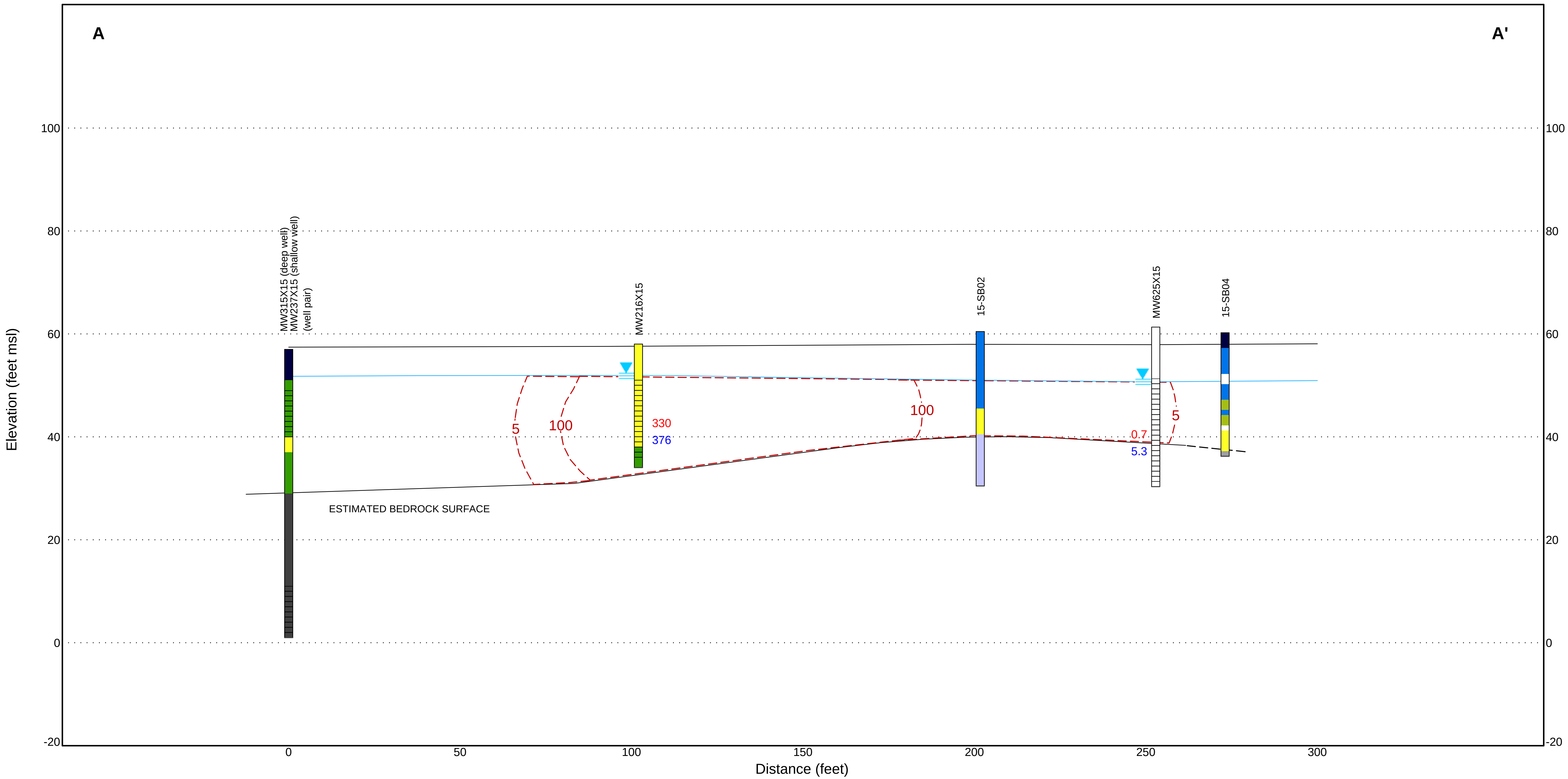


FIGURE 5-1
SS015 SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD\\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG5-1_SS015_SITE.MXD MHASKELL 1/26/2010 12:39:33



SOIL AND LITHOLOGY

SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

— 5 — APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L) BASED ON MAX 2008 DETECTION

SCALE EXAGGERATION - 1.5:1 (H:V)

NOTES:
1) SEE FIGURE 5-4 FOR CROSS SECTION LINE
2) WELL PAIR MW315X15 AND MW237X15 HAVE BEEN DECOMMISSIONED.

NO SAMPLE/NO RECOVERY	WELL GRADED SAND (SW)	LEAN CLAY (CL)
FILL/ASPHALT	POORLY GRADED SAND (SP)	FAT CLAY (CH)
WELL GRADED GRAVEL (GW)	SILTY SAND (SM)	SILTSTONE
POORLY GRADED GRAVEL (GP)	CLAYEY SAND (SC)	SANDSTONE
SILTY GRAVEL (GM)	SILT (ML)	SHALE
CLAYEY GRAVEL (GC)	ELASTIC SILT (MH)	

FIGURE 5-2
SS015 GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

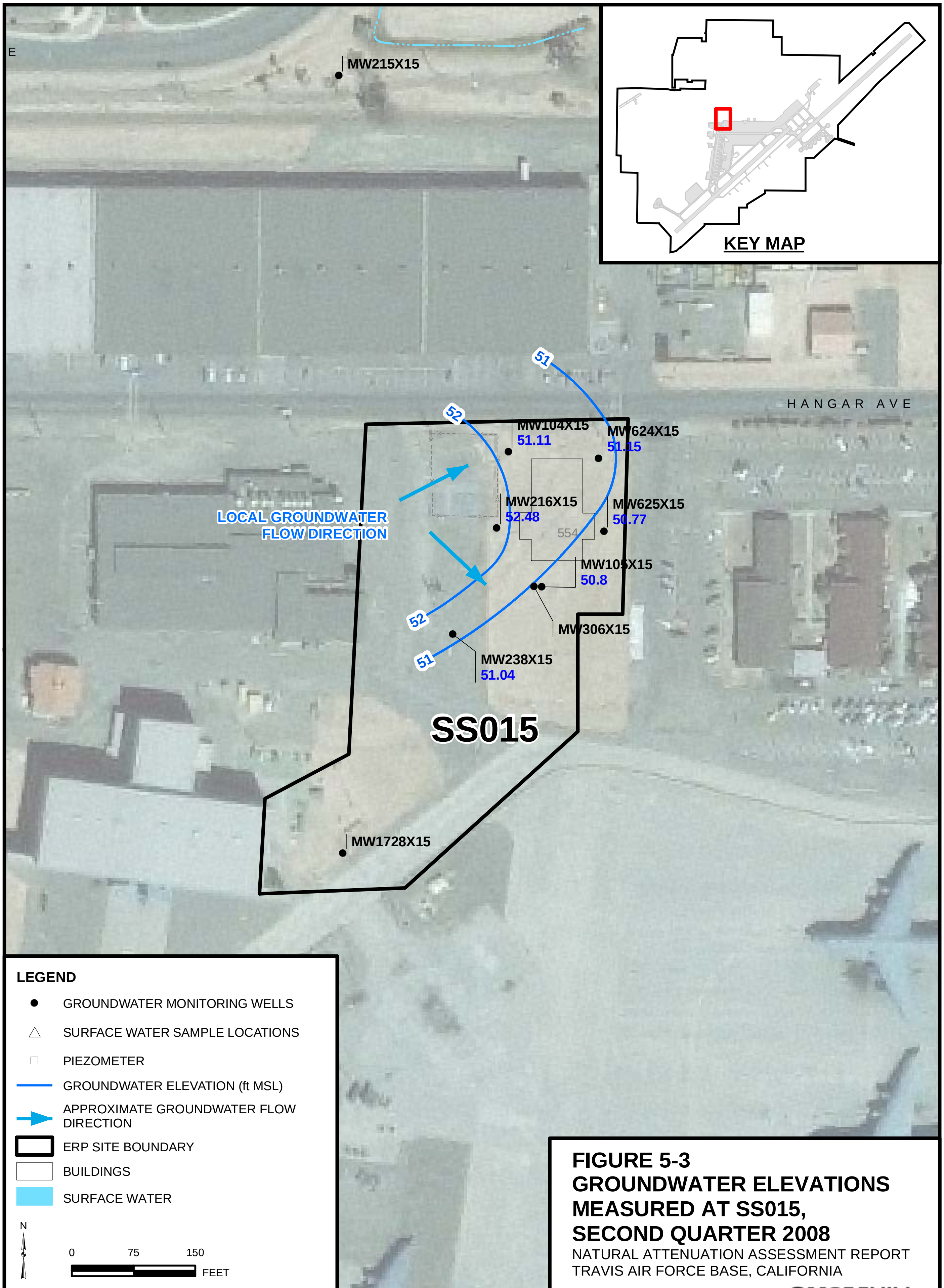
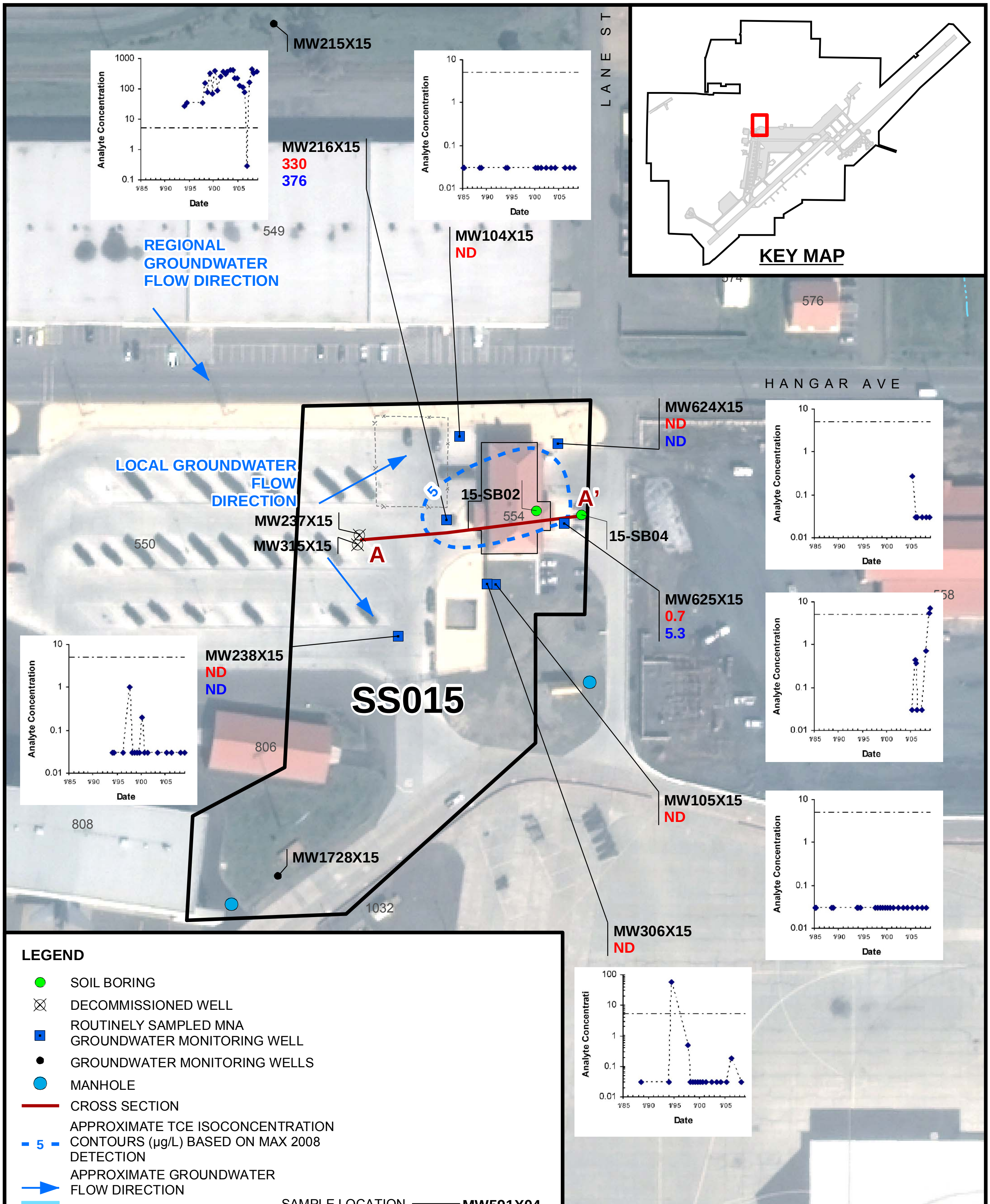


FIGURE 5-3
GROUNDWATER ELEVATIONS MEASURED AT SS015, SECOND QUARTER 2008
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\FIG5-3_SS015_GW_2008.MXD MCLAY1 6/30/2009



LEGEND

- SOIL BORING
- DECOMMISSIONED WELL
- ROUTINELY SAMPLED MNA GROUNDWATER MONITORING WELL
- GROUNDWATER MONITORING WELLS
- MANHOLE
- CROSS SECTION
- 5 APPROXIMATE TCE ISOCONCENTRATION CONTOURS (μg/L) BASED ON MAX 2008 DETECTION
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- SURFACE WATER
- ERP SITE BOUNDARY

SAMPLE LOCATION — MW591X04
TCE (μg/L) 2Q08 — 0.21J
TCE (μg/L) 4Q08 — 0.75J
FLAG

N

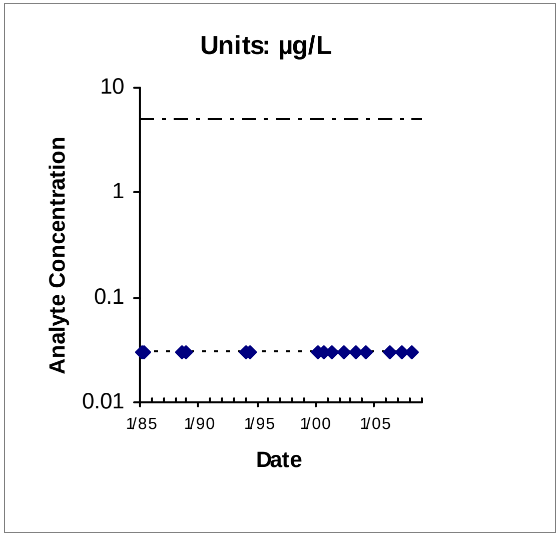
0 150 FEET

NOTE:
J = REPORTED ANALYTICAL VALUE IS ESTIMATED
ND = NOT DETECTED

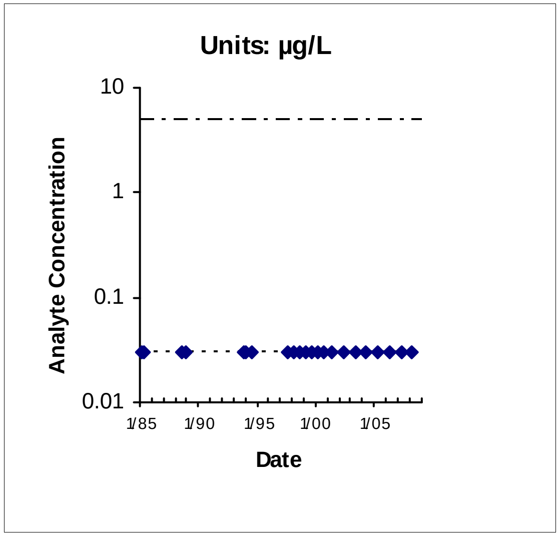
FIGURE 5-4
2008 TCE DISTRIBUTION IN GROUNDWATER AT SS015
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

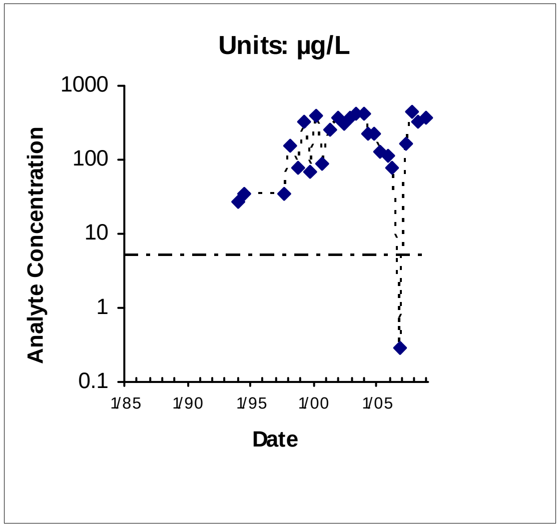
RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_MAY2010\FIG5-4_SS015_TCE.MXD JQUAN 6/2/2010 09:48:18



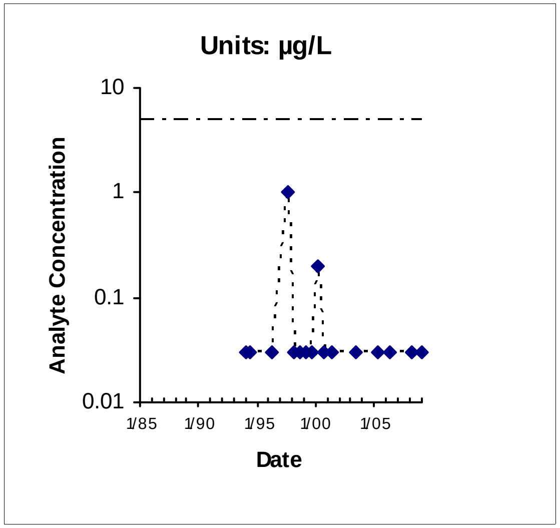
Location: MW104X15 Maximum: 0.03



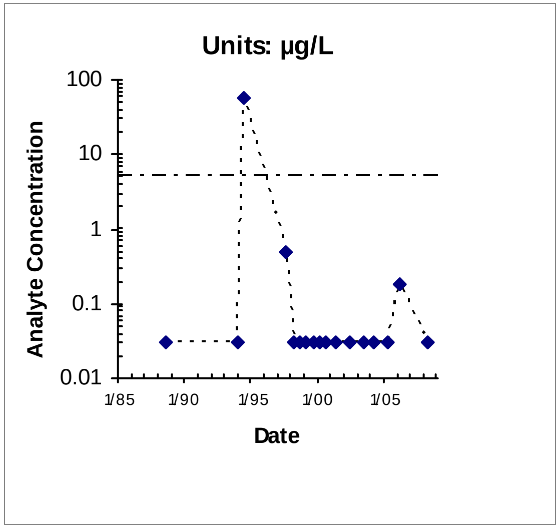
Location: MW105X15 Maximum: 0.03



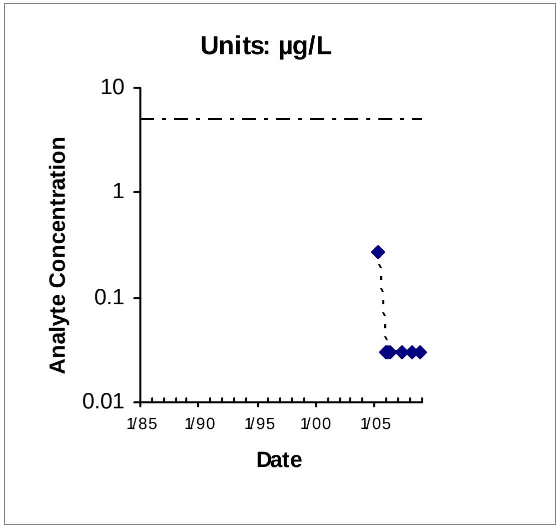
Location: MW216X15 Maximum: 440



Location: MW238X15 Maximum: 1



Location: MW306X15 Maximum: 56



Location: MW624X15 Maximum: 0.27

— - — - — IRG (5 µg/L)

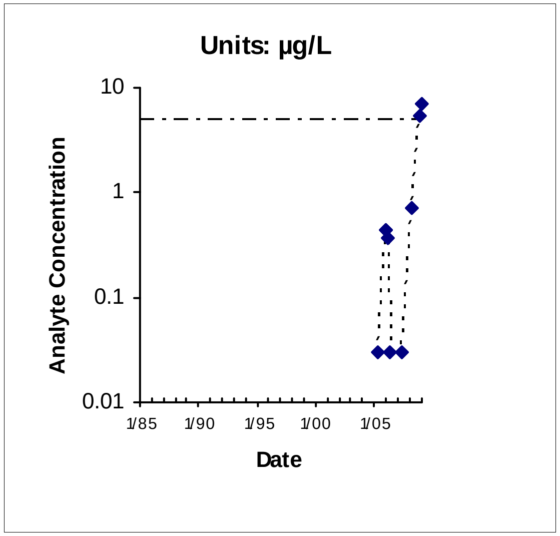
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 5-5

SS015 MNA Wells

TCE

Chemical Time-series Plots



Location: MW625X15 Maximum: 6.9

— - — - — IRG (5 µg/L)

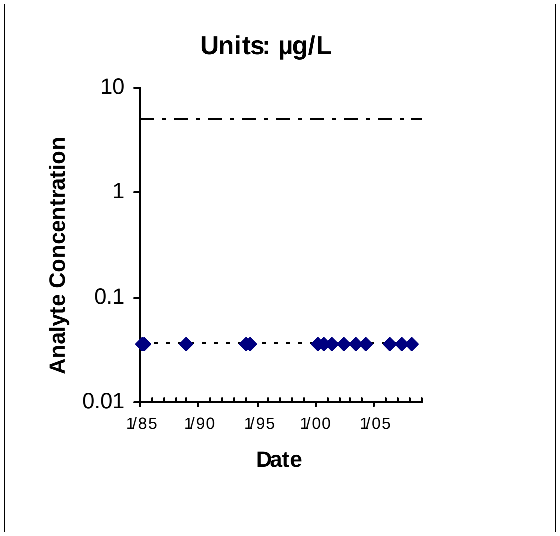
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 5-5

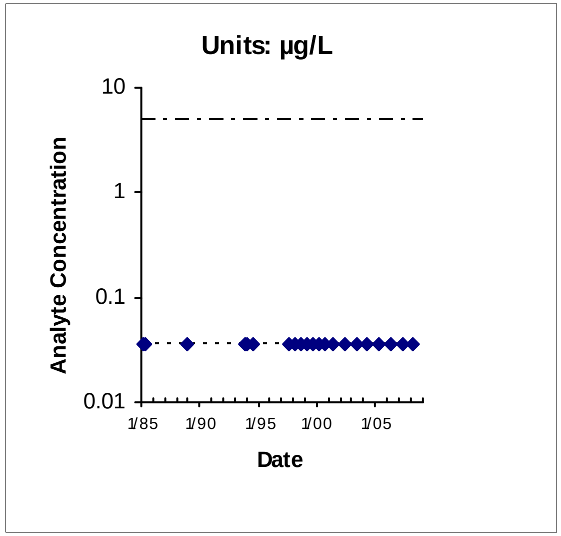
SS015 MNA Wells

TCE

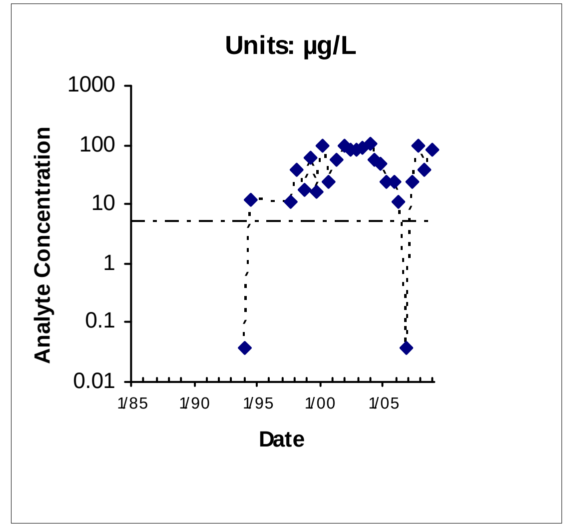
Chemical Time-series Plots



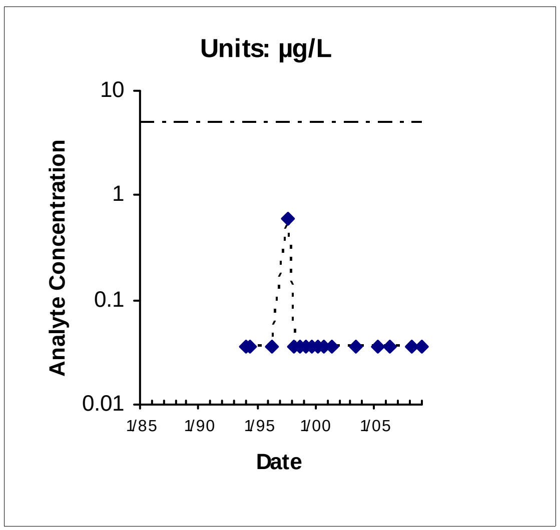
Location: MW104X15 Maximum: 0.0363



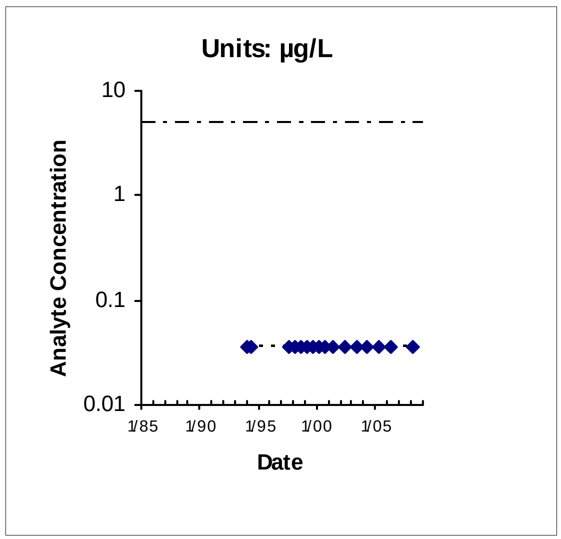
Location: MW105X15 Maximum: 0.0363



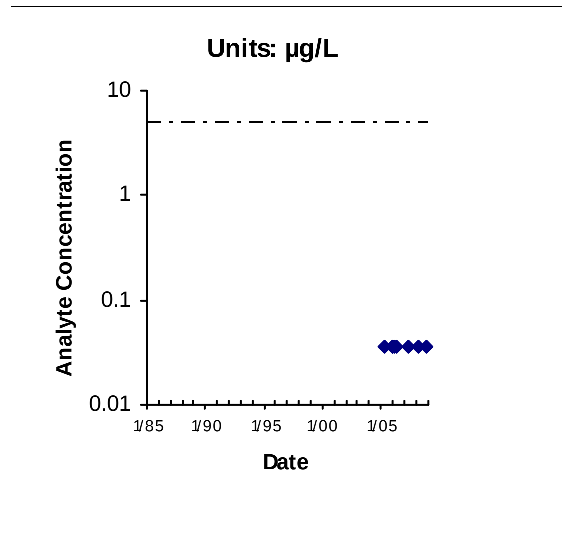
Location: MW216X15 Maximum: 105



Location: MW238X15 Maximum: 0.6



Location: MW306X15 Maximum: 0.0363



Location: MW624X15 Maximum: 0.0363

— - — - — IRG (5 µg/L)

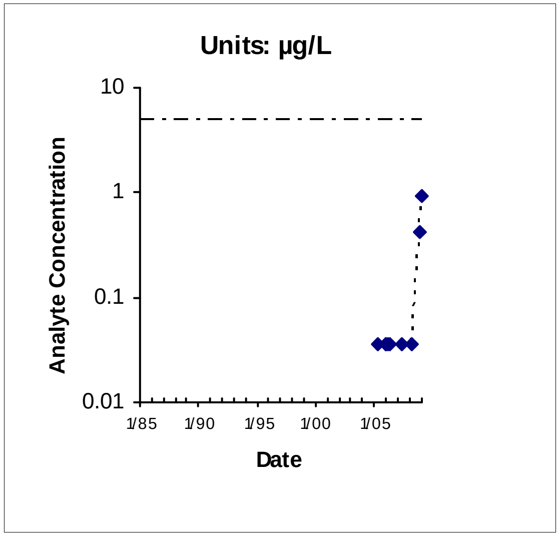
*Nondetects shown as the Method Detection Limit (0.0363 µg/L)

FIGURE 5-6

SS015 MNA Wells

PCE

Chemical Time-series Plots



Location: MW625X15 Maximum: 0.91

— - — - — IRG (5 µg/L)

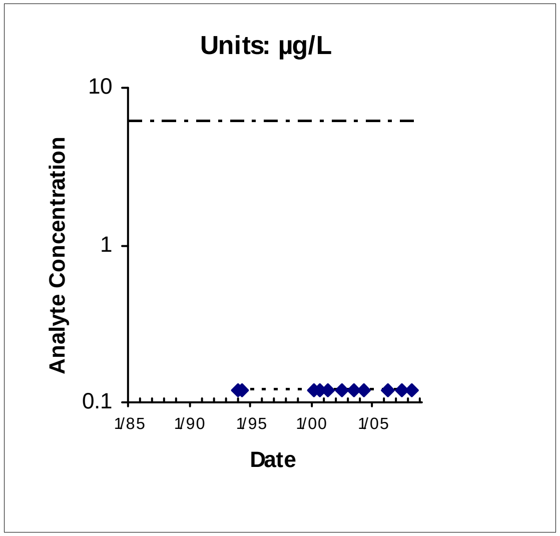
*Nondetects shown as the Method Detection Limit (0.0363 µg/L)

FIGURE 5-6

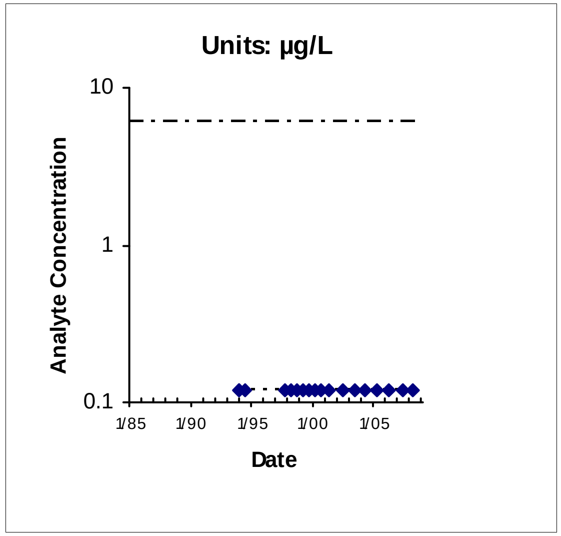
SS015 MNA Wells

PCE

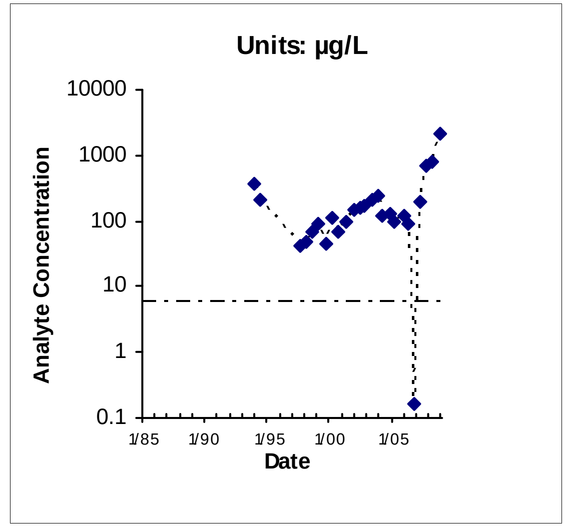
Chemical Time-series Plots



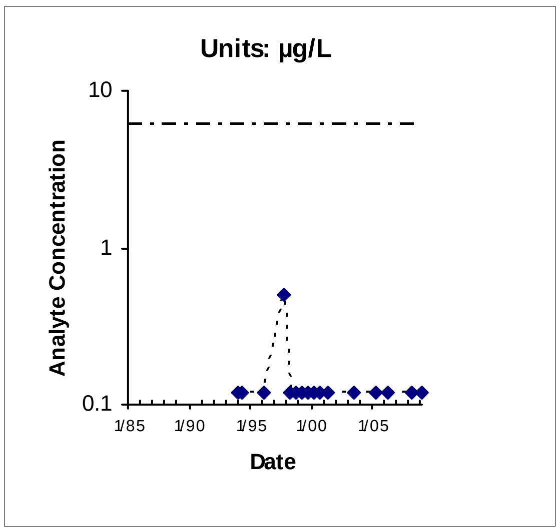
Location: MW104X15 Maximum: 0.12



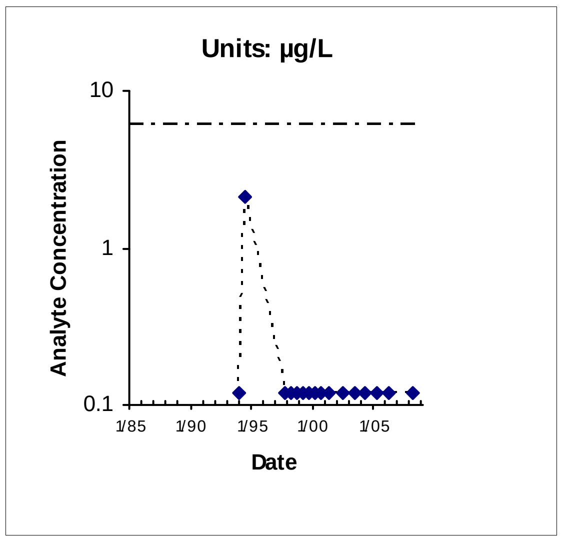
Location: MW105X15 Maximum: 0.12



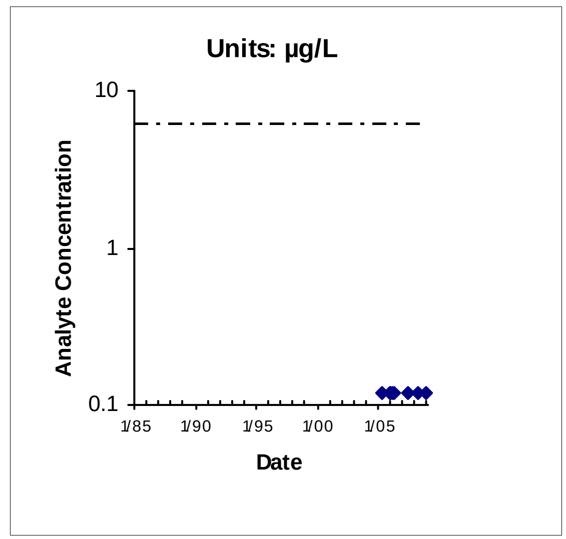
Location: MW216X15 Maximum: 2180



Location: MW238X15 Maximum: 0.5



Location: MW306X15 Maximum: 2.1



Location: MW624X15 Maximum: 0.12

— - — - — IRG (6 µg/L)

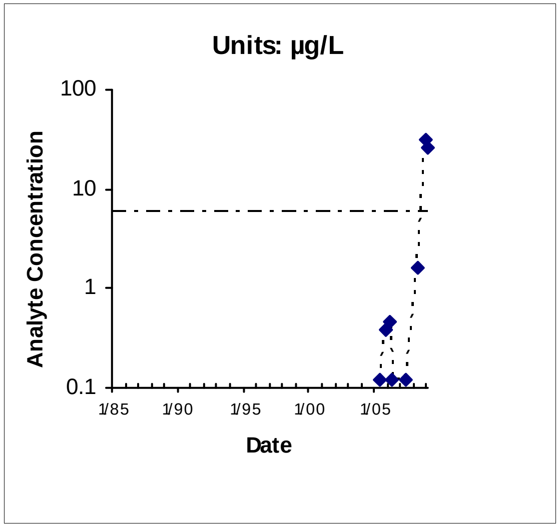
*Nondetects shown as the Method Detection Limit (0.12 µg/L)

FIGURE 5-7

SS015 MNA Wells

Cis-1,2-DCE

Chemical Time-series Plots



Location: MW625X15 Maximum: 30.7

— - — - — IRG (6 µg/L)

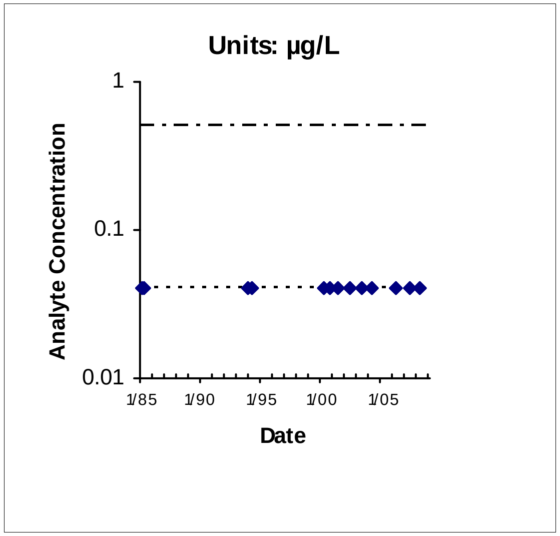
*Nondetects shown as the Method Detection Limit (0.12 µg/L)

FIGURE 5-7

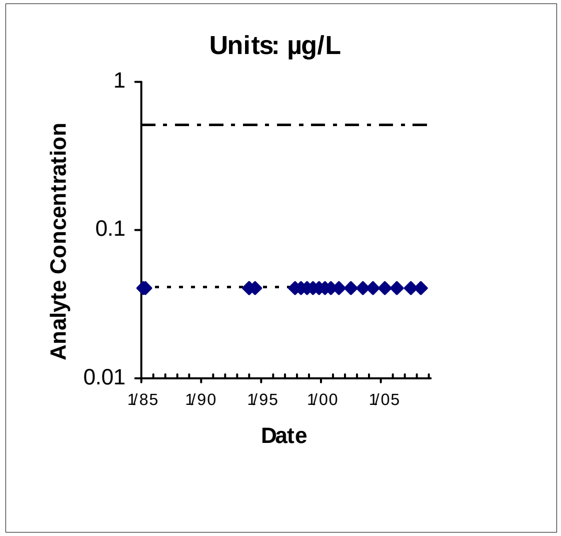
SS015 MNA Wells

Cis-1,2-DCE

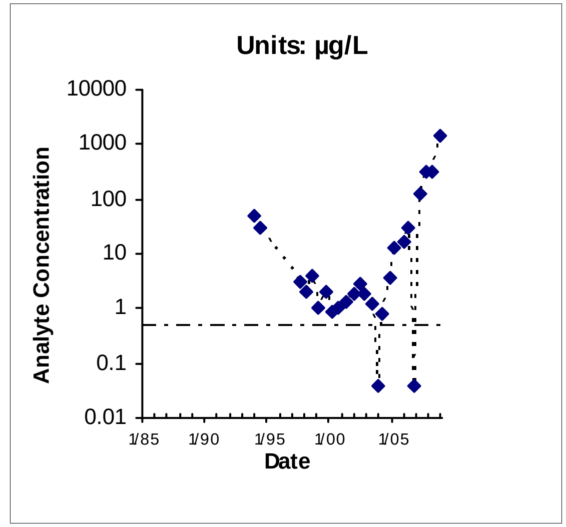
Chemical Time-series Plots



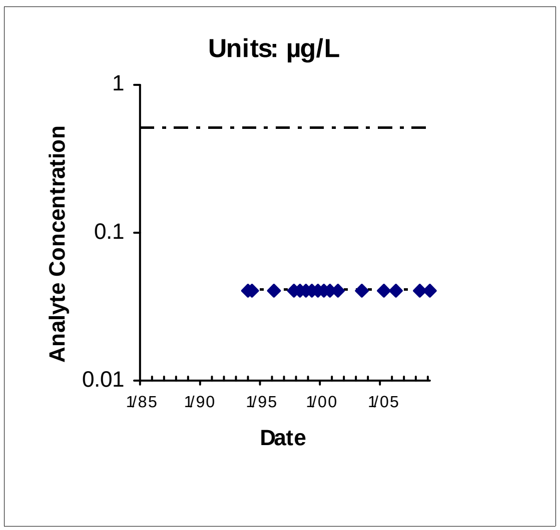
Location: MW104X15 Maximum: 0.04



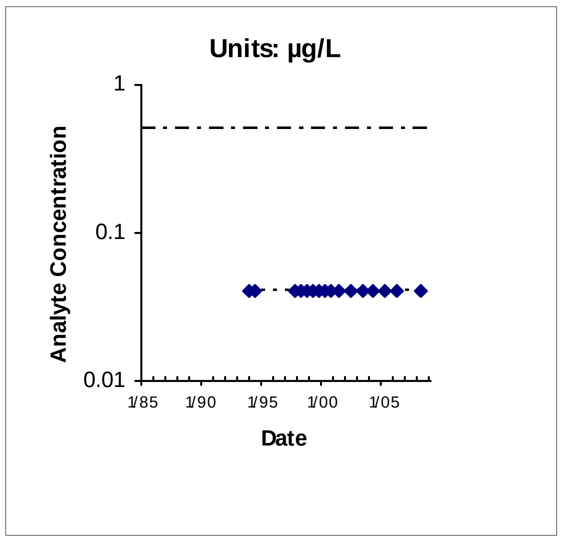
Location: MW105X15 Maximum: 0.04



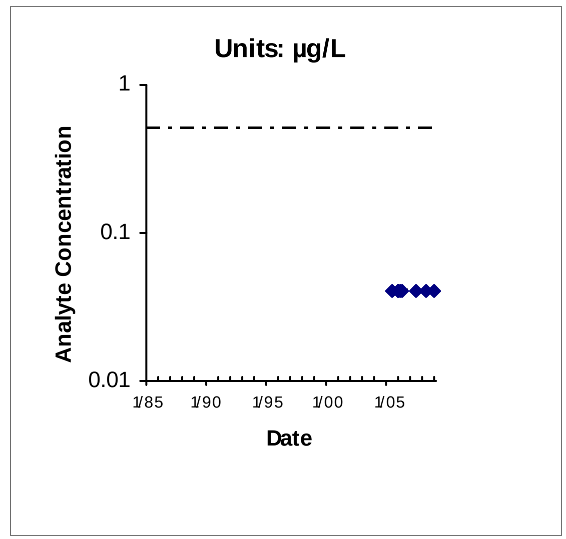
Location: MW216X15 Maximum: 1480



Location: MW238X15 Maximum: 0.04



Location: MW306X15 Maximum: 0.04



Location: MW624X15 Maximum: 0.04

— - — - — IRG (0.5 µg/L)

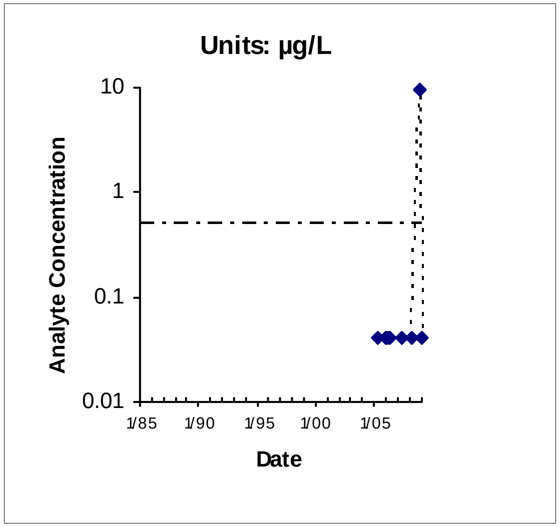
*Nondetects shown as the Method Detection Limit (0.04 µg/L)

FIGURE 5-8

SS015 MNA Wells

Vinyl Chloride

Chemical Time-series Plots



Location: MW625X15 Maximum: 9.6

— - — - — IRG (0.5 µg/L)

*Nondetects shown as the Method Detection Limit (0.04 µg/L)

FIGURE 5-8
SS015 MNA Wells
Vinyl Chloride
Chemical Time-series Plots

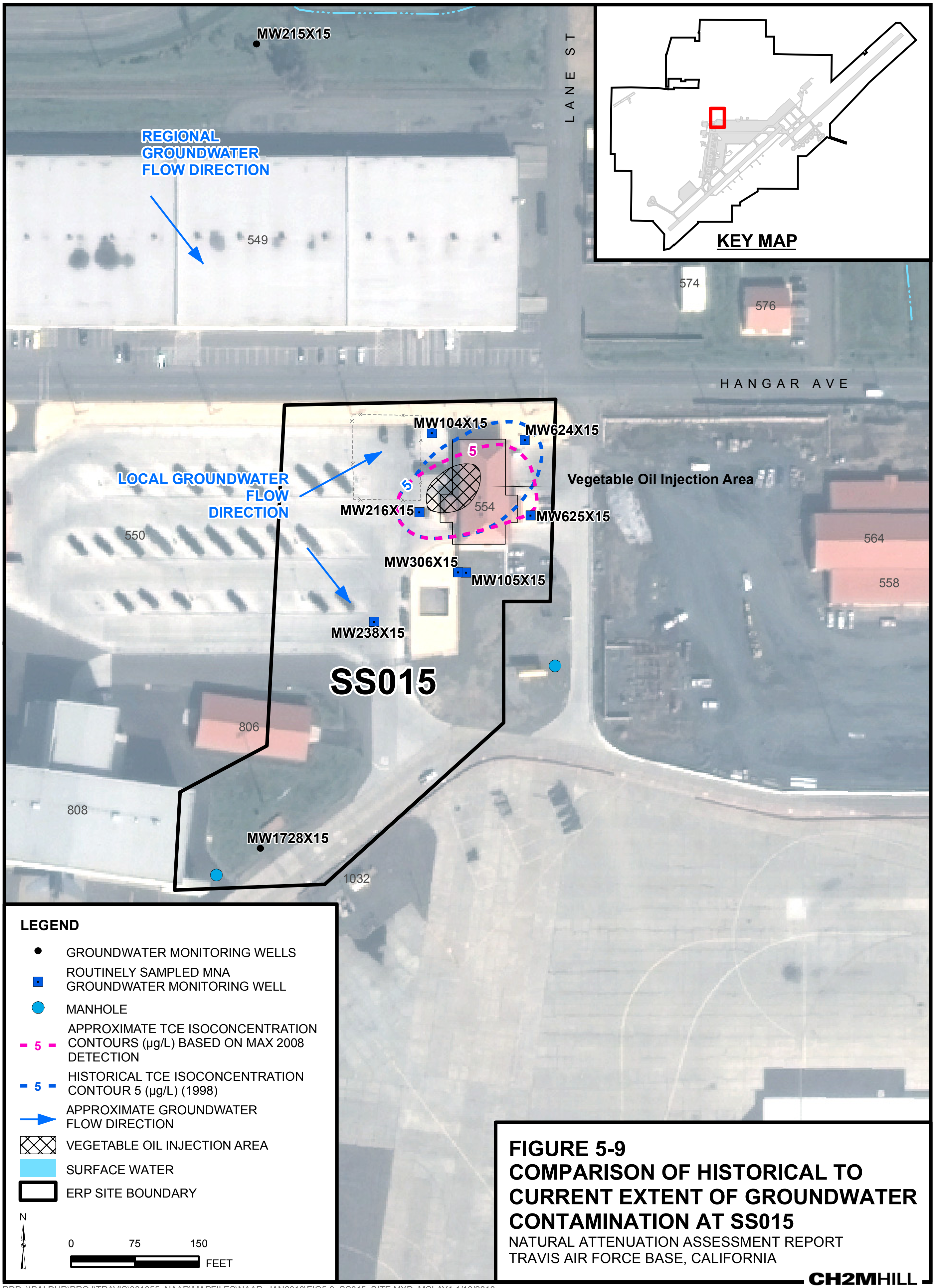


FIGURE 5-9
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT SS015
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG5-9_SS015_SITE.MXD MCLAY1 1/13/2010

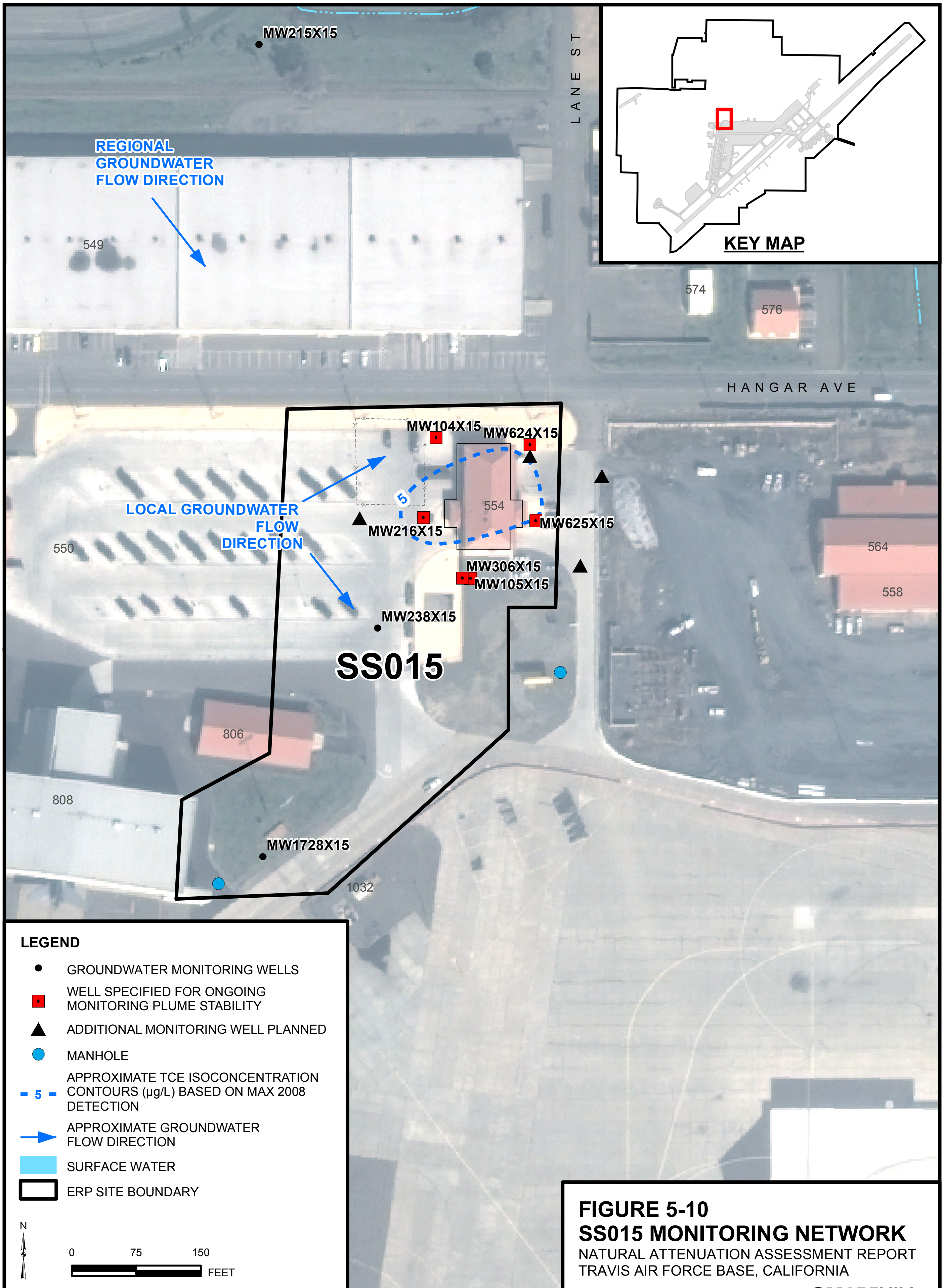


FIGURE 5-10
SS015 MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG5-10_SS015_MONITORINGNETWORK.MXD MCLAY1 1/13/2010

SECTION 6

West Industrial Operable Unit (Sites SD033 and SD037)

Section 6 presents the natural attenuation assessment for the West Industrial Operable Unit (WIOU). A detailed conceptual site model and preliminary natural attenuation assessment are presented in the *WIOU Natural Attenuation Workplan* (WIOU NAAW) (CH2M HILL, 2001b). This section focuses on data collected since the WIOU NAAW was submitted.

6.1 Site Description

The WIOU sites include SS014, SD033, SD034, SS035, SD036, and SD037. Nearby WABOU sites include SS041 and SD043. The sites included in the WIOU are within industrialized areas of the west-central portion of Travis AFB. The west branch of Union Creek flows through the WIOU, generally north to south, with the slope of the topography. Numerous buildings, shops, offices, freight handling and storage areas, vehicle maintenance shops, and aircraft maintenance facilities are included in the WIOU. Activities at the two (2) WABOU sites in the West IRA Area include pesticide mixing and handling and electrical power generation. Figure 6-1 presents a site map of the WIOU, which illustrates the locations of the WIOU sites.

Historical activities at these WIOU sites have resulted in a co-mingled groundwater plume that is being addressed through the IRA of GET in the source area and MNA assessment in the downgradient portion of the plume (beyond the designed capture of the WIOU GET). Specifically, Sites SD033 and SD037 of the WIOU were specified for MNA assessment over the interim period in the NEWIOU Groundwater IROD (Travis AFB, 1997). Figure 6-2 depicts the portion of the southern WIOU undergoing MNA assessment.

Two (2) portions of petroleum only contaminated (POCO) Site SS014 are also located in the southern WIOU (the Abandoned AVGAS Pipeline and the Jet Fuel Spill Area). However, this site will be evaluated separately because it is a POCO site.

6.1.1 Site SD033

Site SD033 consists of two (2) areas: the South Gate Area and Facility 1917. The South Gate Area is near the intersection of Ragsdale Street and Perimeter Road in the southwestern corner of Travis AFB. The site is a flat open field, with exposed soil and grass. A jet fuel distribution pipeline runs through the South Gate Area, parallel to Ragsdale Street. The South Gate Area was originally investigated because of concern that fuel hydrocarbons had been released from the pipeline into the subsurface. During the RI, however, TCE was found in one (1) in situ groundwater sample at a concentration of 12 μg/L. The source of the TCE was not established with certainty, but it was thought to be either Storm Sewer System 2 or a local surface spill (Radian Corporation, 1996). The South Gate Area is included in the natural attenuation assessment because the TCE was detected about 400 feet from the southern Base boundary. Additional investigation was performed in the South Gate Area to support the initial MNA assessment. During the investigation, TCE was not detected at concentrations exceeding the IRG in any sample. TPH-D was detected at two locations exceeding the IRG; the maximum concentration detected was 1,400 µg/L. However, the distribution of TPH-D indicated TPH-D was related to minor historical leakage along the jet fuel pipeline and that a significant TPH-D plume was not present. The investigation concluded that no additional investigation is needed in the South Gate Area (CH2M HILL, 2001b).

Facility 1917 is approximately 1,000 feet east of Site SD037 in the central portion of Travis AFB. The facility was constructed in 1956 and was used as an aircraft washdown area. The facility consists of an OWS and wastewater collection sumps that have been abandoned in place (Radian Corporation, 1996). The former OWS and sumps are located on a flat grassy area and surrounded by asphalt and concrete. Additional investigation was performed at Facility 1917 to support the initial MNA assessment. TCE was not detected at concentrations exceeding the IRG in any sample. However, PCE; cis-1,2-DCE; TPH-G; and TPH-D were detected at concentrations exceeding IRGs at a few locations. The maximum PCE concentration detected was 10 µg/L. The maximum cis-1,2-DCE concentration detected was 36 µg/L. TPH-G was detected at a maximum concentration of 30 J µg/L, and TPH-D was detected at a maximum concentration of 130 µg/L (CH2M HILL, 2001b).

6.1.2 Site SD037

The portions of Site SD037 being evaluated for MNA consist of two (2) areas: Facility 977 and the Area G Ramp. Facility 977, located east of Ragsdale Street near the southwestern corner of the WIOU, is a large air freight terminal surrounded on all sides by asphalt and concrete. A branch of the sanitary sewer system runs along the northern side of the building. Facility 977 was constructed in 1972. Hydraulic equipment is used here to load and unload cargo, which is stored inside the facility. TPH-D was reportedly released from hydraulic rams in the past. The rams were replaced, and the new rams are checked periodically for leaks. Facility 977 was investigated because of concern that petroleum hydrocarbons have been released to the subsurface from the leaky rams. However, TCE was detected in groundwater at this site during the RI. The TCE was believed to originate from the sanitary sewer (Site SD037), not Facility 977, and so the site was recommended for inclusion in the FS as part of Site SD037 (Radian Corporation, 1996).

The Area G Ramp was investigated during the RI based on the results of an earlier investigation that found soil and groundwater beneath the ramp had been contaminated with petroleum hydrocarbons. The contamination was thought to have resulted from surface spills or leaks from the fuel distribution line. However, TCE was also detected in the groundwater during the RI. The TCE was believed to have migrated to the Area G Ramp from upgradient leaks in the sanitary sewer system. Therefore, the site was recommended for inclusion in the FS as part of Site SD037 (Radian Corporation, 1996).

6.2 Site COCs

The groundwater COCs and IRGs at Site SD033 are as follows:

COC	IRG (µg/L)	COC	IRG (µg/L)
TCE	5	cis-1,2-DCE	6
1,1-DCE	6	TPH-G	5
1,2-DCA	0.5	TPH-D	100

The groundwater COCs and IRGs at Facility 877 and the Area G Ramp of Site SD037 are as follows:

COC	IRG (µg/L)	COC	IRG (µg/L)
TCE	5	cis-1,2-DCE	6
PCE	5	TPH-G	5
benzene	1	TPH-D	100

6.3 Status of Interim Remedy

An IRA of GET has been implemented in the northern WIOU, as specified by the NEWIOU Groundwater IROD (Travis AFB, 1997). The GET was designed to capture those areas where VOC contamination is present at concentrations greater than 100 µg/L; source control and migration control is the objective of the GET. The area of the plumes upgradient of the 100-µg/L isopleths are within the hydraulic capture of the GET system, and satisfy the migration control provisions of the IROD. The Travis AFB Second Five-Year Review (CH2M HILL, 2008a) concluded that the WIOU GET system is performing as designed. The operation of the GET system has greatly reduced the extent of the WIOU VOC plume.

An interim action was not specifically identified in the IROD to remedy groundwater contamination beyond the source control target area. However, the Air Force recognized the need to conduct monitoring and evaluate natural attenuation to address contamination not captured by the extraction and treatment system in the southern portions of the WIOU plume. Therefore, the Air Force has performed MNA assessment in the portions of the plume downgradient from the 100-µg/L isopleths.

The downgradient portion of the WIOU plume underwent a natural attenuation assessment in 2000-2001, as documented in the WIOU NAAW (CH2M HILL, 2001b). Since 2001, eleven (11) monitoring wells have been routinely sampled to support the ongoing MNA assessment: MW05x14, MW116x37, MW222x37, MW722x37, MW723x37, MW724x37, MW729x37, MW730x37, MW1208x37, MW1209x37, and MWS1M2x37 (see Figure 6-1). These wells are located in the downgradient and crossgradient portions of the WIOU, to monitor plume migration.

Eight years of data collected from the MNA wells indicate MNA is a viable remedy for the downgradient portion of the plume. VOC concentrations have generally been stable and the Travis AFB Second Five-Year Review concluded that MNA is an appropriate remedy for the distal portion of the plume (CH2M HILL, 2008a).

In summary, the status of the IRAs in the WIOU is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
WIOU Source Area	Source Control and Migration Control	GET	Ongoing GET
WIOU distal area (Sites SD033 and SD037)*	MNA Assessment	Groundwater monitoring	Ongoing groundwater monitoring

*Although no IRA was specified in the IROD for the WIOU distal area, the Air Force is performing MNA assessment over the interim period.

6.4 Conceptual Site Model

6.4.1 Geology

The sediments of the WIOU comprise about 30 to 60 feet of alluvium (known as the Older Alluvium) underlain by semi-consolidated to consolidated folded bedrock (known as the Neroly Sandstone). The Neroly Sandstone is underlain by the Markley Sandstone, which outcrops at the boundary between the WIOU and the EIOU. The bedrock surface is weathered and therefore the bedrock interface can be difficult to interpret from soil borings.

The Older Alluvium consists primarily of silts and clays that are low in permeability and do not transmit groundwater readily. More permeable units, such as sands and gravels, are geographically restricted and occur as lenses rather than continuous beds. These sand and gravel lenses, deposited by streams such as Union Creek, trend to the south-southeast. A geologic cross section through the primary WIOU groundwater TCE plume is presented on Figure 6-3.

6.4.2 Groundwater

As summarized in Table 6-1, depth to water is approximately 10 to 15 feet bgs in the WIOU, and the saturated zone varies widely from approximately 5 to 50 feet. There is a large variation of saturated thickness in the WIOU because the bedrock, which outcrops on the eastern edge of the WIOU, is folded. Groundwater elevations in the WIOU are stable, typically varying by approximately 2 to 5 feet per year.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 6-4 and are consistent with historical groundwater flow directions. Groundwater elevation contours for the northern portion of the WIOU indicate a regional southerly groundwater flow direction. A groundwater trough has formed, running along the center of the WIOU, in response to groundwater extraction. This trough indicates contaminated groundwater is captured by the GET system. In the WIOU, the horizontal hydraulic gradient is approximately 0.004 to 0.007 ft/ft. The horizontal hydraulic gradients are steepest near the groundwater extraction systems. In the southern portion of the WIOU, where MNA is being assessed, the horizontal hydraulic gradient is approximately 0.005 ft/ft.

Vertical gradients derived from shallow/deep monitoring well pairs in the WIOU are generally negligible (less than -0.01 ft/ft) (see Table 6-2). Of the ten (10) well pairs at this site, only one (1) pair, MW535x37/MW512x37, shows significant vertical gradient (consistently greater than 0.01 ft/ft). A downward vertical gradient of -0.6 to -0.1 ft/ft is typical for this well pair. Downward vertical gradients measured in the WIOU well pairs are due to the groundwater extraction that is ongoing at the site.

Several aquifer tests have been performed at the WIOU, and the results are summarized in Table 6-3. Hydraulic conductivities calculated from the aquifer tests ranged from 0.1 to 60 ft/day, reflecting the heterogeneous nature of the sediments and shallow bedrock and the variation the aquifer test methods utilized. The average of the hydraulic conductivities calculated for the WIOU is approximately 10 ft/day.

The average linear flow of groundwater at the WIOU may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.005 ft/ft, an average hydraulic conductivity of 10 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), the approximate groundwater velocity is about 0.25 ft/day or 90 ft/year.

Groundwater at Travis AFB is not used for human consumption. The Base boundary is approximately 2,700 feet from the leading edge of the plume. At the estimated groundwater velocity, it would take approximately 30 years for groundwater in the southern WIOU to reach the Base boundary. Because contaminants do not appear to be migrating in groundwater at this time, and because ongoing monitoring will continue to evaluate whether contamination is migrating in the future, residual groundwater contamination in the WIOU should not pose a risk to receptors.

The West Branch of Union Creek flows through the WIOU. During periods of high groundwater elevations (winter and spring), groundwater within the WIOU may discharge to surface water (Union Creek). However, ongoing monitoring of Union Creek through the GSAP, which is performed within the WIOU and at the Base boundary where Union Creek exits the Base, does not indicate surface water quality is significantly affected. WIOU groundwater COC concentrations detected in surface water are below IRGs.

6.4.3 Current Distribution of Groundwater Contamination

The monitoring wells selected to support the MNA assessment in the downgradient portion of the WIOU over the interim period are MW05x14, MW116x37, MW222x37, MW722x37, MW723x37, MW724x37, MW729x37, MW730x37, MW1208x37, MW1209x37, and MWS1M2x37.

During the 2Q08 and 4Q08 sampling events, the COCs detected at concentrations exceeding IRGs in the area of the WIOU plume selected for MNA assessment were TCE, TPH-G, and TPH-D. Figure 6-5 illustrates the current distribution of TCE in the southern WIOU. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix. In 2008, TCE was detected at concentrations exceeding the IRG at MNA wells MW722x37 (16.2 µg/L) and

MW1208x37 (7.9 µg/L). The furthest downgradient TCE detection during 2008 was at monitoring well MW724x37, where it was detected at 0.9 µg/L in 2Q08. It was not detected at this well during 4Q08.

TPH-G was detected at concentrations exceeding the IRG (5 µg/L) at five (5) MNA wells: MW05x14, MW116x37, MW310x37, MW722x37, and MW730x37. The maximum concentration detected was 1,000 µg/L at well MW05x14. The second highest TPH-G concentration detected was 44 µg/L at MW116x37. TPH-D was detected at concentrations exceeding the IRG (100 µg/L) only at MNA wells MW05x14 (740 µg/L) and MW724x37 (120 µg/L).

A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the portion of the groundwater plume undergoing MNA assessment in the WIOU are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b). The groundwater VOC concentrations in the distal portion of the plume do not indicate potential for VI risk.

6.5 Natural Attenuation Assessment

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has been reduced in size. Over the interim period, the GSAP has been monitoring several wells to evaluate plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 6.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 6.5.2.

6.5.1 Plume Attenuation

Chemical time-series plots of the primary COCs (TCE, TPH-G, and TPH-D) for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 6-6 through 6-8. Figure 6-6 illustrates that TCE concentrations have been stable and low at all of the southern WIOU MNA wells. TCE has not been detected at most of these wells in several years. In 2008, TCE concentrations only exceeded the IRG at MNA wells MW722x37 (16.2 µg/L) and MW1208x37 (7.9 µg/L). TCE concentrations have declined by approximately half at well MW722x37 from the historical maximum of 30 µg/L. TCE concentrations at MW1208x37 have declined by approximately 65 percent from the historical maximum of 25 µg/L. TCE concentrations at well MW723x37 increased slightly in 2008, but remain below the IRG. No significant increasing TCE trend was identified by the Mann-Kendall statistical analysis at this or any other WIOU MNA well (Appendix E).

Figure 6-9 shows the current distribution of TCE exceeding the IRG and the historical extent of TCE contamination in groundwater exceeding the IRG in the southern WIOU. This figure illustrates the reduction in the extent of the WIOU plume over time.

With the exception of POCO Site SS014 wells MW02x14 and MW05x14, Figures 6-7 and 6-8 show that TPH-D and TPH-G detections in the WIOU have been low (generally below the IRG) and sporadic. MW02x14 is located in the SS014 Site 1 source area and MW05x14 is located in the SS014 Site 4 area. TPH concentrations have declined at both wells. The presence of TPH enhances biodegradation of chlorinated solvents. Although there is currently no TCE in the vicinity of MW05x14, if the WIOU TCE plume were to migrate downgradient (southward), the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume.

There is no indication of plume migration. The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of TCE at this site to approximately 0.8 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the portion of the plume beyond the capture of the GET system would be expected to have migrated approximately 560 feet (approximately 70 feet per year) over the 8 years of the MNA assessment period. However, the plume has receded, indicating that natural attenuation processes are occurring at this site.

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the eleven (11) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring wells at which COCs continue to exceed IRGs (MCLs). A point attenuation rate constant was calculated for these two (2) MNA wells: MW1208x37 and MW722x37. Both of these monitoring wells are located beyond the designed extent of hydraulic capture of the GET system, and point attenuation rates calculated for these wells are not expected to be impacted by the ongoing GET IRA. At both monitoring wells, the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW1208x37 is approximately 0.019 per year, and the attenuation rate constant calculated for well MW722x37 is approximately 0.058 per year (Appendix D). At these rates, TCE concentrations at well MW1208x37 would be expected to reach the IRG (5 µg/L) in 2024 and TCE concentrations at well MW722x37 would be expected to reach the IRG in 2029. Little change in aquifer conditions between 2001 (when the initial MNA assessment was performed) and 2008 is evident. The aquifer remains aerobic and, with the exception of areas impacted by historical Site SS014 TPH releases, available carbon is low. Physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. These mechanisms are not anticipated to change in the near future and thus the attenuation rates calculated provide reasonable estimates of time to reach IRGs.

In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for MNA monitoring wells where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.

Bulk attenuation rates have not been calculated for the WIOU at this time because, due to the ongoing GET IRA, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site.

6.5.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for the southern WIOU. Table 6-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from WIOU monitoring wells during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), TOC (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and CO_2 (HACH field test). In addition, pH, temperature, DO, ORP, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Well:** MW07x14
- **Source Well:** MW524x37
- **Plume Wells:** MW513x37, MW531x37, MW540x37, MW722x37, MW1208x37, and MW02x14
- **Distal Wells:** MWS1M2x37, MW724x37, and MW05x14

As shown in Table 6-5, only distal well MW05x14 received a score indicating adequate evidence for biodegradation of chlorinated solvents. This monitoring well has relatively high concentrations of TPH because it is also associated with POCO Site SS014. The presence of petroleum hydrocarbons provides a carbon source for micro-organisms and subsequently enhances biodegradation of chlorinated solvents. Plume wells MW531x37, MW540x37, and MW01x14 received scores between six (6) and fourteen (14) points, providing limited evidence for biodegradation of chlorinated solvents. All other monitoring wells scored three (3) or fewer points, indicating inadequate evidence for biodegradation.

Geochemical parameters indicated both aerobic and anaerobic conditions throughout the plume. The aerobic conditions are at least in part the result of the operation of the GET system, which causes aeration of the aquifer. With the exception of MW05x14, which has relatively high concentrations of petroleum hydrocarbons, the distal area wells received scores of zero (0) points. There are insufficient natural or anthropogenic carbon donors in these low scoring areas to impact geochemical conditions and result in reductive dechlorination.

A similar biodegradation screening was performed in 2000-2001, as documented in the WIOU NAAW (CH2M HILL, 2001b). During the initial biodegradation screening, most monitoring wells scored eight (8) points or less (inadequate to limited evidence of biodegradation). The only monitoring well at which there was adequate to strong evidence of biodegradation was MW05x14 (which scored twenty [20] points). As previously discussed, petroleum hydrocarbons are present in the vicinity of this well, and their presence is beneficial to biodegradation of chlorinated solvents.

6.6 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- There is inadequate evidence for biodegradation of chlorinated COCs in the southern WIOU, with the exception of the area that has been impacted by petroleum hydrocarbons associated with Site SS014. In most areas, there are insufficient natural or anthropogenic carbon donors to impact geochemical conditions and result in reductive dechlorination. In addition, the upgradient GET system is introducing oxygen into the source area. Aerobic conditions found at this site are favorable for promoting degradation of TPH-G and TPH-D.
- There is substantial evidence of physical natural attenuation of COCs in the southern WIOU.
- Over the interim period, TCE concentrations have been stable and low at all of the southern WIOU MNA wells. TCE has not been detected at most of these wells for several years.
- The extent of the WIOU plume has decreased over time.
- The presence of petroleum hydrocarbons in the vicinity of MW05x14 enhances biodegradation of chlorinated solvents. Thus, if the TCE plume were to migrate downgradient toward this well, the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume.
- There is no indication of plume migration. In fact, the plume has been receding.

Based on the results of the natural attenuation assessment, MNA is the Air Force preferred remedy for the downgradient portion of the WIOU groundwater plume.

6.7 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring in the distal portions of the WIOU. The distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells to monitor plume stability is presented on Figure 6-10 and will consist of MW05x14, MW116x37, MW722x37, MW723x37, MW724x37, MW1208x37, and MW1209x37. These wells will be sampled annually for VOCs, TPH-G, and TPH-D. This network will continue to be monitored during the interim period or until such time as the remedy changes. Source area monitoring to support assessment of the WIOU GET performance will continue to be performed as specified in the GSAP annual reports.

TABLE 6-1

WIOU Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SS014									
MW02X14	6.3	21.3	31.7	16.7	37.60	10.41	27.19	11.03	26.57
MW05X14	5	20	34.23	19.23	38.89	15.04	23.85	16.57	22.32
Site: SD033									
EW501X33	13	33	30.9	10.9	42.42	NM	NM	NM	NM
EW503X33	10	30	40	20	38.50	NM	NM	NM	NM
MW270X33	9.6	19.6	18.2	8.2	32.78	12.55	20.23	12.98	19.8
MW502X33	8	48	34.98	-5.02	42.98	13.49	29.49	13.08	29.9
MW504X33	8	28	32.05	12.05	40.06	10.39	29.67	10.75	29.31
MW505X33	11	26	29.38	14.38	39.96	11.05	28.91	11.51	28.45
MW506X33	38	53	1.32	-13.68	39.32	10.43	28.89	10.81	28.51
MW507X33	20	30	20.02	10.02	39.96	11.21	28.75	11.5	28.46
MW508X33	10	15	43	38	52.37	10.44	41.93	10.57	41.8
MW509X33	11.75	41.75	31.42	1.42	42.81	12.09	30.72	12.19	30.62
MW530X33	5	10	32.08	27.08	37.09	8.23	28.86	8.4	28.69
MW1202X33	9	19	45.22	35.22	56.39	13.99	42.4	13.56	42.83
MW1S3X33	No Data	No Data	No Data	No Data	44.53	9.31	35.22	9.02	35.51
PZ556X33	4.5	14.5	32.73	22.73	37.01	NM	NM	5.87	31.14
PZ557X33	4.5	14.5	33.35	23.35	37.41	NM	NM	9.17	28.24
PZ558X33	4.5	14.5	34	24	37.98	NM	NM	9.82	28.16
PZ559X33	7	17	46	36	52.64	NM	NM	11.03	41.61
PZ560X33	7	17	46	36	52.94	NM	NM	11.43	41.51
PZ561X33	7	17	46	36	52.84	11.07	41.77	11.39	41.45
PZ562X33	5	10	48	43	52.32	9.27	43.05	10.21	42.11

Note: Grouped by Site and sorted by Location.
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Site: SD034									
EW01X34	5	25	49	29	53.86	12.44	41.42	11.03	42.83
EW03X34	9	19	45	35	53.25	11.14	42.11	10.19	43.06
MW02X34	10	20	44	34	53.68	11.56	42.12	11.38	42.3
MW04X34	8	18	45	35	52.07	11.71	40.36	10.54	41.53
MW811X34	5	20	47.8	32.8	52.78	11.85	40.93	9.75	43.03
MWSSAX34	10	25	47.23	32.23	53.45	11.08	42.37	11.2	42.25
MWSSBX34	10	25	47.3	32.3	53.58	10.85	42.73	10.9	42.68
PZ01X34	5	25	49	29	53.54	10.37	43.17	10.35	43.19
PZ02X34	5	25	49	29	53.45	10.89	42.56	6.36	47.09
PZ03X34	5	25	49	29	53.45	11.36	42.09	11.31	42.14
PZ04X34	11	21	42	32	52.72	10.86	41.86	10.5	42.22
PZ05X34	5	25	48	28	52.64	9.36	43.28	9.22	43.42
PZ06X34	5	25	48	28	52.63	9.64	42.99	9.02	43.61
Site: SS035									
MW01X35	15	25	38	28	52.76	11.76	41	11.95	40.81
MW02X35	24	34	30	20	53.50	13.51	39.99	13.62	39.88
MW818X35	5	20	48.5	33.5	53.21	13.21	40	13.4	39.81
MW5304X35	No Data	No Data	No Data	No Data	55.53	NM	NM	13.35	42.18
MWRW1X35	No Data	No Data	No Data	No Data	54.86	11.19	43.67	12.34	42.52
MWRW2X35	No Data	No Data	No Data	No Data	55.86	12.92	42.94	13.19	42.67
Site: SD036									
EW593X36	10	50	37	-3	45.84	NM	NM	NM	NM
EW594X36	10	35	34	9	43.79	NM	NM	NM	NM

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Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SD036									
EW595X36	12	47	32	-3	42.08	NM	NM	NM	NM
MW872X36	6	21	38.93	23.93	46.93	12.49	34.44	12.28	34.65
MW873M1X36	7	22	38	23	46.10	10.79	35.31	11.06	35.04
MW873M2X36	38.5	53.5	6.5	-8.5	46.16	12.17	33.99	11.92	34.24
PZ01X36	14.5	17.5	32.5	29.5	47.60	11.98	35.62	13.29	34.31
PZ02x36	16.8	19.8	30.66	27.66	47.46	11.44	36.02	11.57	35.89
PZ03X36	17.8	20.8	41.98	38.98	47.14	10.89	36.25	11.78	35.36
PZ04X36	15.8	18.8	45.27	42.27	47.26	12.23	35.03	12.21	35.05
PZ06DX36	59.5	63.5	-9.5	-13.5	47.16	NM	NM	12.6	34.56
PZ06SX36	16.8	19.8	44.9	41.9	47.13	12.35	34.78	12.25	34.88
PZ07DX36	55.5	59.5	7.5	3.5	45.83	14.16	31.67	10.98	34.85
PZ07SX36	17.8	20.8	45.28	42.28	45.74	12.59	33.15	NM	NM
PZ11DX36	55.5	59.5	7.97	3.97	44.76	9.56	35.2	10.51	34.25
PZ11SX36	19.9	22.9	44.05	41.05	44.61	10.28	34.33	10.34	34.27
PZ12DX36	55.5	59.5	8.75	4.75	45.88	12.34	33.54	19.59	26.29
PZ13X36	17.8	20.8	26.2	23.2	44.12	NM	NM	NM	NM
PZ12SX36	17.8	20.8	46.6	43.6	45.86	11.94	33.92	11.62	34.24
PZ14x36	17.8	20.8	27.55	24.55	45.35	NM	NM	10.52	34.83
PZ15x36	19.3	22.3	24.26	21.26	43.56	NM	NM	9.88	33.68
PZ16x36	16	19	28.74	25.74	44.74	NM	NM	10.75	33.99
PZ17x36	13.2	17.2	32.06	28.06	45.26	11.57	33.69	11.61	33.65
PZ18x36	12.6	16.6	30.76	26.76	43.36	NM	NM	10.79	32.57
PZ19Dx36	57.5	61.5	-14.94	-18.94	42.56	8.71	33.85	8.95	33.61

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Site: SD036									
PZ19Sx36	10	14	32.59	28.59	42.59	8.63	33.96	8.94	33.65
PZ20x36	17.8	20.8	30.2	27.2	46.15	13.42	32.73	13.63	32.52
PZ22x36	17.8	20.8	26.2	23.2	42.41	9.55	32.86	9.63	32.78
PZ23x36	14.4	18.4	30.15	26.15	44.55	NM	NM	NM	NM
PZ24X36	15.8	18.8	26.94	23.94	47.24	NM	NM	10.77	36.47
PZ549Ax36	3	3.5	43.39	42.89	46.25	NM	NM	NM	NM
PZ549Bx36	6.5	7	39.89	39.39	46.23	NM	NM	NM	NM
PZ549Cx36	20	30	26.44	16.44	46.16	NM	NM	12.01	34.15
PZ550Ax36	3	3.5	43.12	42.62	45.89	NM	NM	NM	NM
PZ550Bx36	6.5	7.5	39.62	38.62	45.78	NM	NM	NM	NM
PZ550Cx36	20	30	26.13	16.13	45.81	12.5	33.31	12.29	33.52
PZ551Ax36	3	3.5	42.48	41.98	45.31	NM	NM	NM	NM
PZ551Bx36	7	7.5	38.48	37.98	45.32	NM	NM	NM	NM
PZ551Cx36	19	29	26.53	16.53	45.31	NM	NM	12.34	32.97
Site: SD037									
EW510X37	11	41	30.5	0.5	41.13	NM	NM	NM	NM
EW511X37	13	38	28.5	3.5	41.40	NM	NM	NM	NM
EW599X37	9	39	40	10	47.14	NM	NM	NM	NM
EW700X37	10	40	36	6	44.64	NM	NM	NM	NM
EW701X37	11	41	36	6	45.45	NM	NM	NM	NM
EW702X37	10	40	37	7	45.38	NM	NM	NM	NM
EW703X37	11	31	35	15	44.55	NM	NM	NM	NM
EW704X37	11.5	36.5	34.5	9.5	44.94	NM	NM	NM	NM

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Site: SD037									
EW705X37	10	35	36	11	44.64	NM	NM	NM	NM
EW706X37	13	38	35	10	47.18	NM	NM	NM	NM
EW707X37	15	45	35	5	48.61	NM	NM	NM	NM
MW04X37	7	22	31	16	37.53	9.38	28.15	11.68	25.85
MW116X37	18	38	20.1	0.1	40.57	13.65	26.92	14.18	26.39
MW222X37	9	24	29.28	14.28	38.10	9.5	28.6	10.1	28
MW223X37	5.5	20.5	30.54	15.54	39.53	12.17	27.36	12.58	26.95
MW224X37	5	20	31.38	16.38	39.93	12.55	27.38	12.86	27.07
MW310X37	43	53	-5.77	-15.77	40.78	13.81	26.97	14.25	26.53
MW500X37	19.5	29.5	31	21	50.36	20.98	29.38	21.92	28.44
MW512X37	10	15	36	31	45.59	11.14	34.45	11.4	34.19
MW513X37	10	35	36.5	11.5	46.03	11.45	34.58	12.13	33.9
MW514X37	10	35	36	11	45.84	9.94	35.9	10.33	35.51
MW515X37	13	38	33.5	8.5	46.26	10.01	36.25	10.04	36.22
MW516X37	12	37	32	7	43.50	11.42	32.08	12.39	31.11
MW517X37	9	25	40	24	48.48	16.08	32.4	NM	NM
MW518X37	12	37	29.5	4.5	40.67	9.51	31.16	9.89	30.78
MW519X37	11	41	30.5	0.5	40.73	9.62	31.11	10.01	30.72
MW522X37	9	34	37	12	45.26	10.74	34.52	11.52	33.74
MW523X37	10	35	38	13	47.50	11.61	35.89	11.84	35.66
MW524X37	10	30	39	19	48.30	12.33	35.97	12.45	35.85
MW525X37	11.5	36.5	34.5	9.5	45.45	9.51	35.94	9.41	36.04
MW526X37	13	38	33	8	45.57	10.64	34.93	10.74	34.83

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 6-1

WIOU Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SD037									
MW527X37	10	30	36.5	16.5	46.00	14.71	31.29	13.61	32.39
MW528X37	10	30	38	18	47.61	10.95	36.66	10.99	36.62
MW529X37	14.5	24.5	26	16	40.23	9.09	31.14	9.5	30.73
MW531X37	26	36	18	8	43.92	8.27	35.65	8.34	35.58
MW532X37	13	23	37.5	27.5	50.02	12.02	38	12.42	37.6
MW533X37	32.5	42.5	14.5	4.5	46.22	23.49	22.73	23.68	22.54
MW534X37	10	20	37	27	46.72	9.57	37.15	9.1	37.62
MW535X37	29	34	17	12	45.62	13.34	32.28	13.26	32.36
MW536X37	25	35	24	14	48.45	17.11	31.34	18.32	30.13
MW537X37	19.5	29.5	30.5	20.5	49.77	18.16	31.61	18.48	31.29
MW538X37	19.5	29.5	30	20	49.39	17.37	32.02	19.8	29.59
MW539X37	20	30	30.5	20.5	49.99	10.7	39.29	10.82	39.17
MW540X37	16	26	33.5	23.5	49.11	10.12	38.99	10.2	38.91
MW541X37	14	24	35	25	48.46	7.45	41.01	10.51	37.95
MW596X37	50	60	-9	-19	40.12	9.06	31.06	9.58	30.54
MW722X37	9	19	28.36	18.36	37.32	11.19	26.13	11.34	25.98
MW723X37	9	19	28.87	18.87	37.99	12.77	25.22	12.85	25.14
MW724X37	12	22	23.82	13.82	35.86	11.15	24.71	11.59	24.27
MW729X37	9.75	19.75	28.97	18.97	35.85	7.83	28.02	7.22	28.63
MW730X37	19	29	17.01	7.01	35.85	11.63	24.22	11.88	23.97
MW810M1X37	7	22	48.19	33.19	57.44	11.6	45.84	11.04	46.4
MW810M2X37	No Data	No Data	No Data	No Data	57.13	7.58	49.55	7.27	49.86
MW837X37	No Data	No Data	No Data	No Data	47.50	11.16	36.34	11.54	35.96

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 6-1

WIOU Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SD037									
MW838X37	5	20	41	26	45.95	10.69	35.26	11.28	34.67
MW919X37	5	20	34.18	19.18	41.32	10.5	30.82	10.79	30.53
MW981X37	No Data	No Data	No Data	No Data	42.98	NM	NM	NM	NM
MW1205X37	6.5	16.5	45.43	35.43	54.02	11.91	42.11	12.35	41.67
MW1208X37	8	18	28.6	18.6	36.35	9.14	27.21	10.11	26.24
MW1209X37	8.5	18.5	27.9	17.9	35.65	9.8	25.85	11.12	24.53
MWRVM1X37	No Data	No Data	No Data	No Data	45.07	9.63	35.44	9.44	35.63
MWRVM2X37	6	21	36.9	21.9	47.99	12.87	35.12	13.19	34.8
MWS1M1X37	6.5	16.5	28.9	18.9	39.62	11.71	27.91	12.01	27.61
MWS1M2X37	20	30	18.01	8.01	40.19	14.34	25.85	14.98	25.21
MWS3M2X37	No Data	No Data	No Data	No Data	45.71	NM	NM	9.11	36.6
MWS3M3X37	6	16	42.25	32.25	48.09	11.81	36.28	12.41	35.68
MWSNSM1X37	30	40	17.66	7.66	50.18	10.07	40.11	10.26	39.92
MWSNSM2X37	5	20	42.6	27.6	50.09	10	40.09	10.22	39.87
MWSNSM3X37	No Data	No Data	No Data	No Data	45.33	9.61	35.72	9.5	35.83
MWSNSM4X37	No Data	No Data	No Data	No Data	53.10	9.21	43.89	9.98	43.12
MWSNSM5X37	5	20	33.13	18.13	40.87	12.74	28.13	12.87	28
MWSSBM1X37	No Data	No Data	No Data	No Data	44.05	9.09	34.96	9.55	34.5
MWSSBM2X37	No Data	No Data	No Data	No Data	39.72	9.2	30.52	9.48	30.24
PZ546X37	14.5	24.5	30	20	44.28	NM	NM	8.74	35.54
PZ547X37	14.5	24.5	30	20	44.12	8.54	35.58	8.73	35.39
PZ548X37	14.5	24.5	30	20	43.92	8.31	35.61	8.34	35.58
PZ597x37	No Data	No Data	No Data	No Data	43.92	NM	NM	NM	NM

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: SD037									
PZ598x37	15	25	29.12	19.12	44.12	NM	NM	NM	NM
Site: SS041									
MW01X41	5	15	38.9	28.9	43.61	8.95	34.66	9.74	33.87
MW02X41	17	27	26.6	16.6	43.47	10.43	33.04	11.02	32.45
PZ02X41	18	23	25.72	20.72	43.72	10.03	33.69	10.71	33.01
Site: SD042									
PZ03X42	35	40	28.9	23.9	63.53	NM	NM	30.5	33.03
Site: SD043									
EW555X43	12	22	32.4	22.4	42.39	NM	NM	NM	NM
MW543X43	13	38	19.74	-5.26	43.01	9.8	33.21	10.33	32.68
MW544X43	11	36	21.3	-3.7	42.24	9.39	32.85	10.01	32.23
MW545X43	13	38	19.63	-5.37	43.25	10.3	32.95	10.71	32.54

Note: Grouped by Site and sorted by Location.
btoc = below top of casing
NM = not measured
bgs = below ground surface
msl = mean sea level

TABLE 6-2
WIOU Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base, California

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW506x33	MW507x33	-0.02	0.002	0.005	0.002
MW02x35	MW818x35	-0.004	0.001	-0.001	0.004
PZ06Dx36	PZ06Sx36	-0.01	NA	-0.8	-0.007
PZ11Dx36	PZ11Sx36	-0.004	0.02	0.02	-0.001
PZ19Dx36	PZ19Sx36	-0.009	-0.002	-0.002	-0.001
MW310x37	MW116x37	-0.004	0.002	0.002	0.007
MW535x37	MW512x37	-0.09	-0.06	-0.1	-0.096
MW531x37	PZ548x37	0.000	-0.005	0.004	0.000
MW596x37	MW529x37	-0.006	-0.003	-0.002	-0.005
MWSNSM1x37	MWSNSM2x37	0.001	0.001	0.001	0.002

Note:
Minus sign indicates downward vertical gradient.

TABLE 6-3
Aquifer Test Results for WIOU
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
SS033	MW270x33	9.6–19.6	9/12/91	Rising head slug	15	5% silt; 95% clay
	EW03x33	10–30	7/9/99	Pumping	20	55% clayey sand; 40% clay; 5% gravel
SD036	EW01x36	10–50	8/17/99	Pumping	0.9	50% clayey sand; 40% clay; 10% gravel
SD037	MW222x37	9–24	1988	Gravity-injection	0.1	10% clayey sand; 90% silt
	MW223x37	5.5–20.5	1988	Recovery	60	50% silty, clayey, well-sorted sand; 50% silt and clay
	MW224x37	5–20	1988	Recovery	25	80% silty, clayey sand; 20% silt
	MW04x37	7–22	1996	Pumping	5	NA
	MW531x37	26–36	7/14/98	Pumping	2	80% sandy clay; 20% clayey sand
	MW500x37	19.5–29.5	7/9/98	Pumping	1	80% sand with clay; 20% sandy clay
	MW838x37	5–20	7/16/98	Pumping	5	NA
	MW919x37	5–20	4/22/99	Pumping	3	NA
	EW700x37	10–40	8/30/99	Pumping	7	50% clayey sand; 40% clay; 5% well-graded sand; 5% gravel
	EW703x37	11–31	9/3/99	Pumping	1.2	50% clayey sand; 50% clay
	EW705x37	10–35	8/6/99	Pumping	1	50% clay; 30% poorly-graded sand; 20% silt
	EW707x37	15–45	6/29/99	Pumping	1.3	55% clay; 45% fine sand

Notes:
NA = data not available
Source: CH2M HILL, 2004.

TABLE 6-4

Summary of Analytes Detected in MNA Wells at WIOU in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: SS014							
MW02X14							
	5/6/2008	SW8260	Benzene	**4500**	J	µg/L	1
	5/6/2008	SW8260	Ethylbenzene	**710**	J	µg/L	700
	5/6/2008	SW8260	m,p-Xylene	**3600**	J	µg/L	1750
	5/6/2008	SW8260	o-Xylene	720	J	µg/L	1750
	5/6/2008	SW8260	Toluene	12	J	µg/L	150
	5/6/2008	SW8015-E	TPH-Diesel	**3300**		µg/L	100
	5/6/2008	SW8015-P	TPH-Gasoline	**32000**		µg/L	5
	1/6/2009	E310	Alkalinity	161		mg/L	
	1/6/2009	E300	Chloride	53.4		mg/L	
	1/6/2009	E300	Nitrite	0.59		mg/L	
	1/6/2009	SM4500S2	Sulfide	0.752	J	mg/L	
	1/6/2009	A5310B	Total Organic Carbon	14.5		mg/L	
	1/6/2009	SW8260	Acetone	25.6		µg/L	5110
	1/6/2009	SW8260	Benzene	**584**		µg/L	1
	1/6/2009	SW8260	Ethylbenzene	47.2		µg/L	700
	1/6/2009	SW8260	m,p-Xylene	528		µg/L	1750
	1/6/2009	RSK-175	Methane	4060		µg/L	
	1/6/2009	E300	Nitrate	1.36		mg/L	
	1/6/2009	SW8260	o-Xylene	195		µg/L	1750
	1/6/2009	E300	Sulfate	70.8		mg/L	
	1/6/2009	SW8015-E	TPH-Diesel	**1300**		µg/L	100
	1/6/2009	SW8015-P	TPH-Gasoline	**11400**		µg/L	5
MW05X14							
	5/6/2008	SW8260	1,2-DCB	0.14	J	µg/L	
	5/6/2008	SW8015-E	TPH-Diesel	**580**		µg/L	100
	5/6/2008	SW8015-P	TPH-Gasoline	**700**		µg/L	5
	12/22/2008	E310	Alkalinity	464		mg/L	
	12/22/2008	E300	Chloride	236		mg/L	
	12/22/2008	SM4500S2	No Analytes Detected				
	12/22/2008	A5310B	Total Organic Carbon	8.9		mg/L	
	12/22/2008	RSK-175	Methane	1220	J+	µg/L	
	12/22/2008	SW8260	Methyl tert-butyl ether (MTBE)	3.1	J	µg/L	13
	12/22/2008	E300	Sulfate	1.41	J	mg/L	
	12/22/2008	SW8015-E	TPH-Diesel	**740**		µg/L	100
	12/22/2008	SW8015-P	TPH-Gasoline	**1000**		µg/L	5

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result[a]	Flag	Units	IRG
Site: SD037							
MW116X37							
	4/29/2008	SW8260	Acetone	3.4	J	µg/L	5110
	4/29/2008	SW8260	Methyl tert-butyl ether (MTBE)	11		µg/L	13
	4/29/2008	SW8260	Methylene chloride	0.39	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	TPH-Gasoline	**24**	J	µg/L	5
	12/19/2008	SW8260	Methyl tert-butyl ether (MTBE)	12.7	J	µg/L	13
	12/19/2008	SW8015-P	TPH-Gasoline	**44**	J	µg/L	5
	12/19/2008	SW8015-E	No Analytes Detected				
MW222X37							
	4/29/2008	SW8260	Acetone	2	J	µg/L	5110
	4/29/2008	SW8260	Methylene chloride	0.39	J	µg/L	5
	4/29/2008	SW8015-P	No Analytes Detected				
	4/29/2008	SW8015-E	TPH-Diesel	48	J	µg/L	100
MW310X37							
	4/29/2008	SW8260	Methyl tert-butyl ether (MTBE)	6.1		µg/L	13
	4/29/2008	SW8260	Methylene chloride	0.39	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	TPH-Gasoline	**11**	J	µg/L	5
	12/19/2008	SW8260	Methyl tert-butyl ether (MTBE)	**13.5**	J	µg/L	13
	12/19/2008	SW8015-P	No Analytes Detected				
	12/19/2008	SW8015-E	No Analytes Detected				
MW513X37							
	5/7/2008	SW8260	Acetone	2	J	µg/L	5110
	5/7/2008	SW8260	Chloroform	0.23	J	µg/L	100
	5/7/2008	SW8260	Cis-1,2-DCE	0.36	J	µg/L	6
	5/7/2008	SW8260	Methylene chloride	0.52	J	µg/L	5
	5/7/2008	SW8015-E	No Analytes Detected				
	5/7/2008	SW8260	TCE	**75**		µg/L	5
	5/7/2008	SW8015-P	TPH-Gasoline	**5.9**	J	µg/L	5
	12/18/2008	E310	Alkalinity	270		mg/L	
	12/18/2008	E300	Chloride	45.8		mg/L	
	12/18/2008	SM4500S2	Sulfide	0.556	J	mg/L	
	12/18/2008	A5310B	Total Organic Carbon	4.73		mg/L	
	12/18/2008	E300	Nitrate	5.89	J	mg/L	
	12/18/2008	RSK-175	No Analytes Detected				
	12/18/2008	E300	Sulfate	190		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte
[a] Bold values indicate result greater than IRGs

TABLE 6-4

Summary of Analytes Detected in MNA Wells at WIOU in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD037							
MW513X37							
	12/18/2008	SW8260	TCE	**33**		µg/L	5
MW524X37							
	5/8/2008	SW8260	Acetone	25	J	µg/L	5110
	5/8/2008	SW8260	Cis-1,2-DCE	**69**		µg/L	6
	5/8/2008	SW8260	Methylene chloride	**5.6**	J	µg/L	5
	5/8/2008	SW8015-E	No Analytes Detected				
	5/8/2008	SW8260	TCE	**1600**		µg/L	5
	5/8/2008	SW8015-P	TPH-Gasoline	**69**	J	µg/L	5
	5/8/2008	SW8260	trans-1,2-DCE	29		µg/L	
	12/22/2008	E310	Alkalinity	439		mg/L	
	12/22/2008	E300	Chloride	43		mg/L	
	12/22/2008	SM4500S2	Sulfide	0.74	J-	mg/L	
	12/22/2008	A5310B	Total Organic Carbon	3.93		mg/L	
	12/22/2008	SW8260	1,1-DCE	1.1		µg/L	6
	12/22/2008	SW8260	Chloroform	0.59	J	µg/L	100
	12/22/2008	SW8260	Cis-1,2-DCE	**71**		µg/L	6
	12/22/2008	E300	Nitrate	1.86	J-	mg/L	
	12/22/2008	RSK-175	No Analytes Detected				
	12/22/2008	SW8015-E	No Analytes Detected				
	12/22/2008	SW8260	PCE	0.56		µg/L	5
	12/22/2008	E300	Sulfate	185		mg/L	
	12/22/2008	SW8260	TCE	**1420**		µg/L	5
	12/22/2008	SW8015-P	TPH-Gasoline	**580**		µg/L	5
	12/22/2008	SW8260	trans-1,2-DCE	30.9		µg/L	
MW531X37							
	5/12/2008	SW8260	1,1-DCE	0.47	J	µg/L	6
	5/12/2008	SW8260	Acetone	3.5	J	µg/L	5110
	5/12/2008	SW8260	Chloroform	0.16	J	µg/L	100
	5/12/2008	SW8260	Cis-1,2-DCE	**31**		µg/L	6
	5/12/2008	SW8015-E	No Analytes Detected				
	5/12/2008	SW8260	PCE	1.6		µg/L	5
	5/12/2008	SW8260	TCE	**500**		µg/L	5
	5/12/2008	SW8015-P	TPH-Gasoline	**19**	J	µg/L	5
	5/12/2008	SW8260	trans-1,2-DCE	0.39	J	µg/L	
	5/12/2008	SW8260	Vinyl chloride	**6.5**		µg/L	0.5
	12/18/2008	E310	Alkalinity	324		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 6-4

Summary of Analytes Detected in MNA Wells at WIOU in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD037							
MW531X37							
	12/18/2008	E300	Chloride	138		mg/L	
	12/18/2008	SM4500S2	Sulfide	1.24		mg/L	
	12/18/2008	A5310B	Total Organic Carbon	6.36		mg/L	
	12/18/2008	SW8260	Cis-1,2-DCE	**32.4**		µg/L	6
	12/18/2008	RSK-175	No Analytes Detected				
	12/18/2008	SW8015-E	No Analytes Detected				
	12/18/2008	SW8260	PCE	1.9		µg/L	5
	12/18/2008	E300	Sulfate	39.9		mg/L	
	12/18/2008	SW8260	TCE	**501**		µg/L	5
	12/18/2008	SW8015-P	TPH-Gasoline	**220**		µg/L	5
	12/18/2008	SW8260	Vinyl chloride	**5.2**		µg/L	0.5
MW540X37							
	5/8/2008	SW8260	1,1-DCE	0.19	J	µg/L	6
	5/8/2008	SW8260	Chloroform	0.17	J	µg/L	100
	5/8/2008	SW8260	Cis-1,2-DCE	**26**		µg/L	6
	5/8/2008	SW8260	Methylene chloride	0.37	J	µg/L	5
	5/8/2008	SW8015-E	No Analytes Detected				
	5/8/2008	SW8260	PCE	**49**		µg/L	5
	5/8/2008	SW8260	TCE	**100**		µg/L	5
	5/8/2008	SW8015-P	TPH-Gasoline	**38**	J	µg/L	5
	5/8/2008	SW8260	trans-1,2-DCE	0.15	J	µg/L	
	12/18/2008	E310	Alkalinity	394		mg/L	
	12/18/2008	E300	Chloride	199		mg/L	
	12/18/2008	SM4500S2	Sulfide	0.661	J	mg/L	
	12/18/2008	A5310B	Total Organic Carbon	2.88		mg/L	
	12/18/2008	SW8260	Cis-1,2-DCE	**22.5**		µg/L	6
	12/18/2008	E300	Nitrate	2.56		mg/L	
	12/18/2008	RSK-175	No Analytes Detected				
	12/18/2008	SW8015-E	No Analytes Detected				
	12/18/2008	SW8260	PCE	**37.4**		µg/L	5
	12/18/2008	E300	Sulfate	25		mg/L	
	12/18/2008	SW8260	TCE	**74.7**		µg/L	5
	12/18/2008	SW8015-P	TPH-Gasoline	**56**		µg/L	5
MW722X37							
	4/30/2008	SW8260	1,1-DCA	0.77		µg/L	
	4/30/2008	SW8260	1,1-DCE	0.36	J	µg/L	6

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 6-4

Summary of Analytes Detected in MNA Wells at WIOU in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD037							
MW722X37							
	4/30/2008	SW8260	Cis-1,2-DCE	1.4		µg/L	6
	4/30/2008	SW8260	Methylene chloride	0.34	J	µg/L	5
	4/30/2008	SW8015-E	No Analytes Detected				
	4/30/2008	SW8260	PCE	1.1		µg/L	5
	4/30/2008	SW8260	TCE	**16**		µg/L	5
	4/30/2008	SW8015-P	TPH-Gasoline	**7.8**	J	µg/L	5
	12/18/2008	E310	Alkalinity	369		mg/L	
	12/18/2008	E300	Chloride	202		mg/L	
	12/18/2008	SM4500S2	Sulfide	0.75	J	mg/L	
	12/18/2008	A5310B	Total Organic Carbon	5.04		mg/L	
	12/18/2008	SW8260	1,1-DCA	0.86	J	µg/L	
	12/18/2008	SW8260	Cis-1,2-DCE	0.99	J	µg/L	6
	12/18/2008	E300	Nitrate	4.5		mg/L	
	12/18/2008	RSK-175	No Analytes Detected				
	12/18/2008	SW8015-E	No Analytes Detected				
	12/18/2008	SW8015-P	No Analytes Detected				
	12/18/2008	SW8260	PCE	1.2		µg/L	5
	12/18/2008	E300	Sulfate	122		mg/L	
	12/18/2008	SW8260	TCE	**16.2**		µg/L	5
MW723X37							
	4/30/2008	SW8260	Cis-1,2-DCE	0.38	J	µg/L	6
	4/30/2008	SW8015-E	No Analytes Detected				
	4/30/2008	SW8260	TCE	3.1		µg/L	5
	4/30/2008	SW8015-P	TPH-Gasoline	5	J	µg/L	5
MW724X37							
	5/15/2008	SW8260	Methylene chloride	0.36	J	µg/L	5
	5/15/2008	SW8015-E	No Analytes Detected				
	5/15/2008	SW8015-P	No Analytes Detected				
	5/15/2008	SW8260	TCE	0.9		µg/L	5
	12/18/2008	E310	Alkalinity	338		mg/L	
	12/18/2008	E300	Chloride	182		mg/L	
	12/18/2008	SM4500S2	Sulfide	0.729	J	mg/L	
	12/18/2008	A5310B	Total Organic Carbon	3.25		mg/L	
	12/18/2008	E300	Nitrate	2.03		mg/L	
	12/18/2008	RSK-175	No Analytes Detected				
	12/18/2008	SW8015-P	No Analytes Detected				

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD037							
MW724X37							
	12/18/2008	SW8260	No Analytes Detected				
	12/18/2008	E300	Sulfate	29.9		mg/L	
	12/18/2008	SW8015-E	TPH-Diesel	**120**		µg/L	100
MW729X37							
	4/29/2008	SW8260	Methylene chloride	0.38	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	No Analytes Detected				
MW730X37							
	4/29/2008	SW8260	Methylene chloride	0.38	J	µg/L	5
	4/29/2008	SW8015-E	No Analytes Detected				
	4/29/2008	SW8015-P	TPH-Gasoline	**6.9**	J	µg/L	5
MW1208X37							
	5/15/2008	SW8260	Cis-1,2-DCE	0.19	J	µg/L	6
	5/15/2008	SW8015-E	No Analytes Detected				
	5/15/2008	SW8015-P	No Analytes Detected				
	5/15/2008	SW8260	TCE	**7.4**		µg/L	5
	12/16/2008	E310	Alkalinity	208		mg/L	
	12/16/2008	E300	Chloride	238		mg/L	
	12/16/2008	E300	Nitrite	0.158		mg/L	
	12/16/2008	SM4500S2	No Analytes Detected				
	12/16/2008	A5310B	Total Organic Carbon	4.05		mg/L	
	12/16/2008	E300	Nitrate	5.23	J-	mg/L	
	12/16/2008	RSK-175	No Analytes Detected				
	12/16/2008	SW8015-E	No Analytes Detected				
	12/16/2008	SW8015-P	No Analytes Detected				
	12/16/2008	E300	Sulfate	27.2		mg/L	
	12/16/2008	SW8260	TCE	**7.9**		µg/L	5
MWS1M2X37							
	5/15/2008	SW8260	Acetone	2	J	µg/L	5110
	5/15/2008	SW8260	Methyl tert-butyl ether (MTBE)	2.1		µg/L	13
	5/15/2008	SW8260	Methylene chloride	0.36	J	µg/L	5
	5/15/2008	SW8015-E	No Analytes Detected				
	5/15/2008	SW8015-P	No Analytes Detected				
	12/18/2008	E310	Alkalinity	496		mg/L	
	12/18/2008	E300	Chloride	402		mg/L	
	12/18/2008	SM4500S2	Sulfide	0.75	J	mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte
[a] Bold values indicate result greater than IRGs

TABLE 6-4

Summary of Analytes Detected in MNA Wells at WIOU in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: SD037							
MWS1M2X37							
	12/18/2008	A5310B	Total Organic Carbon	3.59		mg/L	
	12/18/2008	RSK-175	Ethane	0.21	J	µg/L	
	12/18/2008	SW8260	Methyl tert-butyl ether (MTBE)	4.2		µg/L	13
	12/18/2008	E300	Nitrate	3.28		mg/L	
	12/18/2008	SW8015-P	No Analytes Detected				
	12/18/2008	E300	Sulfate	30.5		mg/L	
	12/18/2008	SW8015-E	TPH-Diesel	91	J	µg/L	100

Qualifier Description
J = The analyte was positively identified, the quantitation is an estimate.
F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
B = The analyte was found in an associated blank, as well as in the sample.
M = A matrix effect was present.
none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 6-5
WIOU Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Plume						Distal		
				MW07x14	MW524x37	MW513x37	MW531x37	MW540x37	MW722x37	MW1208x37	MW02x14	MWS1M2x37	MW724x37	MW05x14
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	0	0	3	3	3	0	3	0	0	0	3
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	-3	0	0	0	0	0	0	0	0	0	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	0	0	0	0	0	0	0	0	2
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0	0	0	3
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	2	0	0	0	0	0	0	0	0	0	2
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	3	0	0	0	0	0	0	0
Methane[b]	<0.5 mg/L	VC oxidizes	0	0	0	0	0	0	0	0	3	0	0	3
	>0.5 mg/L	Ultimate reductive daughter product; VC accumulates	3											
ORP[b]	<50 mV	Reductive pathway possible	1	0	1	0	2	1	0	0	1	0	0	2
	<-100 mV	Reductive pathway likely	2											
pH[b]	5< pH <9	Optimal range for reductive pathway	0	0	0	0	0	0	0	0	0	0	0	0
	5> pH >9	Outside optimal range for reductive pathway	-2											
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	0	0	0	0	0	0	0	0	0	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	1	0	0	0	0	0	0	1	0	0	0
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	0	0	0	0	0	0	0	0	0	0	0
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	0	0	0	0	0	0	0	0	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0	0	0	0	2	0	0	0
PCE[b]		Material released	0	0	0	0	0	0	0	0	0	0	0	0
TCE[b]		Material released	0	0	0	0	0	0	0	0	0	0	0	0
		Daughter product of PCE	2[c]											
DCE[b] (all isomers[d])		Materials released	0	0	2	0	2	2	0	0	0	0	0	0
		Daughter product of TCE	2[c]											

TABLE 6-5
WIOU Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source	Plume						Distal		
				MW07x14	MW524x37	MW513x37	MW531x37	MW540x37	MW722x37	MW1208x37	MW02x14	MWS1M2x37	MW724x37	MW05x14
VC		Material released	0	0	0	0	2	0	0	0	0	0	0	0
		Daughter product of DCE	2[c]											
Ethene/ethane	>0.01 mg/L	Daughter product of VC/ethane	2	0	0	0	0	0	0	0	0		0	0
	>0.1 mg/L		3											
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	0	0	0	0	0	0	0	0	0	0
			Sum[e]	**0**	**+3**	**+3**	**+12**	**+6**	**0**	**+3**	**+7**	**0**	**0**	**+15**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C = degree(s) Celsius
mg/L = milligram(s) per liter
mV = millivolt(s)
NA = not analyzed
TCA = trichloroethane

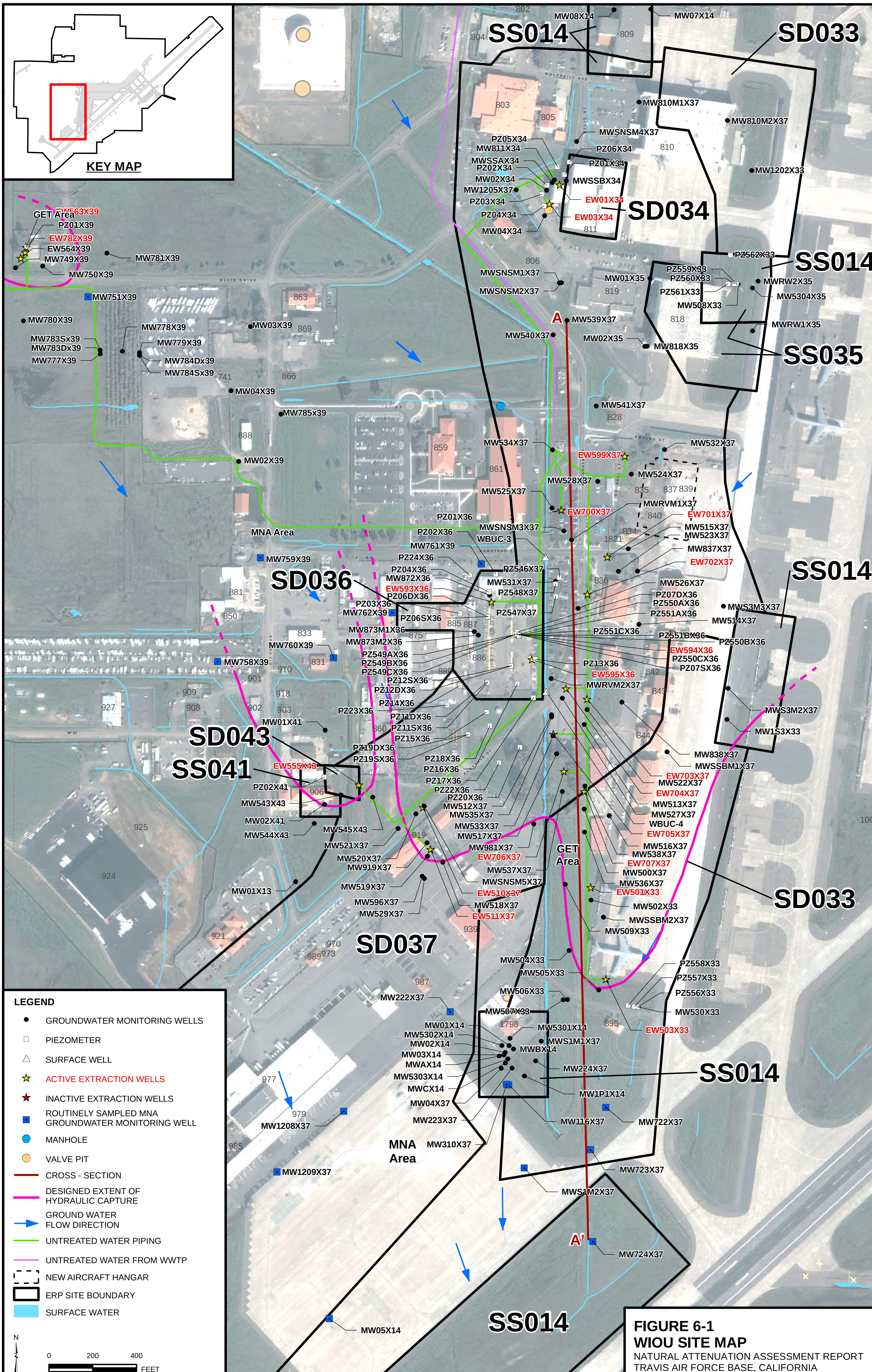


FIGURE 6-1
WIOU SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG6-1_WIOU_SITE.MXD MCLAY1 6/28/2010

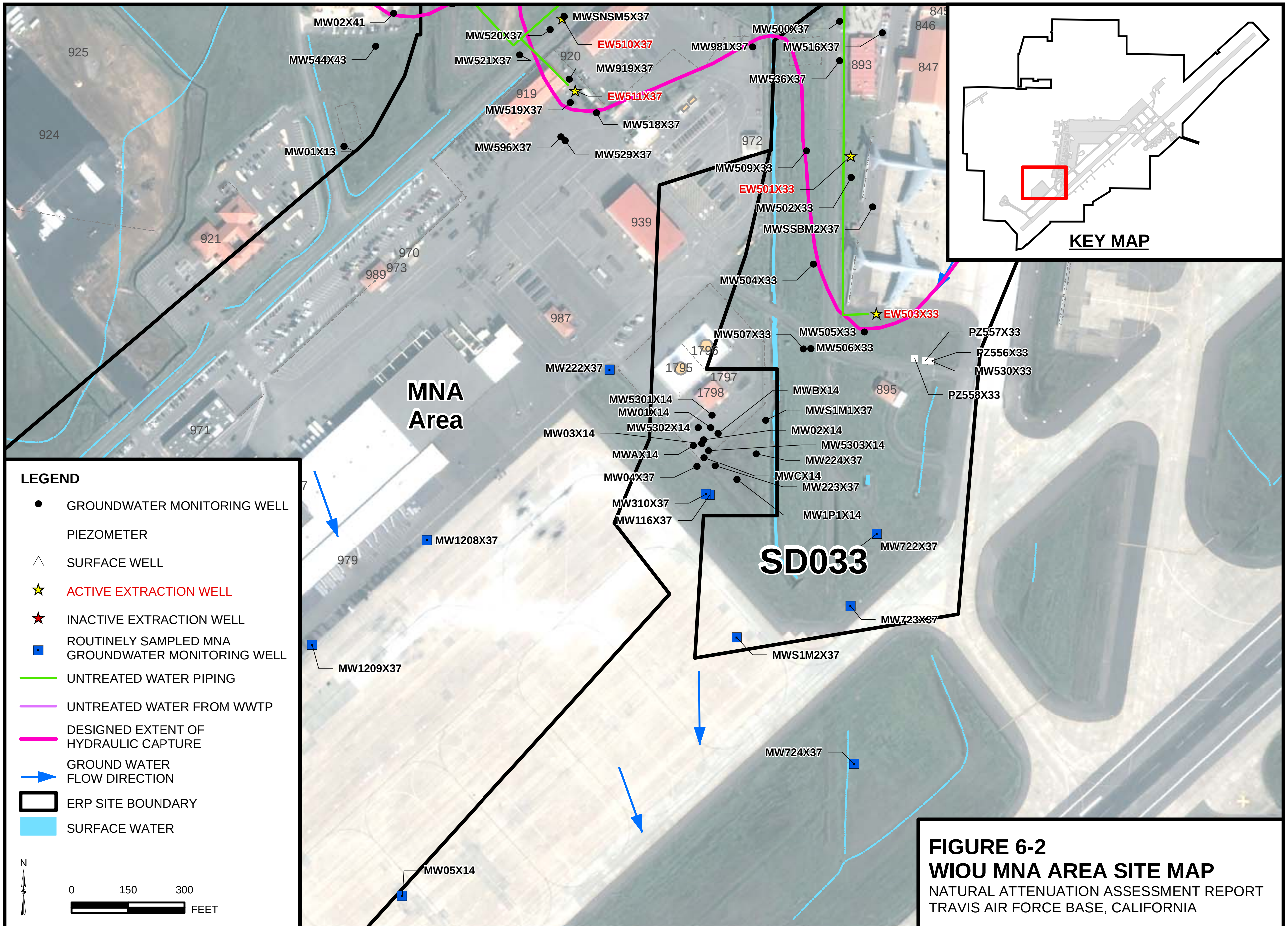
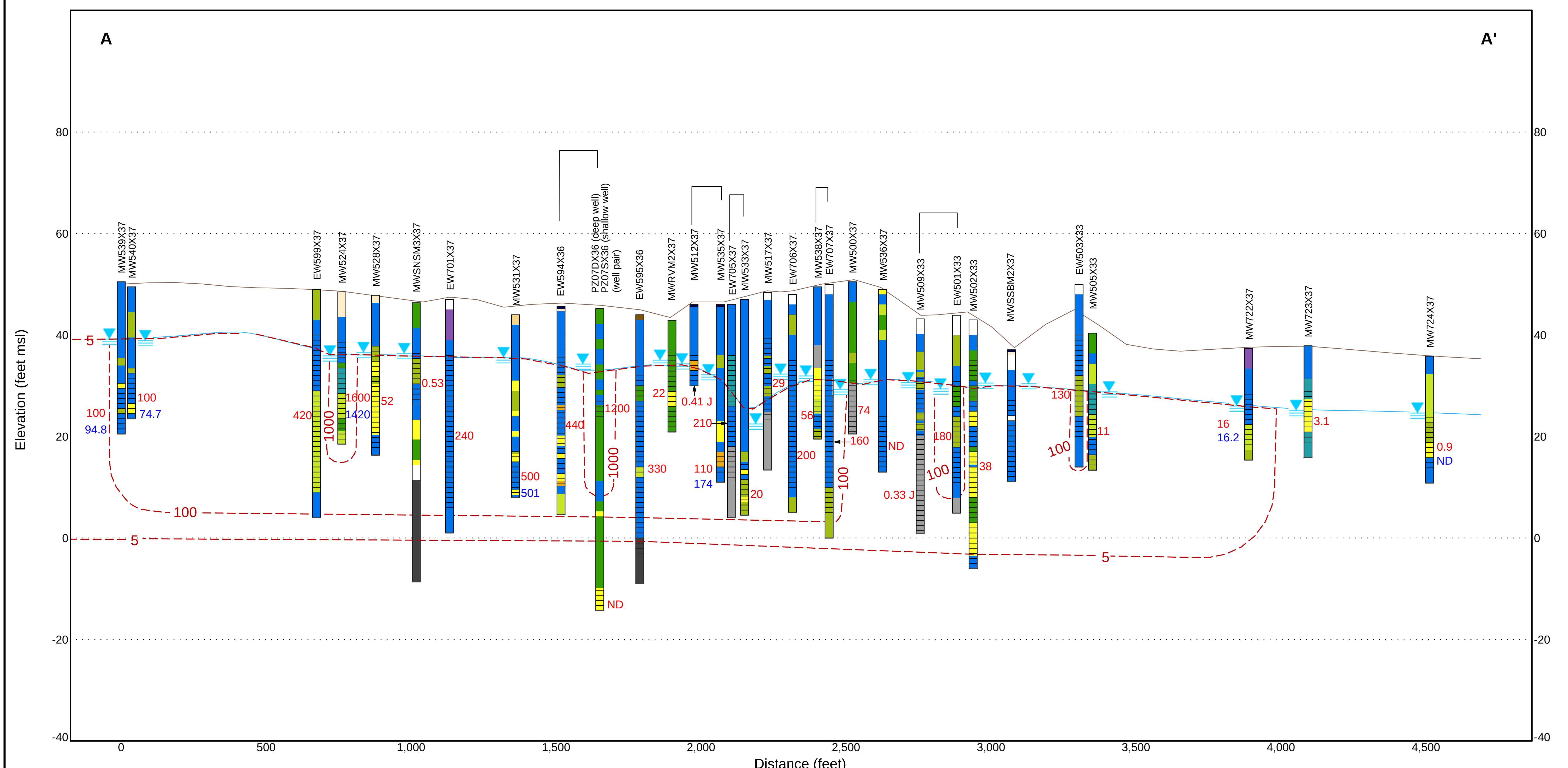


FIGURE 6-2
WIOU MNA AREA SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA



SOIL AND LITHOLOGY

SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

-5- APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L) BASED ON MAX 2008 DETECTION

SCALE EXAGGERATION - 17.5:1 (H:V)

NOTE: SEE FIGURE 6-4 FOR CROSS SECTION LINE

NO SAMPLE/NO RECOVERY
FILL/ASPHALT
WELL GRADED GRAVEL (GW)
POORLY GRADED GRAVEL (GP)
SILTY GRAVEL (GM)
CLAYEY GRAVEL (GC)

WELL GRADED SAND (SW)
POORLY GRADED SAND (SP)
SILTY SAND (SM)
CLAYEY SAND (SC)
SILT (ML)
ELASTIC SILT (MH)

LEAN CLAY (CL)
FAT CLAY (CH)
SILTSTONE
SANDSTONE
SHALE

FIGURE 6-3
WIOU GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

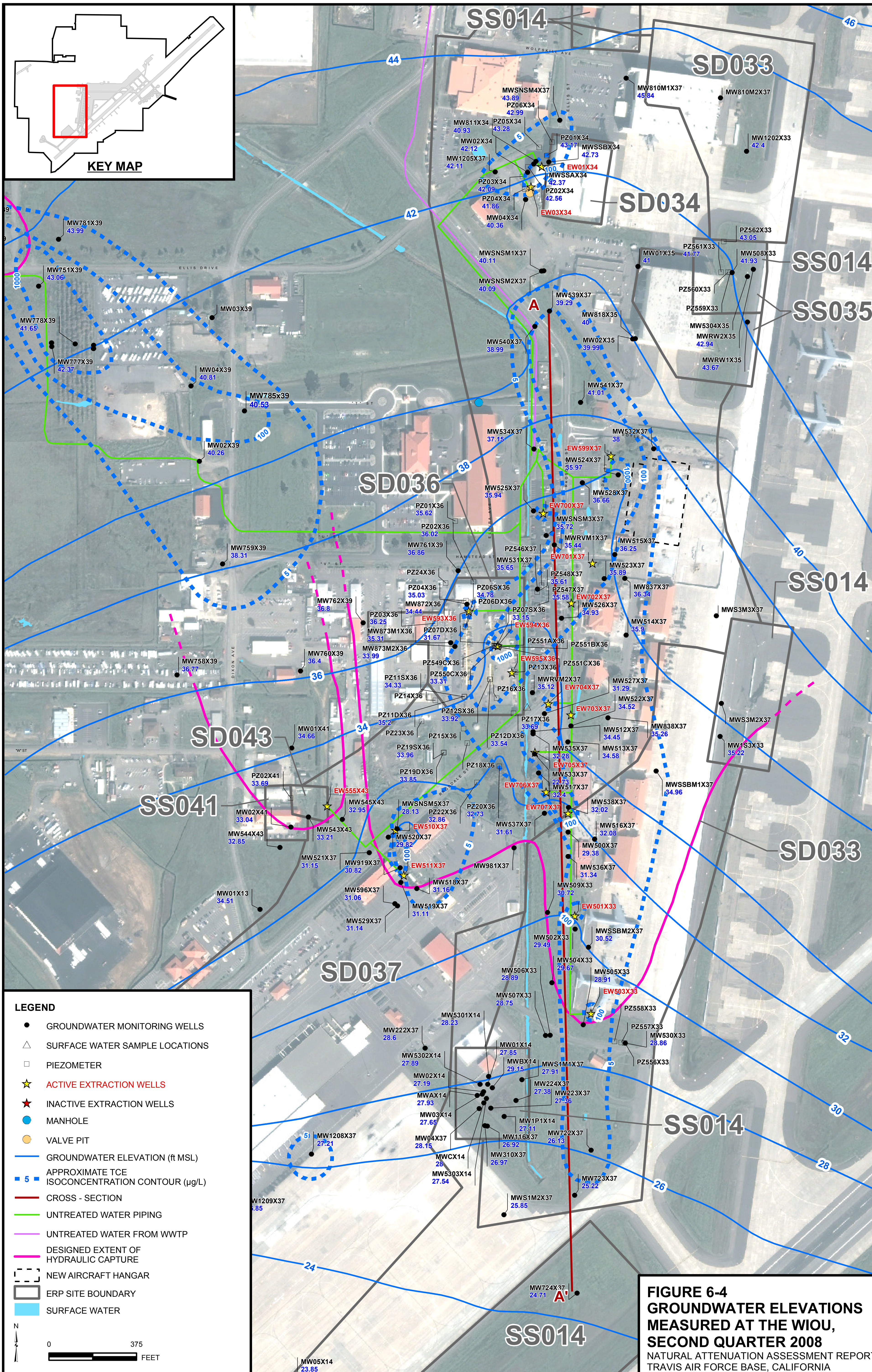


FIGURE 6-4
GROUNDWATER ELEVATIONS MEASURED AT THE WIOU, SECOND QUARTER 2008
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG6-4_WIOU_GW_2008.MXD MCLAY1 1/22/2010

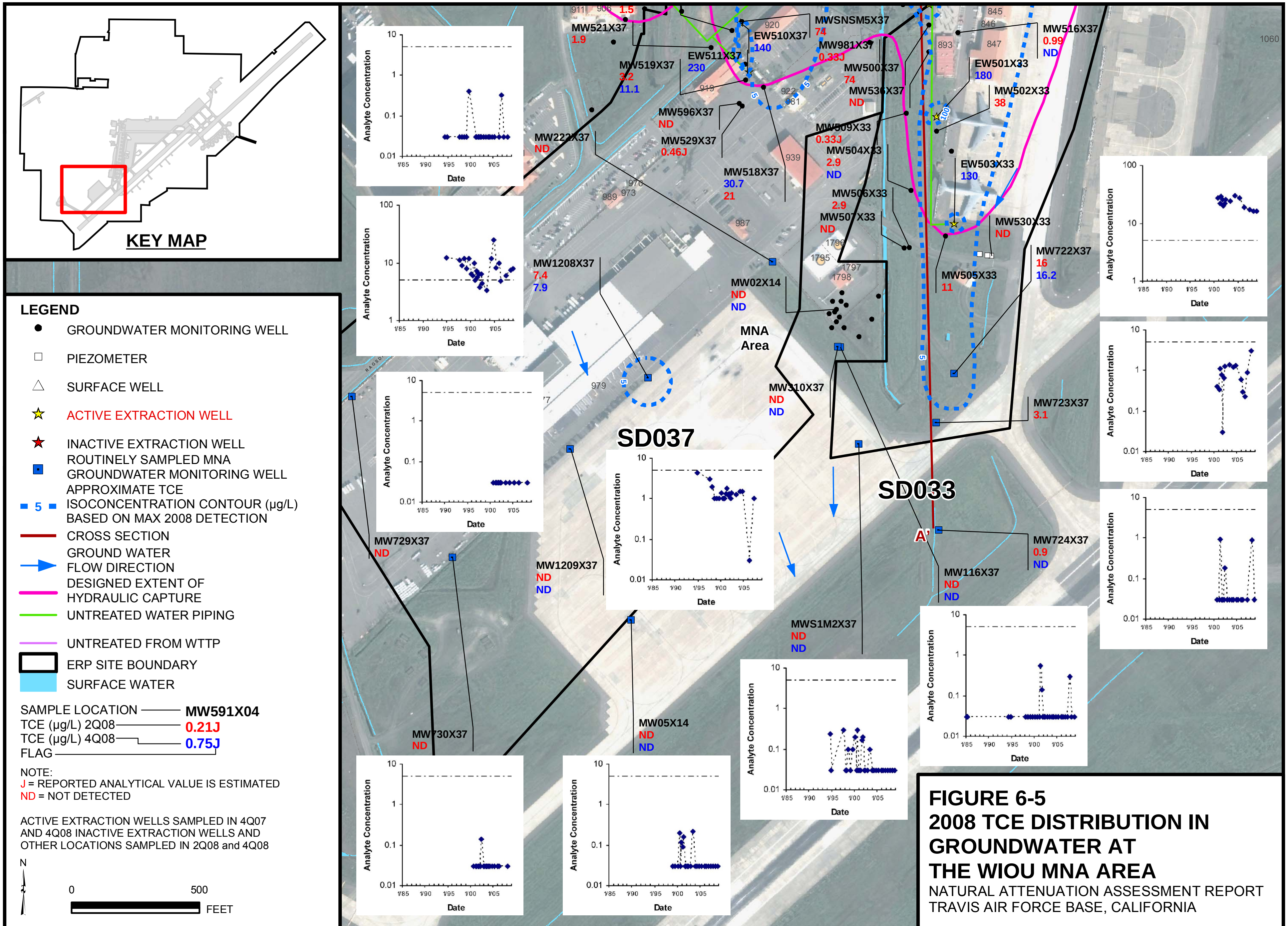
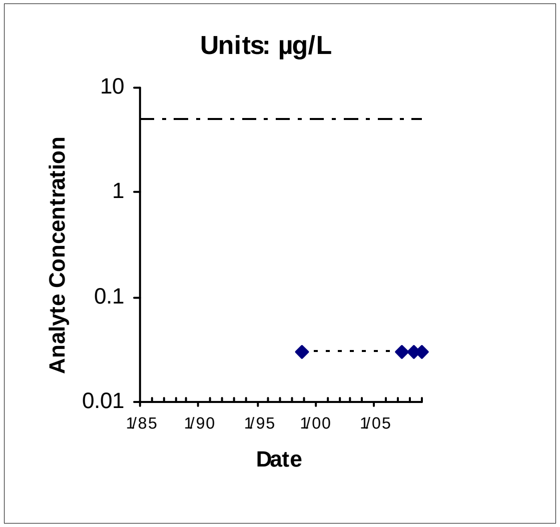


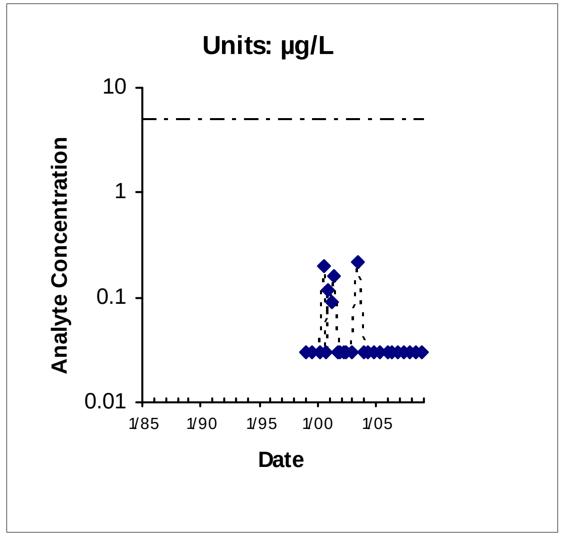
FIGURE 6-5
2008 TCE DISTRIBUTION IN GROUNDWATER AT THE WIOU MNA AREA
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

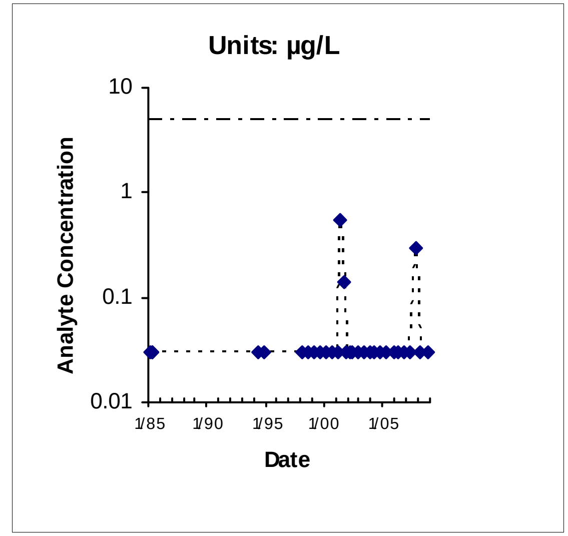
RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_MAY2010\FIG6-5_WIOU_MNA_TCE.MXD JQUAN 6/2/2010 09:55:18



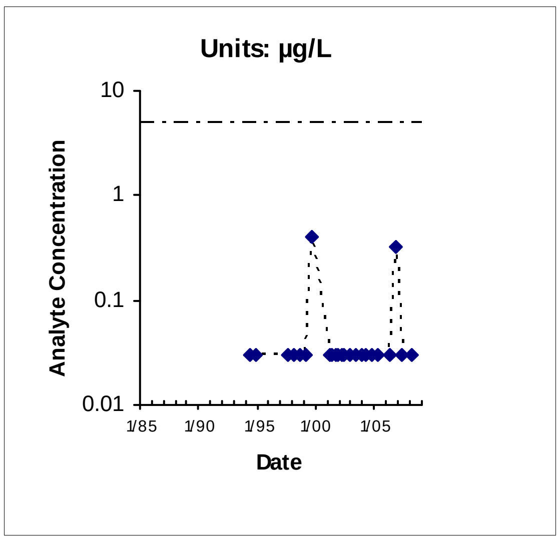
Location: MW02X14 Maximum: 0.03



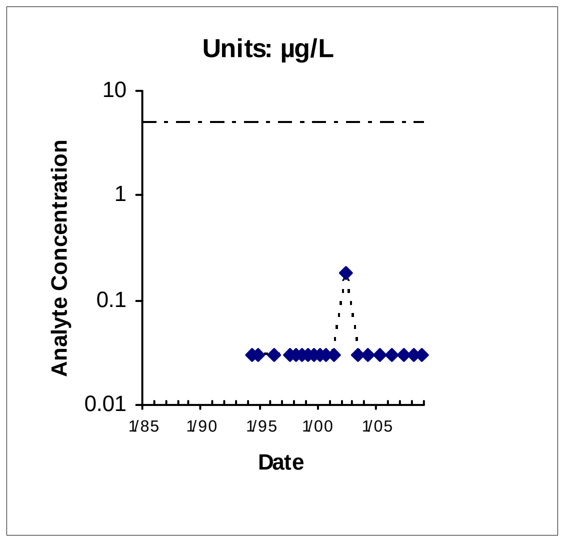
Location: MW05X14 Maximum: 0.22



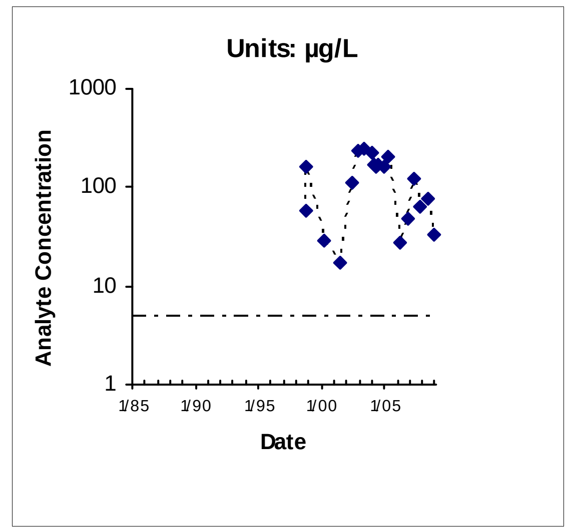
Location: MW116X37 Maximum: 0.56



Location: MW222X37 Maximum: 0.4



Location: MW310X37 Maximum: 0.18



Location: MW513X37 Maximum: 242

FIGURE 6-6

WIOU MNA Wells

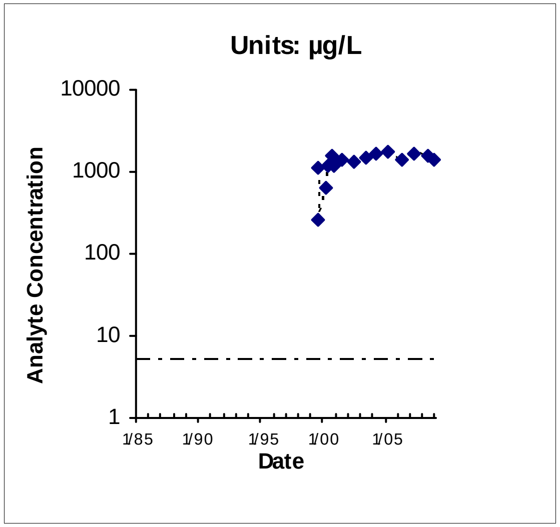
TCE

Chemical Time-series Plots

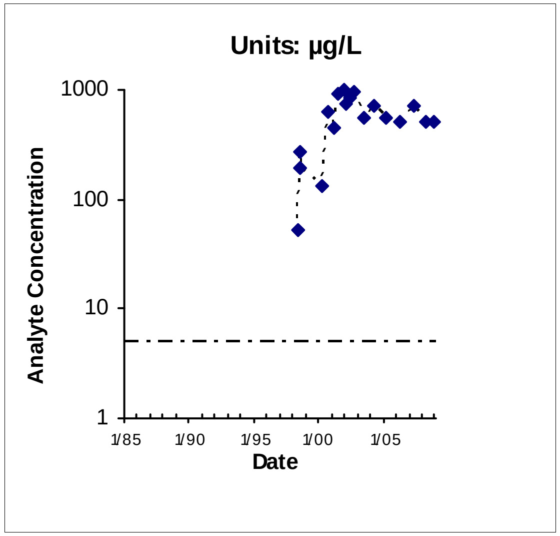
Page 1 of 3

— - — - — IRG (5 µg/L)

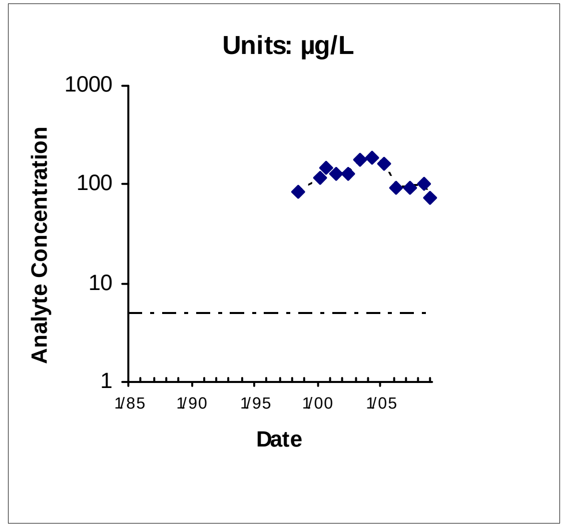
*Nondetects shown as the Method Detection Limit (0.03 µg/L)



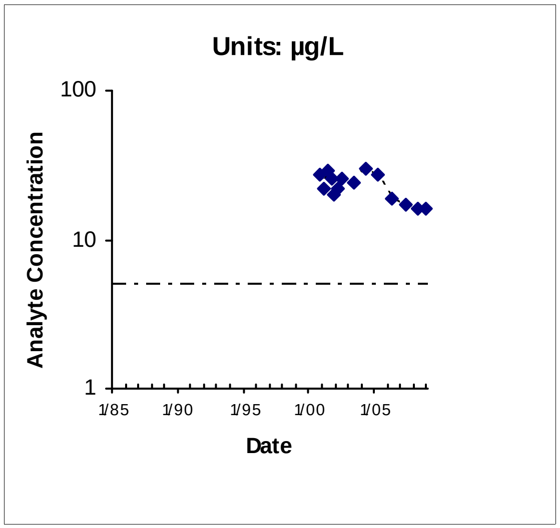
Location: MW524X37 Maximum: 1800



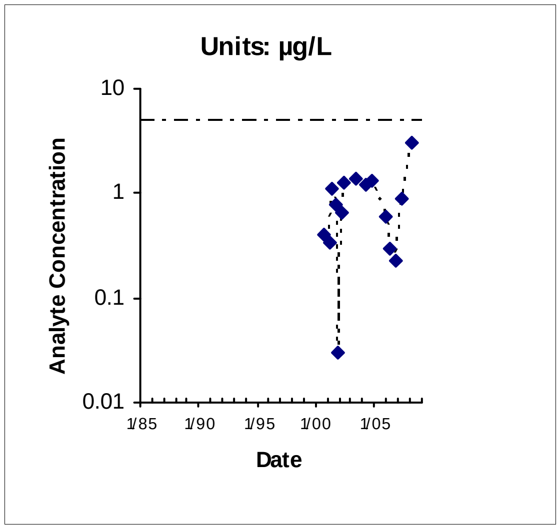
Location: MW531X37 Maximum: 1000



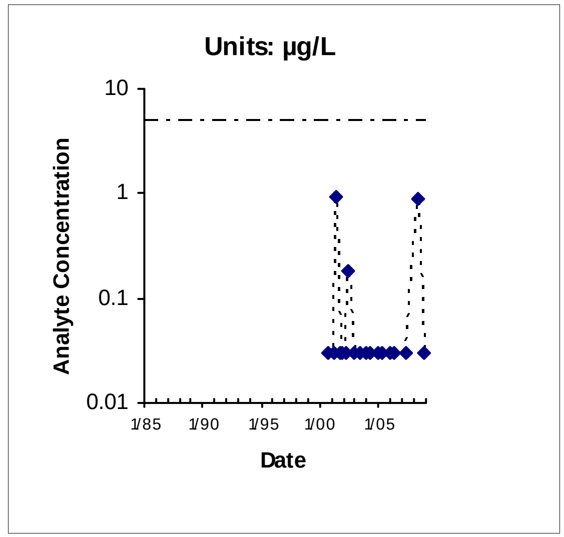
Location: MW540X37 Maximum: 190



Location: MW722X37 Maximum: 30



Location: MW723X37 Maximum: 3.1



Location: MW724X37 Maximum: 0.93

— - — - — IRG (5 µg/L)

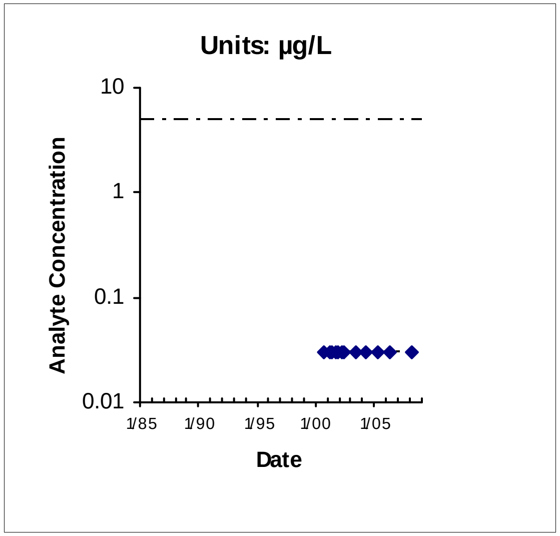
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 6-6

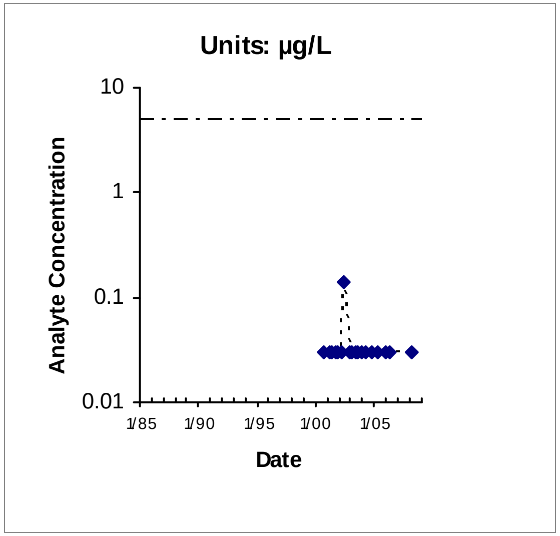
WIOU MNA Wells

TCE

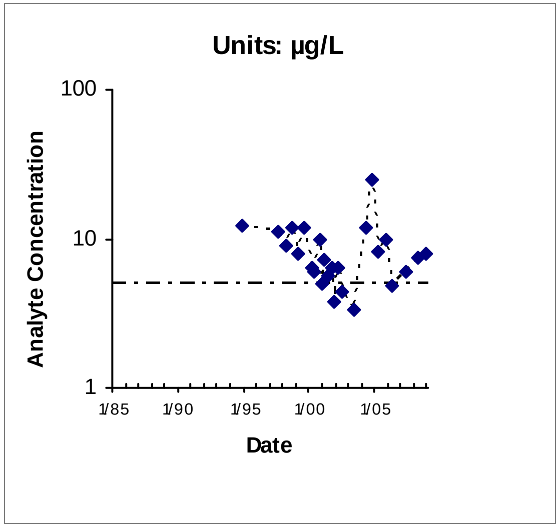
Chemical Time-series Plots



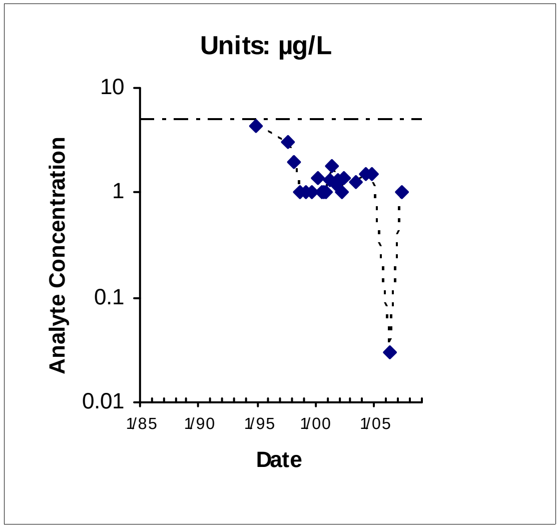
Location: MW729X37 Maximum: 0.03



Location: MW730X37 Maximum: 0.14



Location: MW1208X37 Maximum: 25



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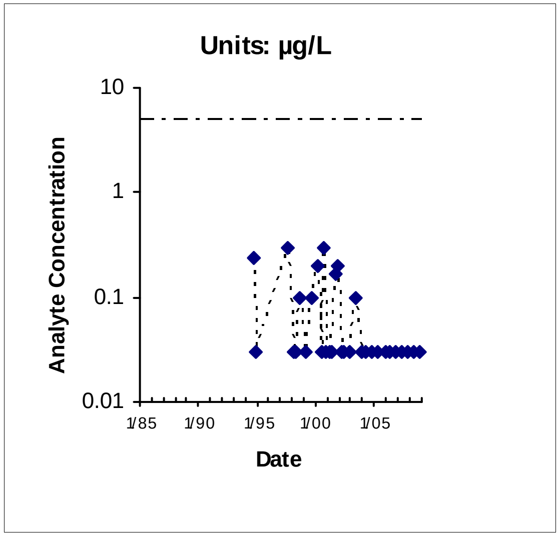


Location: MWS1M2X37 Maximum: 0.3

— - — - — IRG (5 µg/L)

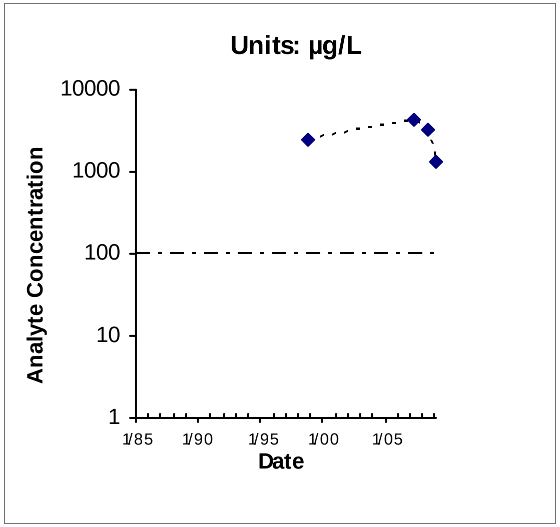
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 6-6

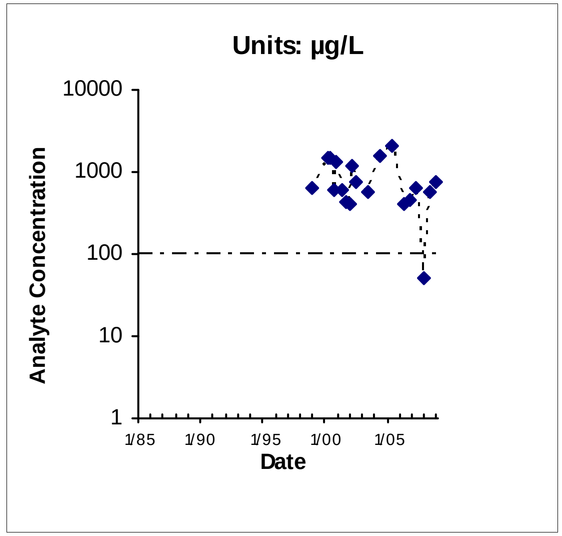
WIOU MNA Wells

TCE

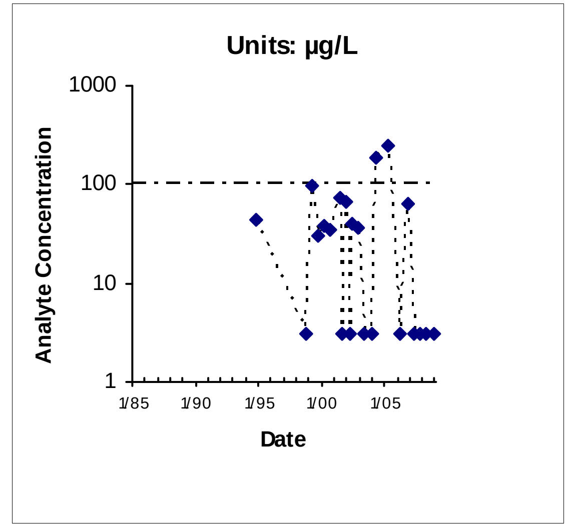
Chemical Time-series Plots



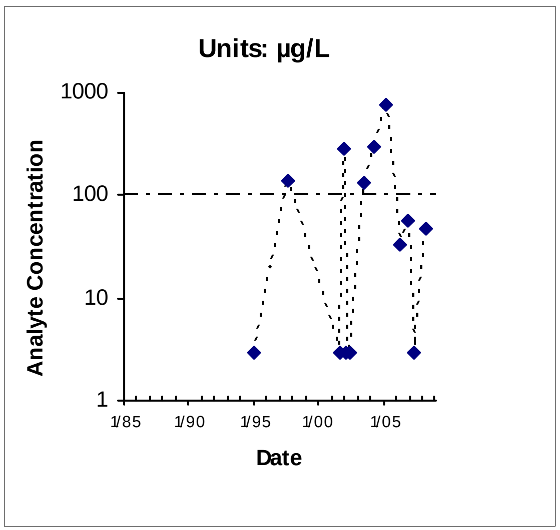
Location: MW02X14 Maximum: 4200



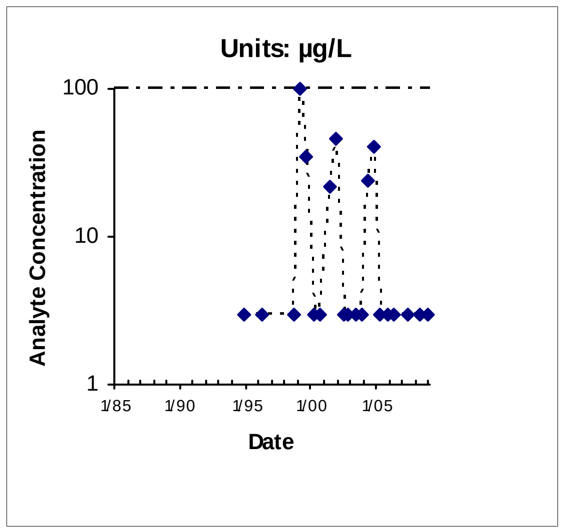
Location: MW05X14 Maximum: 2100



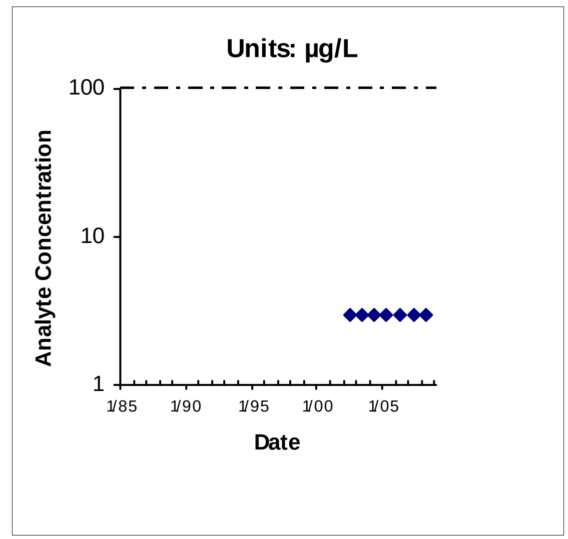
Location: MW116X37 Maximum: 250



Location: MW222X37 Maximum: 770



Location: MW310X37 Maximum: 99



Location: MW513X37 Maximum: 3

— - — - — IRG (100 µg/L)

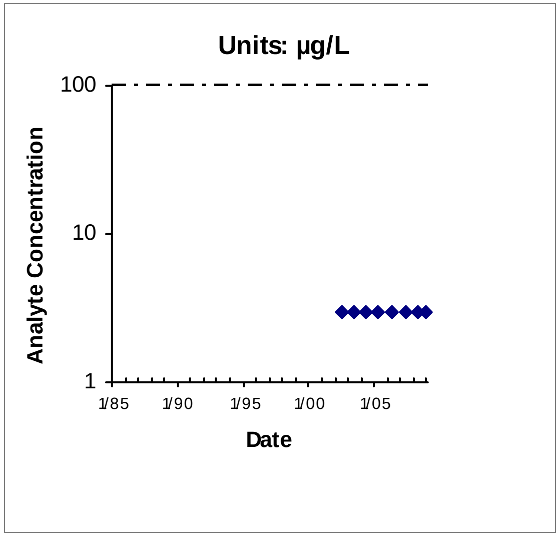
*Nondetects shown as the Method Detection Limit (3 µg/L)

FIGURE 6-7

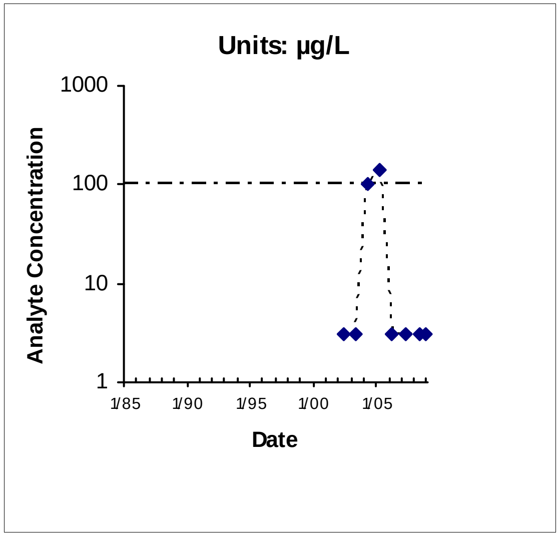
WIOU MNA Wells

TPH-Diesel

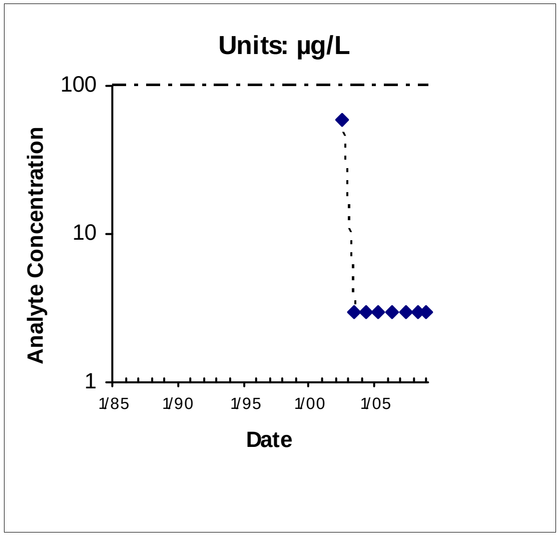
Chemical Time-series Plots



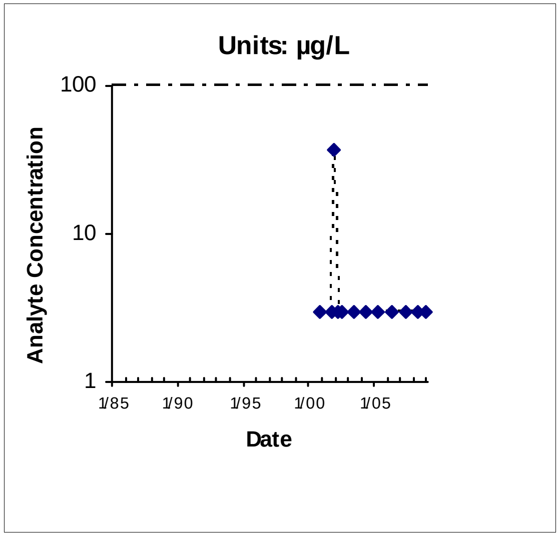
Location: MW524X37 Maximum: 3



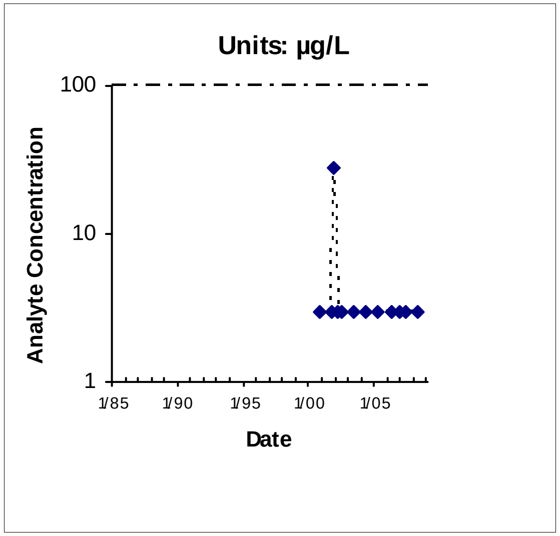
Location: MW531X37 Maximum: 140



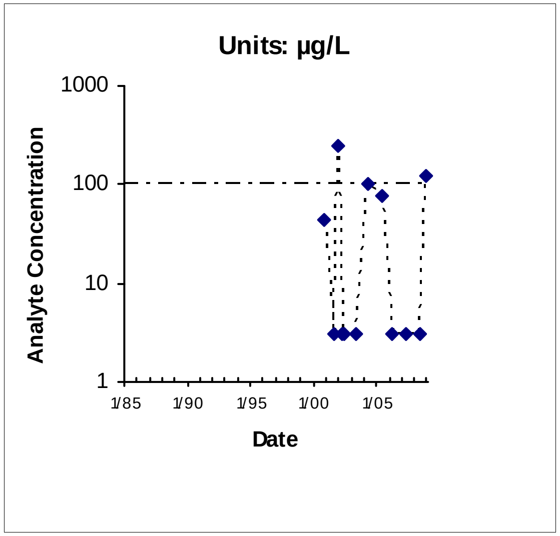
Location: MW540X37 Maximum: 59



Location: MW722X37 Maximum: 37



Location: MW723X37 Maximum: 28



Location: MW724X37 Maximum: 242

— - — - — IRG (100 µg/L)

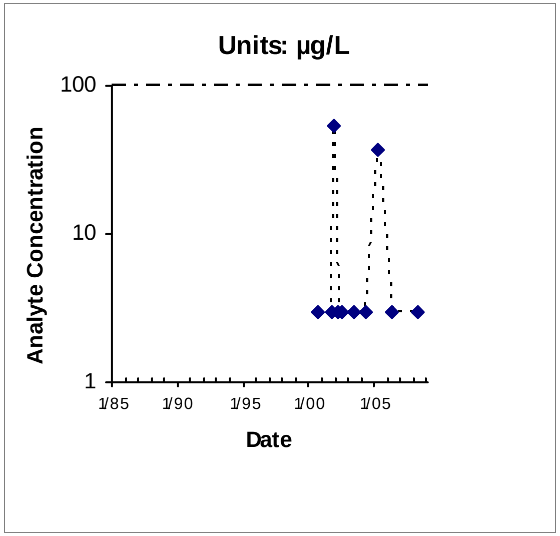
*Nondetects shown as the Method Detection Limit (3 µg/L)

FIGURE 6-7

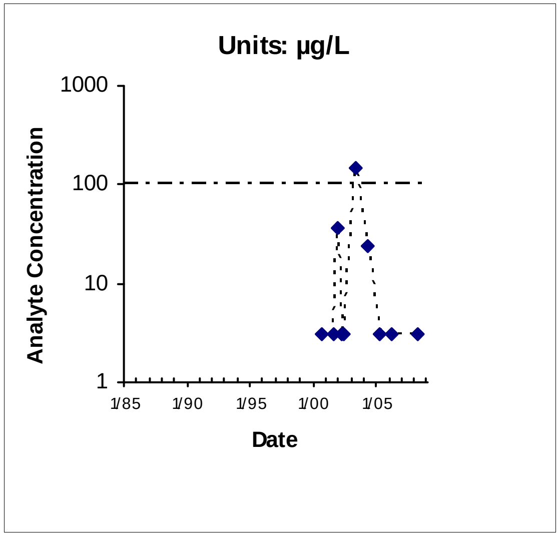
WIOU MNA Wells

TPH-Diesel

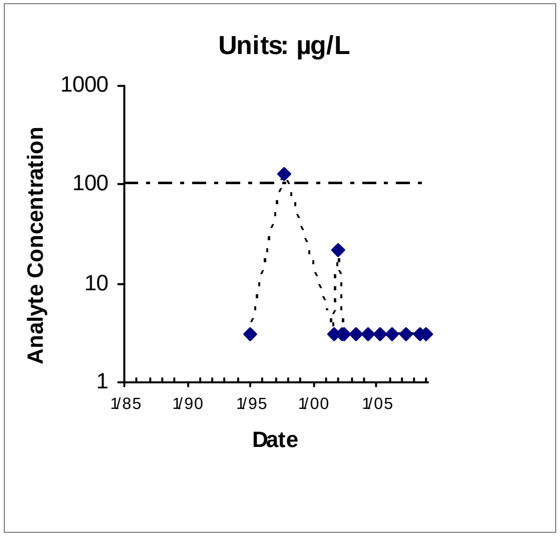
Chemical Time-series Plots



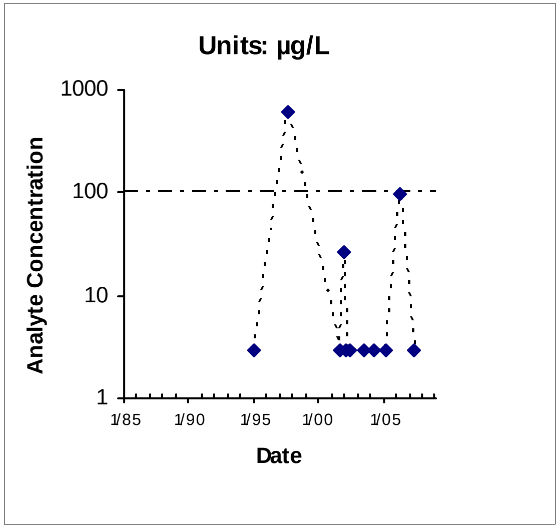
Location: MW729X37 Maximum: 54



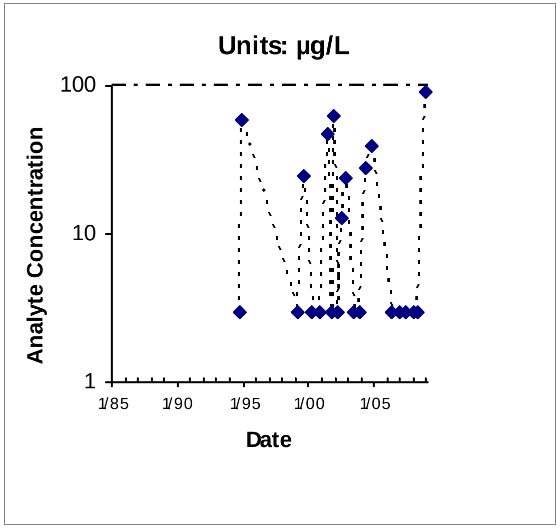
Location: MW730X37 Maximum: 146



Location: MW1208X37 Maximum: 130



Location: MW1209X37 Maximum: 620



Location: MWS1M2X37 Maximum: 91

— - — - — IRG (100 µg/L)

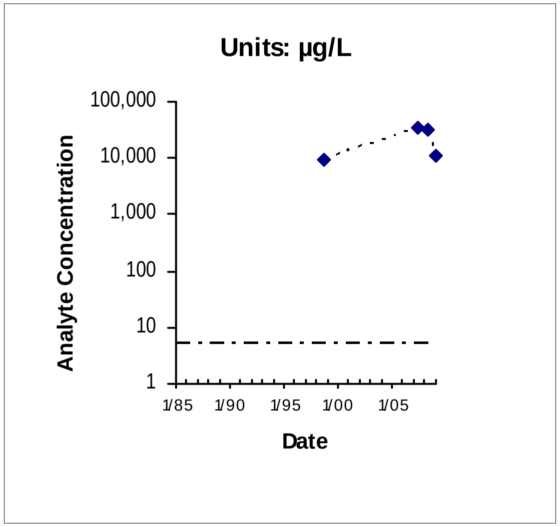
*Nondetects shown as the Method Detection Limit (3 µg/L)

FIGURE 6-7

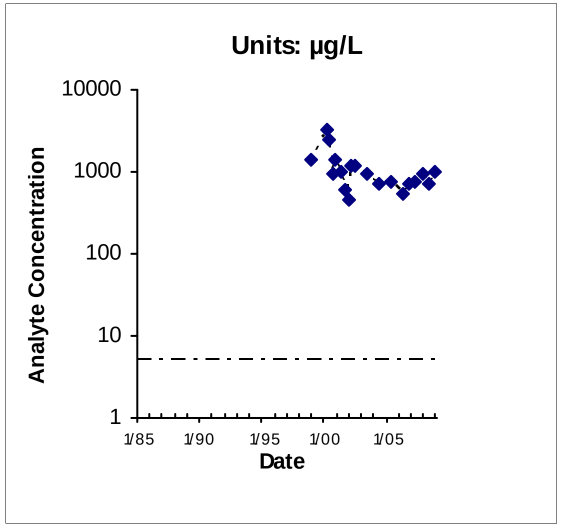
WIOU MNA Wells

TPH-Diesel

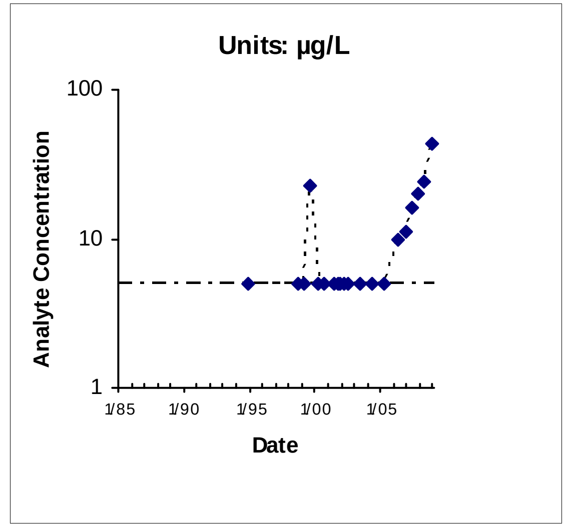
Chemical Time-series Plots



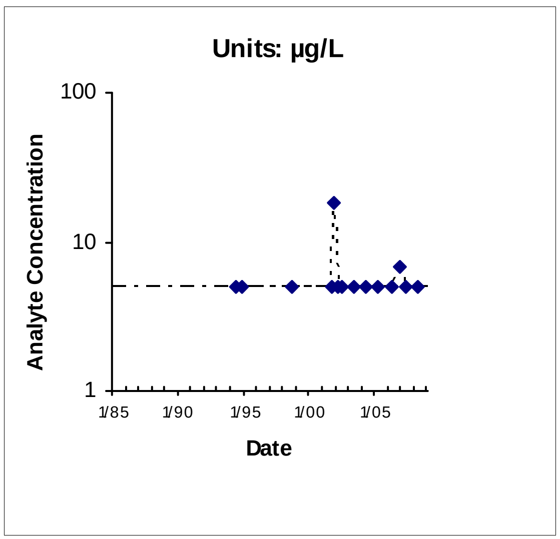
Location: MW02X14 Maximum: 34000



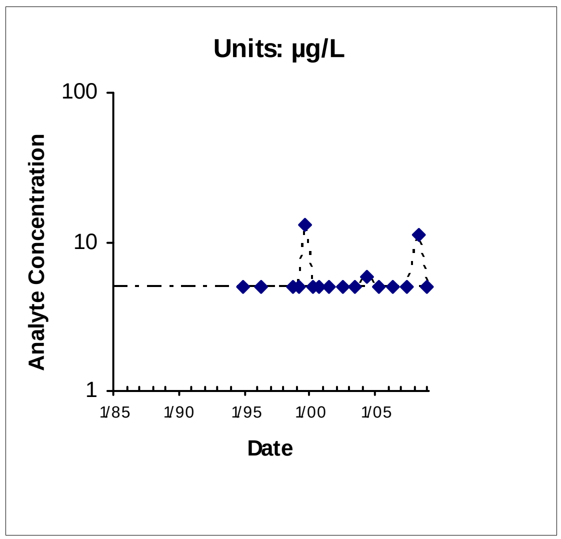
Location: MW05X14 Maximum: 3200



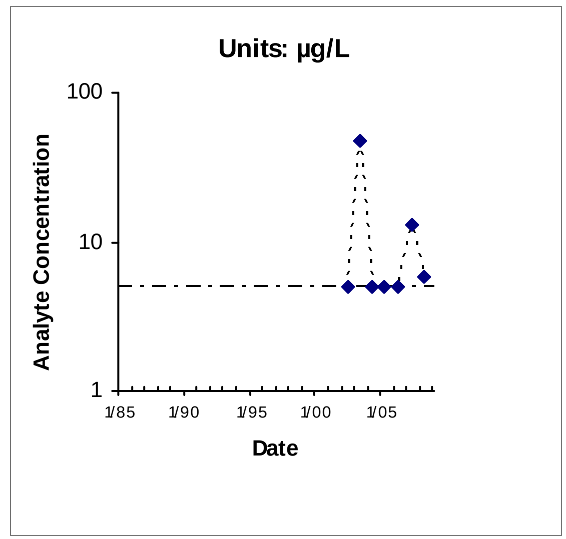
Location: MW116X37 Maximum: 44



Location: MW222X37 Maximum: 18



Location: MW310X37 Maximum: 13



Location: MW513X37 Maximum: 48

— - - — - - — IRG (5 µg/L)

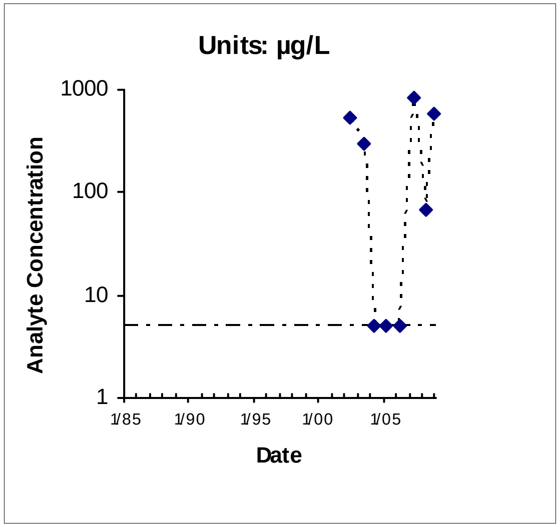
*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 6-8

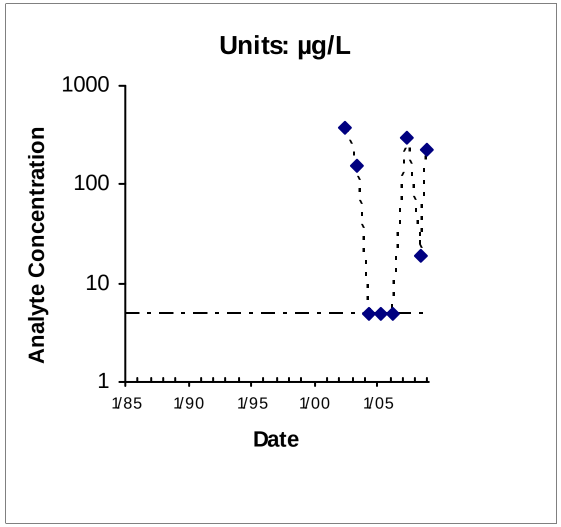
WIOU MNA Wells

TPH-Gasoline

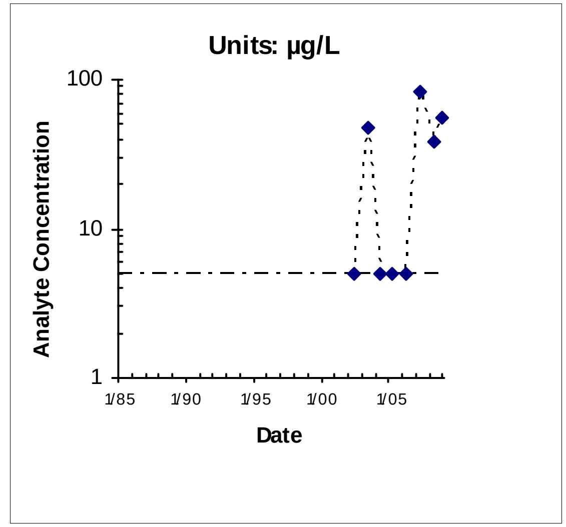
Chemical Time-series Plots



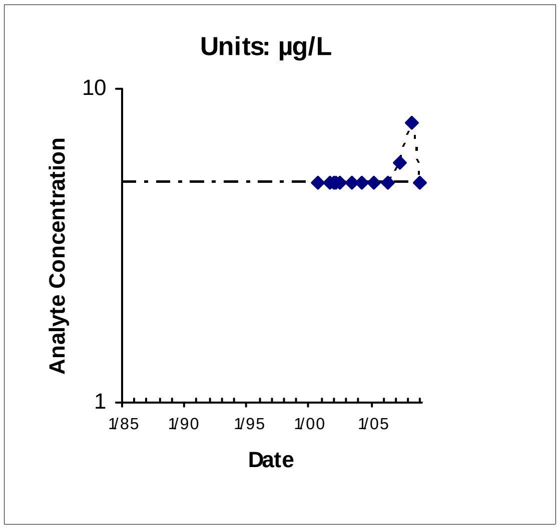
Location: MW524X37 Maximum: 820



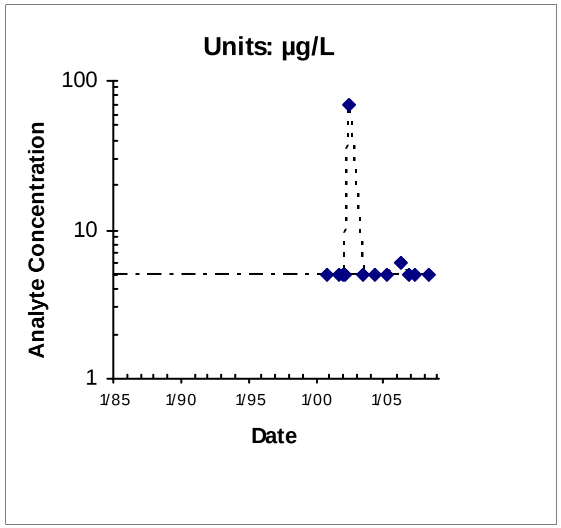
Location: MW531X37 Maximum: 370



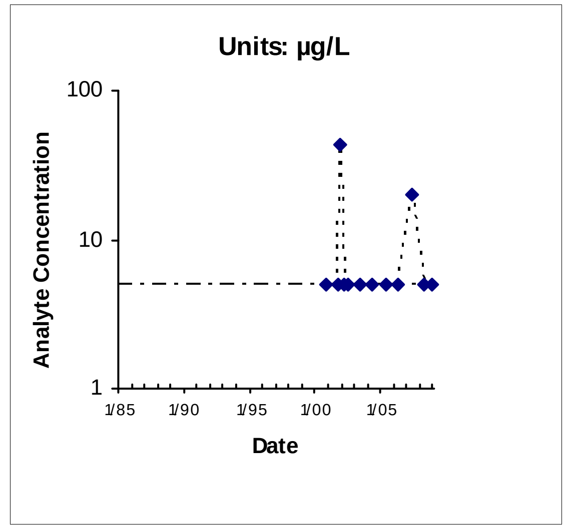
Location: MW540X37 Maximum: 83



Location: MW722X37 Maximum: 7.8



Location: MW723X37 Maximum: 68



Location: MW724X37 Maximum: 43

— - — - — IRG (5 µg/L)

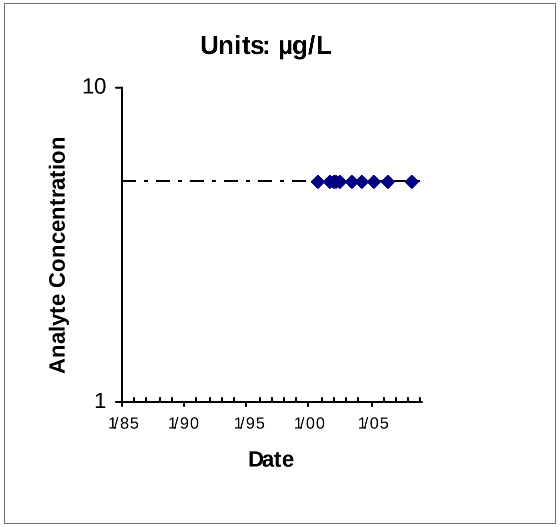
*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 6-8

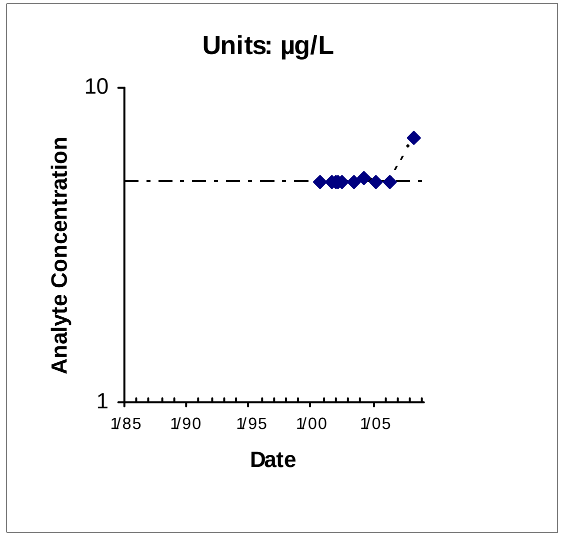
WIOU MNA Wells

TPH-Gasoline

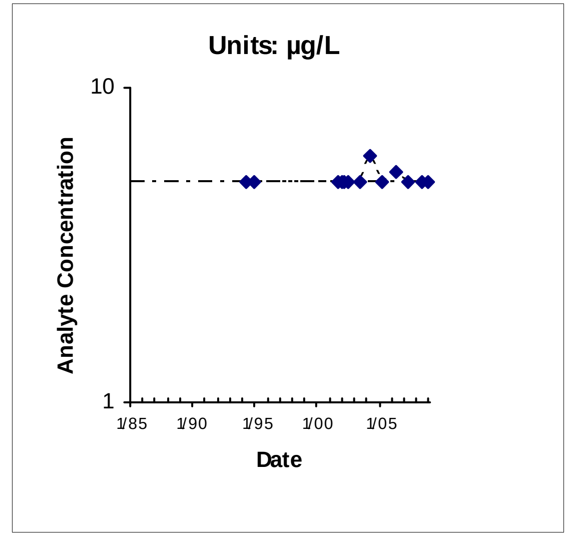
Chemical Time-series Plots



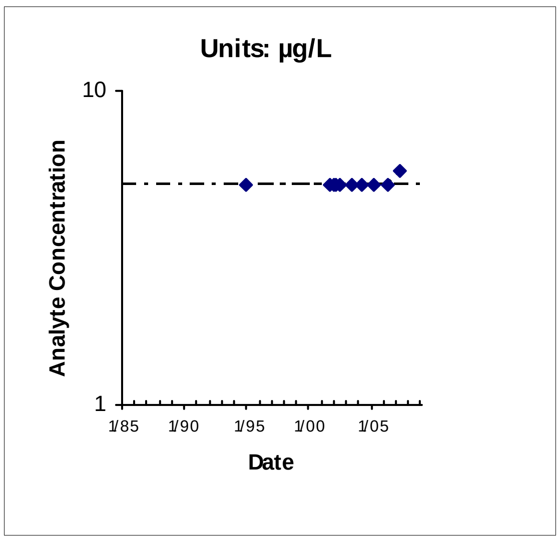
Location: MW729X37 Maximum: 5



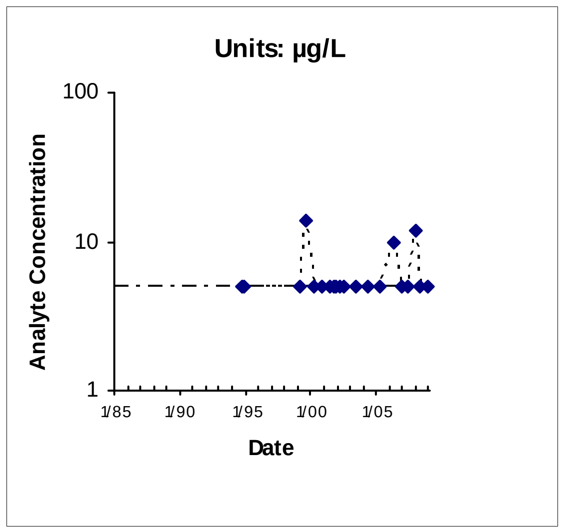
Location: MW730X37 Maximum: 6.9



Location: MW1208X37 Maximum: 6.1



Location: MW1209X37 Maximum: 5.6



Location: MWS1M2X37 Maximum: 14

— - — - — IRG (5 µg/L)

*Nondetects shown as the Method Detection Limit (5 µg/L)

FIGURE 6-8

WIOU MNA Wells

TPH-Gasoline

Chemical Time-series Plots

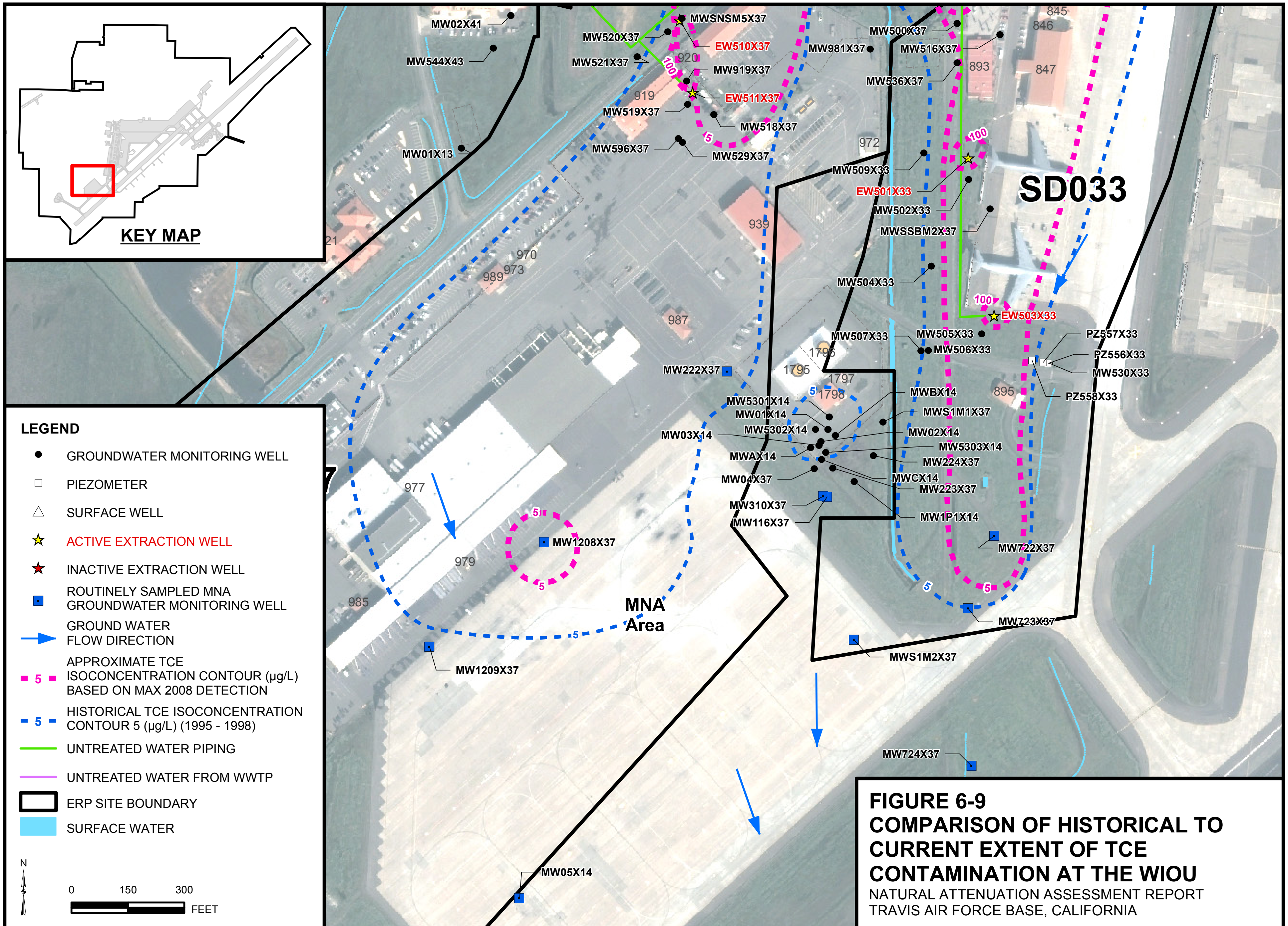


FIGURE 6-9
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF TCE CONTAMINATION AT THE WIOU
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG6-9_WIOU_SITE.MXD MCLAY1 1/14/2010

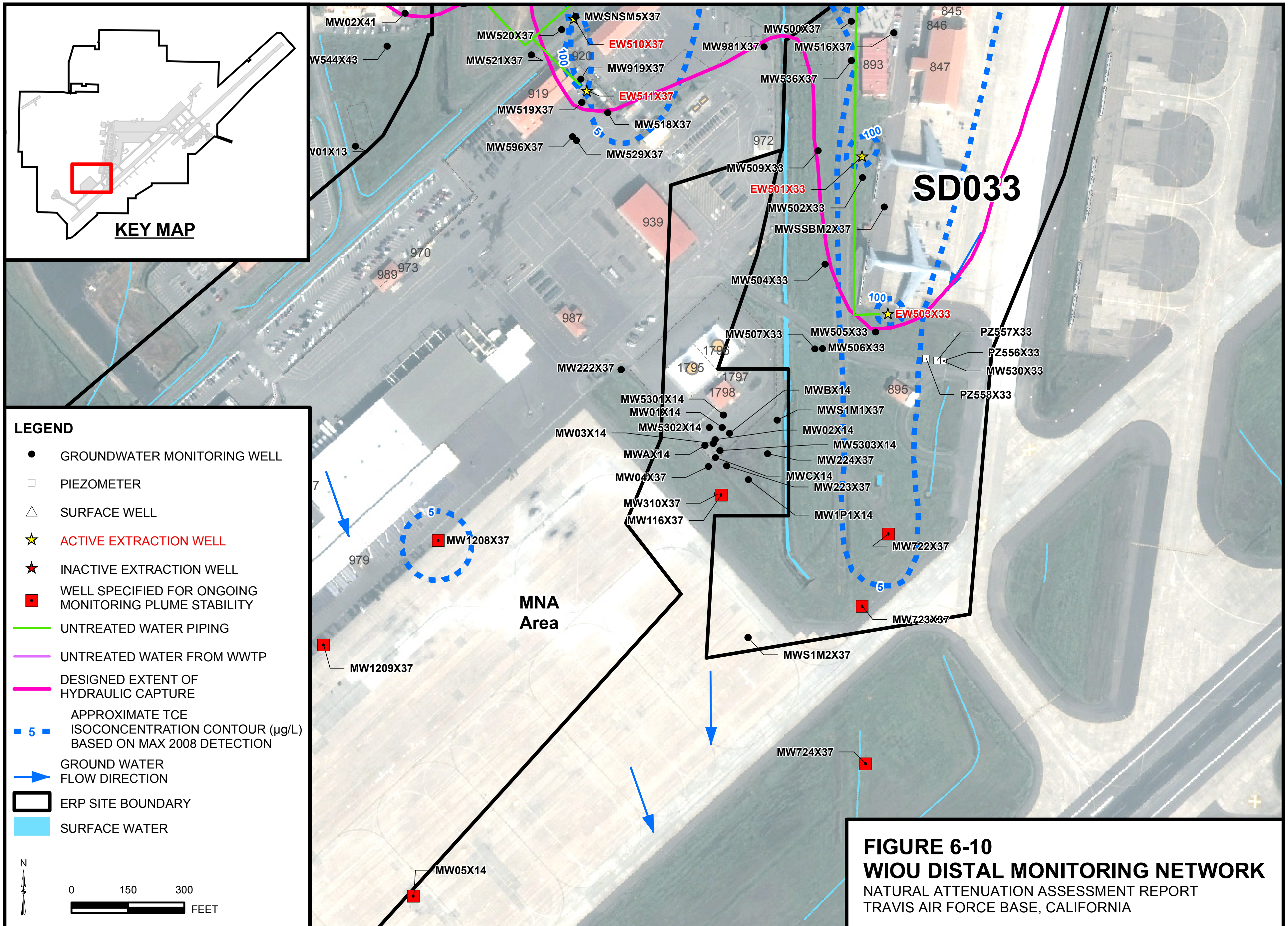


FIGURE 6-10
WIOU DISTAL MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

SECTION 7

Site DP039

Section 7 presents the natural attenuation assessment for Site DP039. A detailed conceptual site model and preliminary natural attenuation assessment are presented in the *DP039 Natural Attenuation Assessment Workplan* (DP039 NAAW) (CH2M HILL, 2001c). This section focuses on data collected since the DP039 NAAW was submitted.

7.1 Site Background

7.1.1 Site Description

Site DP039 site consists of a former rock-filled acid neutralization sump approximately 65 feet west of Building 755, in the northern portion of the WABOU. Until 1978, a pipeline ran from a sink drain within Building 755 to the sump. Figure 7-1 presents a map of Site DP039.

Based on preliminary assessment data, Building 755 was used to test rocket engines, but only petroleum-based liquid fuel was used at the site as part of rocket engine testing. Since 1968, Building 755 has been the location of the Battery and Electric Shop. Before 1978, battery acid solutions and chlorinated solvents reportedly were discharged into the Building 755 sink and drained to the sump. This practice was discontinued in 1978, when the pipeline was dismantled and reconnected to the sanitary sewer line.

In July 1993, the sump was removed and disposed of off-base. The sump was 8 feet long, 8 feet wide, and 4 feet deep. The sump area was lined with visqueen and backfilled with clean soil.

7.1.2 Site COCs

The groundwater COCs at Site DP039 are as follows:

COC	IRG (µg/L)	COC	IRG (µg/L)
TCE	5	PCE	5
1,2-DCA	0.5	methylene chloride	5
1,1,1-trichloroethane (TCA)	0.5	bromodichloromethane	100
1,1,2-TCA	0.5	acetone	5,110

7.1.3 Status of Interim Remedy

An IRA of GET has been implemented in the source area of Site DP039, as specified by the WABOU Groundwater IROD (Travis AFB, 1999). The GET was designed to contain and remediate the source area. Although not specifically defined in the IROD (Travis AFB, 1999); for the purposes of source area remedy evaluation, it is assumed here that the Site DP039

GET target area encompasses VOC concentrations exceeding 1,000 µg/L. The Travis AFB Second Five-Year Review (CH2M HILL, 2008a) concluded that the Site DP039 GET system is only partially achieving the source control objective. While TCE concentrations in the historical source area are declining and the source area in the vicinity of the former sump is being hydraulically contained, TCE concentrations continue to exceed 1,000 µg/L downgradient of the source area and beyond the capture of the source control GET.

In addition to the source area GET specified in the IROD, a solar-powered bioreactor was installed in the source area in fall 2008 (see Figure 7-1). This bioreactor will further treat soil and groundwater contamination in the source area by enhancing the reductive dechlorination of TCE and other VOCs via the recirculation of groundwater through a mulch/gravel composting mixture.

A phytoremediation study area has also been established in the portion of the plume where VOC concentrations continue to exceed 1,000 µg/L. The phytoremediation treatability study area consists of tree plantings engineered to hydraulically control and remove VOC mass from the groundwater. The phytoremediation area was established in 1998 and is upgradient of the area being evaluated for an MNA remedy. Figure 7-1 depicts the approximate zone of influence of the phytoremediation area.

MNA assessment is the selected interim remedy for the downgradient portion of the plume (downgradient of the phytoremediation area). The downgradient portion of Site DP039 underwent a natural attenuation assessment in 2000-2001, as documented in the DP039 NAAW (CH2M HILL, 2001c). Since 2001, six (6) monitoring wells have been routinely sampled to support the ongoing MNA assessment: MW751x39, MW758x39, MW759x39, MW760x39, MW761x39, and MW762x39 (see Figure 7-1). These wells are located primarily in the downgradient portion of the site, to monitor plume migration.

Eight years of data collected from the MNA wells indicate MNA is a viable remedy for the downgradient portion of the plume. The toe of the plume remains stable and VOC concentrations remain below IRGs in these wells (CH2M HILL, 2008a). However, TCE concentrations are increasing in some wells in the central portion of the plume (downgradient of the phytoremediation area), which may indicate future plume migration.

In summary, the status of the IRAs in DP039 is as follows:

Groundwater Plume	IRAO	Implemented IRA	Status of IRA
DP039 Source Area	Source Control Migration Control	GET Bioreactor Phytoremediation Study	GET was replaced with the bioreactor in 2008. Phytoremediation Study ongoing.
DP039 Distal Area	MNA Assessment	Groundwater monitoring	Ongoing groundwater monitoring.

7.2 Conceptual Site Model

7.2.1 Geology

Geologic data collected during investigations at Site DP039 indicate that the subsurface geology at Site DP039 is highly heterogeneous, varying from clays and silts to sands with little or no horizontal continuity of layers (Older Alluvium). Relatively permeable sands and silty/clayey sands are encountered primarily as thin zones, ranging from 2 to 5 feet thick, and are not extensive. Bedrock (Tehama Formation) was encountered on the western side of the site at depths ranging from 35 to 55 feet bgs. The bedrock plunges to the east and becomes progressively deeper in that direction. The subsurface geology at Site DP039 should be viewed as a single, complex, heterogeneous hydrogeologic system of unconsolidated sediments. No clearly defined, laterally extensive layers of discrete aquifers or aquitards are present. A geologic cross section through the Site DP039 groundwater plume is presented on Figure 7-2.

7.2.2 Groundwater

As summarized in Table 7-1, depth to water at Site DP039 is approximately 7 to 30 feet bgs, and the saturated zone ranges in thickness from 15 feet to more than 50 feet. Groundwater elevations at Site DP039 are stable, fluctuating seasonally from about 2 to 4 feet.

Groundwater elevation contours derived from 2Q08 groundwater elevation data are presented on Figure 7-3 and are consistent with historical groundwater flow directions. The regional groundwater flow direction in the vicinity of Site DP039 is toward the southeast. The horizontal gradient is approximately 0.004 ft/ft in the vicinity of Site DP039.

Two (2) well pairs are available at Site DP039 for evaluation of vertical gradients. Vertical gradients are negligible (less than 0.01 ft/ft) and slightly downward at well pair MW783Sx39/MW783Dx39). Well pair MW784Sx39/MW784Dx39 has a consistently upward vertical gradient, typically between 0.02 and 0.05 ft/ft (Table 7-2).

Several aquifer tests have been performed at Site DP039, and the results are summarized in Table 7-3. Hydraulic conductivities calculated from the aquifer tests ranged from 0.3 to 10 ft/day, reflecting the low permeability of the sediments. The average of the hydraulic conductivities calculated for Site DP039 is approximately 5 ft/day.

The average linear flow of groundwater at Site DP039 may be estimated by Darcy's Law. Using a horizontal hydraulic gradient of 0.004 ft/ft, an average hydraulic conductivity of 5 ft/day, and assuming an effective porosity of 20 percent (typical for the fine-grained sediments encountered at the site), the approximate groundwater velocity is about 0.1 ft/day or approximately 40 ft/year.

Groundwater at Travis AFB is not used for human consumption and groundwater at Site DP039 does not discharge to surface water. The Base boundary is approximately 5,600 feet from the leading edge of the plume. At the estimated groundwater velocity, it would take approximately 140 years for groundwater at Site DP039 to reach the Base boundary. Groundwater contamination at Site DP039 does not currently pose a risk to receptors. Ongoing monitoring will continue to evaluate whether contamination is migrating away from the site.

7.2.3 Current Distribution of Groundwater Contamination

The monitoring wells selected to support the MNA assessment in the downgradient portion of Site DP039 over the interim period are MW751x39, MW758x39, MW759x39, MW760x39, MW761x39, and MW762x39. During the 2Q08 and 4Q08 sampling events, the COCs detected at concentrations exceeding IRGs at Site DP039 MNA wells were TCE and 1,1-DCE. 1,1-DCE exceeded the IRG (6 µg/L) only at MNA well MW751x39; the maximum concentration detected was 303 µg/L at this location. MW751x39 is located in the center of the plume, upgradient of the phytoremediation study area, where VOC concentrations exceed 1,000 µg/L. Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability sand matrix.

TCE is the COC most frequently detected and most widely distributed at the site. Figure 7-4 illustrates the current distribution of TCE at Site DP039. TCE concentrations exceeded the IRG at two (2) Site DP039 MNA wells: MW751x39 and MW759x39. The TCE concentrations detected at the plume MNA well MW751x39 well during 2008 were 1,400 µg/L in 2Q08 and 1,050 µg/L in 4Q08. The TCE concentrations detected at downgradient MNA well MW759x39 in 2008 were much lower: 7.6 µg/L in 2Q08 and 36.5 µg/L in 4Q08. TCE was detected in only one (1) other MNA well during 2008: MW758x39. TCE concentrations were below the IRG at this well.

While not a site COC, cis-1,2-DCE was also detected at concentrations exceeding IRGs at MNA source area well MW751x39. Cis-1,2-DCE is a biodegradation product of PCE and TCE.

A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in some portions of the DP039 plume undergoing MNA assessment exceed the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009b), indicating potential for VI. However, soil gas data collected to date do not indicate significant VI at existing Site DP039 buildings (CH2M HILL, 2009b). Building 755, near the source of the VOCs in groundwater, was recently torn down, and there are no plans for new construction within its footprint.

7.3 Natural Attenuation Assessment

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has been reduced in size. Over the interim period, the GSAP has been monitoring several wells to evaluate plume stability. An evaluation of COC concentration trends in the MNA wells and changes in plume size over time is presented in Section 7.3.1. In addition, several monitoring wells were sampled for geochemical indicators of biodegradation during the 4Q08 GSAP event. The results of the biodegradation screening are presented in Section 7.3.2.

7.3.1 Plume Attenuation

Chemical time-series plots of the primary COCs (TCE and 1,1-DCE), and biodegradation daughter product cis-1,2-DCE for the MNA wells and site wells that were sampled to support the biodegradation screening are provided on Figures 7-5 through 7-7. Figure 7-7 illustrates both increasing and decreasing TCE trends in wells selected for MNA.

TCE concentrations have been declining in source well MW751x39. The historical maximum TCE concentration detected at this well was 3,800 µg/L; and TCE concentrations had declined to 1,050 µg/L in 4Q08. TCE concentrations had also been declining significantly in MNA well MW759x39, located in the distal portion of the plume. However, TCE concentrations rebounded at this well in 4Q08, although the most recent TCE concentration detected (36.5 µg/L) remains below the historical maximum concentration detected (46 µg/L). Two (2) downgradient MNA wells display generally increasing TCE trends: MW758x39 and MW760x39. However, TCE concentrations at MW758x39 decreased slightly in 4Q08, and concentrations remain below the IRG. TCE concentrations at MW760x39 have been decreasing since 2006, and TCE was not detected at this well in 4Q08.

Figure 7-8 shows that the current distribution of TCE is the maximum historical extent of TCE contamination in groundwater at Site DP039. The southern toe of the plume has remained stable (below IRGs) but has not receded over the interim period. Although the toe of the plume is stable, TCE concentrations have been increasing in distal well MW02x39 (which was not selected as an MNA well). After an initial period of increasing concentrations, TCE concentrations appear to have stabilized at monitoring well MW785x39 (to the northeast of MW02x39). Both of these wells were sampled for biodegradation parameters in 4Q08, and chemical time-series plots are included for these wells in addition to the MNA wells.

1,1-DCE has only been detected at MNA wells MW761x39 (source area) and MW759x39 (distal area). The trends of 1,1-DCE at these wells parallel the TCE trends. Cis-1,2-DCE has only been consistently detected at concentrations exceeding 1 µg/L at source MNA well MW761x39.

The advective rate of contaminant transport is equal to the average linear velocity of groundwater flow. Advective transport is modified by natural attenuation (processes such as dispersion, diffusion, biodegradation) and the chemical retardation characteristics of the individual contaminants and the alluvium. Disregarding natural attenuation processes, and assuming that retardation slows the transport of TCE at this site to approximately 0.8 times the linear velocity of groundwater (based on the EPA on-line retardation factor calculator located at http://www.epa.gov/ATHENS/learn2model/part-two/onsite/retard.html), then the portion of the plume beyond the capture of the GET system would be expected to have migrated approximately 240 feet (approximately 30 feet per year) over the 8 years of the MNA assessment period. However, the southern toe of the plume has remained stable, indicating that natural attenuation processes are occurring at this site.

Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the six (6) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring wells at which COCs continue to exceed IRGs (MCLs). A point attenuation rate was calculated for these two (2) MNA wells: MW751x39 and MW759x39. At both monitoring wells, the only COC that continues to exceed IRGs is TCE. Both of these monitoring wells are located beyond the designed extent of hydraulic capture of the GET and the area impacted by the bioreactor treatability study. Well MW751x39 is located upgradient of the phytoremediation study area, and well MW759x39 is located downgradient of the phytoremediation study area. Point attenuation rates calculated for these wells are not expected to be impacted by the GET IRA or the treatability studies. The attenuation rate constant calculated for well MW751x39 is approximately 0.092 per year, and the attenuation rate constant calculated for well MW759x39 is approximately 0.14 per year (Appendix D). At these rates, TCE concentrations at well MW751x39 would be expected to reach the IRG (5 µg/L) in 2067, and TCE concentrations at well MW759x39 would be expected to reach the IRG in 2015. The long attenuation period for monitoring well MW751x39 is due to its location within the portion of the plume where TCE concentrations continue to exceed 1,000 µg/L. This well was selected for source area monitoring in the NAAW and is not located in the portion of the distal plume where MNA is being assessed as a potential remedy.

Little change in aquifer conditions between 2001 (when the initial MNA assessment was performed) and 2008 is evident in the portions of the aquifer evaluated for MNA. Outside of the treatability study areas, the aquifer remains aerobic and available carbon is low; physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. Enhancements to natural attenuation (the bioreactor treatability study and planned biobarrier) are designed to increase biodegradation rates in targeted areas of the plume. However, outside of these areas enhanced by MNA, physical processes are expected to remain the dominant mechanisms for attenuation. Thus, the attenuation rates calculated provide reasonable estimates of time to reach IRGs in these portions of the plume.

In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for MNA monitoring wells where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system. Bulk attenuation rates have not been calculated for DP039 at this time because, due to the recent GET IRA and ongoing bioreactor and phytoremediation treatability studies, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and treatability studies and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site.

7.3.2 Geochemical Indicators

This section presents the results of the biological screening evaluation for Site DP039. Table 7-5 presents the scores for biodegradation potential for chlorinated solvents based on geochemical parameters analyzed in samples collected from Site DP039 monitoring wells during 4Q08. During the 4Q08 event, groundwater samples were analyzed for VOCs (Method SW8260), methane/ethane/ethene (Method RSK-175), TOC (Method SW9060), nitrate/sulfate/chloride (Method E300.1), alkalinity (Method E310.1), sulfide (Method SW9034), ferrous iron (HACH field test), and CO_2 (HACH field test). In addition, pH, temperature, DO, ORP, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected. The following wells were sampled in 4Q08 to support the biological screening evaluation:

- **Background Well:** MW07x14
- **Source Well:** MW751x39 and MW784Sx39
- **Plume Wells:** MW02x39, MW759x39, and MW785x39
- **Distal Wells:** MW758x39 and MW762x39

As shown in Table 7-5, no monitoring wells received scores indicating adequate evidence for biodegradation of chlorinated solvents. Two (2) wells (source area well MW751x39 and plume well MW759x39) received scores between six (6) and fourteen (14) points, indicating limited evidence of biodegradation. All other wells sampled scored five (5) points or less, indicating inadequate evidence for biodegradation of chlorinated solvents.

Geochemical parameters indicated generally aerobic conditions throughout the plume. The aerobic conditions may at least in part result from the operation of the GET system in the source area, which causes aeration of the aquifer. The distal area wells scored between minus three (-3) and one (1) points. However, similar low scores (one [1]) were received by two (2) plume wells (MW784Sx39 and MW02x39), which have TCE concentrations an order of magnitude above the IRG.

A similar biodegradation screening was performed in 2000-2001, as documented in the DP039 NAAW (CH2M HILL, 2001c). During the initial biodegradation screening, the monitoring wells scored twelve (12) points or less (inadequate to limited evidence of biodegradation). The monitoring well scoring the highest (twelve [12] points) during the preliminary screening was source area well MW751x39.

7.4 Natural Attenuation Assessment Conclusions

The following conclusions may be drawn from the natural attenuation assessment:

- There is inadequate evidence for biodegradation of COCs at Site DP039. More favorable conditions for anaerobic degradation of COCs likely existed in the source area before the GET was installed. The GET introduced oxygenated groundwater to the source and inhibited biodegradation. The conversion of the source area GET to an in situ bioreactor is intended to reestablish anaerobic biodegradation in the source area.

- The evidence of physical natural attenuation of COCs at Site DP039 is mixed.

- Evidence for physical natural attenuation at Site DP039 includes the decreasing COC trends at source area monitoring well MW751x39 and the stability of southern toe of the plume (remaining below IRGs).

- However, increasing COC trends are evident in distal area well MW02x39. In addition, the extent of the plume has not reduced in size as has been observed at most of the other MNA assessments sites.

- Downgradient MNA wells MW758x39 and MW760x39 also display generally increasing TCE trends. Although TCE concentrations have recently decreased in both wells and remain below IRGs.
- The stability of the eastern portion of the plume is uncertain because there is not a long monitoring history in this area. In 2007, it was discovered that the TCE plume extends further eastward than anticipated (MW785x39 is located in this portion of the plume). However, after an initial period of increasing concentrations, TCE concentrations appear to have stabilized at monitoring well MW785x39.

Based on the results of the natural attenuation assessment, MNA may not be adequate to prevent plume migration. Consequently, the Air Force plans to implement enhanced natural attenuation by installing a biobarrier in the middle of the plume in addition to the bioreactor that has been installed in the source area. The conceptual design of the biobarrier is presented in the Draft Site DP039 Remedial Process Optimization Work Plan (CH2M HILL, 2009c) and is depicted on Figure 7-1. Enhanced MNA is the Air Force preferred remedy for DP039.

7.5 Ongoing Monitoring

Assessing plume stability during the interim period (leading up to the Groundwater ROD) will continue to be the focus of groundwater monitoring in the distal portion of DP039. The distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment. The monitoring network has been modified to reflect changed plume conditions. The distal network of wells to monitor plume stability is presented on Figure 7-9 and will consist of MW02x39, MW785x39, MW759x39, MW758x39, MW760x39, MW761x39, and MW762x39. These wells will be sampled annually for VOCs. This network will continue to be monitored during the interim period or until such time as the remedy changes. Source area monitoring to support assessment of the DP039 GET, bioreactor, and phytoremediation performance will continue to be performed as specified in the GSAP annual reports.

TABLE 7-1

DP039 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: DP039									
EW563X39	10	40	63.5	33.5	72.53	NM	NM	NM	NM
EW564X39	10	40	63	33	71.77	NM	NM	NM	NM
EW782X39	11	46	61.85	26.85	72.17	NM	NM	NM	NM
MW01X39	23	33	49.7	39.7	74.39	29.64	44.75	30.1	44.29
MW02X39	15	30	38.3	23.3	53.32	13.06	40.26	14.84	38.48
MW03X39	16	26	39.5	29.5	55.41	13.74	41.67	15.39	40.02
MW04X39	16	26	39.5	29.5	54.90	14.09	40.81	15.87	39.03
MW749X39	22	42	52.16	32.16	72.24	28.66	43.58	27.74	44.5
MW750X39	21.5	41.5	51.83	31.83	73.07	29.64	43.43	29.8	43.27
MW751X39	15.5	45.5	54.73	24.73	69.97	26.91	43.06	28.03	41.94
MW758X39	51	61	-5.82	-15.82	44.94	8.17	36.77	9.27	35.67
MW759X39	11	20	36.18	27.18	47.00	8.69	38.31	10.13	36.87
MW760X39	28	38	16.23	6.23	43.97	7.57	36.4	8.31	35.66
MW761X39	40	50	7.07	-2.93	46.78	9.92	36.86	10.5	36.28
MW762X39	37	47	10.55	0.55	47.27	10.47	36.8	11.42	35.85
MW777X39	16	26	46.03	36.03	61.52	19.15	42.37	20.51	41.01
MW778X39	16	26	45.79	35.79	61.57	19.92	41.65	20.41	41.16
MW779X39	16	26	45.37	35.37	61.05	19.3	41.75	20.94	40.11
MW780X39	23	33	43.06	33.06	65.92	22.27	43.65	22.03	43.89
MW781X39	27	37	44.07	34.07	70.78	26.79	43.99	28.59	42.19
MW783Sx39	41	47	21.18	15.18	61.91	19.59	42.32	20.52	41.39
MW783Dx39	52	58	10.18	4.18	61.88	19.64	42.24	20.74	41.14
MW784Sx39	41	48	19.86	12.86	60.44	18.87	41.57	20.31	40.13

Note: Grouped by Site and sorted by Location.
btoc = below top of casing
NM = not measured
bgs = below ground surface
msl = mean sea level

TABLE 7-1

DP039 Monitoring Wells and 2008 Groundwater Elevation Data

Natural Attenuation Assessment Report

Monitoring Well	Well Screen Beginning Depth (feet bgs)	Well Screen Ending Depth (feet bgs)	Well Screen Beginning Elevation (feet msl)	Well Screen Ending Elevation (feet msl)	Top of Casing Elevation (feet msl)	Depth to Water in 2Q 2008 (feet btoc)	Groundwater Elevation in 2Q 2008 (feet msl)	Depth to Water in 4Q 2008 (feet btoc)	Groundwater Elevation in 4Q 2008 (feet msl)
Site: DP039									
MW784Dx39	54	59	6.86	1.86	60.60	18.47	42.13	19.99	40.61
MW785X39	38	48	12.67	2.67	50.72	10.19	40.53	11.75	38.97
PZ01X39	23	28	49.5	44.5	73.80	NM	NM	NM	NM

Note: Grouped by Site and sorted by Location.

btoc = below top of casing

NM = not measured

bgs = below ground surface

msl = mean sea level

TABLE 7-2
DP039 Vertical Gradients
Natural Attenuation Assessment Report, Travis Air Force Base

Deep Well	Shallow Well	2Q07	4Q07	2Q08	4Q08
MW783Dx39	MW783Sx39	-0.005	0.000	-0.007	-0.023
MW784Dx39	MW784Sx39	0.02	0.03	0.05	0.04

Note:

Minus sign indicates downward vertical gradient.

TABLE 7-3
Aquifer Test Results for DP039
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Monitoring Well	Screened Interval of Pumped Well (ft bgs)	Date	Test Type	Horizontal Hydraulic Conductivity (ft/day)	Approximate Lithology of Saturated Screened Interval
DP039	MW02x39	15–30	1996	Pumping	10	60% clay; 20% silty sand; 10% sand; 10% silt
	MW02x39	15–30	1996	Recovery	10*	60% clay; 20% silty sand; 10% sand; 10% silt
	MW04x39	16–26	1996	Pumping	4.9	70% silt; 20% silty sand; 10% sand
	MW751x39	15.5–45.5	2000	Pumping	4.9	55% clayey sand; 40% clay; 5% gravel
	MW758x39	51–61	2000	Pumping	3.2	50% clayey sand; 50% clay
	MW759x39	11–20	2000	Recovery	2.1	70% sand; 20% silt; 10% clay
	EW563x39	10–40	2000	Pumping	0.6	50% clay; 20% silty sand; 20% clayey sand; 10% sand
	EW564x39	10–40	2000	Pumping	0.3	40% clay; 30% silt; 30% sand

* Analyzed by a modified form of Theis Recovery Method to account for a variable pumping rate during drawdown.

Note:

Source: CH2M HILL, 2004.

TABLE 7-4

Summary of Analytes Detected in MNA Wells at DP039 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result[a]	Flag	Units	IRG
Sample Media: Groundwater							
Site: DP039							
MW01X39							
	5/5/2008	SW8260	Methylene chloride	0.33	J	µg/L	5
MW02X39							
	5/6/2008	SW8260	1,1-DCE	3.4		µg/L	6
	5/6/2008	SW8260	Cis-1,2-DCE	0.16	J	µg/L	6
	5/6/2008	SW8260	TCE	**34**		µg/L	5
	12/15/2008	E310	Alkalinity	288		mg/L	
	12/15/2008	E300	Chloride	492		mg/L	
	12/15/2008	SM4500S2	No Analytes Detected				
	12/15/2008	A5310B	Total Organic Carbon	2.6		mg/L	
	12/15/2008	SW8260	1,1-DCE	5.2	J	µg/L	6
	12/15/2008	E300	Nitrate	8.95	J-	mg/L	
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	E300	Sulfate	19.9		mg/L	
	12/15/2008	SW8260	TCE	**42.4**		µg/L	5
MW751X39							
	4/29/2008	SW8260	1,1-DCA	3.6		µg/L	
	4/29/2008	SW8260	1,1-DCE	**300**		µg/L	6
	4/29/2008	SW8260	Acetone	11	J	µg/L	5110
	4/29/2008	SW8260	Chloroform	1	J	µg/L	100
	4/29/2008	SW8260	Cis-1,2-DCE	**73**		µg/L	6
	4/29/2008	SW8260	Methylene chloride	2.8	J	µg/L	5
	4/29/2008	SW8260	TCE	**1400**		µg/L	5
	1/7/2009	E310	Alkalinity	210		mg/L	
	1/7/2009	E300	Chloride	147		mg/L	
	1/7/2009	SM4500S2	Sulfide	2.77		mg/L	
	1/7/2009	A5310B	Total Organic Carbon	2.07		mg/L	
	1/7/2009	SW8260	1,1-DCA	4.2	J	µg/L	
	1/7/2009	SW8260	1,1-DCE	**303**		µg/L	6
	1/7/2009	SW8260	Cis-1,2-DCE	**76.7**		µg/L	6
	1/7/2009	RSK-175	Ethane	1.4		µg/L	
	1/7/2009	RSK-175	Methane	410		µg/L	
	1/7/2009	E300	Nitrate	4.26		mg/L	
	1/7/2009	E300	Sulfate	7.21		mg/L	
	1/7/2009	SW8260	TCE	**1050**		µg/L	5
	1/7/2009	SW8260	trans-1,2-DCE	3.8		µg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: DP039							
MW758X39							
	4/24/2008	SW8260	TCE	2.2		µg/L	5
	12/15/2008	E310	Alkalinity	256		mg/L	
	12/15/2008	E300	Chloride	169		mg/L	
	12/15/2008	SM4500S2	No Analytes Detected				
	12/15/2008	A5310B	Total Organic Carbon	1.36		mg/L	
	12/15/2008	E300	Nitrate	2.3		mg/L	
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	E300	Sulfate	23.5		mg/L	
	12/15/2008	SW8260	TCE	1.3		µg/L	5
MW759X39							
	4/25/2008	SW8260	1,1-DCE	0.37	J	µg/L	6
	4/25/2008	SW8260	TCE	**7.6**		µg/L	5
	12/15/2008	E310	Alkalinity	204		mg/L	
	12/15/2008	E300	Chloride	485		mg/L	
	12/15/2008	SM4500S2	No Analytes Detected				
	12/15/2008	A5310B	Total Organic Carbon	1.94		mg/L	
	12/15/2008	SW8260	1,1-DCE	4.6	J	µg/L	6
	12/15/2008	E300	Nitrate	4.52		mg/L	
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	E300	Sulfate	14.6		mg/L	
	12/15/2008	SW8260	TCE	**36.5**		µg/L	5
MW760X39							
	4/24/2008	SW8260	No Analytes Detected				
MW761X39							
	4/24/2008	SW8260	No Analytes Detected				
MW762X39							
	4/29/2008	SW8260	Methylene chloride	0.4	J	µg/L	5
	12/15/2008	E310	Alkalinity	293		mg/L	
	12/15/2008	E300	Chloride	197		mg/L	
	12/15/2008	SM4500S2	Sulfide	0.567	J	mg/L	
	12/15/2008	A5310B	Total Organic Carbon	1.64		mg/L	
	12/15/2008	E300	Nitrate	1.26		mg/L	
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	SW8260	No Analytes Detected				
	12/15/2008	E300	Sulfate	50.9		mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 7-4

Summary of Analytes Detected in MNA Wells at DP039 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: DP039							
MW784SX39							
	5/5/2008	SW8260	1,1,1-TCA	**1.6**	J	µg/L	0.5
	5/5/2008	SW8260	1,1-DCA	9.4		µg/L	
	5/5/2008	SW8260	1,1-DCE	**600**		µg/L	6
	5/5/2008	SW8260	Chloroform	0.89	J	µg/L	100
	5/5/2008	SW8260	Cis-1,2-DCE	**99**		µg/L	6
	5/5/2008	SW8260	Methylene chloride	1.6	J	µg/L	5
	5/5/2008	SW8260	TCE	**1900**		µg/L	5
	1/7/2009	E310	Alkalinity	232		mg/L	
	1/7/2009	E300	Chloride	214		mg/L	
	1/7/2009	SM4500S2	No Analytes Detected				
	1/7/2009	A5310B	Total Organic Carbon	2.47		mg/L	
	1/7/2009	SW8260	1,1-DCA	0.31	J	µg/L	
	1/7/2009	SW8260	1,1-DCE	**9**		µg/L	6
	1/7/2009	SW8260	Benzene	0.45	J	µg/L	1
	1/7/2009	SW8260	Bromodichloromethane	0.51		µg/L	100
	1/7/2009	SW8260	Chloroform	1.9		µg/L	100
	1/7/2009	SW8260	Cis-1,2-DCE	1.6		µg/L	6
	1/7/2009	E300	Nitrate	4.21		mg/L	
	1/7/2009	RSK-175	No Analytes Detected				
	1/7/2009	E300	Sulfate	35.3		mg/L	
	1/7/2009	SW8260	TCE	**58.3**		µg/L	5
MW785X39							
	5/5/2008	SW8260	1,1-DCA	0.17	J	µg/L	
	5/5/2008	SW8260	1,1-DCE	**8.4**		µg/L	6
	5/5/2008	SW8260	Chloroform	0.6		µg/L	100
	5/5/2008	SW8260	Cis-1,2-DCE	1.8		µg/L	6
	5/5/2008	SW8260	Methylene chloride	0.35	J	µg/L	5
	5/5/2008	SW8260	TCE	**130**		µg/L	5
	12/15/2008	E310	Alkalinity	256	J-	mg/L	
	12/15/2008	E300	Chloride	222	J+	mg/L	
	12/15/2008	SM4500S2	No Analytes Detected				
	12/15/2008	A5310B	Total Organic Carbon	1.51		mg/L	
	12/15/2008	SW8260	1,1-DCE	**7.5**	J	µg/L	6
	12/15/2008	SW8260	Chloroform	0.57	J	µg/L	100
	12/15/2008	SW8260	Cis-1,2-DCE	1.7		µg/L	6
	12/15/2008	E300	Nitrate	6.34	J-	mg/L	

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 7-4

Summary of Analytes Detected in MNA Wells at DP039 in 2Q08 and 4Q08 GSAP Events

Natural Attenuation Assessment Report

Location	Sample Date	Method	Analyte	Result [a]	Flag	Units	IRG
Site: DP039							
MW785X39							
	12/15/2008	RSK-175	No Analytes Detected				
	12/15/2008	E300	Sulfate	43.1	J+	mg/L	
	12/15/2008	SW8260	TCE	**151**	J-	µg/L	5

Qualifier Description
J = The analyte was positively identified, the quantitation is an estimate.
F = The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
B = The analyte was found in an associated blank, as well as in the sample.
M = A matrix effect was present.
none = A flag is not applied. This place holder is for calculating QC criteria issues without flagging.

Note: Grouped by Site and Location, sorted by Field ID and Analyte

[a] Bold values indicate result greater than IRGs

TABLE 7-5
DP039 Biological Screening Evaluation for Chlorinated Solvents
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source		Plume			Distal	
				MW07x14	MW751x39	MW784Sx39	MW02x39	MW759x39	MW785x39	MW758x39	MW762x39
Oxygen[b]	<0.5 mg/L	Tolerated; suppresses the reductive pathway at higher concentrations	3	0	3	0	0	0	0	0	0
Oxygen[b]	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	-3	0	-3	-3	0	0	-3	0
Nitrate[b]	<1 mg/L	At higher concentrations, might compete with reductive pathway	2	0	0	0	0	0	0	0	0
Iron II[b]	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0
Sulfate[b]	<20 mg/L	At higher concentrations, might compete with reductive pathway	2	2	2	0	2	2	0	0	0
Sulfide[b]	>1 mg/L	Reductive pathway possible	3	0	3	0	0	0	0	0	0
Methane[b]	<0.5 mg/L >0.5 mg/L	VC oxidizes Ultimate reductive daughter product; VC accumulates	0 3	0	0	0	0	0	0	0	0
ORP[b]	<50 mV <-100 mV	Reductive pathway possible Reductive pathway likely	1 2	0	0	0	0	0	1	0	0
pH[b]	5< pH <9 5> pH >9	Optimal range for reductive pathway Outside optimal range for reductive pathway	0 -2	0	0	0	0	0	0	0	0
TOC	>20 mg/L	Carbon and energy sources; drives dechlorination; can be natural or anthropogenic	2	0	0	0	0	0	0	0	0
Temperature[b]	>20°C	At T>20°C biochemical process is accelerated	1	1	0	0	0	0	0	0	1
Carbon dioxide	>2 × background	Ultimate oxidative daughter product	1	0	0	0	0	0	0	0	0
Alkalinity	>2 × background	Results from interaction of carbon dioxide with aquifer minerals	1	0	0	0	0	0	0	0	0
Chloride[b]	>2 × background	Daughter product of organic chlorine	2	0	0	0	2	2	0	0	0
Hydrogen	>1 nanomole	Reductive pathway possible, VC may accumulate	3	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen	<1 nanomole	VC oxidized	0	NA	NA	NA	NA	NA	NA	NA	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	NA	NA	NA	NA	NA	NA	NA	NA
BTEX[b]	>0.1 mg/L	Carbon and energy source; drive dechlorination	2	0	0	0	0	0	0	0	0
PCE[b]		Material released	0	0	0	0	0	0	0	0	0
TCE[b]		Material released Daughter product of PCE	0 2[c]	0	0	0	0	0	0	0	0
DCE[b] (all isomers[d])		Materials released Daughter product of TCE	0 2[c]	0	2	2	0	2	2	0	0

TABLE 7-5
DP039 Biological Screening Evaluation
Natural Attenuation Assessment Report, Travis Air Force Base, California

Analysis	Criteria	Interpretation	Possible Value[a]	Background	Source		Plume			Distal	
				MW07x14	MW751x39	MW784Sx39	MW02x39	MW759x39	MW785x39	MW758x39	MW762x39
VC		Material released	0	0	0	0	0	0	0	0	0
		Daughter product of DCE	2[c]								
Ethene/ethane	>0.01 mg/L	Daughter product of VC/ethane	2	0	0	0	0	0	0	0	0
	>0.1 mg/L		3								
1,1-DCE[b]		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[c]	0	2	2	0	2	2	0	0
			Sum[e]	**0**	**+12**	**+1**	**+1**	**+8**	**+5**	**-3**	**+1**

[a] Wiedemeier et al., 1996.
[b] Required analysis.
[c] Points awarded only if it can be shown that the compound is the daughter product (i.e., not a constituent of the source nonaqueous phase liquid).
[d] Isomers are 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE. If cis-1,2-DCE is greater than 80 percent of total DCE, it is likely a daughter product of TCE.
[e] Per Wiedemeier et al., 1996, scores indicate the following: zero (0) to five (5) points = inadequate evidence of biodegradation of chlorinated hydrocarbons; six (6) to fourteen (14) points = limited evidence; fifteen (15) to twenty (20) points = adequate evidence; over twenty (20) points = strong evidence.

Notes:

°C = degree(s) Celsius
mg/L = milligram(s) per liter
NA = not analyzed
TCA = trichloroethane

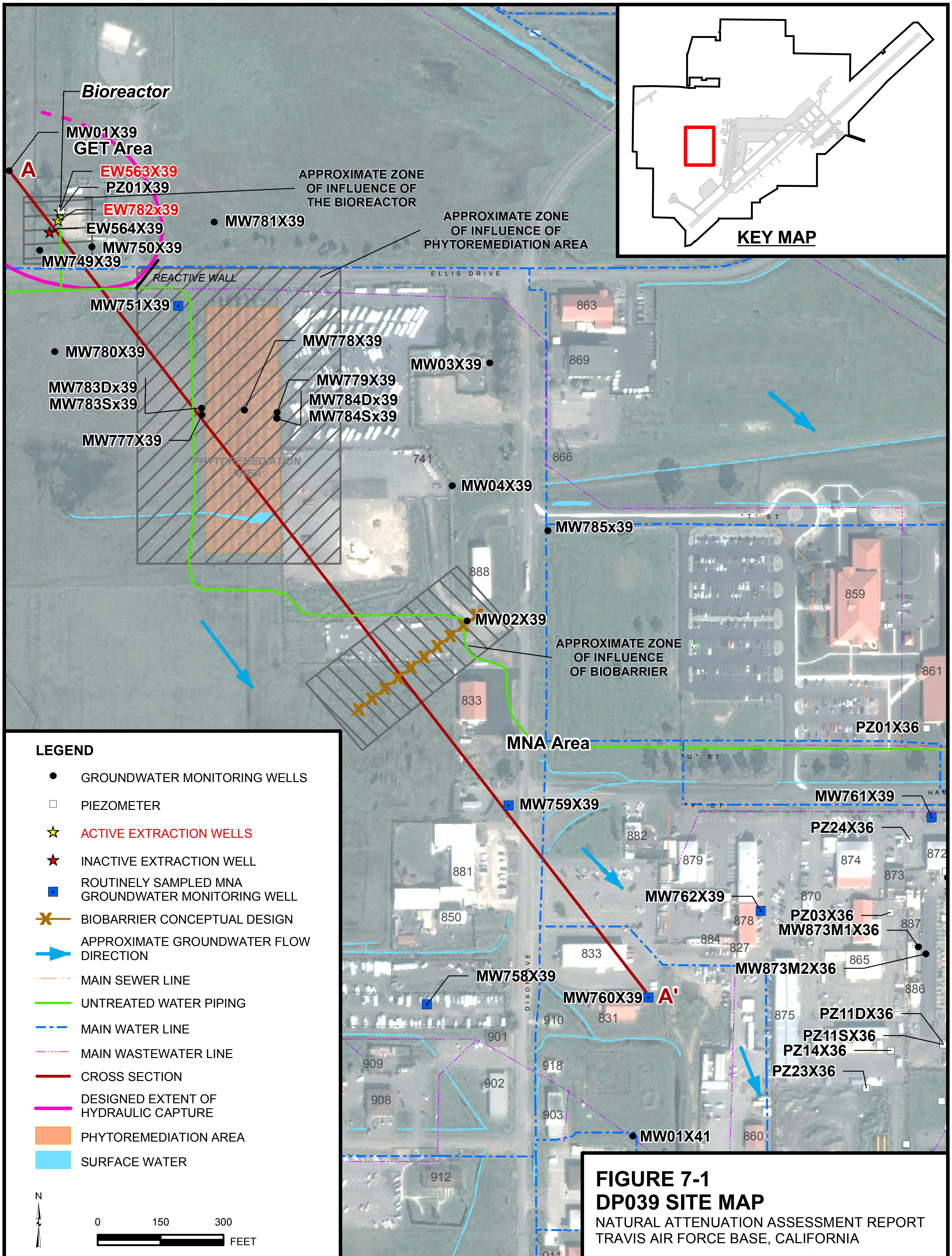
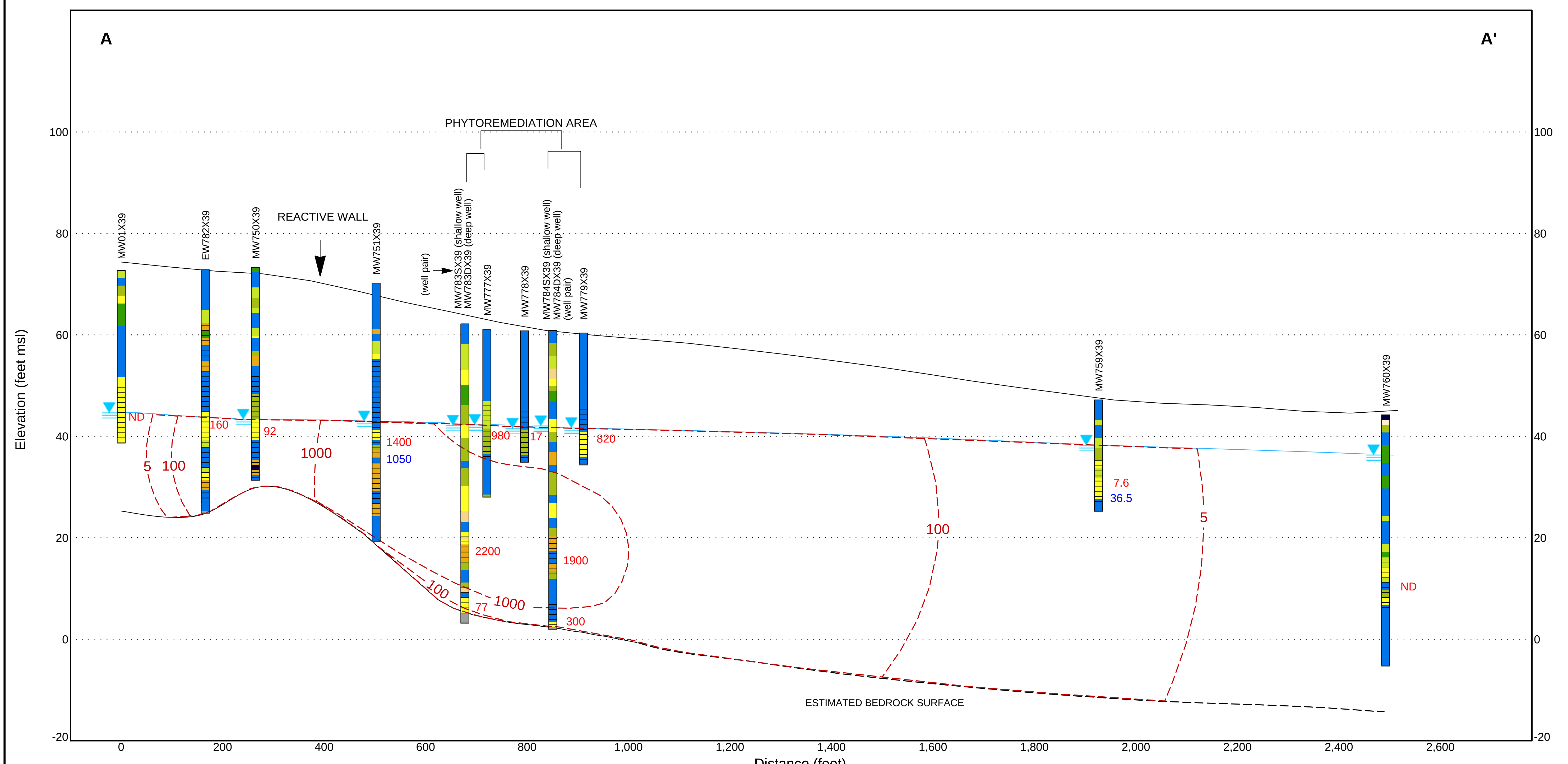


FIGURE 7-1
DP039 SITE MAP
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG7-1_DP039_SITE.MXD MCLAY1 1/22/2010



SOIL AND LITHOLOGY

SCREEN INTERVAL

APPROXIMATE SECOND QUARTER 2008 GROUNDWATER ELEVATION (ft MSL)

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE SECOND QUARTER 2008

6.7 TCE CONCENTRATION (µg/L) DETECTED IN THE FOURTH QUARTER 2008

- - 5 - - APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L) BASED ON MAX 2008 DETECTION

SCALE EXAGGERATION - 10:1 (H:V)

NOTE: SEE FIGURE 7-4 FOR CROSS SECTION LINE

NO SAMPLE/NO RECOVERY
FILL/ASPHALT
WELL GRADED GRAVEL (GW)
POORLY GRADED GRAVEL (GP)
SILTY GRAVEL (GM)
CLAYEY GRAVEL (GC)
WELL GRADED SAND (SW)
POORLY GRADED SAND (SP)
SILTY SAND (SM)
CLAYEY SAND (SC)
SILT (ML)
ELASTIC SILT (MH)
LEAN CLAY (CL)
FAT CLAY (CH)
SILTSTONE
SANDSTONE
SHALE

FIGURE 7-2
DP039 GEOLOGIC CROSS SECTION
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

\\YOSEMITE\PROJ\TRAVISAIRFORCEBASE\COMMONFILES\GINT FILES\TRAVIS_AFB_GINT_SECTIONS\MASTER_DATA\TRAVIS_2008_SAMPLING_EVENT.GPJ;

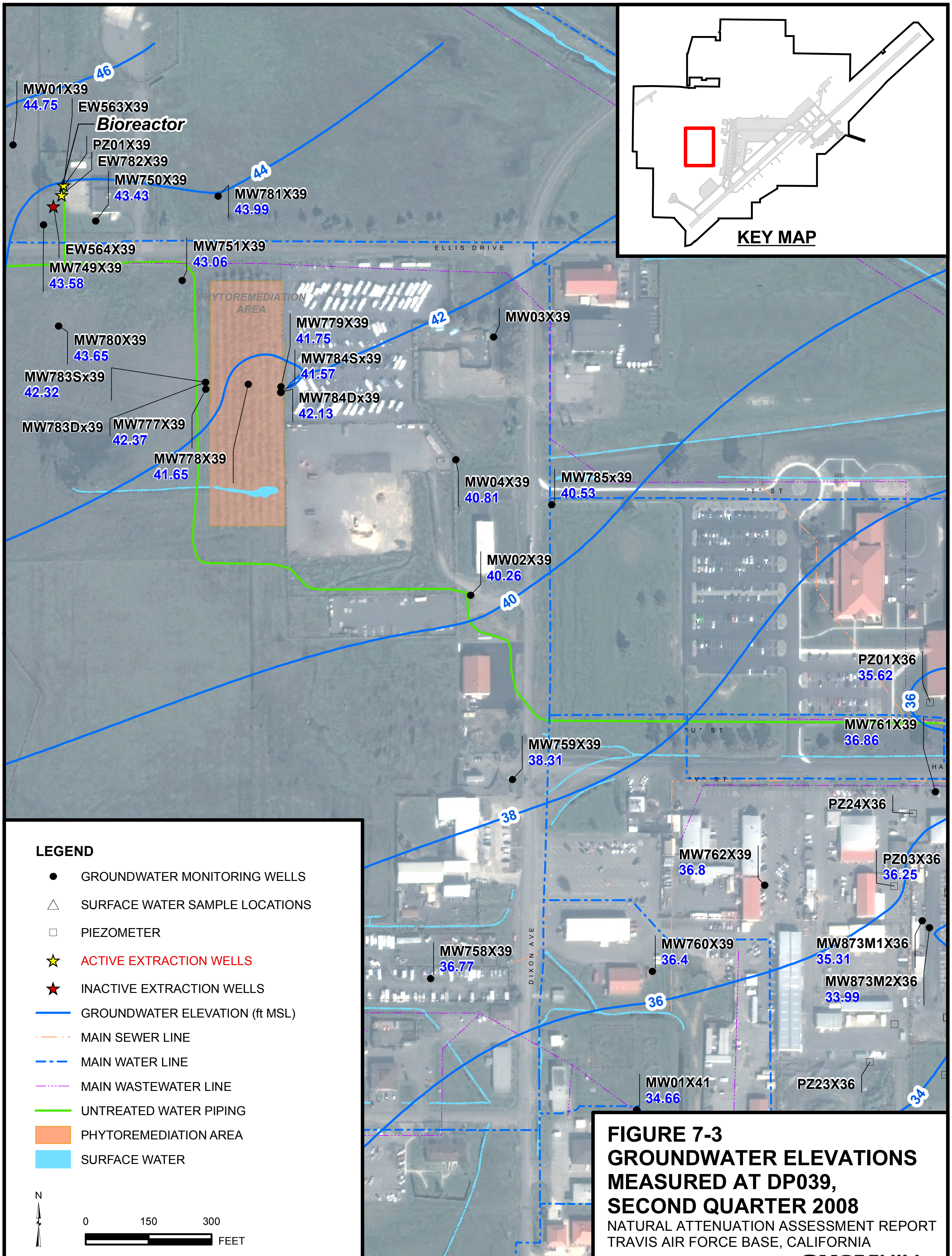


FIGURE 7-3
GROUNDWATER ELEVATIONS MEASURED AT DP039, SECOND QUARTER 2008
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG7-3_DP039_GW_2008.MXD MCLAY1 1/14/2010

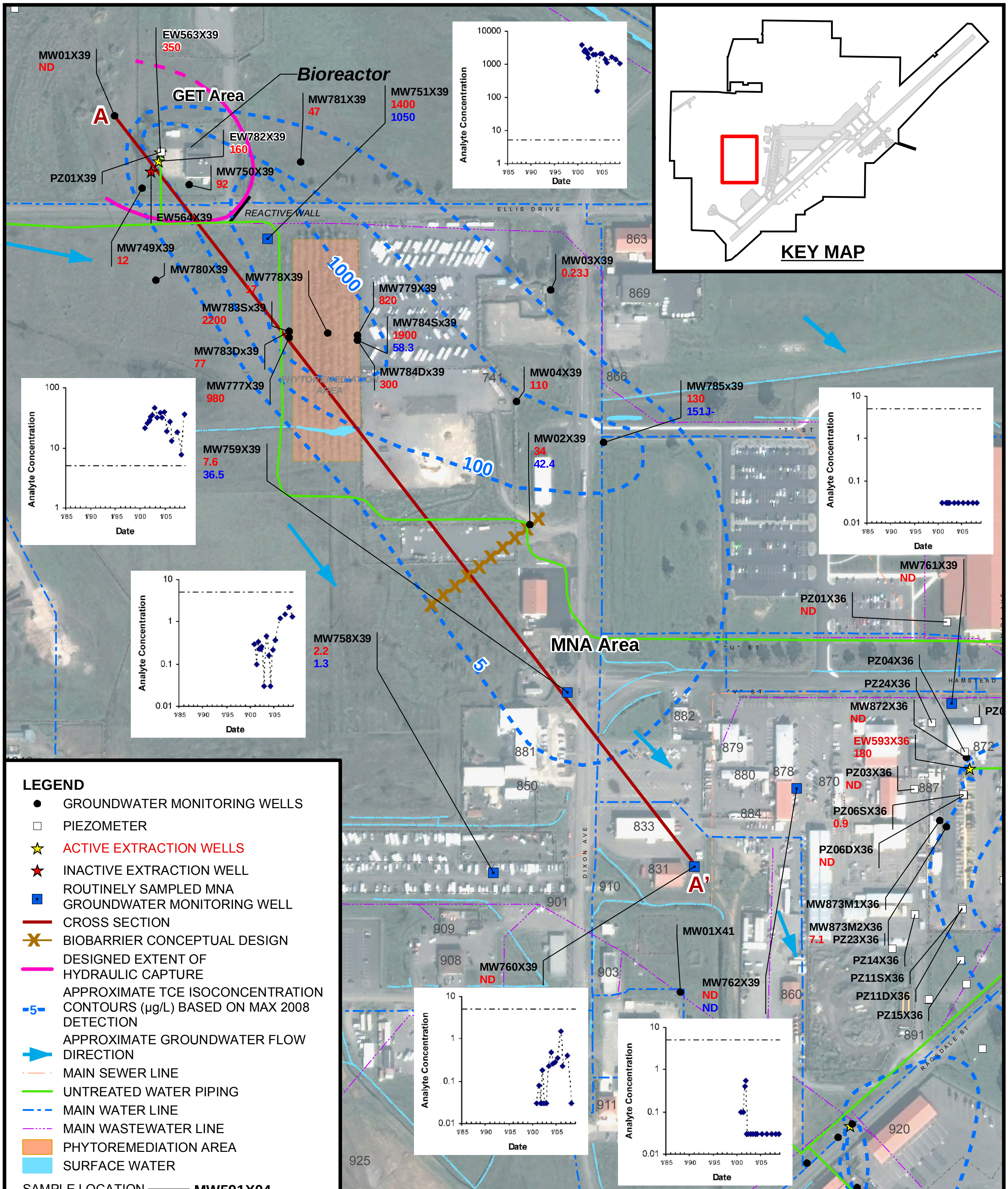
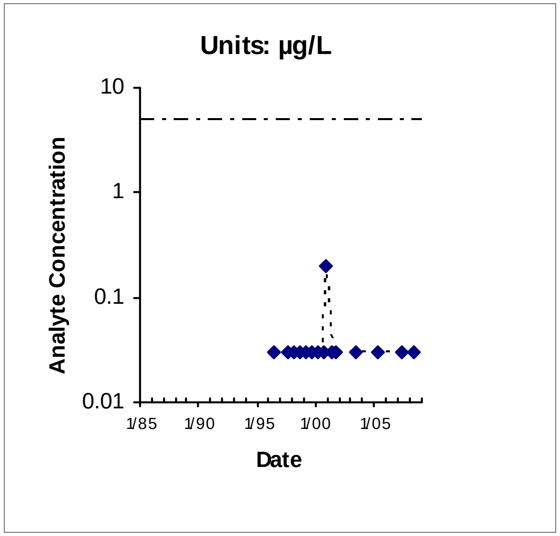


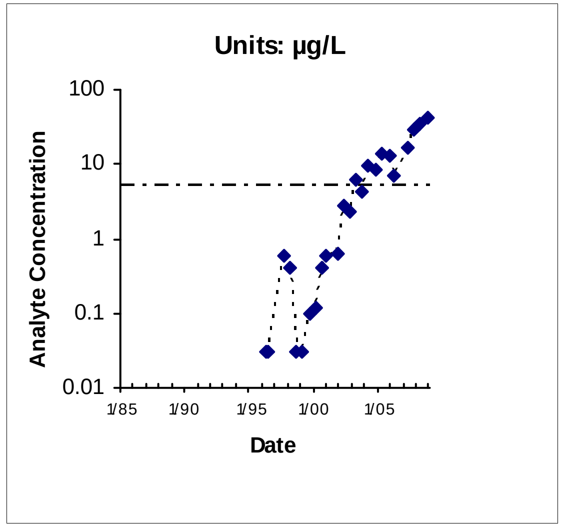
FIGURE 7-4
2008 TCE DISTRIBUTION IN GROUNDWATER AT DP039
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

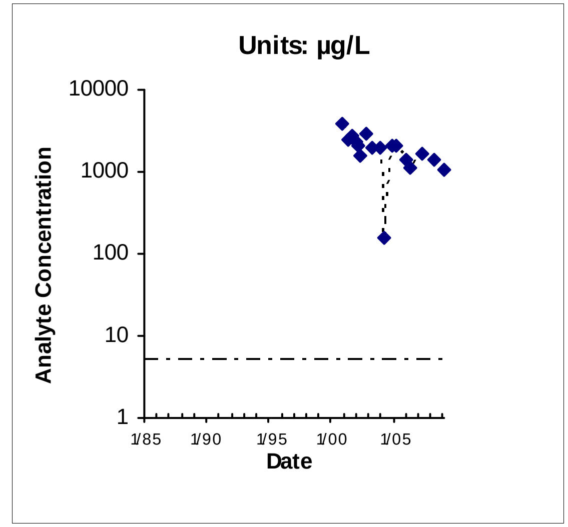
RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_MAY2010\FIG7-4_DP039_TCE.MXD JQUAN 6/2/2010 10:31:59



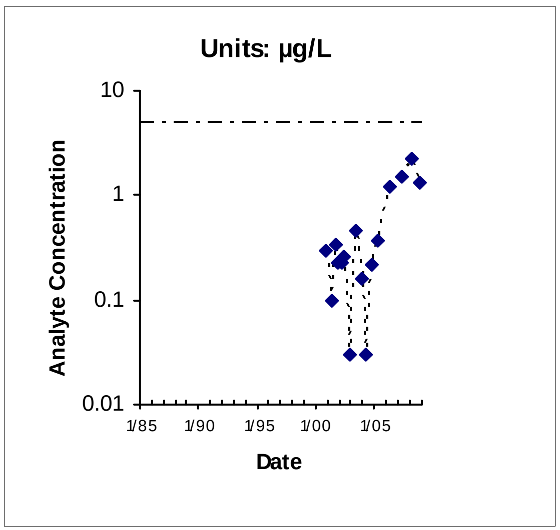
Location: MW01X39 Maximum: 0.2



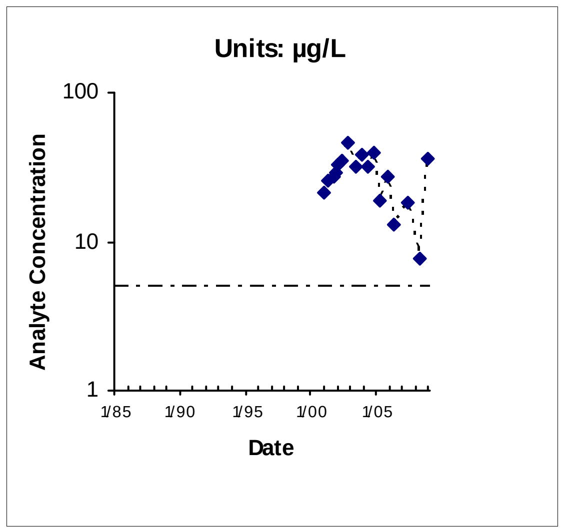
Location: MW02X39 Maximum: 42.4



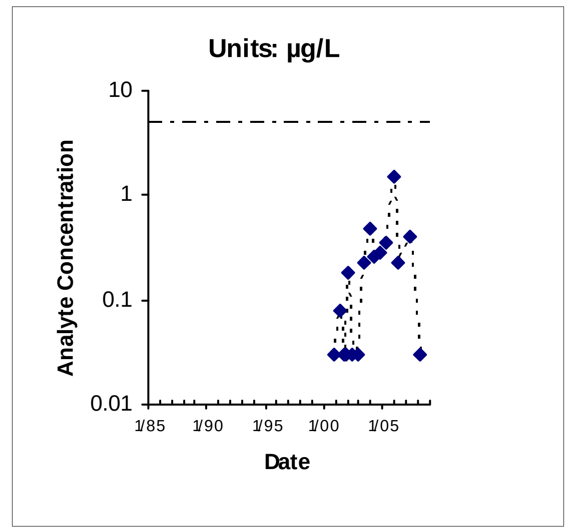
Location: MW751X39 Maximum: 3800



Location: MW758X39 Maximum: 2.2



Location: MW759X39 Maximum: 46



Location: MW760X39 Maximum: 1.5

— - — - — IRG (5 µg/L)

*Nondetects shown as the Method Detection Limit (0.03 µg/L)

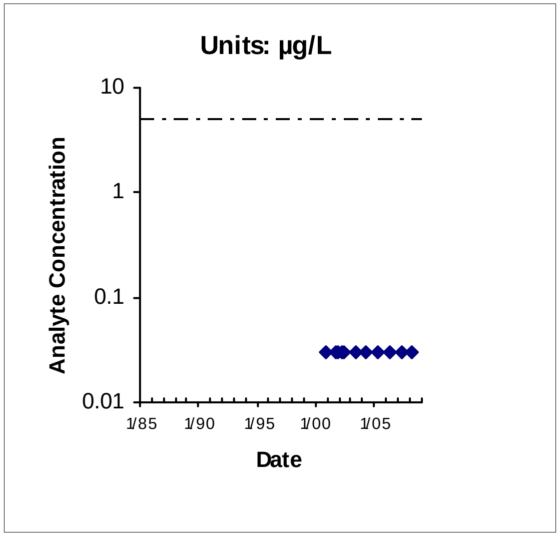
FIGURE 7-5

DP039 MNA Wells

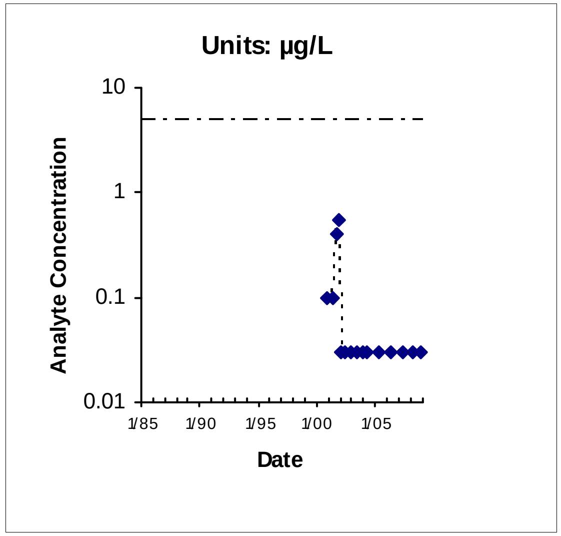
TCE

Chemical Time-series Plots

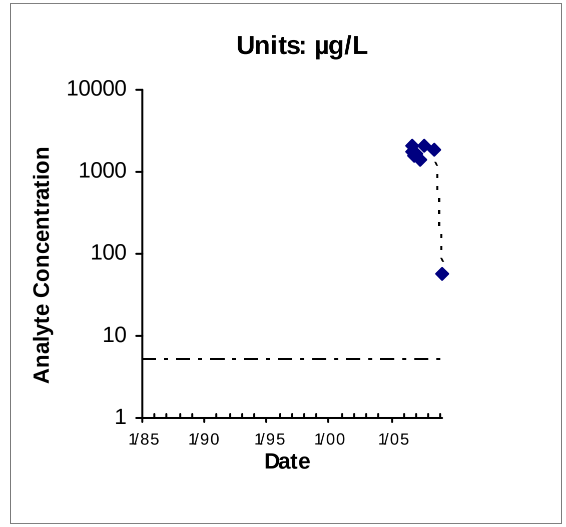
Page 1 of 2



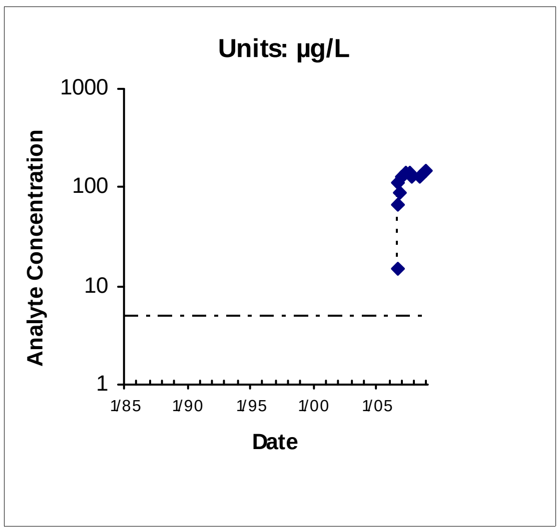
Location: MW761X39 Maximum: 0.03



Location: MW762X39 Maximum: 0.54



Location: MW784Sx39 Maximum: 2100



Location: MW785X39 Maximum: 151

— - — - — IRG (5 µg/L)

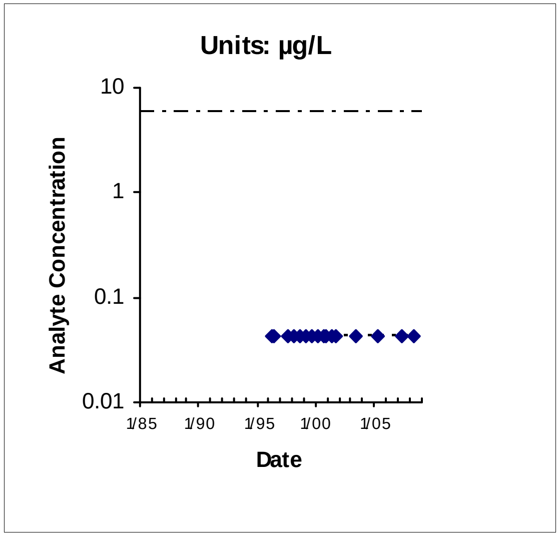
*Nondetects shown as the Method Detection Limit (0.03 µg/L)

FIGURE 7-5

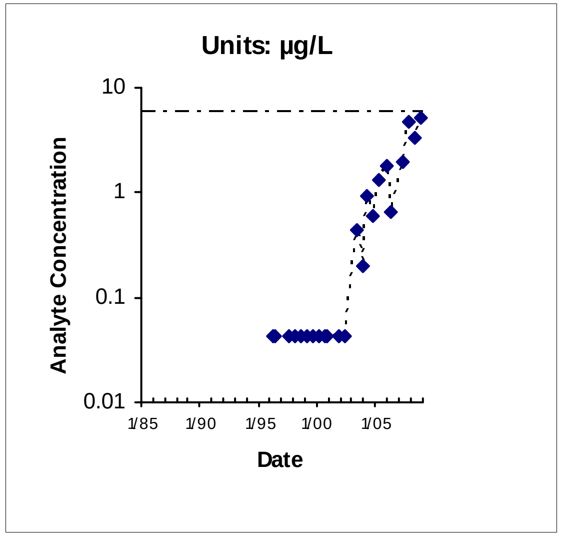
DP039 MNA Wells

TCE

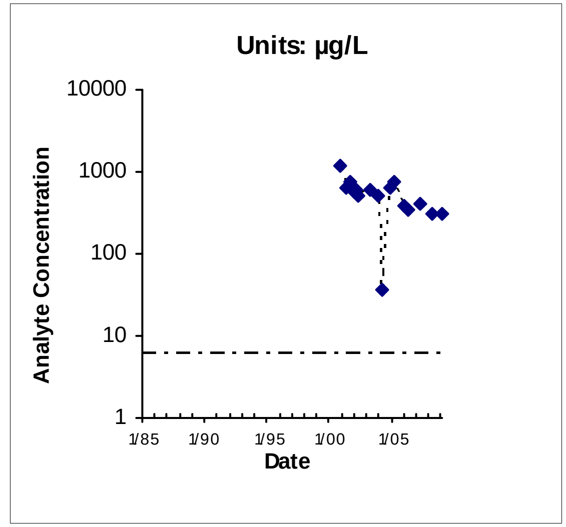
Chemical Time-series Plots



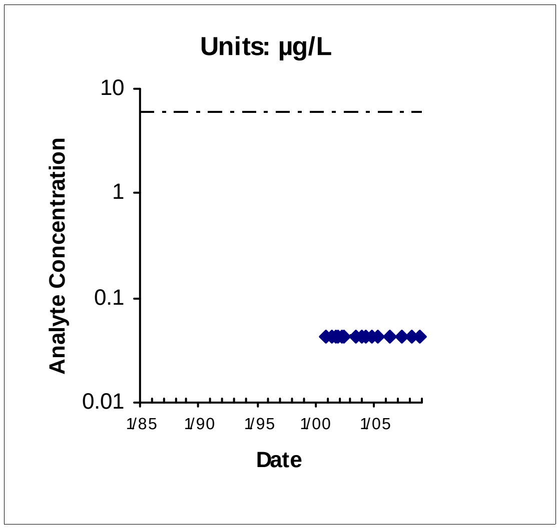
Location: MW01X39 Maximum: 0.0436



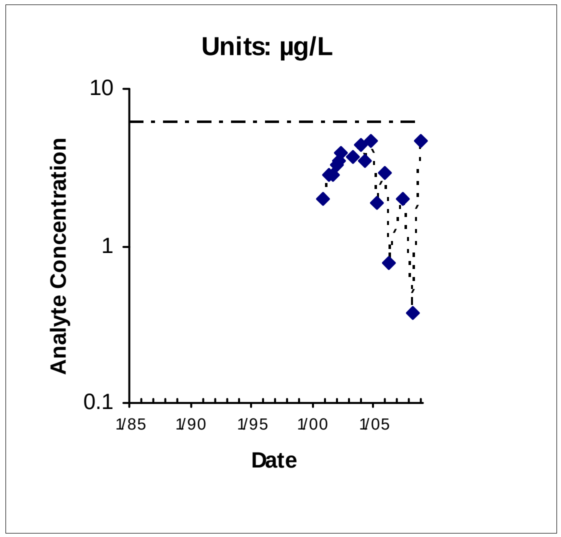
Location: MW02X39 Maximum: 5.2



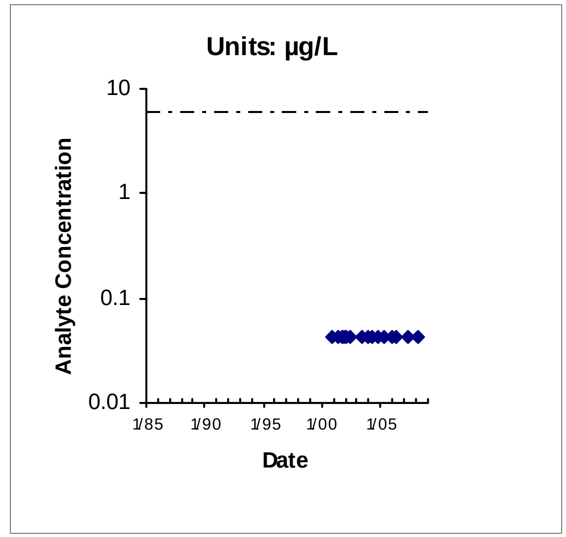
Location: MW751X39 Maximum: 1200



Location: MW758X39 Maximum: 0.0436



Location: MW759X39 Maximum: 4.7



Location: MW760X39 Maximum: 0.0436

— - — - — IRG (6 µg/L)

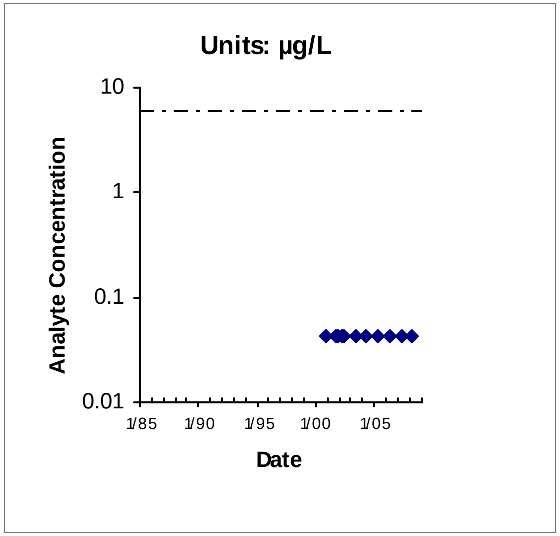
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 7-6

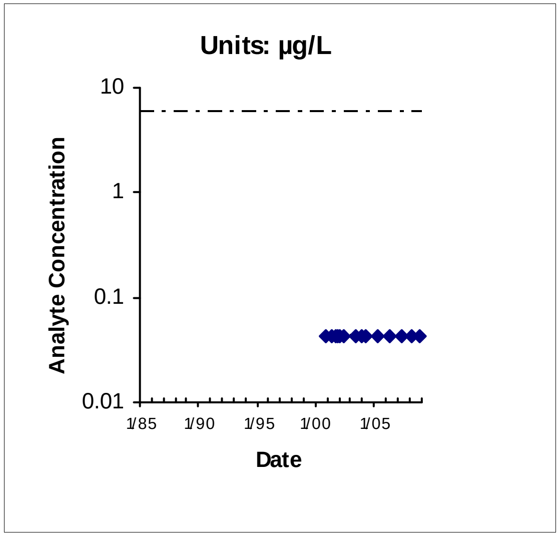
DP039 MNA Wells

1,1-DCE

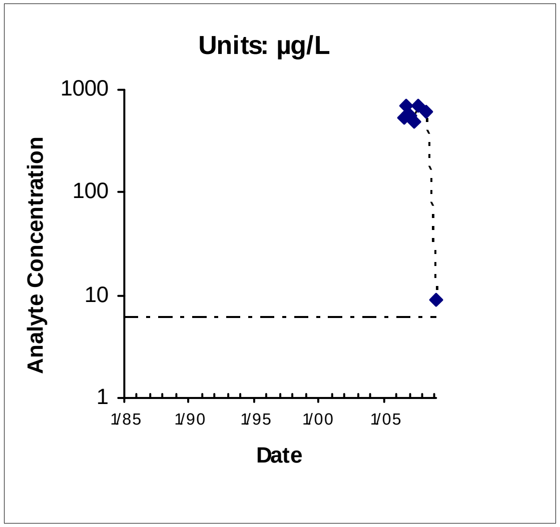
Chemical Time-series Plots



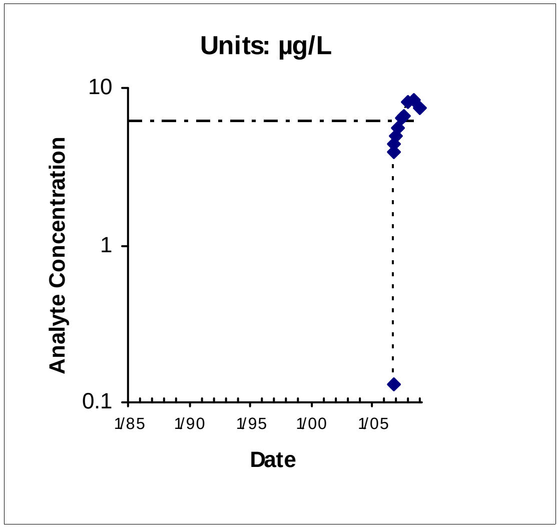
Location: MW761X39 Maximum: 0.0436



Location: MW762X39 Maximum: 0.0436



Location: MW784Sx39 Maximum: 700



Location: MW785X39 Maximum: 8.4

— - — - — IRG (6 µg/L)

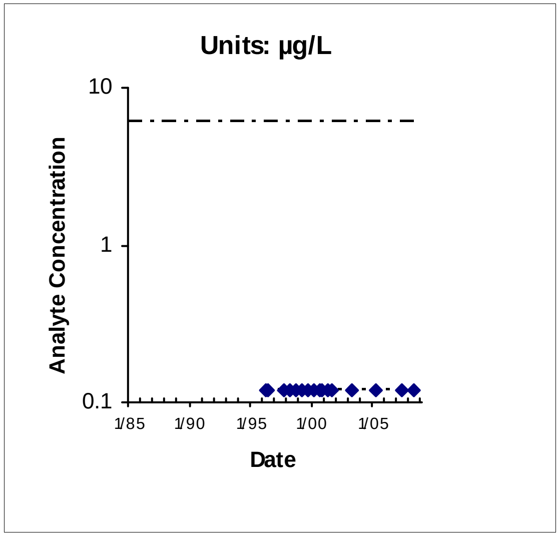
*Nondetects shown as the Method Detection Limit (0.0436 µg/L)

FIGURE 7-6

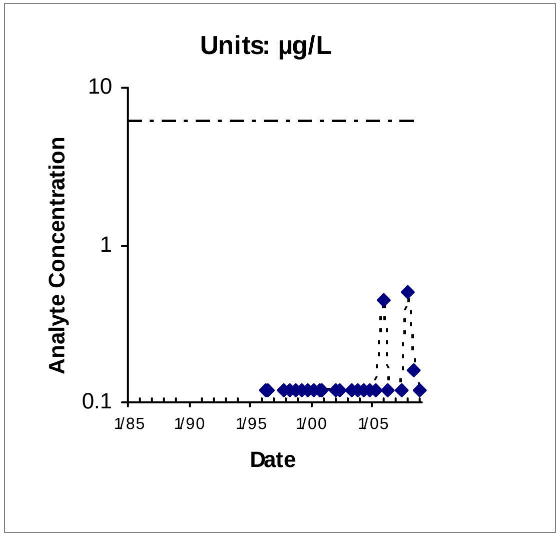
DP039 MNA Wells

1,1-DCE

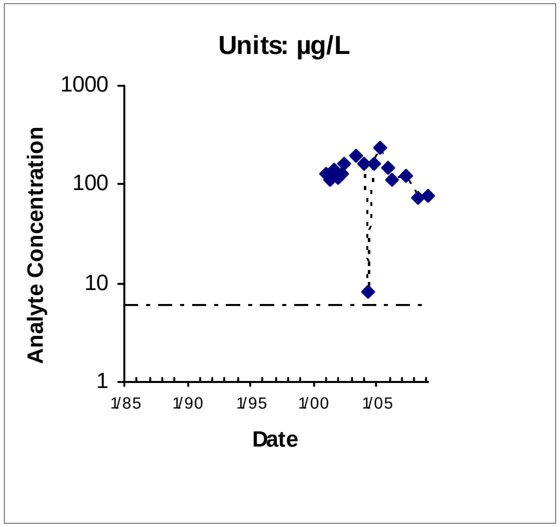
Chemical Time-series Plots



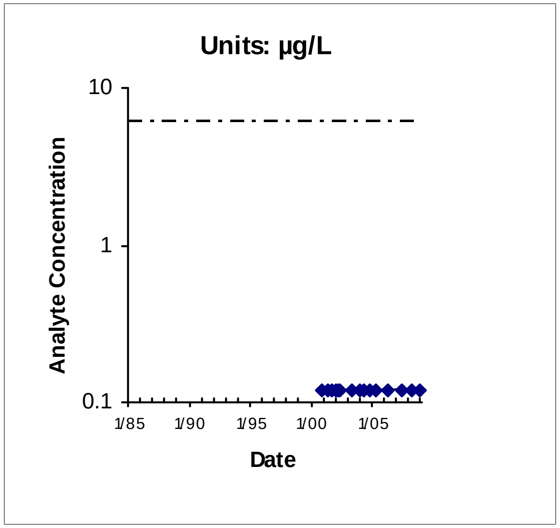
Location: MW01X39 Maximum: 0.12



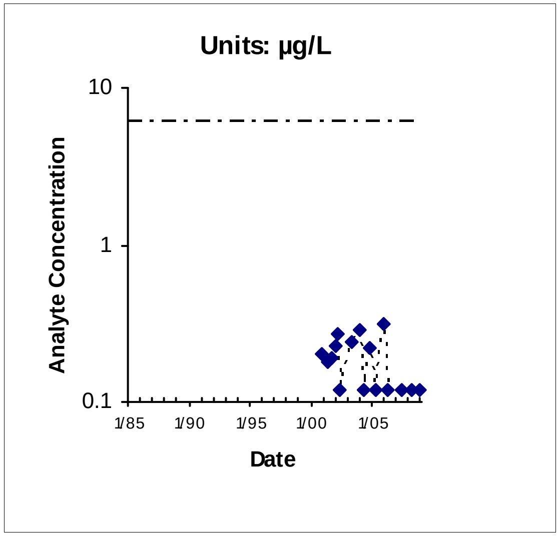
Location: MW02X39 Maximum: 0.5



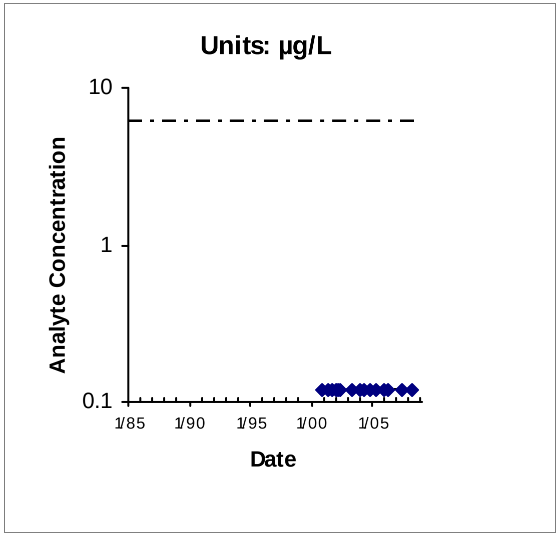
Location: MW751X39 Maximum: 230



Location: MW758X39 Maximum: 0.12



Location: MW759X39 Maximum: 0.31



Location: MW760X39 Maximum: 0.12

FIGURE 7-7

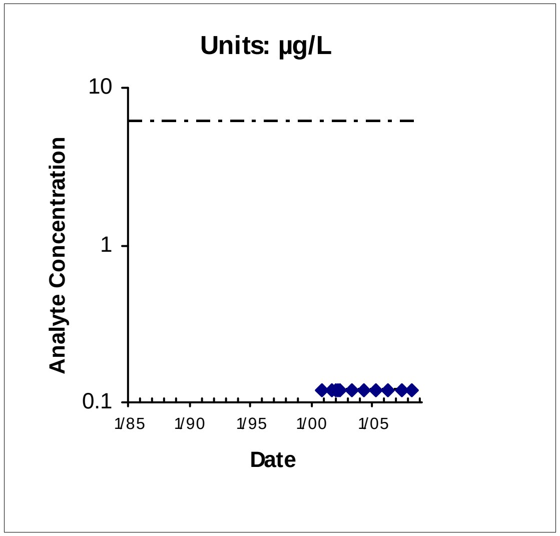
DP039 MNA Wells

Cis-1,2-DCE

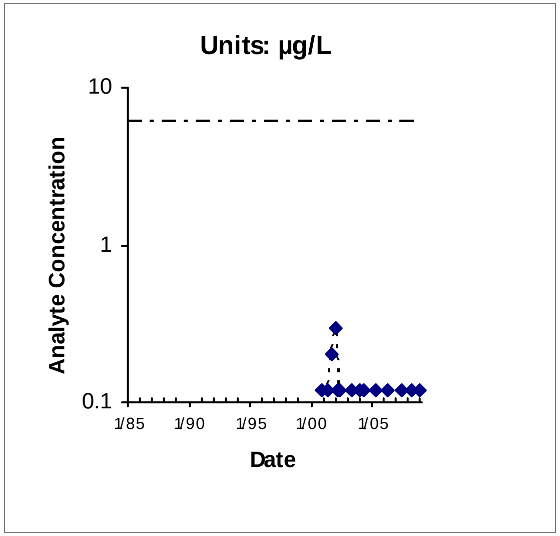
Chemical Time-series Plots

— - — - — IRG (6 µg/L)

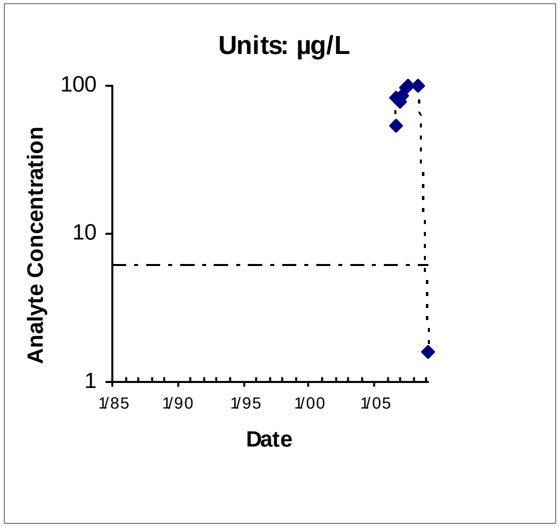
*Nondetects shown as the Method Detection Limit (0.12 µg/L)



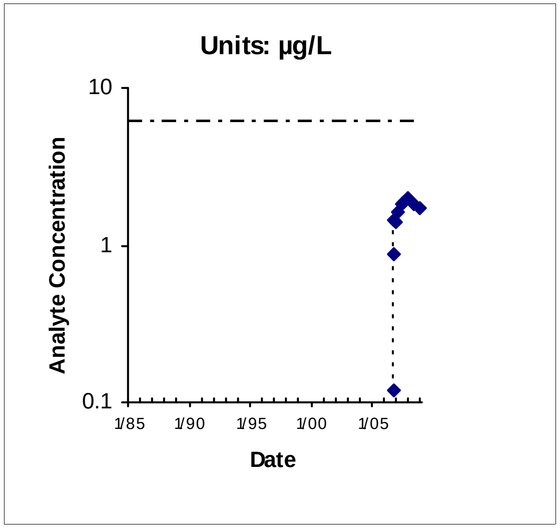
Location: MW761X39 Maximum: 0.12



Location: MW762X39 Maximum: 0.3



Location: MW784Sx39 Maximum: 100



Location: MW785X39 Maximum: 2

— - — - — IRG (6 µg/L)

*Nondetects shown as the Method Detection Limit (0.12 µg/L)

FIGURE 7-7

DP039 MNA Wells

Cis-1,2-DCE

Chemical Time-series Plots

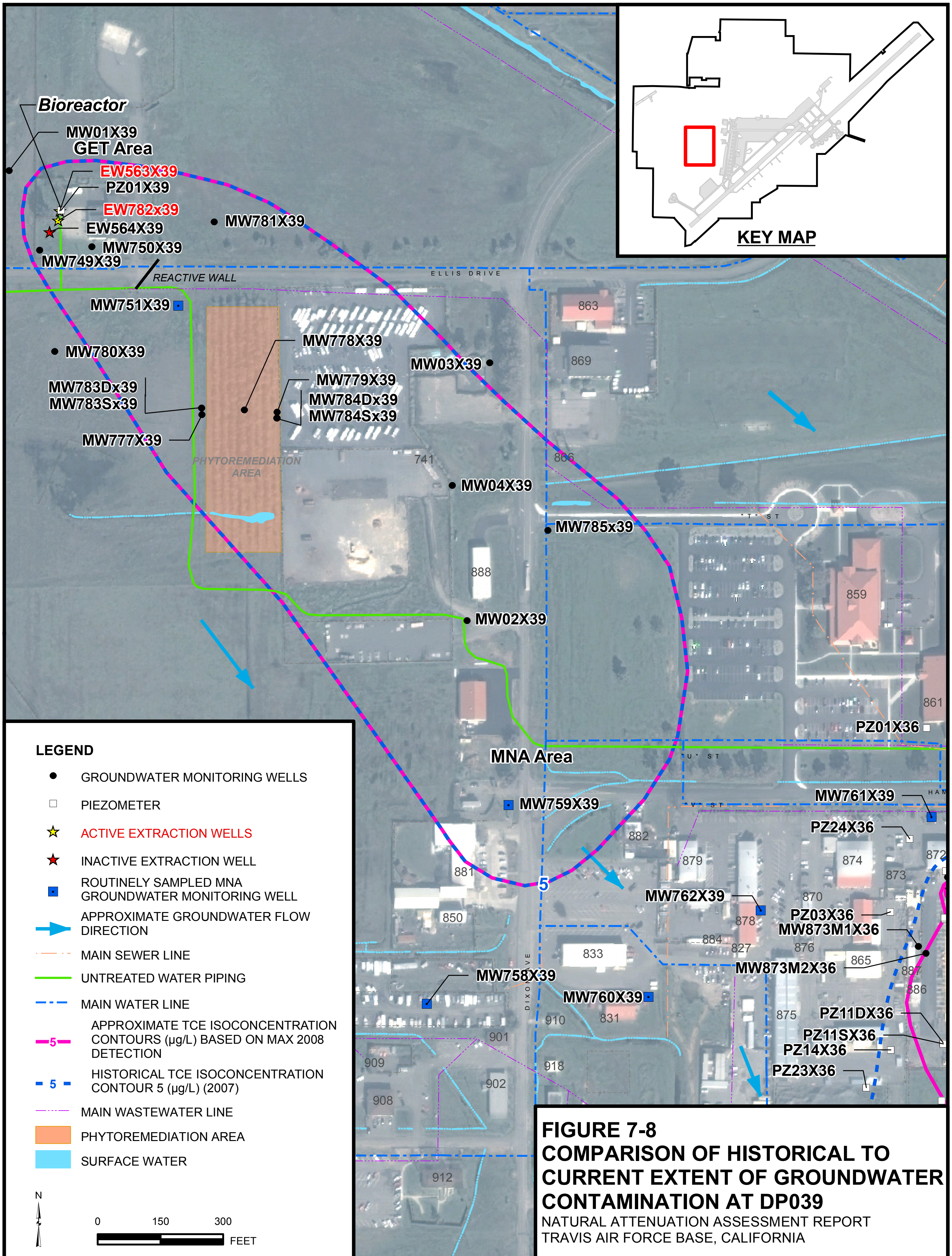
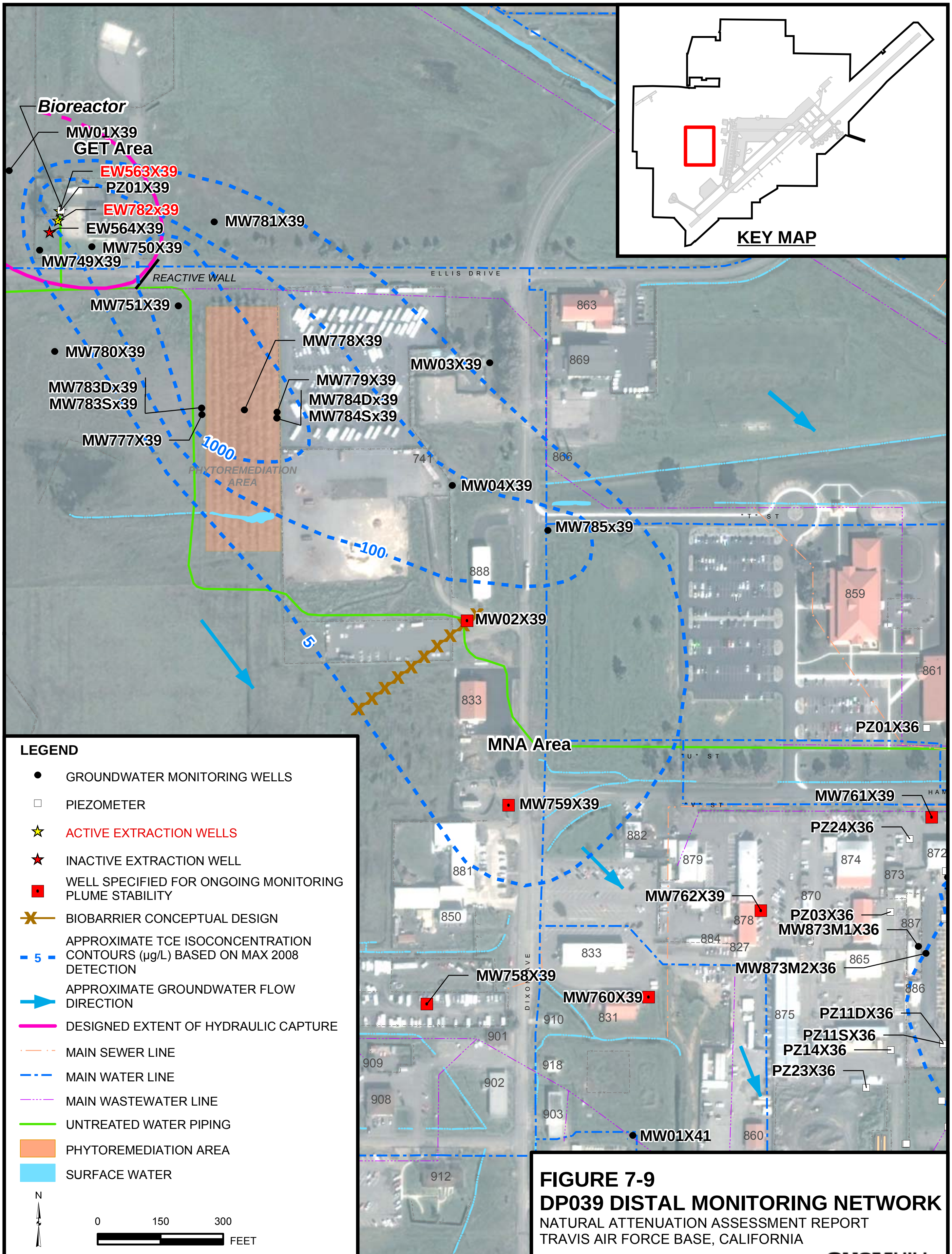


FIGURE 7-8
COMPARISON OF HISTORICAL TO CURRENT EXTENT OF GROUNDWATER CONTAMINATION AT DP039
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL



LEGEND

- GROUNDWATER MONITORING WELLS
- PIEZOMETER
- ACTIVE EXTRACTION WELLS
- INACTIVE EXTRACTION WELL
- WELL SPECIFIED FOR ONGOING MONITORING PLUME STABILITY
- BIOBARRIER CONCEPTUAL DESIGN
- 5 APPROXIMATE TCE ISOCONCENTRATION CONTOURS (µg/L) BASED ON MAX 2008 DETECTION
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- DESIGNED EXTENT OF HYDRAULIC CAPTURE
- MAIN SEWER LINE
- MAIN WATER LINE
- MAIN WASTEWATER LINE
- UNTREATED WATER PIPING
- PHYTOREMEDIATION AREA
- SURFACE WATER

N

0 150 300 FEET

FIGURE 7-9
DP039 DISTAL MONITORING NETWORK
NATURAL ATTENUATION ASSESSMENT REPORT
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

RDD \\BALDUR\PROJ\TRAVIS\381355_NAAR\MAPFILES\NAAR_JAN2010\FIG7-9_DP039_MONITORINGNETWORK.MXD MCLAY1 1/15/2010

SECTION 8

Conclusions

This NAAR presents the natural attenuation assessments for Sites FT004, LF006, LF007, SS015, SD031, SD033, SD037, and DP039. The main purpose of the NAAR is to determine whether MNA is an effective remedy at each of these sites. The conclusion of the MNA assessment for each site is presented in Table 8-1.

The primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has been reduced in size. Over the interim period (8 to 10 years, depending on the site), the GSAP has been monitoring several wells to evaluate plume stability. At most sites, the plume has not only been stable, but has receded over the interim period, indicating that MNA is an effective remedy at the site. At Sites SS015 and DP039, the results of the natural attenuation assessment indicate that plume remediation and stability would be improved through enhanced MNA.

In addition to monitoring for plume stability, a biological screening was performed to evaluate the dominant mechanism for natural attenuation at each site. At most sites, the evidence for biological degradation is inadequate to limited. Aquifer conditions are generally aerobic, which is favorable for TPH biodegradation but is not conducive to biodegradation of chlorinated solvents. At several of these sites, GET is performed in the source area, which introduces oxygen into the aquifer and results in aerobic conditions in the source area. In addition, there are currently insufficient natural or anthropogenic carbon donors in most areas to impact geochemical conditions and result in reductive dechlorination. At some sites, the plume may have originally exhibited "mixed behavior," where anthropogenic carbon (such as TPH) may have been present in the source area (Type 1 behavior) but inadequate carbon was present in the downgradient portion of the plume to drive biodegradation (Type 3 behavior).

At most sites, physical processes are currently the dominant mechanism for the attenuation observed at the site over the interim period. Physical processes include diffusion, dispersion, dilution, adsorption, and volatilization, and generally result in a reduction in the concentration, toxicity, or mobility of contaminants without reducing the overall mass or volume of the contaminant. However, the physical process of volatilization does result in a reduction in contaminant mass in groundwater, as the contaminant goes from liquid to vapor phase.

Groundwater monitoring will continue at all of these sites to support the FS and selection of the final remedy in the ROD. The monitoring focus over this time period will be to continue to monitor for plume migration in the portion of the site specified for MNA or MNA assessment over the interim period. Table 8-2 summarizes the monitoring networks for ongoing monitoring of plume stability. In addition to MNA, many of these sites have interim remedies of GET in the source area. Source area monitoring to support assessment of GET performance will continue to be performed as specified in the GSAP annual reports.

TABLE 8-1
MNA Assessment Conclusions
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Interim Remedy	Has the Plume Been Stable over the Interim Period?	Dominant Natural Attenuation Mechanism	Conclusion of MNA Assessment
FT004	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
LF006	MNA for entire site	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the entire plume.
LF007B	MNA assessment for entire subarea	Yes, in fact, COCs are no longer detected in groundwater.	Physical	MNA is an appropriate remedy for the entire plume.
LF007D	MNA assessment for entire subarea	Yes, in fact, the plume has receded.	Biological in source area, physical in distal areas	MNA is an appropriate remedy for the entire plume.
SS015	MNA assessment for entire site	The plume was stable for several years but now appears to be migrating. The long period of plume stability is due to vegetable oil injection performed in 2000-2001 (enhanced MNA).	Biological (enhanced by vegetable oil injection)	Enhanced MNA is a potential remedy for the site.
SD031	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
SD033	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
SD037	MNA assessment in distal portion of plume	Yes, in fact, the plume has receded.	Physical	MNA is an appropriate remedy for the distal portion of the plume.
DP039	MNA assessment in distal portion of plume	Uncertain. The southern toe of the plume has remained stable over the interim period. However, increasing COC trends at some areas within the plume suggest that MNA alone may not be sufficient to prevent plume migration.	Physical	Enhanced MNA is an appropriate remedy for the distal portion of the plume. Existing bioreactor will provide enhanced biodegradation of source area residuals. The planned biobarrier will enhance degradation in the central portion of the plume.

Note:

Distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment.

TABLE 8-2
Wells for Ongoing Monitoring of Plume Stability
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Well	Sampling Frequency	Analyses		
			VOCs (SW8260)	TPH-G (SW8015B-P)	TPH-D (SW8015B-E)
ERP Sites					
FT004/SD031 MNA	MW134X04	Annual	X		
	MW584X04	Annual	X		
	MW587x04	Annual	X		
	MW591X04	Annual	X		
	MW757X04	Annual	X		
	MW571X31	Annual	X		
	MW574X31	Annual	X		
LF006 MNA	MW208X06	Annual	X	X	X
	MW208DX06	Annual	X	X	X
	MW259X06	Annual	X	X	X
	MW1729X31	Annual	X	X	X
	MW1730x31	Annual	X	X	X
	MW1731X31	Annual	X	X	X
LF007 MNA	MWBX07	Annual	X		
	MWCX07	Annual	X		
	MW129X07	Annual	X		
	MW261X07	Annual	X		
	MW601X07	Annual	X		
	MW612X07	Annual	X		
	MW613X07	Annual	X		
SS015 MNA	MW104X15	Annual	X		
	MW105X15	Annual	X		
	MW216X15	Annual	X		
	MW306X15	Annual	X		
	MW624X15	Annual	X		
	MW625X15	Semiannual	X		
WIOU MNA	MW05X14	Annual	X	X	X
	MW116X37	Annual	X	X	X
	MW722X37	Annual	X	X	X
	MW723X37	Annual	X	X	X
	MW724X37	Annual	X	X	X
	MW1208X37	Annual	X	X	X
	MW1209X37	Annual	X	X	X

TABLE 8-2
Wells for Ongoing Monitoring of Plume Stability
Natural Attenuation Assessment Report, Travis Air Force Base, California

Site	Well	Sampling Frequency	Analyses: VOCs (SW8260)	Analyses: TPH-G (SW8015B-P)	Analyses: TPH-D (SW8015B-E)
DP039 MNA	MW02X39	Annual	X		
	MW758X39	Annual	X		
	MW759X39	Annual	X		
	MW760X39	Annual	X		
	MW761X39	Annual	X		
	MW762X39	Annual	X		
	MW785X39	Annual	X		

Appendix A
Acronyms and Abbreviations

APPENDIX A
Acronyms and Abbreviations

2Q08	second quarter 2008
4Q08	fourth quarter 2008
°C	degree(s) Celsius
µg/L	microgram(s) per liter
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and the Environment
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAMU	Correction Action Management Unit
COC	chemical of concern
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DO	dissolved oxygen
DRMO	Defense Reutilization and Marketing Office
EIOU	East Industrial Operable Unit
ERP	Environmental Restoration Program
ft bgs	feet below ground surface
ft/day	feet per day
ft/ft	feet per foot
ft/year	feet per year
FS	feasibility study
FTA-3	Fire Training Area No. 3
GET	groundwater extraction and treatment
GSAP	Groundwater Sampling and Analysis Program
IRA	interim remedial action
IRAO	interim remedial action objective

IRG	interim remediation goal
IROD	interim record of decision
MCL	maximum contaminant level
MNA	monitored natural attenuation
NAAP	natural attenuation assessment plan
NAAR	natural attenuation assessment report
NAAW	natural attenuation assessment workplan
NEWIOU	North, East, West Industrial Operable Unit
NOU	North Operable Unit
ORP	oxygen reduction potential
OSWER	Office of Solid Waste and Emergency Response
OWS	oil/water separator
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
POCO	petroleum only contaminated
POL	petroleum, oil, and lubricants
RAO	remedial action objective
RI	remedial investigation
ROD	record of decision
SSA	Solvent Spill Area
TCA	trichloroethane
TCE	trichloroethene
TOC	total organic carbon
TPH-D	total petroleum hydrocarbons as diesel
TPH-G	total petroleum hydrocarbons as gasoline
WABOU	West/Annexes/Basewide Operable Unit
WIOU	West Industrial Operable Unit
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound

Appendix B
References

APPENDIX B

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Appendix C
Field Parameters

Appendix C

Summary of Field Parameters Measured in 4Q08 GSAP

Natural Attenuation Assessment Report, Travis Air Force Base, California

Grouped by Site, sorted by Location and Date

Site	Location	Sample Date	pH (units)	Conductivity (mMho/cm)	Temperature ('C)	Dissolved O2 (mg/L)	Turbidity (ntu)	Redox (mvolts)	CO2 (mg/L)	Iron (mg/L)
Site FT004/SD031										
Site FT004										
Groundwater										
	MW131x04	12/3/2008	7.09	4.9	18.1	1.94	11.3	150	300	0
	MW134x04	12/4/2008	7.66	85.4	17.4	1.58	5.5	-23	160	0
	MW202x04	12/2/2008	7.37	2.5	17.7	1.08	10.5	90	100	0.2
	MW264x04	11/21/2008	6.83	23.4	19.39	0.33	57.8	87	83	0
	MW266x04	12/2/2008	6.75	2.23	18	4.09	116	105	135	0
	MW582x04	12/1/2008	7.69	2.98	18.9	5.7	12.8	104	70	0
	MW591x04	12/1/2008	7.57	6.09	17.6	1.78	25.8	100	48	0
	MW752x04	12/3/2008	7.51	2.05	17.9	1.6	0.03	123	150	
	MW753x04	12/3/2008	7.72	2.08	17.7	1.34	17.2	100	116	0
	MW754x04	12/3/2008	7.47	1.99	18	1.55	4.6	116	110	0
Site SD031										
Groundwater										
	MW570x31	12/9/2008	7.22	1.58	20.22	0.65	32.4	123	190	0
	MW571x31	12/9/2008	7.11	9.99	18.9	1.18	0	93	128	0
	MW574x31	12/10/2008	7.59	77.2	20.8	1.52	48.8	109	112	0
	MW1730x31	12/9/2008	7.86	2.09	19.56	1.93	8.5	34	170	0
Site LF006										
Site LF006										
Groundwater										
	MW01Dx06	12/10/2008	7.7	1.39	19.03	0.82	4.7	129	120	0
	MW01Sx06	12/15/2008	7.95	1.63	19.46	1.65	0	147	116	0
	MW207x06	11/21/2008	7.18	14.6	19.78	0.45	40.5	-78	65	3
	MW208Dx06	12/10/2008	7.67	1.56	18.3	1.9	4	36	124	0
	MW210x06	12/16/2008	7.27	1.59	17.31	0	82.5	90	120	0
	MW259x06	12/10/2008	7.34	1.91	17.8	1.87	1.6	-40	150	1
Site LF007										
Groundwater										
	MW129x07	12/4/2008	7.7	1.84	16.9	1.74	0	98	122	0
Site SD031										
Groundwater										
	MW1729x31	12/9/2008	7.98	1.2	18.7	5.27	0	106	64	0
	MW1730x31	12/9/2008	7.86	2.09	19.56	1.93	8.5	34	170	0
	MW1731x31	12/9/2008	7.59	1.71	18	2.87	50.6	36	72	0
Site LF007										
Site FT004										
Groundwater										
	MW264x04	11/21/2008	6.83	23.4	19.39	0.33	57.8	87	83	0
Site LF006										
Groundwater										
	MW207x06	11/21/2008	7.18	14.6	19.78	0.45	40.5	-78	65	3

Appendix C

Summary of Field Parameters Measured in 4Q08 GSAP

Natural Attenuation Assessment Report, Travis Air Force Base, California

Grouped by Site, sorted by Location and Date

Site	Location	Sample Date	pH (units)	Conductivity (mMho/cm)	Temperature ('C)	Dissolved O2 (mg/L)	Turbidity (ntu)	Redox (mvolts)	CO2 (mg/L)	Iron (mg/L)
Site LF006										
Groundwater										
	MW210x06	12/16/2008	7.27	1.59	17.31	0	82.5	90	120	0
Site LF007										
Groundwater										
	MW129x07	12/4/2008	7.7	1.84	16.9	1.74	0	98	122	0
	MW261x07	11/24/2008	7.32	11.9	20.2	0.73	247	-130		1.5
	MW600x07	12/10/2008	7.33	3.01	14.68	0.63	2.4	171	174	0
	MW601x07	12/9/2008	7.41	3.94	19.15	1.48	0	129	202	0
	MW612x07	12/4/2008	6.98	6.83	17.6	2.39	0	124	380	0
	MW613x07	12/4/2008	7.17	99.9	17.5	1.44	63.3	-5	236	1.4
	MWAx07	12/9/2008	7.05	3.24	18.5	1.09	12.8	100	260	0
	MWCx07	11/24/2008	7.28	4.72	20.3	0.61	4.6	-25	234	0.3
	MWFx07	11/24/2008	8.64	3.31	18.4	0.76	4.6	64	51	0
	MWGx07	11/21/2008	7.26	5.86	18.83	0.31	114	-52	56	0
Site SS015										
Site SS015										
Groundwater										
	MW216x15	12/22/2008	6.93	6.88	20.62	1.22	2.8	30	700	0
	MW238x15	1/12/2009	6.76	5.01	20.15	0.04	0	122	208	0
	MW624x15	12/22/2008	8.03	4.74	18.73	4.05	11.8	125	118	0
	MW625x15	12/22/2008	7.28	4.4	19.3	0.91	46.6	-73	260	2.3
The WIOU										
Site SS014										
Groundwater										
	MW02x14	1/6/2009	6.96	0.69	20.11	0.9	18	-98		
	MW05x14	12/22/2008	6.58	1.97	19.01	0	7.7	-176		2
Site SD037										
Groundwater										
	MW116x37	12/19/2008	7.19	1.56	18.66	0.75	0	121		
	MW310x37	12/19/2008	7	1.41	16.21	1.33	0	80		
	MW513x37	12/18/2008	7.3	1.12	17.5	0.46	0	144	116	0
	MW524x37	12/22/2008	7.01	1.15	17.72	0	13.2	-6	140	0
	MW531x37	12/18/2008	7.46	1.14	18.44	0.44	0	-185	96	1
	MW540x37	12/18/2008	7.12	1.33	19.41	0	0	20	136	0
	MW722x37	12/18/2008	7.61	1.68	17.31	2.37	3	168	142	0
	MW724x37	12/18/2008	7.93	1.29	18.63	1.06	12.2	112	186	0
	MW1208x37	12/16/2008	7.11	1.26	18.15	0	8.9	96	138	0
	MWS1M2x37	12/18/2008	7.71	2	19.79	1.83	17	89	144	0
Site DP039										
Site DP039										
Groundwater										
	MW02x39	12/15/2008	7.01	1.79	17.67	6.54	1	125	148	0

Appendix C

Summary of Field Parameters Measured in 4Q08 GSAP

Natural Attenuation Assessment Report, Travis Air Force Base, California

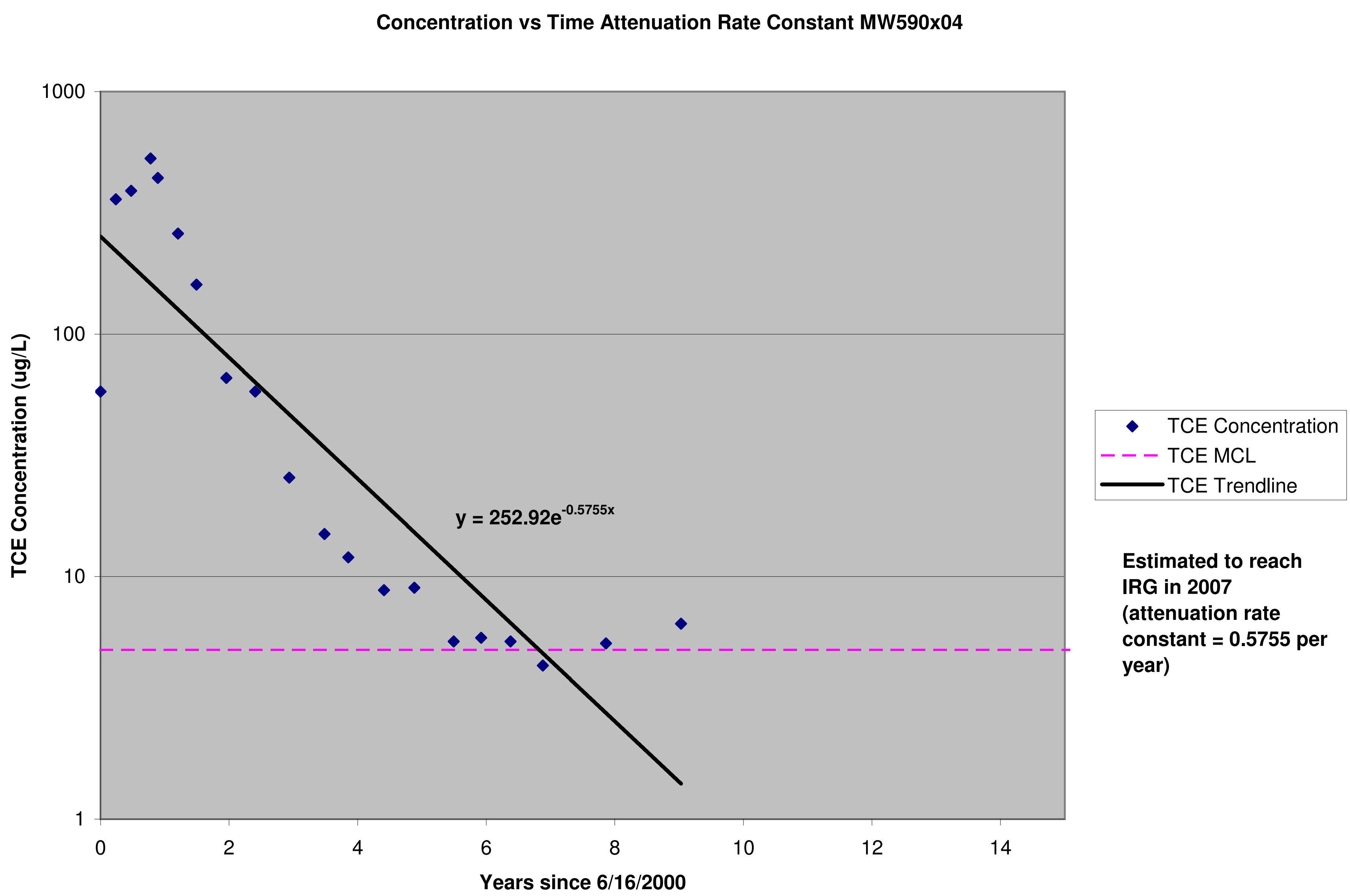
Grouped by Site, sorted by Location and Date

Site	Location	Sample Date	pH (units)	Conductivity (mMho/cm)	Temperature ('C)	Dissolved O2 (mg/L)	Turbidity (ntu)	Redox (mvolts)	CO2 (mg/L)	Iron (mg/L)
Site DP039										
Groundwater										
	MW751x39	1/7/2009	7.4	0.84	16.36	0	17.7	61	128	0
	MW758x39	12/15/2008	7.85	1.1	19.07	8.93	3.9	174	110	0
	MW759x39	12/15/2008	7.17	1.83	18.94	4.6	0	195	144	0
	MW762x39	12/15/2008	7.96	1.37	20.15	3.28	0	163	120	0
	MW784Sx39	1/7/2009	7.7	1.07	15.04	11.17	0	88	56	0
	MW785x39	12/15/2008	7.5	1.19	17.71	1.49	187	28	84	0

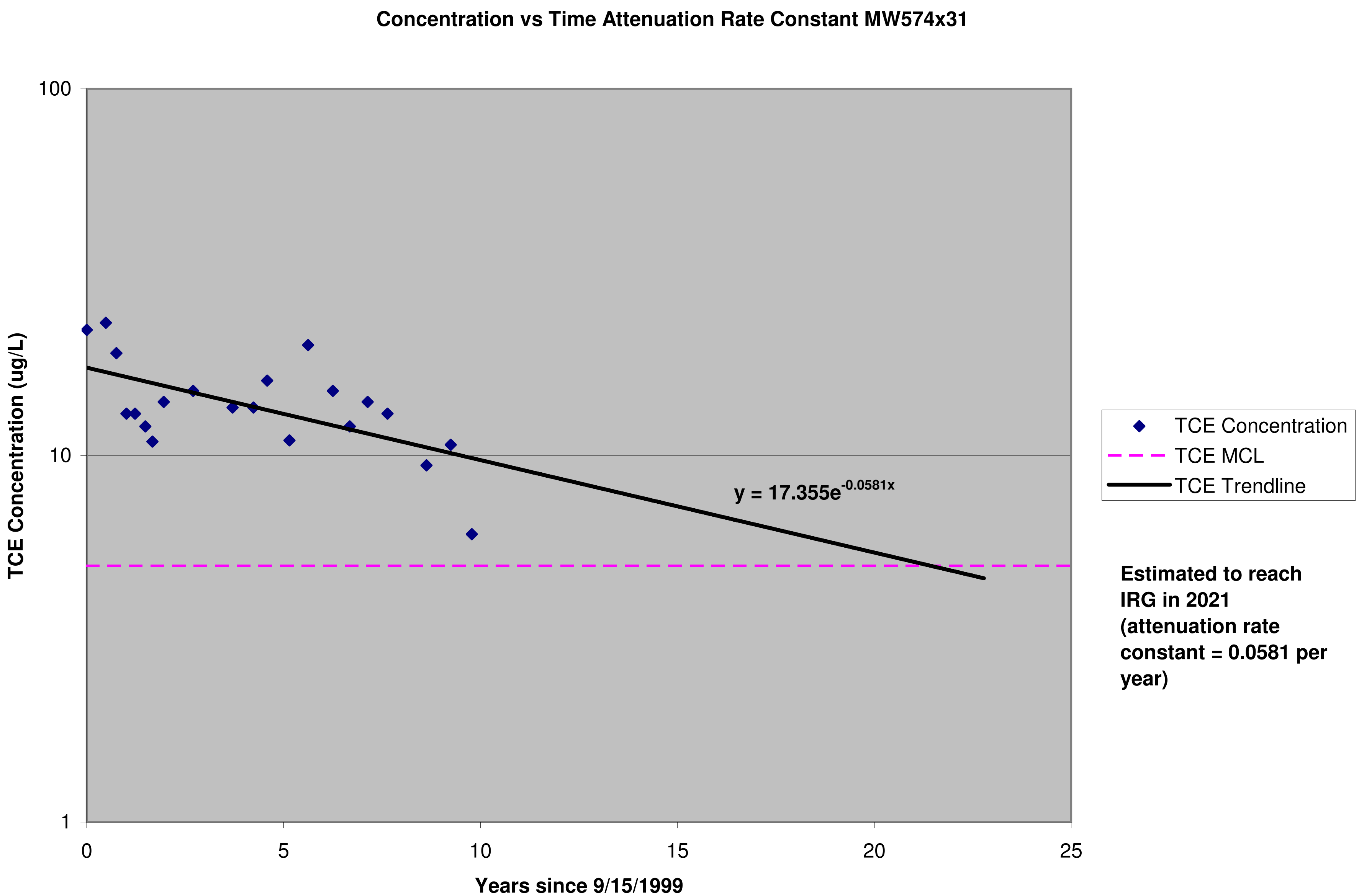
Note: carbon dioxide and ferrous iron field analysis were performed only at wells included in the biological screening evaluation.

\\Odin\proj\DV\Travis_AFB\Reports\NatAtten_12132009\FieldParameters.mdb; rptFieldParameters

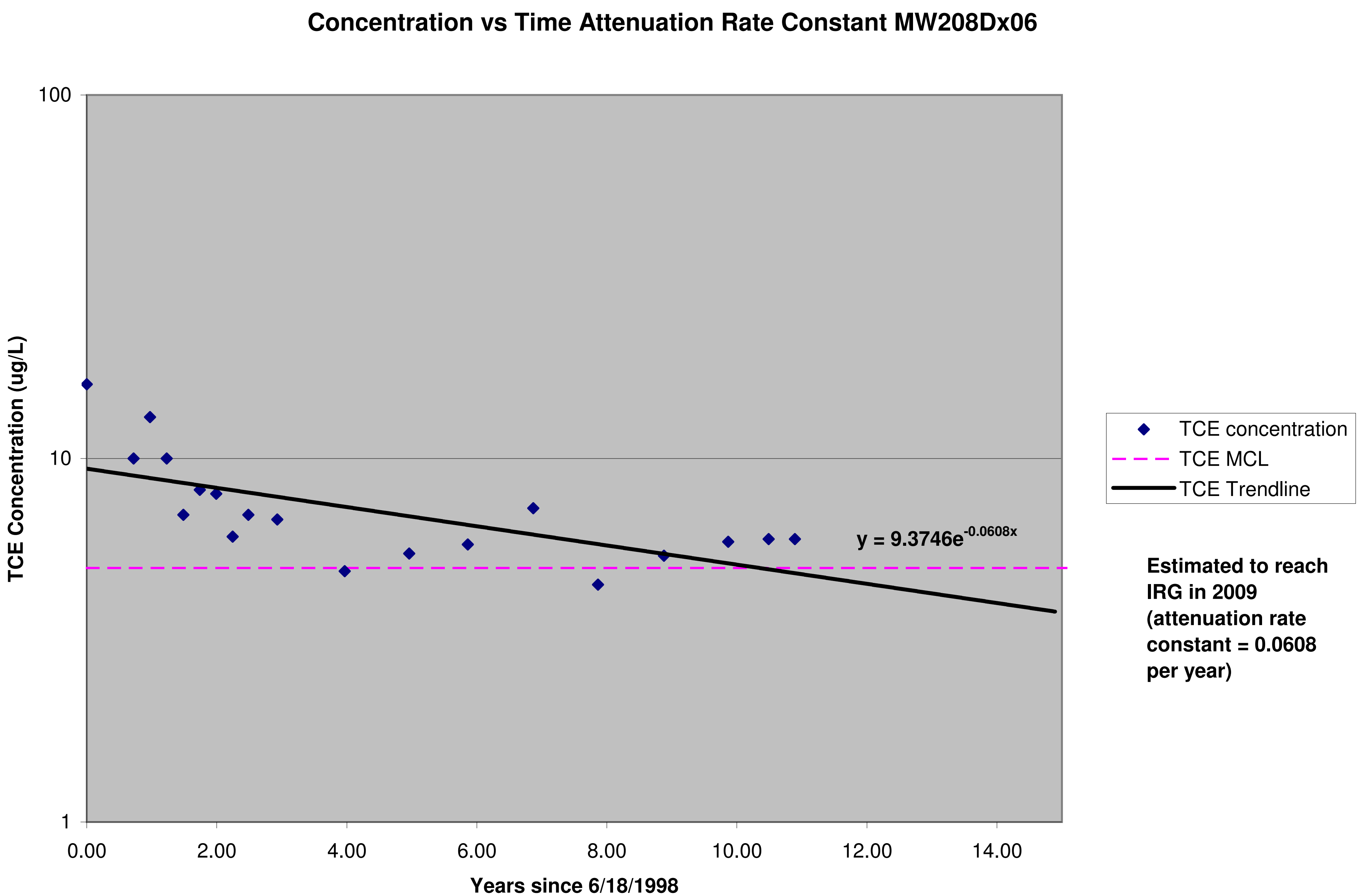
Appendix D
Concentration vs. Time Rate Constants



Concentration vs Time Attenuation Rate Constant MW590x04
1000
100
10
1
TCE Concentration (ug/L)
0
2
4
6
8
10
12
14
Years since 6/16/2000
y = 252.92e-0.5755x
TCE Concentration
TCE MCL
TCE Trendline
Estimated to reach IRG in 2007 (attenuation rate constant = 0.5755 per year)

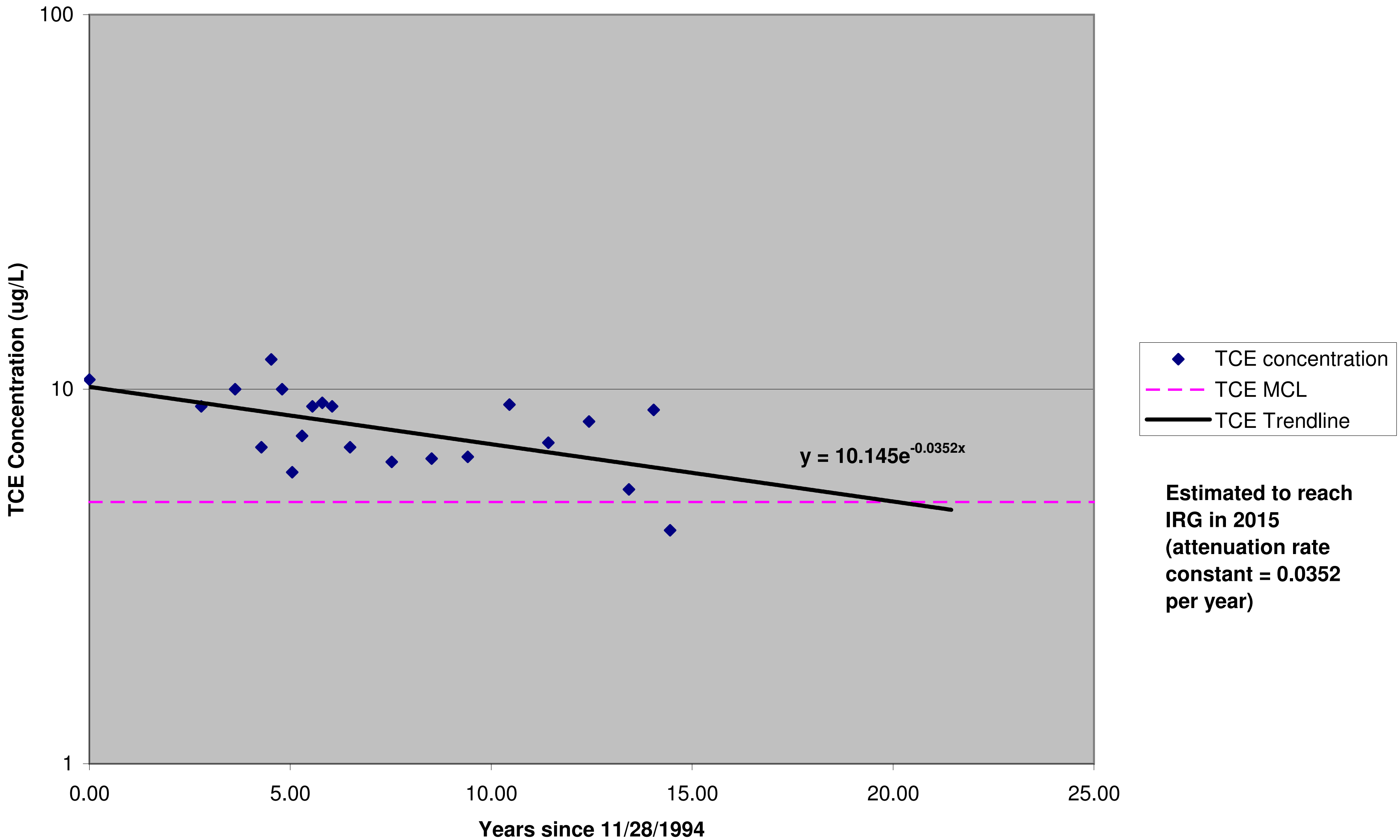


Estimated to reach IRG in 2021 (attenuation rate constant = 0.0581 per year)



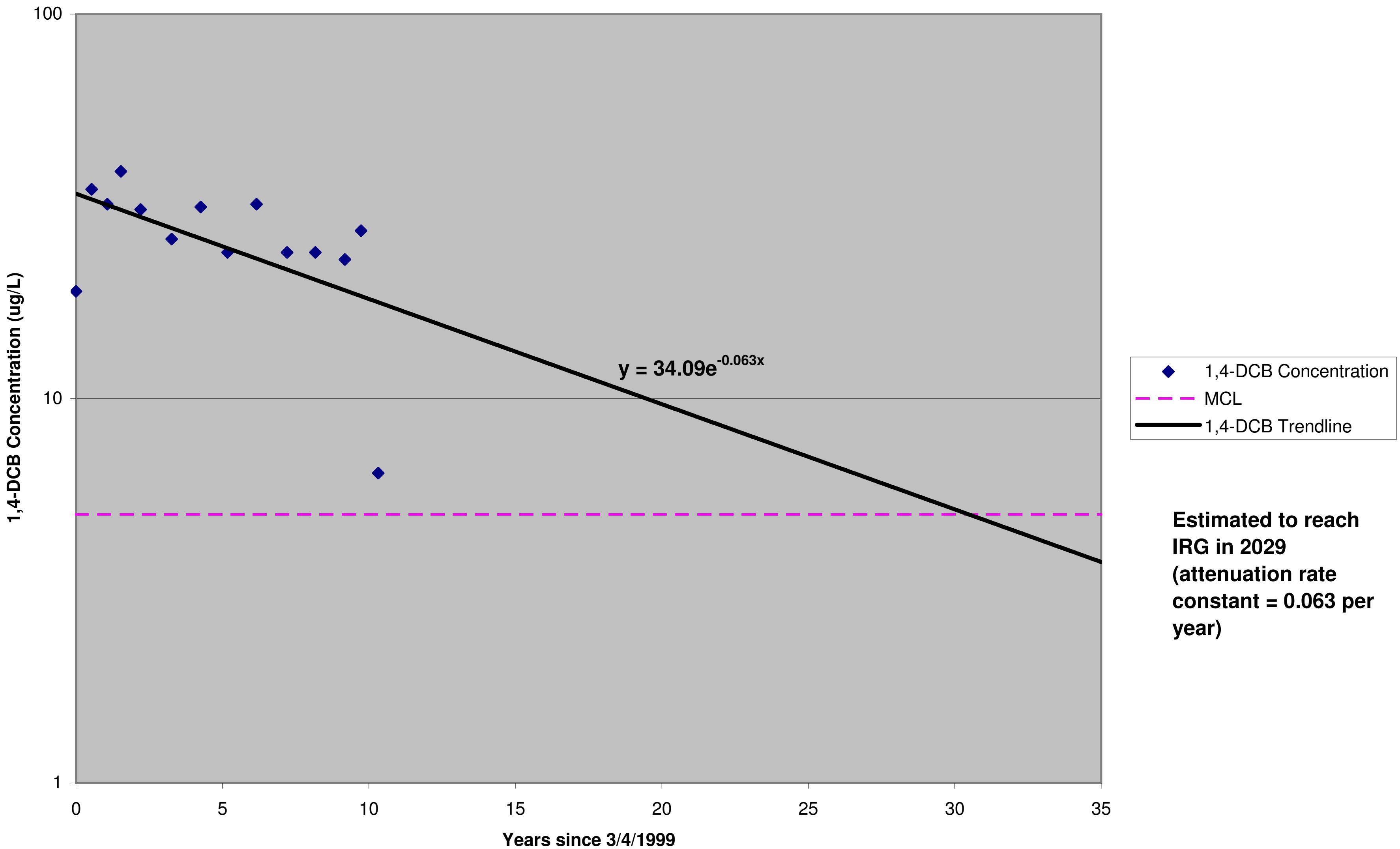
Concentration vs Time Attenuation Rate Constant MW208Dx06
100
10
1
TCE Concentration (ug/L)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Years since 6/18/1998
y = 9.3746e^-0.0608x
TCE concentration
TCE MCL
TCE Trendline
Estimated to reach IRG in 2009 (attenuation rate constant = 0.0608 per year)

Concentration vs Time Attenuation Rate Constant MW259x06

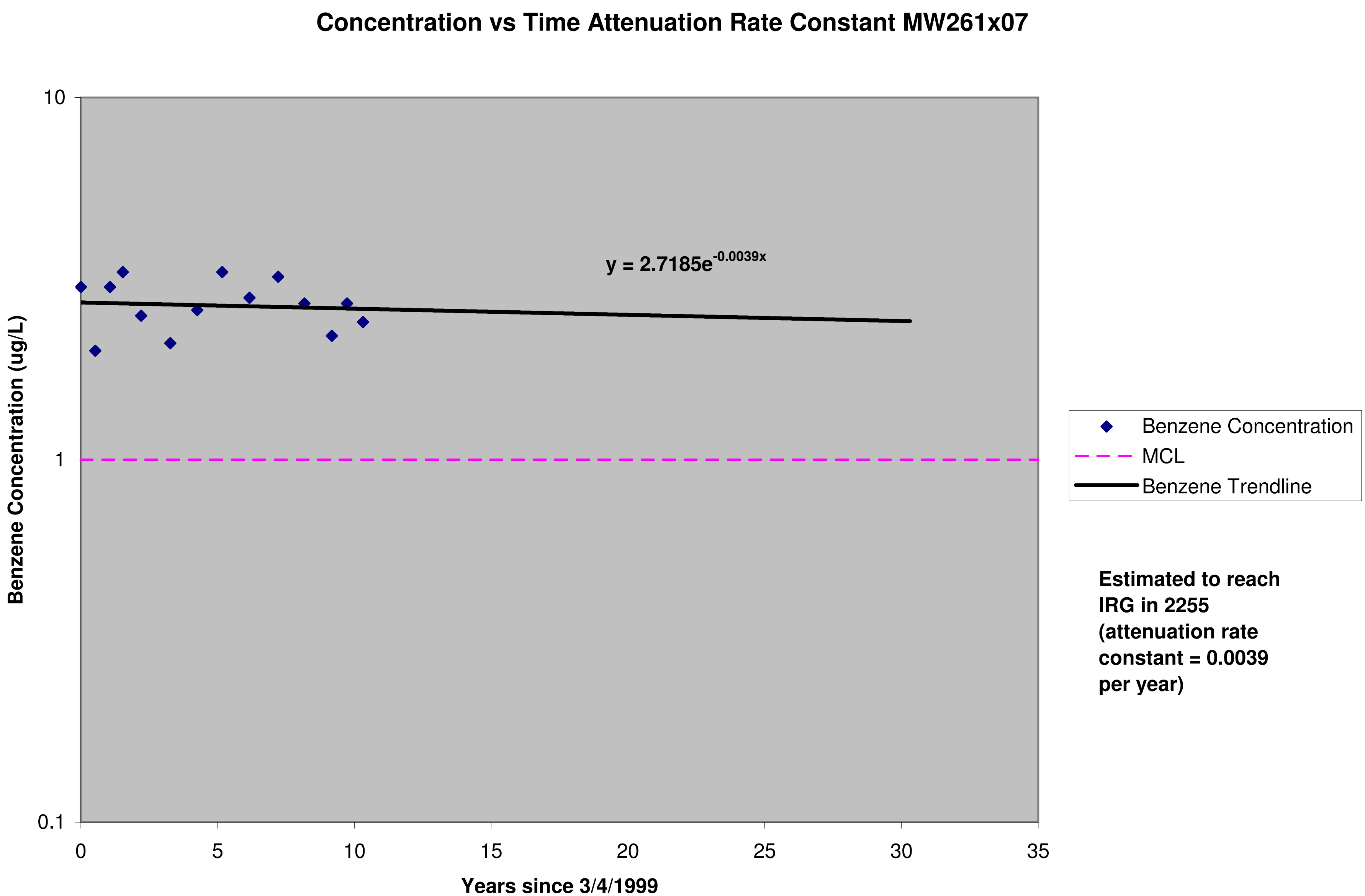


Estimated to reach IRG in 2015 (attenuation rate constant = 0.0352 per year)

Concentration vs Time Attenuation Rate Constant MW261x07

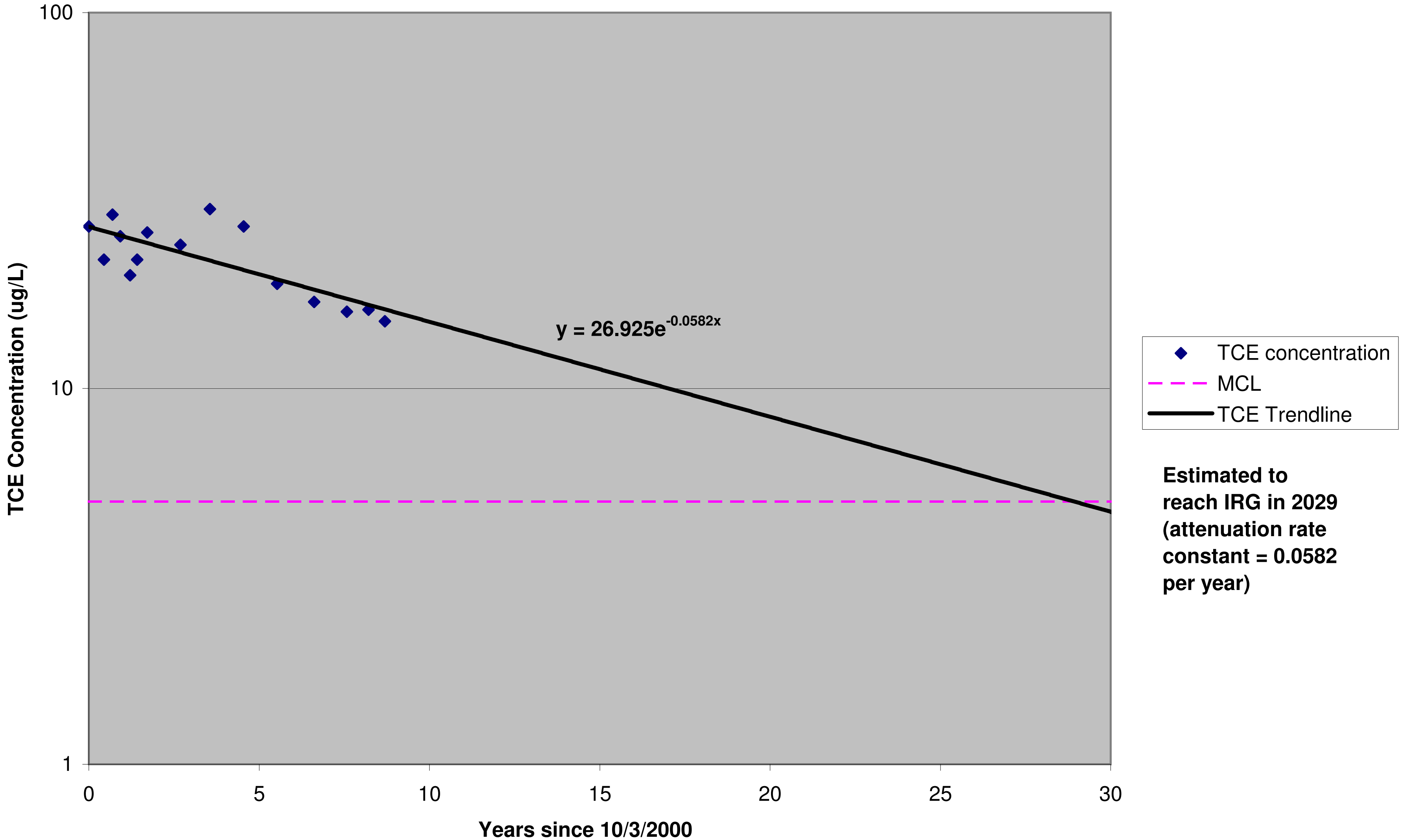


Estimated to reach IRG in 2029 (attenuation rate constant = 0.063 per year)



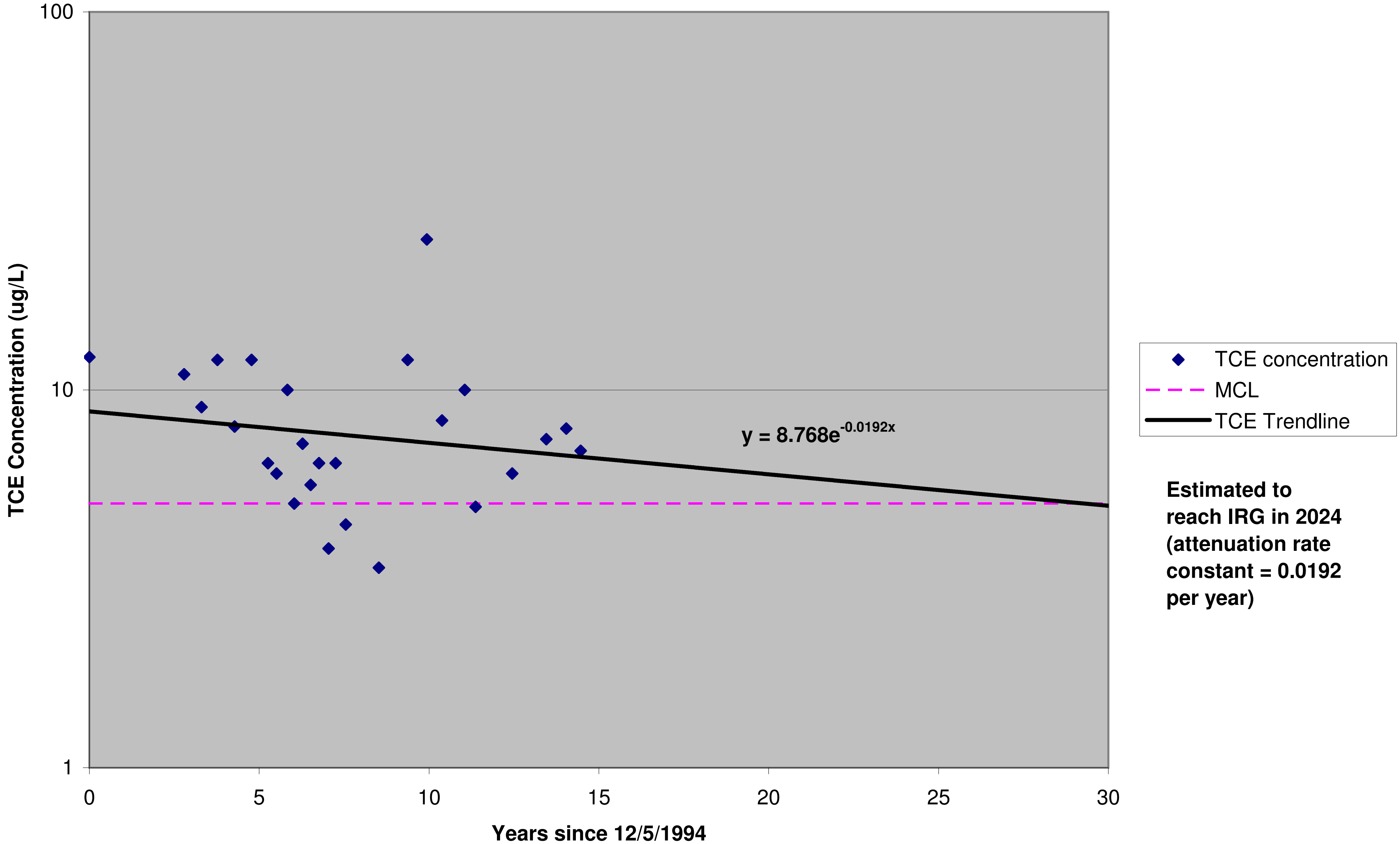
Concentration vs Time Attenuation Rate Constant MW261x07
10
1
0.1
Benzene Concentration (ug/L)
y = 2.7185e^-0.0039x
0
5
10
15
20
25
30
35
Years since 3/4/1999
Benzene Concentration
MCL
Benzene Trendline
Estimated to reach IRG in 2255 (attenuation rate constant = 0.0039 per year)

Concentration vs Time Attenuation Rate Constant MW722x37

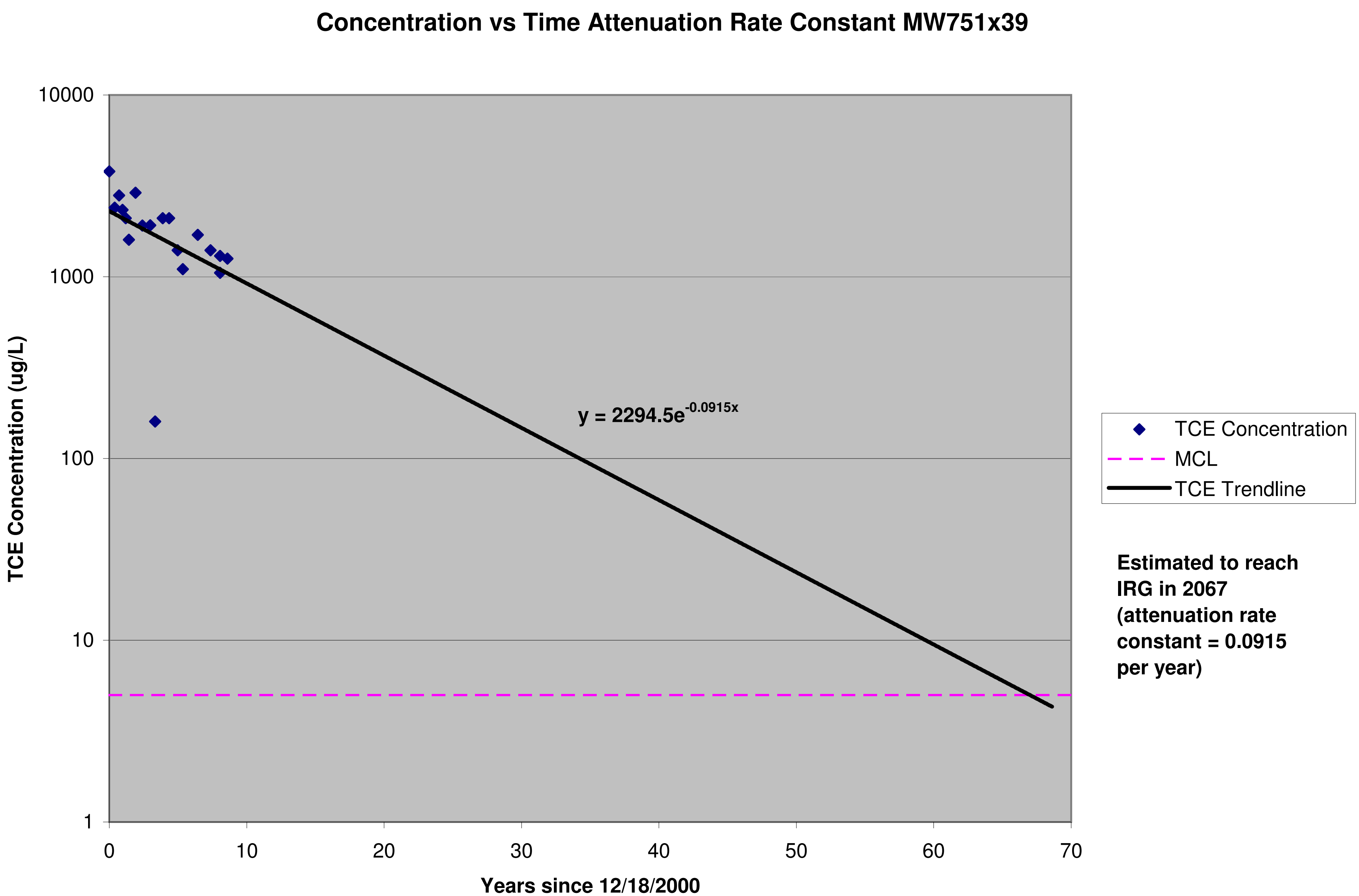


Estimated to reach IRG in 2029 (attenuation rate constant = 0.0582 per year)

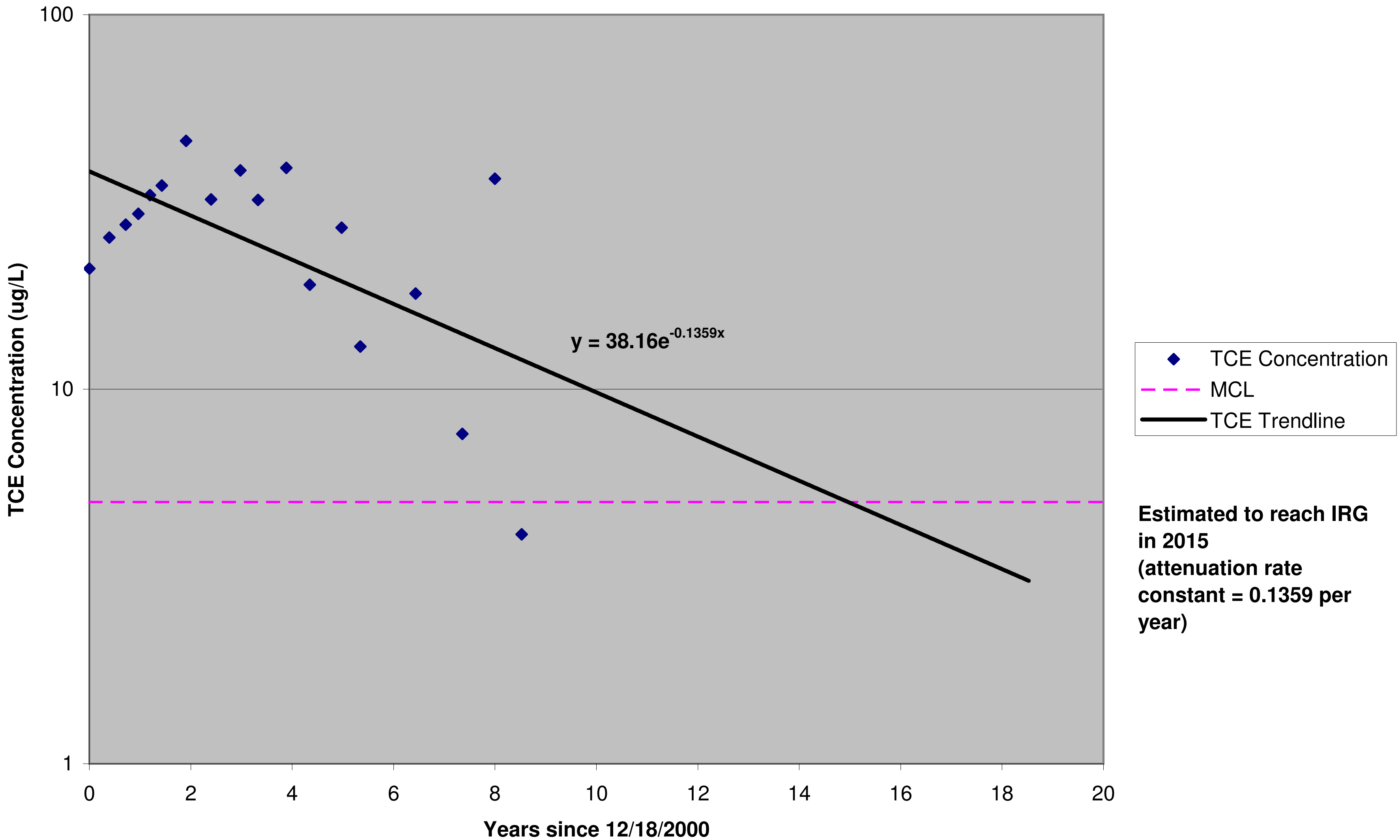
Concentration vs Time Attenuation Rate Constant MW1208x37



Estimated to reach IRG in 2024 (attenuation rate constant = 0.0192 per year)


Concentration vs Time Attenuation Rate Constant MW751x39
TCE Concentration (ug/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
Years since 12/18/2000
y = 2294.5e^-0.0915x
TCE Concentration
MCL
TCE Trendline
Estimated to reach IRG in 2067 (attenuation rate constant = 0.0915 per year)

Concentration vs Time Attenuation Rate Constant MW759x39



Estimated to reach IRG in 2015 (attenuation rate constant = 0.1359 per year)

Appendix E
Mann-Kendall Statistical Analysis

APPENDIX E

Mann-Kendall Statistical Analysis

The Mann-Kendall trend statistical analysis test was used to evaluate concentration trends in Site Chemicals of Concern (COCs) at monitoring wells designated for sampling to support the monitored natural attenuation (MNA) assessments. These wells were selected for routine monitoring in site specific Natural Attenuation Assessment Workplans (NAAWs).

The Mann-Kendall test, a non-parametric test, was performed to evaluate site COC concentration trends at each MNA well. The Mann-Kendall test compares the relative magnitudes of sample data rather than the data values themselves. One benefit of this test is that the data need not conform to any particular distribution (such as a normal distribution). In addition, non-detects can be included by assigning them a common value that is less than the lowest value reported in the data set.

This evaluation used current and historical results for the site groundwater COCs at each MNA monitoring well. Tentatively identified compound (TIC) data were excluded from the analyses. Non-detects were assigned a value of 0. "J" flagged data, where the result is greater than or equal to the method detection limit and less than the practical quantitation limit (the analyte concentration is an estimated value), were included in the evaluation. The Mann-Kendall test was applied to all sample results (excluding TICs) for wells under evaluation that had at least four (4) sample results (the minimum number of results considered sufficient to perform the test). If less than four (4) sample results for an analyte were available, the trend was described as indeterminable. If the analyte has never been reported in the samples from a well, the analyte was not included in the test. A 95 percent probability was the threshold used to define a statistically significant trend.

The results of the Mann-Kendall Analysis are summarized in the attached table. Definitions for the column headings of the Mann-Kendall test results are as follows:

- **Count** indicates the total number of comparisons made for the Mann-Kendall test, based on comparisons between each sample and previous samples.
- **S-statistic** indicates the strength and direction of the trend. A negative value indicates a decreasing trend, and a positive value indicates an increasing trend. Larger values indicate stronger trends.
- **p-value** indicates the probability that a trend exists. A lower p-value indicates a higher probability that a trend exists. All p-values less than 0.05 (95 percent confidence level) were assumed to be significant.

The results for the Mann-Kendall tests should be considered in conjunction with the time-series plots that are provided in the main report. For example, a statistically significant trend may not be supported by a time-series plot because of the small concentration ranges involved, the influence from one (1) or two (2) higher or lower concentration results, or other factors that may be apparent when the overall context of the evaluation is considered.

A generally increasing or decreasing trend can be indicated in the time-series plots but may be too recent, or the results too variable, to be quantified as statistically significant.

Chemical time-series plots are provided in each site-specific section of the main report. The time-series plots illustrate how analyte concentrations have changed over the period of record for each well. Non-detects are shown as the analytical method detection limit. The scale of the concentration axis (y axis) on each plot is chosen (in a log scale) relative to the maximum concentration of each analyte reported in samples collected from each well. The dates shown on the date axis (x axis) on each plot are chosen based on the timeframe for which data are available for each well.

Location	Analyte	Count	S-Statistic	p-Value	Trend
Site FT004/SD031					
Site FT003					
MW205X03	TCE	15	0	0.50	NO TREND
MW206X03	1,1-DCE	26	2	0.49	NO TREND
	1,2-DCA	26	5	0.46	NO TREND
	Cis-1,2-DCE	26	-41	0.19	NO TREND
	TCE	27	-63	0.10	NO TREND
Site FT004					
MW589X04	1,1-DCE	19	-43	0.07	NO TREND
	Bromodichloromethane	19	18	0.28	NO TREND
	Chloroform	19	18	0.28	NO TREND
	Cis-1,2-DCE	19	-66	0.01	DECREASING
	TCE	21	-169	0.00	DECREASING
MW590X04	1,1-DCE	17	-58	0.01	DECREASING
	Bromodichloromethane	17	16	0.27	NO TREND
	Chloroform	17	16	0.27	NO TREND
	Cis-1,2-DCE	17	-75	0.00	DECREASING
	TCE	19	-139	0.00	DECREASING
MW591X04	TCE	21	54	0.05	NO TREND
MW752X04	1,2-DCA	15	-11	0.31	NO TREND
	Chloroform	15	-23	0.14	NO TREND
	Cis-1,2-DCE	15	-22	0.15	NO TREND
	TCE	17	-61	0.01	DECREASING
MW753X04	Chloroform	15	-3	0.46	NO TREND
	Cis-1,2-DCE	15	-2	0.48	NO TREND
	TCE	17	-68	0.00	DECREASING
MW754X04	TCE	14	-9	0.33	NO TREND
MW755X04	TCE	11	-30	0.01	DECREASING
MW756X04	Cis-1,2-DCE	14	-17	0.19	NO TREND
	TCE	14	-4	0.44	NO TREND
MW757X04	Cis-1,2-DCE	14	22	0.13	NO TREND
	TCE	14	-61	0.00	DECREASING
Site SD031					
MW572X31	1,1-DCE	21	-97	0.00	DECREASING
	1,2-DCA	20	-9	0.40	NO TREND
	Benzene	20	-24	0.23	NO TREND
	Carbon tetrachloride	20	-5	0.45	NO TREND
	Chloroform	20	11	0.37	NO TREND

Note: Grouped by Site and Location, sorted by Analyte

Location	Analyte	Count	S-Statistic	p-Value	Trend
Site SD031					
MW572X31	Cis-1,2-DCE	20	-44	0.08	NO TREND
	TCE	20	-63	0.02	DECREASING
MW573X31	1,1-DCE	19	-131	0.00	DECREASING
	1,2-DCA	18	0	0.50	NO TREND
	Benzene	18	-15	0.30	NO TREND
	Bromodichloromethane	18	0	0.50	NO TREND
	Carbon tetrachloride	18	-5	0.44	NO TREND
	Cis-1,2-DCE	18	-98	0.00	DECREASING
	TCE	19	-129	0.00	DECREASING
MW574X31	1,1-DCE	22	33	0.18	NO TREND
	Cis-1,2-DCE	20	120	0.00	INCREASING
	TCE	20	-61	0.03	DECREASING
MW575X31	1,1-DCE	20	27	0.20	NO TREND
	1,2-DCA	18	-7	0.41	NO TREND
	Cis-1,2-DCE	18	77	0.00	INCREASING
	TCE	18	-30	0.14	NO TREND
Site LF006					
MW02DX06	TCE	21	-115	0.00	DECREASING
	TPH-Diesel	15	-21	0.16	NO TREND
	TPH-Gasoline	16	18	0.22	NO TREND
MW02SX06	TCE	21	-37	0.14	NO TREND
	TPH-Diesel	15	-18	0.20	NO TREND
	TPH-Gasoline	16	41	0.04	INCREASING
MW207X06	Bis (2-ethylhexyl) phthalate	2	1	0.50	INDETERMINABLE
	TPH-Gasoline	9	8	0.24	NO TREND
MW208DX06	1,1-DCE	18	-22	0.21	NO TREND
	TCE	18	-95	0.00	DECREASING
	TPH-Diesel	16	15	0.26	NO TREND
	TPH-Gasoline	17	0	0.50	NO TREND
MW208X06	1,1-DCE	23	-23	0.28	NO TREND
	TCE	22	-137	0.00	DECREASING
	TPH-Diesel	18	-5	0.44	NO TREND
	TPH-Gasoline	18	11	0.35	NO TREND
MW210X06	TPH-Gasoline	10	-1	0.50	NO TREND
MW259X06	1,1-DCE	20	-17	0.30	NO TREND
	TCE	20	-63	0.02	DECREASING

Note: Grouped by Site and Location, sorted by Analyte

Location	Analyte	Count	S-Statistic	p-Value	Trend
MW259X06	TPH-Gasoline	18	-11	0.35	NO TREND
MW1743X06	1,1-DCE	19	-16	0.30	NO TREND
	TCE	19	-149	0.00	DECREASING
	TPH-Diesel	17	-17	0.25	NO TREND
	TPH-Gasoline	15	-10	0.33	NO TREND
Site LF007					
MW129X07	Bis (2-ethylhexyl) phthalate	4	0	0.50	NO TREND
	TCE	24	-17	0.35	NO TREND
	TPH-Diesel	16	-15	0.26	NO TREND
	TPH-Gasoline	18	4	0.45	NO TREND
Site SD031					
MW1729X31	1,1-DCE	23	-23	0.28	NO TREND
	TCE	23	-123	0.00	DECREASING
	TPH-Diesel	18	-26	0.17	NO TREND
	TPH-Gasoline	19	-47	0.05	NO TREND
MW1730X31	TCE	24	-17	0.35	NO TREND
	TPH-Diesel	16	-22	0.17	NO TREND
	TPH-Gasoline	18	11	0.35	NO TREND
MW1731X31	TCE	26	-50	0.14	NO TREND
	TPH-Diesel	17	-23	0.18	NO TREND
	TPH-Gasoline	19	17	0.29	NO TREND
Site LF007					
Site FT004					
MW264X04	1,4-DCB	20	-11	0.37	NO TREND
	Bis (2-ethylhexyl) phthalate	2	1	0.50	INDETERMINABLE
Site LF006					
MW207X06	Bis (2-ethylhexyl) phthalate	2	1	0.50	INDETERMINABLE
	TPH-Gasoline	9	8	0.24	NO TREND
MW210X06	TPH-Gasoline	10	-1	0.50	NO TREND
MW128X07	1,1-DCE	18	-11	0.35	NO TREND
	Benzene	17	0	0.50	NO TREND
	Bis (2-ethylhexyl) phthalate	3	0	0.50	INDETERMINABLE
MW129X07	Bis (2-ethylhexyl) phthalate	4	0	0.50	NO TREND
	TCE	24	-17	0.35	NO TREND
	TPH-Diesel	16	-15	0.26	NO TREND
	TPH-Gasoline	18	4	0.45	NO TREND
MW261X07	1,4-DCB	17	-8	0.39	NO TREND

Note: Grouped by Site and Location, sorted by Analyte

Location	Analyte	Count	S-Statistic	p-Value	Trend
MW261X07	Aroclor-1016	9	11	0.21	NO TREND
	Benzene	18	29	0.14	NO TREND
	Bis (2-ethylhexyl) phthalate	1	0	1.00	INDETERMINABLE
	Chlorobenzene	17	70	0.00	INCREASING
	Vinyl chloride	18	-7	0.41	NO TREND
MW284X07	1,1-DCE	16	-11	0.33	NO TREND
	Benzene	15	0	0.50	NO TREND
	Bis (2-ethylhexyl) phthalate	4	1	0.50	NO TREND
MW303X07	1,1-DCE	17	-12	0.33	NO TREND
	Bis (2-ethylhexyl) phthalate	1	0	1.00	INDETERMINABLE
MW612X07	Bis (2-ethylhexyl) phthalate	9	9	0.27	NO TREND
MW613X07	Bis (2-ethylhexyl) phthalate	9	9	0.27	NO TREND
MWAX07	Bis (2-ethylhexyl) phthalate	3	0	0.50	INDETERMINABLE
MWBX07	1,4-DCB	13	-40	0.01	DECREASING
	Chlorobenzene	13	-25	0.09	NO TREND
MWCX07	1,4-DCB	11	-6	0.35	NO TREND
	Benzene	11	-4	0.41	NO TREND
	Bis (2-ethylhexyl) phthalate	2	0	0.50	INDETERMINABLE
	Chlorobenzene	11	-24	0.04	DECREASING
MWFX07	Aroclor-1260	4	0	0.50	NO TREND
	Bis (2-ethylhexyl) phthalate	3	0	0.50	INDETERMINABLE
Site SS015					
MW105X15	TCE	22	0	0.50	NO TREND
MW216X15	Cis-1,2-DCE	27	142	0.00	INCREASING
	PCE	27	53	0.14	NO TREND
	TCE	27	119	0.01	INCREASING
	Vinyl chloride	27	104	0.02	INCREASING
MW238X15	Cis-1,2-DCE	16	-9	0.36	NO TREND
	PCE	16	-9	0.36	NO TREND
	TCE	16	-9	0.36	NO TREND
MW306X15	Cis-1,2-DCE	16	-13	0.29	NO TREND
	TCE	17	-11	0.34	NO TREND
MW624X15	TCE	8	-7	0.32	NO TREND
MW625X15	Cis-1,2-DCE	10	19	0.05	NO TREND
	PCE	10	17	0.08	NO TREND
	TCE	10	14	0.13	NO TREND

Note: Grouped by Site and Location, sorted by Analyte

Location	Analyte	Count	S-Statistic	p-Value	Trend
MW625X15	Vinyl chloride	10	7	0.30	NO TREND
The WIOU (Sites SD033/SD037)					
Site SS014					
MW05X14	Benzene	25	-222	0.00	DECREASING
	TCE	25	-50	0.13	NO TREND
	TPH-Diesel	15	-7	0.39	NO TREND
	TPH-Gasoline	19	-65	0.01	DECREASING
Site SD037					
MW116X37	1,2-DCA	28	0	0.50	NO TREND
	Benzene	29	19	0.37	NO TREND
	Cis-1,2-DCE	26	-17	0.36	NO TREND
	TCE	30	16	0.39	NO TREND
	TPH-Diesel	18	-16	0.29	NO TREND
	TPH-Gasoline	20	84	0.00	INCREASING
MW222X37	1,2-DCA	21	0	0.50	NO TREND
	Benzene	23	0	0.50	NO TREND
	TCE	23	7	0.44	NO TREND
	TPH-Diesel	10	15	0.11	NO TREND
	TPH-Gasoline	14	3	0.46	NO TREND
MW722X37	1,1-DCE	14	-41	0.01	DECREASING
	Cis-1,2-DCE	14	-48	0.00	DECREASING
	PCE	14	-19	0.17	NO TREND
	TCE	14	-37	0.02	DECREASING
	TPH-Diesel	10	-5	0.36	NO TREND
	TPH-Gasoline	12	17	0.17	NO TREND
MW723X37	Cis-1,2-DCE	15	-15	0.25	NO TREND
	PCE	15	-1	0.50	NO TREND
	TCE	15	17	0.22	NO TREND
	TPH-Diesel	9	-4	0.38	NO TREND
	TPH-Gasoline	12	10	0.27	NO TREND
MW724X37	Cis-1,2-DCE	17	-12	0.33	NO TREND
	TCE	18	-4	0.45	NO TREND
	TPH-Diesel	10	5	0.36	NO TREND
	TPH-Gasoline	12	-1	0.50	NO TREND
MW729X37	TPH-Diesel	9	1	0.50	NO TREND
MW730X37	TCE	18	-5	0.44	NO TREND
	TPH-Diesel	9	1	0.50	NO TREND

Note: Grouped by Site and Location, sorted by Analyte

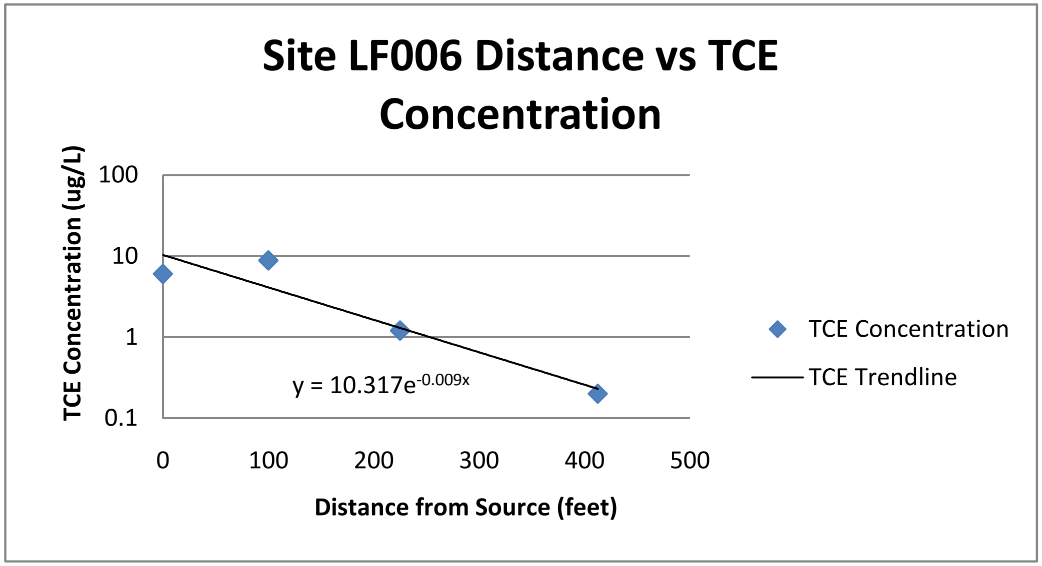
Location	Analyte	Count	S-Statistic	p-Value	Trend
Site SD037					
MW730X37	TPH-Gasoline	10	13	0.15	NO TREND
MW1208X37	1,2-DCA	25	0	0.50	NO TREND
	Benzene	25	0	0.50	NO TREND
	Cis-1,2-DCE	26	10	0.42	NO TREND
	TCE	25	-70	0.05	NO TREND
	TPH-Diesel	11	-13	0.18	NO TREND
	TPH-Gasoline	13	7	0.41	NO TREND
MW1209X37	1,2-DCA	21	0	0.50	NO TREND
	Benzene	21	0	0.50	NO TREND
	PCE	22	5	0.46	NO TREND
	TCE	21	-29	0.20	NO TREND
	TPH-Diesel	9	-9	0.27	NO TREND
	TPH-Gasoline	10	9	0.24	NO TREND
MWS1M2X37	Benzene	31	-22	0.35	NO TREND
	Cis-1,2-DCE	31	-31	0.30	NO TREND
	PCE	31	-115	0.03	DECREASING
	TCE	31	-117	0.02	DECREASING
	TPH-Diesel	18	21	0.22	NO TREND
	TPH-Gasoline	20	10	0.39	NO TREND
Site DP039					
MW751X39	1,1,1-TCA	17	-95	0.00	DECREASING
	1,1,2-TCA	17	-26	0.15	NO TREND
	1,1-DCE	17	-72	0.00	DECREASING
	1,2-DCA	17	-9	0.37	NO TREND
	Acetone	17	-3	0.47	NO TREND
	Methylene chloride	17	12	0.33	NO TREND
	PCE	17	-31	0.11	NO TREND
	TCE	18	-93	0.00	DECREASING
MW758X39	TCE	16	46	0.02	INCREASING
MW759X39	1,1,1-TCA	16	-13	0.29	NO TREND
	1,1-DCE	16	1	0.50	NO TREND
	TCE	17	-12	0.33	NO TREND
MW760X39	Acetone	15	7	0.39	NO TREND
	TCE	16	52	0.01	INCREASING
MW762X39	Methylene chloride	14	9	0.33	NO TREND
	TCE	15	-39	0.03	DECREASING

Note: Grouped by Site and Location, sorted by Analyte

Appendix F
Bulk Attenuation Rate Constants

Well	Distance from source (ft)	TCE Concentration (ug/L)
MW208Dx06	0	6
MW259x06	100	8.8
MW1729x31	225	1.2
MW1731x31	412.5	0.2
MW02Dx06	587.5	ND

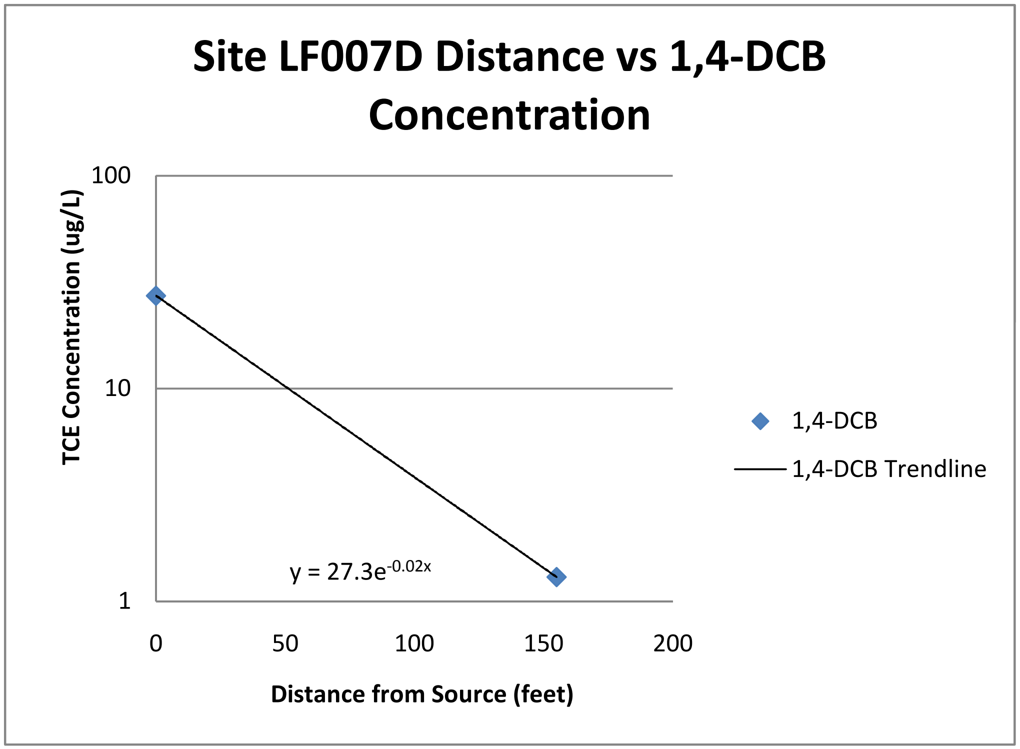
Seepage Velocity (ave linear flow velocity)=	100	ft/year
TCE Retardation Factor =	1.2	
Slope of TCE Trendline =	-0.009	per foot
Bulk Attenuation Rate Constant =	**0.75**	**per year**
Travel Time to Reach IRG (5 ug/L)=	**0.75**	**years**
Plume extent =	**63**	**feet**



LF007D

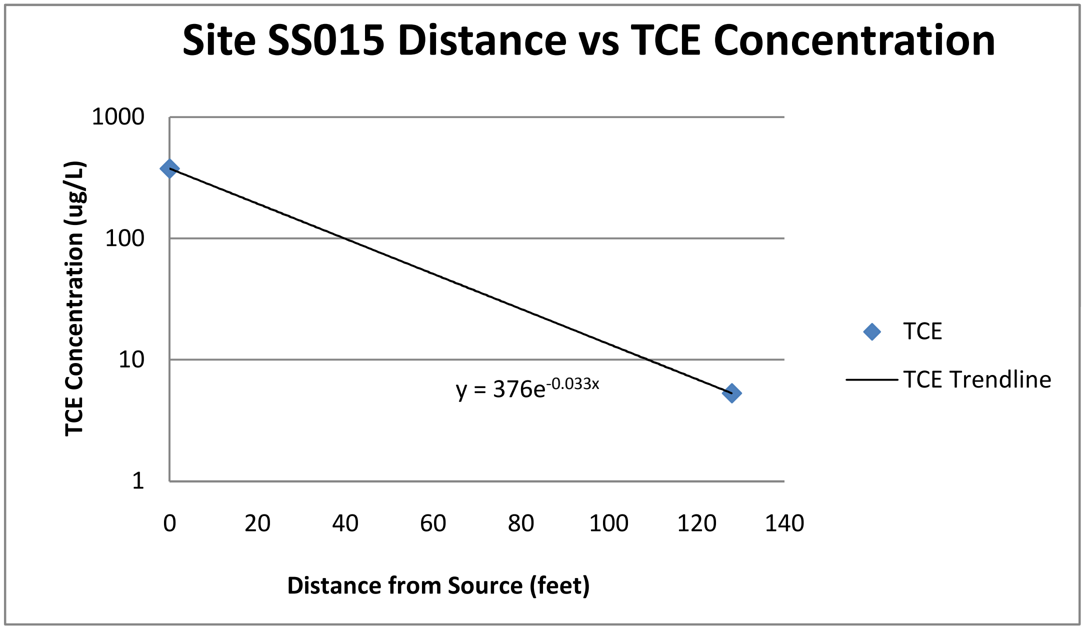
Well	**Distance from source (ft)**	**1,4-DCB Concentration (ug/L)**
MW261x07	0	27.3
MWCx07	155	1.3

Seepage Velocity (ave linear flow velocity)=	150	ft/year
TCE Retardation Factor =	1.7	
Slope of TCE Trendline =	-0.02	per foot
Bulk Attenuation Rate Constant =	**1.8**	**per year**
Travel Time to Reach IRG (5 ug/L)=	**0.96**	**years**
Plume extent =	**85**	**feet**



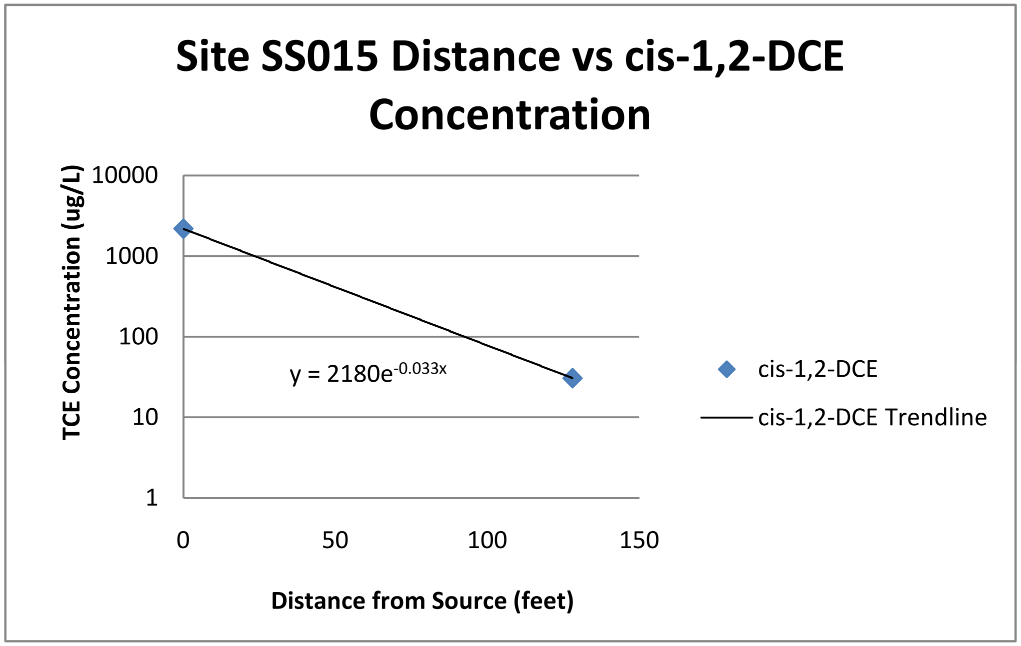
Well	Distance from source (ft)	TCE Concentration (ug/L)
MW216x15	0	376
MW625x15	128	5.3

Seepage Velocity (ave linear flow velocity)=	300	ft/year
TCE Retardation Factor =	1.2	
Slope of TCE Trendline =	-0.033	per foot
Bulk Attenuation Rate Constant =	**8.3**	**per year**
Travel Time to Reach IRG (5 ug/L)=	**0.52**	**years**
Plume extent =	**131**	**feet**



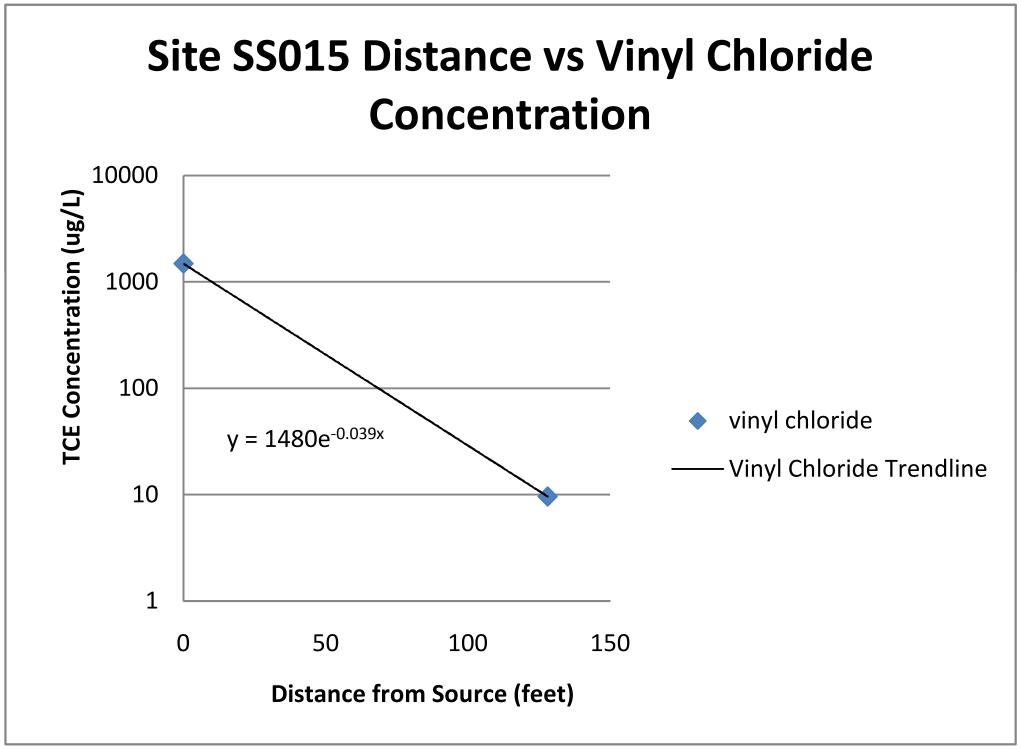
Well	Distance from source (ft)	cis-1,2-DCE Concentration (ug/L)
MW216x15	0	2180
MW625x15	128	30.7

Seepage Velocity (ave linear flow velocity)=	300	ft/year
cis-1,2-DCE Retardation Factor =	1	
Slope of TCE Trendline =	-0.033	per foot
Bulk Attenuation Rate Constant =	**9.9**	**per year**
Travel Time to Reach IRG (6 ug/L)=	**0.60**	**years**
Plume extent =	**179**	**feet**



Well	Distance from source (ft)	vinyl chloride Concentration (ug/L)
MW216x15	0	1480
MW625x15	128	9.6

Seepage Velocity (ave linear flow velocity)=	300	ft/year
Vinyl Chloride Retardation Factor =	1	
Slope of TCE Trendline =	-0.039	per foot
Bulk Attenuation Rate Constant =	**12**	**per year**
Travel Time to Reach IRG (0.5 ug/L)=	**0.68**	**years**
Plume extent =	**205**	**feet**



Appendix G
Response to Comments

Response to Comments on the Draft Natural Attenuation Assessment Report Travis Air Force Base, California

EPA Region IX

No.	Comments	Responses
REVIEW COMMENTS – James Chang, EPA Region IX dated October 7, 2009		
SUMMARY COMMENT		
1.	The Draft Natural Attenuation Assessment Report (NAAR) does not provide a complete evaluation of the lines of evidence that allows a conclusion that Monitored Natural Attenuation (MNA) is currently an appropriate remedy for the volatile organic compounds that are present in groundwater at sites within Travis Air Force Base. While the reported decreasing volatile organic compound (VOC) concentrations in monitoring wells do indicate that some attenuation processes may be operating, the mass removal efforts (such as groundwater extraction) confound the interpretation of MNA as an appropriate remedy, either in the context of current site conditions or in the future when active groundwater remediation has been completed. The mass removal efforts have also complicated the evaluation of plume stability, which is one criteria of MNA. The NAAR also does not provide any quantitative assessment of the rate of VOC attenuation and VOC longevity in the plumes where MNA is being invoked as a remedy. EPA requests that the NAAR be revised to address the comments below, and develop an approach for MNA after active remediation has been completed.	There is substantial agreement between the EPA and the Air Force on the main conclusions of the NAAR as evidenced by EPA's specific comments No. 25 through 31. Those conclusions are: 1. MNA appears to be an appropriate remedy at Sites LF006, LF007B, LF007D, and the downgradient portions of Sites FT004 and SD031 and the WIOU. 2. MNA alone does not appear to be a sufficient remedy at Site SS015 and the downgradient portion of Site DP039. EPA signed the IRODs in which MNA Assessment was identified at several sites as the interim remedy for the entire or downgradient portion of the plume. As described in the NAAR, the purpose of the NAAR is to evaluate the data collected over the interim period since the site-specific natural assessment work plans (NAAWs) were submitted and agreed upon by the regulatory agencies. These NAAWs prescribed a monitoring program focused on verifying plume stability over the interim period which would be used to evaluate whether MNA was or could in the future be an appropriate remedy for all or a portion of the site. At most of these sites, there has been no migration, and therefore it is reasonable to select MNA as a remedy for most of these sites in the Basewide Groundwater Record of Decision (ROD). It is beyond the scope of this NAAR to develop an approach for MNA after active remediation has been completed. However, active remedies at the site will not be shut down until sufficient rebound periods have elapsed or groundwater modeling has shown that no migration will occur after the shutdown. The NAAR presents the data collected over the interim period and draws conclusions on whether MNA is an effective remedy at each of the sites or a portion of the sites. As stated in response to General Comment 1 below, these conclusions were further supported by calculation of a Concentration vs. Time Attenuation Rate constant for all MNA wells with COC concentrations currently exceeding IRGs and an established decreasing COC trend. The results will were used to estimate the amount of time to reach IRGs at each site or the portion of the site at which MNA assessment is an IRA.

No.	Comments	Responses
		These conclusions will be used to support selection of groundwater remedies in the upcoming Basewide Groundwater ROD. However, in order to select a remedy in the ROD it is not necessary to prove in advance that the remedy will be effective, particularly when site conditions (e.g., active remediation) preclude the ability to acquire such proof. Rather, the Air Force must show that a preponderance of evidence indicates that it is likely to work and must have a contingency plan in place in the event it does not work after implementation and evaluation. In many cases, MNA implementation will not take place until the active remedy achieves a designated level of performance Once initiated, a monitoring program will be established, and a contingency remedy (e.g., a return to the active remedy) will be invoked in the event that MNA does not perform as designed. The Basewide Groundwater ROD will contain contingency language that will describe how the Air Force will respond to future plume migration, including MNA Enhancement (in situ treatment), if appropriate.
GENERAL COMMENTS		
1.	The *Draft Natural Attenuation Assessment Report* (August 2009) (the NAAR) does not address several topics necessary for a thorough evaluation of MNA as required by EPA guidance (*Performance Monitoring of MNA Remedies for VOCs in Ground Water, EPA/540/R-03/004, OSWER 9355.4-25, September 2003*.) While the information in this NAAR is useful for demonstrating the likely occurrence of some attenuation processes in the context of the current partial interim groundwater remedy, a more complete evaluation of MNA as an appropriate remedy is required. Deficiencies in the Draft NAAR are as follows: • The remedial action objectives (RAOs) for the sites are not presented, and the interim remedial goals (IRGs) are also not clearly presented. It is then not clear whether MNA is capable of achieving the RAOs, and therefore that MNA is an appropriate remedy for any site. In the context of a partial interim groundwater remedy, please revise the NAAR to present the RAOs and IRGs clearly for each site, in a list or table. • The maximum acceptable time frame until RAOs are reached is not presented. It is then uncertain whether MNA is capable of achieving the RAOs in a reasonable time period. Thus, it is not clear whether MNA is an appropriate remedy for any site. Please revise the NAAR to present the maximum acceptable time period until RAOs are achieved for each site. • The NAAR does not discuss rates of attenuation. It is not clear what the apparent rates of attenuation are for each site, or how those rates have changed with time (see Calculation and use of First Order Rate Constants for MNA Studies, EPA/540/S-02/500, November 2002.) The rates of	RAOs are not presented in the NAAR because they do not yet exist. RAOs will be presented in the Basewide Groundwater Focused Feasibility Study. However Interim Remedial Action Objectives (IRAO's) do exist and are described for each site in the "Status of Interim Remedy" subsections. For clarity, we revised the text to show the IRAO's in text tabular form within the "Status of Interim Remedy" subsections. • We listed each Site COC and corresponding IRG in text tabular form under the "Site COCs" subsection. However, please note that all of the site contaminant discussions, tables, and figures present contaminant data in terms of whether or not IRGs are exceeded. • It is beyond the scope of the NAAR to determine the maximum acceptable time-frame until RAO's are achieved, since RAOs have not been presented to and accepted by the regulatory agencies. In those cases where an enhanced version of MNA has been initiated, our expectation would be for RAOs to be reached in a shorter time period. The Basewide Groundwater ROD will need to describe the performance metrics for MNA and MNA enhancement sites, the timeframes (e.g., Five-Year Reviews, established evaluation periods associated with the GSAP) for achieving or making progress toward achieving those metrics, and the contingency actions to initiate if the metrics are not met. • COC concentrations in most of the MNA monitoring wells are already below IRGs, therefore IRAOs have already been achieved for the most part. However, we calculated a Concentration vs. Time Attenuation Rate constant for all MNA wells with COC concentrations currently exceeding IRGs and an established decreasing COC trend. We added these calculations into a new Appendix D. We used the

No.	Comments	Responses
	attenuation are important to estimate the length of time required for MNA to achieve RAOs. The NAAR also does not discuss statistics related to concentration decreases. As such, it is not clear whether current concentrations of contaminants of concern (COCs) are statistically less than concentrations in 1998. Please revise the NAAR to discuss the rates of attenuation at each site, including how the rates have changed with time. Please revise the NAAR to present evidence showing that concentrations of COCs are currently statistically less than concentrations in 1998. • Institutional controls (ICs) are not discussed. The use of MNA as a remedy generally requires the concurrent use of ICs to ensure that receptors are not exposed to the contaminated media while natural attenuation is in process. It is not discussed whether receptors are currently appropriately protected from contaminated groundwater while MNA is claimed to occur. Please revise the NAAR to discuss the ICs currently in effect at each site. • Potential groundwater receptors are not discussed. For example, it is not stated whether groundwater plumes are located near drinking water wells. Please revise the NAAR to discuss whether groundwater moves toward drinking water wells, discharges to surface water, or in any other way may reach receptors. • The Conceptual Site Model (CSM) does not adequately provide for an understanding of the site structure, processes and factors impacting plume behavior. The CSM for MNA should show the qualitative and quantitative description of the migration and fate of contaminants respective to potential receptors and the geochemical, biologic, geologic, anthropogenic, and hydrologic factors that impact contaminant distribution. If the CSM is to be provided in the upcoming Groundwater Sampling and Analysis Program document, it should contain the same level of details as requested here for MNA.	calculations to estimate the amount of time to reach IRGs at each site or the portion of the site at which MNA assessment is an IRA. In addition, we used Mann-Kendall statistical analysis to evaluate whether decreasing trends observed are statistically significant. We added the results of the Mann-Kendall analysis into a new Appendix E. We added the following text to Section 2.3.1: "Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the 17 monitoring wells in the MNA assessment network, there are currently only three (3) monitoring wells at which COCs continue to exceed IRGs (MCLs). A point attenuation rate constant was calculated for two (2) of these three (3) MNA wells: MW571x31 and MW590x04. An attenuation rate constant could not be calculated for well MW591x04, where TCE concentrations recently increased. At both monitoring wells MW571x31 and MW590x04, the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW574x31 is approximately 0.058 per year and the attenuation rate constant calculated for well MW590x04 is approximately 0.58 per year (Appendix D). At these rates, TCE concentrations at well MW574x31 are expected to reach the IRG (5 µg/L) in 2021 and TCE concentrations at well MW590x04 would be expected to reach the IRG in 2007. TCE concentrations at well MW590x04 were below the IRG in 2007, but slightly exceeded the IRG of 5 µg/L in 2008 (TCE was detected at a concentration of 5.3 µg/L in 2008). However, it should be noted that both wells MW571x31 and MW590x04 are located along the designed extent of hydraulic capture of the GET system. Therefore attenuation rates at these wells were likely affected by the GET system. The rate of attenuation at these wells may decrease if groundwater extraction at the site ceases." We added the following text to Section 3.3.1: "Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the twelve (12) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring wells at which COCs continue to exceed IRGs (MCLs). A point attenuation rate constant was calculated for these two (2) MNA wells: MW208Dx06 and MW259x06. At both monitoring wells the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW208Dx06 is

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		approximately 0.061 per year and the attenuation rate constant calculated for well MW259x06 is approximately 0.035 per year (Appendix D). At these rates, TCE concentrations at well MW208Dx06 would be expected to reach the IRG (5 µg/L) in 2009 and TCE concentrations at well MW259x06 would be expected to reach the IRG in 2014. Little change in aquifer conditions between 1999 (when the initial MNA assessment was performed) and 2008 is evident. The aquifer remains aerobic and available carbon is low; physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. These mechanisms are not anticipated to change in the near future and thus the attenuation rates calculated provide reasonable estimates of time to reach IRGs. ” We added the following text to Section 4.3.1: “Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the twenty (20) monitoring wells in the MNA assessment network, there is currently only one (1) monitoring well at which COCs continue to exceed IRGs (MCLs). Point attenuation rate constants were calculated for the one (1) MNA well at which COCs continue to exceed IRGs: MW261x07. At this monitoring well two COCs continues to exceed IRGs: 1,4-DCB and benzene. Attenuation rate constants were calculated for both COCs. The attenuation rate constant calculated for 1,4-DCB at well MW261x07 is approximately 0.054 per year. At this attenuation rate, the 1,4-DCB concentrations would be expected to reach the IRG (5 µg/L) in 2029. Benzene concentrations have declined very slightly over the last 10 years; an attenuation rate constant of approximately 0.0039 per year was calculated (Appendix D). At this attenuation rate, benzene concentrations would be expected to continue to exceed the MCL (1 µg/L) for over 100 years at this location. Although the current anaerobic conditions in the immediate vicinity of well MW261x07 (evident in monitoring data collected at this well from the initial MNA assessment in 1999 through 2008) are conducive to biodegradation of chlorinated solvents (such as 1,4-DCB), aerobic conditions are more favorable for biodegradation of benzene. Once the degradation of 1,4-DCB is complete, conditions near well MW261x07 are expected to gradually become aerobic, like the rest of the site, and more conducive to benzene degradation. The benzene concentrations detected at this well only slightly exceed the MCL (ranging from 2.2 to 2.7 µg/L in 2008) and are restricted to the immediate vicinity of this well. In addition, this well is located in a capped landfill and there are no receptors.”

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		We added the following text to Section 5.3.1: "Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the seven (7) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring well at which COCs continue to exceed IRGs (MCLs). However, a point attenuation rate constant could not be calculated for these Site SS015 wells (MW216x15 and MW625x15) because COC concentrations have recently been increasing at both of these wells." We added the following text to Section 6.5.1: "Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the eleven (11) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring well at which COCs continue to exceed IRGs (MCLs). A point attenuation rate constant was calculated for these two (2) MNA wells: MW1208x37 and MW722x37. Both of these monitoring wells are located beyond the designed extent of hydraulic capture of the GET system and point attenuation rates calculated for these wells are not expected to be impacted by the ongoing GET IRA. At both monitoring wells the only COC that continues to exceed IRGs is TCE. The attenuation rate constant calculated for well MW1208x37 is approximately 0.019 per year and the attenuation rate constant calculated for well MW722x37 is approximately 0.058 per year (Appendix D). At these rates, TCE concentrations at well MW1208x37 would be expected to reach the IRG (5 µg/L) in 2024 and TCE concentrations at well MW722x37 would be expected to reach the IRG in 2029. Little change in aquifer conditions between 2001 (when the initial MNA assessment was performed) and 2008 is evident. The aquifer remains aerobic and, with the exception of areas impacted by historical Site SS014 TPH releases, available carbon is low. Physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. These mechanisms are not anticipated to change in the near future and thus the attenuation rates calculated provide reasonable estimates of time to reach IRGs. " We added the following text to Section 7.3.1: "Concentration vs. time attenuation (or point attenuation) rates can be calculated for individual wells as described in Calculation and Use of First-Order Rate Constants for

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		Monitored Natural Attenuation Studies (EPA, 2002). The point attenuation rate can be used to evaluate reduction in contaminant concentration over time at a single point and can further be used to estimate the time needed to reach IRGs at that point. Of the six (6) monitoring wells in the MNA assessment network, there are currently only two (2) monitoring well at which COCs continue to exceed IRGs (MCLs). A point attenuation rate was calculated for these two (2) MNA wells: MW751x39 and MW759x39. At both monitoring wells the only COC that continues to exceed IRGs is TCE. Both of these monitoring wells are located beyond the designed extent of hydraulic capture of the GET and the area impacted by the bioreactor treatability study. Well MW751x39 is located upgradient of the phytoremediation study area and well MW759x39 is located downgradient of the phytoremediation study area. Point attenuation rates calculated for these wells are not expected to be impacted by the GET IRA or the treatability studies. The attenuation rate constant calculated for well MW751x39 is approximately 0.092 per year and the attenuation rate constant calculated for well MW759x39 is approximately 0.14 per year (Appendix D). At these rates, TCE concentrations at well MW751x39 would be expected to reach the IRG (5 µg/L) in 2067 and TCE concentrations at well MW759x39 would be expected to reach the IRG in 2015. The long attenuation period for monitoring well MW751x39 is due to its location within the portion of the plume where TCE concentrations continue to exceed 1,000 µg/L. This well was selected for source area monitoring in the NAAW, and is not located in the portion of the distal plume where MNA is being assessed as a potential remedy. Little change in aquifer conditions between 2001 (when the initial MNA assessment was performed) and 2008 is evident in the portions of the aquifer evaluated for MNA. Outside of the treatability study areas, the aquifer remains aerobic and available carbon is low; physical attenuation processes (such as dispersion, dilution, sorption, and volatilization) remain the dominant mechanisms for reduction in plume size over time. Enhancements to natural attenuation (the bioreactor treatability study and planned biobarrier) are designed to increase biodegradation rates in targeted areas of the plume. However, outside of these areas enhanced by MNA, physical processes are expected to remain the dominant mechanisms for attenuation. Thus the attenuation rates calculated provide reasonable estimates of time to reach IRGs in these portions of the plume.” • Discussion of Institutional Controls (ICs) is beyond the scope of this NAAR. However, ICs and the protection of receptors are presented in the Travis AFB 5-Year Reviews (CH2M HILL, 2003 and 2008). ICs will be evaluated as a potential remedy in the upcoming Basewide Groundwater Focused Feasibility Study and will be described in detail in the Basewide Groundwater Record of Decision. The upcoming Annual Report on the Status of Land Use Controls on Restoration Sites in 2009 will describe existing land use controls on Travis AFB. • Groundwater at Travis AFB is not used for human consumption. We updated the “Groundwater” subsections of each site discussion to state the distance to the

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		nearest offbase groundwater receptor and whether or not the groundwater from the site or portion of the site evaluated for MNA discharges to surface water. • We added the distance to potential receptors in the "Groundwater "subsections of each site discussion and time-to-cleanup estimates (Appendix D) to support the evaluation. Detailed CSMs have been provided in the NAAWs. Relevant geologic, hydrogeologic, and chemical data are provided in the NAAR to support an assessment of plume behavior over time.
2.	It is uncertain how consistently biotransformation parameters used for evaluating MNA were measured, and the representativeness of the data. It is not clear whether the concentrations of oxygen, iron II, sulfide, benzene, toluene, ethylbenzene, xylenes (BTEX), vinyl chloride (VC), and chloroethane or the parameters of oxidation reduction potential, pH, and temperature were measured for each site. It appear that these parameters were not measured for every site, according to Tables 2-4, 3-4, 4-4, 5-4, 6-4, and 7-4 (Summary of Analytes Detected in MNA Wells). These parameters are all required analyses for biodegradation potential and appear in Tables 2-5, 3-5, 4-5, 5-5, 6-5, and 7-5 (Biological Screening Evaluation for Chlorinated Solvents). Please revise the NAAR to list when and at which wells the required analytes and biotransformation parameters were measured. In addition, only one monitoring event was used to determine these parameters. The text states that "geochemical parameters were collected at each of the MNA sites during the 4Q08 GSAP sampling event" in Section ES.3 (Background), and further geochemical parameter sampling is not discussed. It is reasonable that some of these parameters may change seasonally. For example, at Site LF007, groundwater elevations—and therefore potentially groundwater flow directions and groundwater geochemical characteristics—are variable, according to Section 4.2.2 (Groundwater). This variability is important because the data are interpreted to indicate that "adequate" evidence exists that biodegradation was occurring in the source area that overlaps Area LF007B. It is not clear that data over the year would indicate "adequate" evidence for biodegradation. Please revise the NAAR to discuss how a single monitoring event for geochemical parameters is sufficient to characterize the evidence for biodegradation at each site.	The results of the laboratory analyses, which included benzene, toluene, ethylbenzene, xylenes (BTEX), vinyl chloride (VC), and chloroethane are presented in Tables 2-4, 3-4, 4-4, 5-4, 6-4, and 7-4 (Summary of Analytes Detected in MNA Wells). Oxygen, pH, and temperature were measured in the field using a Horiba U-22 meter. Fe^{2+} and CO_2 were analyzed in the field using HACH field test kits. A new Appendix C presents a field measurement table, which includes the results for pH, oxygen, ORP, Fe^{2+} and CO_2 for all of the sites. The results of both laboratory and field analyses were used in Tables 2-5, 3-5, 4-5, 5-5, 6-5, and 7-5 (Biological Screening Evaluation for Chlorinated Solvents). If a parameter in Tables 2-5, 3-5, 4-5, 5-5, 6-5, and 7-5 (Biological Screening Evaluation for Chlorinated Solvents) was not analyzed, a "NA" is entered for that value (hydrogen, for example). As stated in the "Status of Interim Remedy" subsections, MNA assessments (including collection of geochemical parameters) had previously been performed at all of the sites and documented in site specific NAAWs, with the exception of SS015, at which a treatability study of enhanced MNA through vegetable oil injection was initiated but not completed. These NAAWs, which were reviewed by the EPA, specified that routine monitoring at these sites would not include biodegradation parameters, but rather include only site COCs and typical daughter products. This is because the stakeholders (Travis AFB, EPA, and the State of California) agreed at the time that the evidence for biodegradation was unconvincing, and that the ultimate tests of MNA would be plume stability and declining COC concentrations. By these tests, assessment data supports the selection of MNA as an appropriate remedy. A comparison of the preliminary biodegradation screening results (documented in the NAAW) to the 4Q08 screening results is provided in the "Geochemical Indicators" subsections. No sites showed overall strong evidence of biodegradation in the preliminary assessments, which is consistent with the findings of the 4Q08 assessment.

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3.	It is not clear whether any threat to human health results from the (VOC) plumes which lie underneath buildings. For example, it appears that the TCE plume at Site SS015 lies under Building 554, according to Figure ES-5 (Comparison of Historical and Current Extent of Groundwater Contamination at SS015). The TCE plume at Site SD033 appears to lie under Building 895, according to Figure ES-6 (Comparison of Historical and Current Extent of Groundwater Contamination at WIOU). The TCE plume at Site DP039 appears to lie under Buildings 741 and 888, according to Figure ES-6 (Comparison of Historical and Current Extent of Groundwater Contamination at WIOU). The text does not discuss whether the risks from indoor vapor intrusion have been analyzed and, if so, what the results of the analysis were. As such, it is not clear that human receptors are sufficiently protected from the indoor air intrusion pathway. Please revise the NAAR to discuss the possibility of indoor vapor intrusion from plumes which lie underneath buildings.	A basewide Vapor Intrusion (VI) assessment is currently underway at Travis AFB. A draft report presenting the results of the assessment is scheduled for agency review in January 2010. Results of the VI assessment will be used to support the Groundwater Record of Decision. It is premature to discuss the conclusions of the VI assessment in the NAAR; however, we added the following text to the “Current Distribution of Groundwater COCs” sections: 2.2.3: “A basewide Vapor Intrusion (VI) assessment is currently underway at Travis AFB. The purpose of the VI assessment is to evaluate potential for VI in buildings due to underlying VOC groundwater plumes. The VOC concentrations in the portion of the groundwater plume undergoing MNA assessment at Sites FT004/SD031 are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009). The groundwater VOC concentrations in the distal portion of the plume do not indicate potential for VI risk.” 3.2.3: “A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site LF006 groundwater plume are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009). The groundwater VOC concentrations at Site LF006 do not indicate potential for VI risk.” 4.2.3 “A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site LF007 groundwater plumes are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009). The groundwater VOC concentrations at Site LF007 do not indicate potential for VI risk.” 5.2.3 “A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the Site SS015 groundwater plume exceed the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009); indicating potential for VI. However, the Air Force constructed Building 554 at Site SS015 with a vapor barrier and passive vent system to protect the building from potential VI from the underlying groundwater plume.” 6.4.3 “A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in the portion of the groundwater plume undergoing MNA assessment in the WIOU are below the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009). The groundwater VOC concentrations in the distal portion of the plume do not indicate potential for VI risk.” 7.2.3 “A basewide VI assessment is currently underway at Travis AFB. The VOC concentrations in some portions of the DP039 plume undergoing MNA assessment exceed the groundwater screening levels developed in the Draft Phases 1 and 2 Vapor Intrusion Report (CH2M HILL, 2009); indicating potential for VI. However, soil gas data collected to date do not indicate significant VI at existing Site DP039

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		buildings (CH2M HILL, 2009). Building 755 near the source of the VOCs in groundwater was recently torn down, and there are no plans for new construction within its footprint.”
4.	In many cases, the areal segment of the plume where MNA is the designated remedy is unclear. In Table ES-2 (MNA Assessment Conclusions), MNA is listed as “an appropriate remedy for the distal portion of the plume” for Sites FT004, SD031, SD033, and SD037; MNA is listed as “an appropriate remedy for Areas LF007B and LF007D” for Site LF007. The “distal” portions of the plumes are not marked on any figure. There are, or were, groundwater extraction and treatment (GET) systems in operation at Sites FT004, SD031, and SD033. However, the radius of influence of these systems is not depicted on any map, and therefore it is not known what specific areas were treated by the GET system and which areas remained for MNA. Similarly, it is not clear what areas are intended to be remediated by the bioreactor, the phytoremediation study area, and biobarrier at Site DP039. Consequently, it cannot be evaluated whether MNA alone is appropriate for these sites or whether the planned monitoring network is appropriate. For example, the monitoring network shown in Figure 2-10 (FT004/SD031 Distal Monitoring Network) for the FT004 area does not assess most of the plume. Much of the plume will be addressed by the GET system, but it is not obvious where the transition occurs, so it cannot be evalauted whether the monitoring system is sufficient to monitor MNA. Please revise the NAAR to indicate clearly which areas of the plume are intended for MNA, which areas are intended for a different technology, and the extent of influence of the non-MNA technology.	The wells identified on the figure legends as “routinely sampled MNA wells” are those located in the distal portion of the plume where MNA is being evaluated. We added a line showing the extent of hydraulic capture to figures where GET is part of the interim remedy at the site. The portion of the site beyond the hydraulic capture is the portion of the plume being evaluated for MNA, and is labeled “MNA Area.” For DP039, the boundaries for the MNA area in the downgradient portion of the plume are not completely established, because the biobarrier has not been installed. Once the installation is complete, the area downgradient of the biobarrier will be considered to be the MNA area. We revised figure 7-1 to depict the approximate zones of influence of the bioreactor, phytostabilization area, and conceptual design of the biobarrier. The MNA area is downgradient of all of these treatment areas.
5.	The text repeatedly states that “the primary indication of whether natural attenuation is an appropriate remedy at a site is whether or not the groundwater plume is stable or has reduced in size”, which is not consistent with guidance. According to the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (September 1998, EPA/600/R-98/128) (MNA Guidance), “when [natural attenuation] processes are shown to be capable of attaining site-specific remediation objectives in a time period that is reasonable compared to other alternatives, they may be selected”. It is misleading to suggest that any other criterium is similarly important to the achievement of RAOs in a reasonable time period. In particular, it is misleading to suggest that the stability of a plume is sufficient to demonstrate whether MNA is appropriate, as other lines of evidence are also required. A plume may be stable and yet never achieve RAOs if the plume concentrations are stable at levels above remedial goals (RGs). For example, benzene detections in well MW261x07 at Site LF007 have been “stable” at concentrations ranging from 2.2 to 2.7 micrograms per Liter (µg/L), according	The NAAWs, which were reviewed by the EPA, established plume stability as the primary criterion for evaluating the appropriateness of MNA at these sites because the stakeholders (Travis AFB, EPA, and the State of California) agreed at the time that the evidence for biodegradation was unconvincing and that the ultimate tests of MNA would be plume stability and declining COC concentrations. The most significant line of evidence supporting the MNA remedy is the basic conclusion whether COC concentrations are stable or declining at a site. The NAAR shows that most COCs are declining at most sites at Travis AFB, and identifies sites (e.g., Sites SS015 and DP039) where the evidence is not currently favorable for MNA. Since EPA signed the IRODs, 12 years of monitoring data have been collected. The plume stability data during that 12-year period strongly supports the use of MNA at most sites. As previously noted, no RAOs have been established; consequently discussion of RAO achievement cannot be included in this report. We calculated a Concentration vs. Time Attenuation Rate constant for all MNA wells with COC concentrations currently exceeding IRGs and an established decreasing COC trend. We used the constant to estimate the amount of time to reach IRGs at each site or the portion of the site at

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	to Section 4.3.1 (Plume Attenuation). However, the IRG for benzene at this site was 1 µg/L, according to Section 4.2.3 (Current Distribution of Groundwater Contamination). Presumably the RAO for this site involved the benzene concentration decreasing below the IRG. If concentrations of benzene remain "stable" above the IRG, such an RAO will never be met. Please revise the text to recognize that the predicted achievement of RAOs in a predetermined length of time is an important determinant of whether MNA is an appropriate remedy.	which MNA assessment is the IRA. We agree that the RAO for LF007 will be a reduction of the benzene concentration to the selected cleanup level. We added the following text to the last paragraph of Section 1.3: "In addition, achievement of Remedial Action Objectives (RAOs) which will be presented in the upcoming Basewide Groundwater Focused Feasibility Study, and the estimated time to cleanup are important considerations for remedy selection."
6.	The NAAR does not include discussions of vertical migration for any site. The text discusses vertical gradients but does not elaborate on whether the observed gradients are sufficient for contaminants to migrate. In particular, it is uncertain if contaminants may migrate to a drinking water aquifer or strata of high hydraulic conductivity that will cause the plume to spread. In addition, the discussion of vertical gradients in the text is limited to those which are "significant", defined as "consistently greater than 0.01 ft/ft" in Section 2.2.2 (Groundwater). However, in this same section, horizontal gradients are discussed which are as low as 0.003 ft/ft. Such limitations of discussion of vertical gradients to a range that is an order of magnitude larger than that of the horizontal gradients discussed are also found in Sections 3.2.2, 4.2.2, 5.2.2, 6.2.2, and 7.2.2 (Groundwater). The vertical gradients described in Section 4.2.2, at Site LF007, are particularly concerning because they are sometimes more than 0.01 ft/ft downward, as much as 0.03 ft/ft downward. Vertical gradients described in Section 6.2.2, at the West Industrial Operable Unit (WIOU), are also strong and downward, between 0.06 and 0.1 ft/ft downward. These vertical gradients indicate a potential for contaminants to migrate downward. If the monitoring wells are not screened in the region to which the contaminants are migrating, the apparent decrease in plume sizes at these sites may in fact be due to the plume sinking to a lower stratum. Please revise the text to discuss vertical migration of contaminants.	The NAAR does not include a discussion of vertical migration of contamination because, as described in the "Groundwater" subsections for each site and illustrated on the geologic cross sections, the saturated zone at Travis AFB is thin, and consists of alluvium that is heterogeneous; primarily silts and clays with discontinuous sand lenses. As a result, there are no continuous, high permeability strata and there are no groundwater production wells on Base (there is no drinking water aquifer or strata at Travis AFB). Groundwater contamination extends fairly uniformly throughout the saturated zone as it migrates laterally and vertically through lenses of higher permeability materials (also illustrated on the geologic cross sections). We added the following sentence "Groundwater contamination extends through the saturated zone to bedrock but is mainly restricted to thin sand lenses contained within a low-permeability matrix" to each of the "Current Distribution of Groundwater COCs" subsections. We expanded paragraph 3 of Section 4.2.2 as follows: "While the vertical gradients are typically less than 0.01 ft/ft at LF007, a downward vertical gradient of -0.03 ft/ft was measured at well pair MW128x07/MW303x07 in 2Q08. Downward vertical gradients measured at this site are due to the presence of shallow bedrock and an adjacent basin. It is a recharge zone." We expanded paragraph 3 of Section 6.4.2 as follows: "Downward vertical gradients measured in the WIOU well pairs are due to the groundwater extraction that is ongoing at the site."
7.	EPA agrees with conclusions that attenuation due to transformation processes is not occurring at some sites. However, in the absence of strong evidence of transformation processes, then physical processes (dispersion, sorption, dilution with advection) will be important contributors as MNA processes. Demonstration of MNA as an appropriate remedy may then require groundwater modeling and likely additional monitoring wells to calibrate and validate the model. The placement and installation of monitoring wells will also be important because of the stratigraphic complexity of the subsurface. Please address these information needs in the revision of the NAAR.	The Air Force agrees that physical processes are the dominant natural attenuation mechanisms at Travis AFB. Groundwater modeling, a predictive tool, may not be necessary for the MNA sites because there is direct empirical evidence of the attenuation that has occurred over an 8 to 10 year period. Note that in order to select a remedy in the ROD it is not necessary to prove in advance that a remedy will be effective, particularly when site conditions (e.g., active remediation) preclude the ability to acquire such proof. Rather, the Air Force must show that a preponderance of evidence indicates that it is likely to work and must have a contingency plan in place in the event it does not work after implementation and evaluation. However, Concentration vs. Time Attenuation Rate constants have been calculated to support

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		selection of the final remedy. When MNA is initiated either as a final remedy or after an active remedy has achieved site-specific performance standards, a MNA well network will be designed and installed, and a contingency remedy will be invoked in the event that MNA does not perform as designed.
8.	It is not clear how the retardation values for contaminant transport were derived. The text states a retardation constant of 0.8 for all sites except LF007, where a constant of 0.6 is used. The assumptions used to derive these values are not stated. It is therefore not clear why a different value has been applied for Site LF007. Please revise the NAAR to discuss the derivation of the retardation constants.	Retardation factors are chemical specific. TCE is the primary groundwater COC at all of the sites except LF007B and LF007C, where 1,4-DCB is the primary COC. The EPA on-line tool “Retardation Factor Calculator” was used to calculate the retardation factors. We added this citation to subsection 4.3.1.
9.	The concentrations of the isoconcentration contours are not always presented. Figure ES-7 (Comparison of Historical and Current Extent of Groundwater Contamination at DP039) does not include any posting of the concentration at the isoconcentration lines. Several isoconcentration lines in Figure 6-4 (Groundwater Elevations Measured at the WIOU, Second Quarter 2008) are not labeled. Isoconcentration labels are absent or overlapping in several areas of Figure 6-5 (2008 TCE Distribution in Groundwater at the WIOU MNA Area). Labels for isoconcentration contours are also missing in Figure 7-8 (Comparison of Historical to Current Extent of Groundwater Contamination at DP039). Please revise the NAAR such that all isoconcentration contours are clearly labeled.	We added the missing isoconcentration contour lines to the NAAR figures.
10.	The operation of the GETS system should be discussed for the appropriate MNA sites as it may be a major reason why some of the plumes have not spread. Discontinuation of the GETS system over time may allow the plumes to migrate.	Operation of the GET systems are discussed in the “Status of Interim Remedy” sections. As discussed in these sections, the portions of the plumes that are being assessed for MNA are beyond the hydraulic capture zones of the GET systems. Generally, in the absence of MNA, we would expect the portion of a plume beyond a GET system capture zone to migrate.
11.	Some biodegradation is evident. Unfortunately, biodegradation of chlorinated compounds can create other more mobile and toxic compounds in the process (e.g. vinyl chloride). Where this is the case, MNA may not be an appropriate remedy for long term protectiveness considerations.	The Air Force recognizes that the biodegradation process results in the breakdown of chlorinated solvents into other chlorinated daughter products in the transition to complete degradation to ethene/ethane. Since physical MNA is predominant at most sites, daughter products have generally not been detected in the MNA monitoring wells. The MNA assessment area with significant vinyl chloride detections is at Site SS015, where MNA was enhanced through the injection of vegetable oil. We also had a few low VC detections at SD037 in the portion of the plume addressed by GET. At sites where biodegradation occurs, the production of daughter products is expected as part of the degradation process. Therefore daughter products as well as the COCs are monitored to assess plume stability and completion of the degradation process. Potential remedial alternatives, including MNA or MNA components, will be evaluated using the nine CERCLA criteria in the upcoming Focused Feasibility Study. The

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		evaluation will address the impact of daughter products on remedy selection and implementation.
12.	It is not clear which parameters are being monitored for natural attenuation. It is also not obvious the difference between the routine GSAP monitoring and the monitoring for natural attenuation parameters.	We listed the parameters monitored during the 4Q08 event in each "Geochemical Indicators" subsection as follows: "During the 4Q08 event, groundwater samples were analyzed for VOCs (method SW8260), methane, ethane, ethene (method RSK-175), total organic carbon (method SW9060), nitrate/sulfate/chloride (method E300.1), alkalinity (method E310.1), sulfide (method SW9034) and Fe^{2+} and CO_2 (HACH field test). In addition, pH, temperature, dissolved oxygen, oxidation reduction potential, conductivity, and turbidity field measurements were recorded at each well using a Horiba U-22 instrument. Routine sampling at the site consists of monitoring for the site COCs only; geochemical parameters are not collected."
SPECIFIC COMMENTS		
1.	**Table ES-1, Status of Natural Attenuation Sites:** It is not clear why the status of SS015 is different from the status of all other sites. The status for SS015 is "Ongoing monitoring to support natural attenuation evaluation," while the status for all other sites is "Initial MNA assessment has been performed; ongoing monitoring to support natural attenuation evaluation". It is not clear why an initial MNA assessment is not considered to have been performed for SS015. The description of SS015 in Section ES.5.4 (Site SS015) derives conclusions "based on the results of the natural attenuation assessment," suggesting that a natural attenuation assessment has been performed. Please revise the table to include a footnote explaining why SS015 is not considered to have had an "initial MNA assessment" performed.	The first paragraph of Section ES-3 explains why the status of SS015 is different from the other sites. We added the following footnote to Table ES-1: "The SS015 NAAW was not completed, because the site was selected by AFCEE for a vegetable oil injection treatability study." The status of Site SS015 in Table ES-1 has also been changed to "Ongoing monitoring to support enhanced natural attenuation evaluation."
2.	**Section 2.3.1, Plume Attenuation, Page 2-4:** The text does not discuss the appearance of TCE in 2008 in an area where TCE was not observed in the period 1998 to 2000. According to Figure 2-9 (Comparison of Historical and Current Extent of Groundwater Contamination at FT004/SD031), an area of TCE contamination was observed in 2008 in the southern tip of the SD031 1,1-dichloroethylene (1,1-DCE) plume. No TCE was observed in this vicinity in the period 1998 to 2000, according to the figure. While 1,1-DCE is a possible biotransformation product of TCE, the transformation of 1,1-DCE into TCE is not generally considered possible via biodegradation. The figure therefore appears to suggest that either a new source of TCE appeared, or that some TCE migrated to this area from another plume. Please revise the text to discuss the appearance of TCE in the southern end of the SD031 plume in 2008.	No historical TCE plume was shown for Site SD031, because the most widespread COC at the site is 1,1-DCE. To avoid confusion, we removed the current TCE plume delineation from Site SD031, and only the current and historical 1,1-DCE plumes are depicted for this site.

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3.	**Section 3.5, Ongoing Monitoring, Page 3-5:** It is not explained why well MW1730x31 will not continue to be sampled. This well is the only downgradient well that is cross-gradient to the east of the plume. Thus, this well should be regularly sampled to ensure that the plume does not migrate to the east due to changing groundwater flow direction. Please revise the text to note that well MW1730x31 will be sampled or to justify why sampling this well is not required.	We added well MW1730x31 to the MNA network.
4.	**Section 3.5, Ongoing Monitoring, Page 3-5:** It is not clear that it is appropriate to discontinue total petroleum hydrocarbons as diesel (TPH-D) analysis at all areas of the site except well MW208Dx06. The text states that "TPH-D analysis will be discontinued at the rest of the site because it has not been detected in any other well since 2004." However, since it is unknown why TPH-D has suddenly appeared in MW208Dx06, it is not certain that hydrocarbons will not appear at any other well in the future. Until the cause of the reappearance of TPH-D has been found, all wells should continue to be monitored for TPH-D to ensure that any TPH-D contamination is identified. Please revise the text to state that all wells will be analyzed for TPH-D in the future or to justify the rationale that TPH-D is not expected to appear in wells other than MW208Dx06.	TPH-D was not detected at well MW208Dx06 in the subsequent 2Q09 sampling event. The single detection of 120 μg/L (which is only slightly above the reporting limit) at this monitoring well does appear to be anomalous. However, TPH-D will continue to be analyzed at the site over the remainder of the interim period to support deletion of TPH-D as a site COC. We revised the Ongoing Monitoring section as follows: "These wells will be sampled annually for VOCs, TPH-G, and TPH-D. This network will continue to be monitored during the interim period or until such time as the remedy changes."
5.	**Figure 3-5, TPH-G Distribution in Groundwater at LF006:** The figure does not depict isoconcentration contours of total petroleum hydrocarbons as gasoline (TPH-G). While the detections of TPH-G are "sporadic," as characterized in Section 3.1.3 (Status of Interim Remedy), sufficient data appears to exist to estimate the extent of TPH-G contamination surrounding each well in which it was detected. Such contours are useful for estimating the full areal extent of contamination. Please revise the figure to include estimated isoconcentration contours.	For TPH-G, the IRG (5 μg/L) is below the Practical Quantitation Limit (50 μg/L), so every detection shown on figure 3-5 has a J value assigned to it. As a result, the TPH-G concentrations are only estimates, and there are no quantified data points available to draw an isoconcentration contour. In addition, the chemical time-series plots illustrate that TPH-G concentrations in most wells fluctuate between 10 μg/L and non-detect (less than 5 μg/L) from one event to another. Therefore, unlike TCE, there is no consistent TPH-G plume at the site.
6.	**Section 4.1.3, Status of the Interim Remedy, Page 4-2:** It is not clear that it is appropriate to omit well MW617x07 as an MNA assessment monitoring well. The text states that "well MW617x07, located near the northern boundary of LF007B, is considered an LF007C well because it has been impacted by the TCE concentration in this area" and that "therefore, it was not selected as an MNA assessment monitoring well". However, since the well is located within the area for which MNA is the chosen remedy, it appears that only from MNA sampling can be used to address contamination detected in this well. As such, the fluctuations of concentrations of contaminants in this well, even if these were due to migration of contamination from another area, should be considered in the MNA assessment. In addition, Area LF007B appears to be the distal portion of a plume with its source in Area LF007C. As such, it is	Although the NEWIOU IROD states that the onbase portion of the LF007C TCE plume will undergo a MNA assessment, the Air Force plans to address the offbase and onbase portions of the LF007C TCE plume, including well MW617x07, through GET not MNA. This avoids the difficulty associated with managing GET so close to a MNA area. Therefore, this well is not included in the MNA assessment, but will continue to be monitored to support the LF007C GET Remedial Process Optimization. Note that this well is directly upgradient from extraction well EW614x07, and any contamination in the vicinity of MW617x07 will be captured by EW614x07. LF007C is not upgradient from LF007B; the local groundwater flow direction is different from the regional flow direction.

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	expected that contamination from LF007C will reach LF007B, since "the LF007 system is not fully achieving the design objectives." Unless the contamination observed in this well will be remediated by another technology, well MW617x07 should be considered an MNA assessment monitoring well. Please revise the text to state that MW617x07 will be an MNA assessment monitoring well.	
7.	**Section 4.2.3, Current Distribution of Groundwater Contamination, Pages 4-3 and 4-4:** The text does not discuss the limitations in data that were used to develop the TCE isoconcentration contour shown in Figure 4-5 (2008 TCE Distribution in Groundwater at LF007). The TCE plume extending from Area LF007C into LF007B is bounded to the south by well MW601x07. However, according to Figure 4-3 (LF007B Geologic Cross Section), well MW601x07 is not screened in the strata in which the TCE contamination was observed in well MW617x07, the southernmost well in which TCE was observed. The edge of the TCE contour that is within Area LF007B will be remediated by MNA, so it is relevant to discuss the details of the determination of this contour in the NAAR. Please revise the text to discuss how the southern extent of the TCE plume in Areas LF007c and LF007B was determined.	As depicted on the cross section, the screened intervals of the monitoring wells overlap. Well MW617x07 is screened from 15 to 50 feet bgs and well MW601x07 is screened from 5 to 25 feet bgs. The lithology at well MW617x07 from 25 feet to 50 feet bgs consists of low permeability lean clay and silt, so this depth interval is expected to yield little groundwater. Groundwater primarily enters the screen over the most permeable zone (silty sand) which was encountered approximately 20 to 25 feet bgs. This is also the depth interval monitored by MW601x07.
8.	**Figure 4-10, Comparison of Historical to Current Extent of Groundwater Contamination at LF007B and LF007D:** The figure does not include the historical or current isoconcentration contours for TCE in Area LF007B. The figure only includes the isoconcentration contours for 1,4-Dichlorobezene in LF007D. The TCE isoconcentration contours were depicted for the year 2008 in Figure 4-5 (2008 TCE Distribution in Groundwater at LF007). The extent to which the plume in Area LF007B has been stable or has decreased over time is not clear. Please revise the figure to include historical and current TCE isoconcentration contours.	TCE is not a site COC at Areas LF007B or LF007D, which are the Areas of LF007 that are being evaluated for MNA. Therefore the historical extent of TCE at this site does not support the MNA assessment. TCE is a site COC only at Area LF007C, which is being addressed by GET. To avoid confusion, we removed Figure 4-5 from the report.
9.	**Section 5.2.3, Current Distribution of Groundwater Contamination, Page 5-4:** The text does not discuss the absence of data to support the western extent of the plume. The text notes that "the current extent of COCs to the northeast of the site is uncertain." However, there exist no monitoring wells to the west of the plume that are sampled, only abandoned wells. Thus, the western extent of the plume is also unknown. Please revise the text to discuss the data gap associated with the western extent of the plume.	We added the following text to the section "There is currently no monitoring well directly upgradient of source area well MW216x15; therefore, recent analytical data upgradient of the source area are not available."
10.	**Section 5.4, Natural Attenuation Assessment Conclusions, Page 5-7:** It is not clear that enhanced MNA is an appropriate remedy for this site. The rebound of COC concentrations to the extent that they have "exceeded historical maximum concentrations," as discussed in Section 5.3.1 (Plume	As discussed in Section 5.4, the reasons enhanced MNA should be considered as a potential remedy for this site are: 1. The elevated concentrations of breakdown products (cis-1,2-DCE and VC) relative to the concentrations of parent compounds (PCE and TCE) confirm that

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	Attenuation), suggests that enhanced MNA may be difficult to implement. Currently, the historical comparison of TCE isoconcentration contours shown in Figure 5-9 (Comparison of Historical to Current Extent of Groundwater Contamination at SS015) can be interpreted that, in the long run, enhanced MNA did not reduce contaminant concentrations in the plume. The plumes appear almost identical, except that the 2008 plume may extend farther to the northeast, particularly considering that MW624x15, the well in that region, is not screened in the contaminated saturated zone. Please revise the text to discuss why enhanced MNA is an appropriate remedy, considering the rebound and current migration of the plume.	the vegetable oil injection enhanced biodegradation. 2. The concentrations of daughter products are currently an order of magnitude higher than the concentrations of the parent compounds. 3. The amount of vegetable oil injected during the treatability study was insufficient to completely degrade the groundwater contamination at the site. However, the treatability study shows that it is possible to enhance biodegradation at the site. Note that the vegetable oil injection was a treatability study that was cut short to support a military construction project, not a full scale implementation of enhanced MNA. Based on the partial results of this study, enhanced MNA looks promising. We added the following text to the first paragraph of Section 5.1.3 “The purpose of this treatability study was to demonstrate that it was possible to initiate reductive dechlorination under site-specific conditions by injecting an organic carbon source into the subsurface. Over the course of the treatability study approximately 227 gallons of vegetable oil were injected. The treatability study was limited in extent and was not designed to be an enhanced MNA remedy.”
11.	**Section 5.4, Natural Attenuation Assessment Conclusions, Page 5-7:** The conclusions of the MNA assessment are indefinite and do not suggest a timeframe for a final determination. The text states that “MNA alone may not be a sufficient remedy at this site” and that “enhanced MNA is a potential remedy for this site”. It is not clear what additional data or analyses are required to determine whether MNA alone, enhanced MNA, or another technology is the most appropriate remedy. It is not clear when the additional data will be collected or analyses will be performed. An anticipated date is not presented for when the remedy for this site will be chosen. Therefore, it is not clear when action will be taken (if action is required) to remediate this site. Please revise the text to discuss the timeframe for determining the remedy to be used at Site SS015.	It is beyond the scope of the NAAR to discuss the timeframe for determining the remedy to be used at Site SS015. The purpose of the NAAR is to evaluate the data collected during the interim period of remediation and assess whether MNA is an appropriate remedy for the site. At SS015, based on the data collected to date, it appears that MNA alone may not be an effective remedy at this site and that further investigation is needed. The final groundwater remedy will be selected in the Basewide Groundwater ROD, and remediation will officially start as a post-ROD remedial action. We added the following text to the last bullet of Section 5.4: “Installation of these monitoring wells is planned for 2010.”
12.	**Section 5.5, Ongoing Monitoring, Page 5-7:** The text does not note definitely whether any new monitoring wells will be installed, although additional wells appear to be required. The text states that “any additional monitoring wells installed at the site will be sampled semiannually for 2 years.” Neither the text nor Figure 5-10 (SS015 Monitoring Network) show new monitoring wells. However, the text notes in Section 5.3.1 (Plume Attenuation) that “the extent of the plume in [the northeast] is uncertain because there are no monitoring wells screened in the saturated zone above bedrock in this area (MW625x15 is screened in bedrock)” and that “the plume has recently expanded slightly to the east (in the vicinity of MW625x15).” Thus, an additional monitoring well near the current well MW625x15 screened in the saturated zone above bedrock is warranted. In addition, Figure 5-10 suggests that there are no wells	The text describes the approximate locations of the additional monitoring wells and they are depicted on Figure 5-10 (they are the black triangle symbols described in the legend as “additional monitoring well planned”). For example, we need one additional monitoring well upgradient (to the west of) MW216x15. We modified the text as follows “One additional monitoring well to the west of MW216x15 is needed to monitor the upgradient portion of the plume.” We added the following text to the last bullet of Section 5.4: “Installation of these monitoring wells is planned for 2010.” When the wells have been installed, they will be incorporated into routine sampling at the site.

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	outside the plume to the west or east. While the western edge of the plume is upgradient, at least one upgradient well should be sampled in the event of changing groundwater flow directions. The eastern edge of the plume is downgradient, so a monitoring well to the east of the plume is required to ensure the plume does not migrate down gradient. Please revise the text to note that additional monitoring wells to the west and east of the plume, and in the vicinity of well MW625x15, are warranted and will be installed and sampled as part of the ongoing remedy for Site SS015.	
13.	**Section 6.3, Status of Interim Remedy, Page 6-3:** It is not clear what remedy is in place for regions of the TCE plume upgradient of the GET regions. The text states that "the Air Force has performed MNA assessment in the portions of the plume downgradient from the 100 µg/L isopleths" and that "the GET was designed to capture those areas where VOC contamination is present at concentrations greater than 100 µg/L". However, the text does not discuss what remedy is used for portions of the plume upgradient from the 100 µg/L isopleths. Thus, it is not clear whether all TCE at the site is being addressed. Please revise the text to discuss the remedy in place for the portions of the plume upgradient from the 100 µg/L isopleths.	We added the following sentence to Section 6.3: "The area of the plumes upgradient of the 100 µg/L isopleths are within the hydraulic capture of the GET systems, and satisfy the "Migration Control" provisions of the IROD."
14.	**Section 6.5.1, Plume Attenuation, Page 6-5:** The discussion of TCE trends omits discussion of well MW723x37, in which TCE concentration has been increasing. The text only notes those wells for which TCE concentration is decreasing. The text states that "TCE concentrations have been stable and low at all of the southern WIOU MNA wells." While the concentration at well MW723x37 has remained under below the IRG, it has not been stable, according to Figure 6-6 (WIOU MNA Wells; TCE). In addition, this well is located at the southern edge of the SD033 TCE plume. It is misleading to omit mention of this well. Please revise the text to recognize that TCE concentrations have been increasing in well MW723x37, at the down gradient edge of the SD033 plume.	We expanded the text of Section 6.5.1 as follows: "TCE concentrations at well MW723x37 increased slightly in 2008, but remain below the IRG. No significant increasing TCE trend was identified by the Mann-Kendall statistical analysis at this or any other WIOU MNA well (Appendix E)."
15.	**Section 6.5.1, Plume Attenuation, Page 6-5:** The discussion of TPH in well MW05x14 neglects the condition that this well is not within the historical or current TCE plume. The text states that "the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume." However, MW05x14 is south of the farthest reach of TCE above the IRG by about 600 feet, according to Figure 6-9 (Comparison of Historical to Current Extent of TCE Contamination at the WIOU). It is unlikely that TPH detected in this well contributes to the biodegradation of the main plume. Please revise the text to discuss the apparent condition that TPH in well ME05x14 is not collocated with TCE.	The presence of TPH and conditions favorable to biodegradation downgradient of the WIOU TCE plume is advantageous because degradation of TCE would be enhanced if it were to migrate into this area, thus contributing to the stability of the plume. We revised the last paragraph in section 6.5.1 as follows: "The presence of TPH enhances biodegradation of chlorinated solvents. Although there is currently no TCE in the vicinity of MW05x14, if the WIOU TCE plume were to migrate downgradient (southward), the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume."

No.	Comments	Responses
16.	**Section 6.6, Natural Attenuation Assessment Conclusions, Page 6-7:** While it is often correct that “the presence of petroleum hydrocarbons in the vicinity of MW05x14 enhances biodegradation of chlorinated solvents,” there are no observed chlorinated chemicals in the vicinity of well MW05x14. Well MW05x14 is south of the farthest reach of TCE above the IRG by about 600 feet, according to Figure 6-9 (Comparison of Historical to Current Extent of TCE Contamination at the WIOU). It is unlikely that TPH detected in this well contributes to the biodegradation of the main plume. Please revise the text to omit mention of TPH in the vicinity of MW05x14 enhancing the biodegradation of chlorinated solvents.	We revised this bullet as follows: “The presence of petroleum hydrocarbons in the vicinity of MW05x14 enhanced degradation of chlorinated solvents. Thus, if the TCE plume were to migrate downgradient towards this well, the presence of TPH in the southern portion of the WIOU plume may contribute to the stability of the plume.”
17.	**Section 7.1.3, Status of Interim Remedy, Page 7-1:** The location of the bioreactor installed in 2008 is not clear. The text does not include a reference to a figure depicting the location of the bioreactor and it is uncertain what the areal extent of the bioreactor treatment is intended to be. Consequently, the areal extent of groundwater which requires a different remedy beyond the operation of the bioreactor is unknown. Please revise the text to provide a reference to a figure depicting the location and area of remediation of the bioreactor system.	The location of the bioreactor is shown on Figures 7-1, 7-3, 7-4, and 7-9. We added a reference to Figure 7-1 to the text where the bioreactor is described. As stated in the text, the bioreactor is intended to treat the source area.
18.	**Section 7.1.3, Status of Interim Remedy, Page 7-2:** It is not stated when the study area undergoing phytoremediation was established. Thus, it is not clear that a MNA assessment, in contrast to an enhanced MNA assessment, has been performed for Site DP039. If the phytoremediation area was established toward the beginning of the MNA assessment period, then the natural attenuation evaluation may have been affected by the phytoremediation. It is therefore not clear to what extent natural attenuation versus phytoremediation was responsible for any observed attenuation of the COCs. Please revise the text to state when the phytoremediation study area was established and how this study may have contributed to the observed MNA conclusions.	The effectiveness of phytoremediation is being evaluated by another study. The contribution of the phytoremediation system towards remediation at DP039 is not related to the MNA assessment, since these potential remedies are being studies in different portions of the solvent plume. The Air Force is designing and installing a biobarrier downgradient of the phytoremediation study area to address higher contaminant concentrations in the central part of the solvent plume and to support MNA in the downgradient portion of DP039. We added the following sentences to the second paragraph of Section 7.1.3: “The phytoremediation study area was established in 1998 and is upgradient of the area being evaluated for an MNA remedy. Figure 7-1 depicts the approximate zone of influence of the phytoremediation area.” We revised figure 7-1 to illustrate the approximate zone of influence of the phytoremediation area.
19.	**Section 7.4, Natural Attenuation Assessment Conclusions, Page 7-6:** The planned location of the biobarrier is not stated. The text does not include a reference to a figure depicting its location. As such, it is not clear what the areal extent of the biobarrier influence is intended to be. Thus, the areal extent of groundwater that will continue to be addressed by MNA is not clear. Please revise the text to provide a reference to a figure depicting the location and area of influence of the biobarrier.	The design of the biobarrier is a work in progress; we added a reference to the “Draft Site DP039 Remedial Process Optimization Work Plan” (CH2M HILL, October 2009) to the text. We added the conceptual location of the biobarrier to Figures 7-1, 7-4, and 7-9.

No.	Comments	Responses
20.	**Section 7.5, Ongoing Monitoring, Page 7-6:** The text does specify whether any new monitoring wells will be installed, although additional wells appear to be required for more complete site characterization. There are no wells to the east or west of the plume to verify the plume is not spreading due to changing groundwater flow patterns. The interior of the plume has only two monitoring wells, despite a lateral extent of about 1,000 ft at the widest point. There are no monitoring wells within the 100 µg/L contour in the MNA region. Please revise the text to recognize that additional monitoring wells to the west and east of the plume are required, in addition to more wells in the interior of the plume, and will be installed and sampled as part of the ongoing remedy for Site SS015.	Additional site characterization is currently underway at DP039. As part of this effort, monitoring wells will be constructed in the central portion of the plume to support the biobarrier study area and upgradient portion of the MNA area.
21.	The text consistently abbreviates the time (sampling event) at which samples were taken, but these abbreviations are not defined. For example, “4Q08” is used to denote a sampling event, presumably to indicate the fourth quarter of the year 2008. These abbreviations are not defined in Appendix A (Acronyms and Abbreviations). Please revise the text to use the full name of each sampling event time or to define the abbreviations in Appendix A.	We added the abbreviations for the sampling events to the Acronyms and Abbreviations table in Appendix A.
22.	**Section ES.5.5, West Industrial Operable Unit (Sites SD037 and SD033), Page ES-6:** The text does not state the quality of the evidence for biotransformation for all areas. The text states that “there is inadequate evidence for biodegradation of chlorinated COCs in the southern WIOU, with the exception of the area that has been impacted by petroleum hydrocarbons associated with Site SS014.” It is not clear whether the “inadequate evidence” for biodegradation is a lack of sampling locations, an incomplete list of analytes, or number of sampling events. Please revise the text to discuss the quality of evidence in this area in the context of data usability in an MNA context.	The AFCEE point system used to evaluate biodegradation potential, including definitions of *inadequate evidence*, *limited evidence, adequate evidence*, and *strong evidence*, is described Sections ES.3 and 1.3. We added the following text to Sections ES.3 and 1.3, following the listing and definitions of the AFCEE scoring system: “The adjective “inadequate” as defined in the AFCEE scoring system means that site conditions are not conducive to biodegradation of chlorinated solvents. Use of “inadequate” in the context of the AFCEE scoring system does not indicate a lack of data points or poor data quality.”
23.	**Table ES-2, MNA Assessment Conclusions**: The table does not address whether LF007B and LF007D are sources or distal areas of the plume. Thus, it is not clear from the table whether biological or physical attenuation is dominant in these areas, which are the only areas considered for natural attenuation. Please revise the table to note whether Areas LF007B and LF007D are source or distal.	Areas LF007B and LF007D are separate plumes within Site LF007. For clarity, we revised the table to show one entry for LF007B and one entry for LF007D. The Interim Remedy for each subarea is now described as “MNA assessment for entire subarea.”
24.	**Section 2.3.1, Plume Attenuation, Page 2-4:** The text states that “TCE concentrations have increased slightly at…MW591x31,” but there is no well MW591x31 listed at Site FT004 or Site SD031. It is not clear to which well the text refers. Please revise the text to correct this apparent misstatement.	We corrected the well designation to MW591x04.

No.	Comments	Responses
25.	**Site FT004** • From Table 2-4, some of the wells at FT004, especially MW131X04, and MW264X04 show very high levels of sulfate. Sulfate concentrations at SD031 wells are much lower. Chloride is high in well MW264X04. • The MNA areas shown on Figure 2-5 and Figure 2-6 for site FT004 indicate that contaminant concentrations are low in these areas and thus this area appears suitable for monitored natural attenuation provided the GETS continues to operate. It is unclear if long term shutdown of the GETS for FT004 would allow the plume to migrate again.	As a result of the concentrations of these natural attenuation parameters, several of the FT004 wells received a score of "inadequate evidence of biodegradation," as did all of the other site wells. The GET system for FT004/SD031 has been shut down for a rebound study over the remainder of the interim period. Monitoring of the plume over this period will verify the plume's lack of mobility.
26.	**Site SD031 -** The MNA area indicated on Figure 2-5 and Figure 2-6 for SD031 shows that contaminant concentrations remain low and the plume is not migrating. Monitored natural attenuation may be appropriate for the MNA area indicated.	Groundwater monitoring over the remainder of the interim period will verify the plume's lack of mobility.
27.	**Site LF006 -** Review of Figures 3-4, 3-5 and 3-9 indicate that contamination levels are low and the plume is not migrating. MNA may be an appropriate remedy for LF006.	Groundwater monitoring over the remainder of the interim period will verify the plume's lack of mobility.
28.	**Site LF007** • Figure 4-11 shows TCE is limited to a small area for LF007D and to a very few detections for LF007B (Figure 4-5). A small area of 1,4-DCB contamination also remains at LF007D (Figure 4-6). Sites LF007B and LF007D appear suitable for MNA. • Methane and chloride is very high at MW261X07 and sulfate is very low. These results appear rather unusual. Sulfate is very high at MW601X07, MW612X07, and MW613x07.	Groundwater monitoring over the remainder of the interim period will verify the plume's lack of mobility. As indicated in Table 4-5, conditions at well MW261x07 are conducive to biodegradation of chlorinated solvents. The relatively high methane and chloride concentrations at well MW261x07 are due to the biodegradation of 1,4-DCB in the vicinity of this well. The low sulfate concentrations are conducive to biodegradation, as high sulfate concentrations may compete with the reductive pathway. High sulfate concentrations at MW601x07, MW612x07, and MW613x07 are similar to those detected at Site SS015 where gypsum crystals have been observed.
29.	**Site SS015** • Table 5-4 and Figure 5-8 show a spike in vinyl chloride (VC) concentrations of 310 µg/L and 1,480 µgl/L for MW216X15. Vinyl chloride is a biodegradation product of TCE/1,1-DCE. The MCL is 0.5 µg/L. This well is in the location of the vegetable oil injection area which may have contributed to the VC breakdown product through the biodegradation process. Air Force should confirm the vegetable oil is not promoting the anaerobic conditions causing the VC issues before injecting more oil to any site. • Wells at this site show very high levels of sulfate. • As indicated on page 5-7 Section 5.4, the SS015 plume is migrating and is	The presence of VC is likely due to the vegetable oil injection, is expected as part of the biodegradation process, and demonstrates that reductive dechlorination has not stalled at the cis-1,2 DCE stage. Note that VC quickly breaks down in aerobic environments (outside the area of influence of the vegetable oil), and any post-ROD remedial design will take the presence of VC into account to ensure that human health is protected and that any enhanced MNA is allowed to completely break down TCE into ethane/ethane. We agree that high levels of sulfate are present at this site, probably related to gypsum crystals observed during drilling at SS015. The Air Force agrees that based on the data collected to date, it appears that MNA alone may not be an effective remedy at Site SS015 and that further investigation is

No.	Comments	Responses
	thus not a good candidate for natural attenuation.	needed. The final groundwater remedy will be selected in the Basewide Groundwater ROD, and remediation will officially start as a post-ROD remedial action. We added the following text to the last bullet of Section 5.4: “Installation of these monitoring wells is planned for 2010.”
30.	**Site SD033 -** The area indicated for monitored natural attention on Figure 6-9 is appropriate as long as the GETS continues to operate.	The GET system will continue to operate until stakeholders agree that IRAOs or future RAOs have been achieved and a rebound study may be performed.
31.	**Site SD037** • Vinyl chloride was detected above the MCL at well MW531X37. • The area indicated for monitored natural attention on Figure 6-9 is appropriate as long as the GETS continues to operate.	Well MW531x37 is within the portion of the plume where TCE concentrations exceed 100 µg/L (TCE was detected at 500 µg/L at this well) and is therefore addressed by GET. Groundwater monitoring over the remainder of the interim period will verify the plume’s lack of mobility.
32.	**Site DP039 -** As indicated in Section 7.4, MNA alone may not be adequate to prevent plume migration.	The Air Force is further characterizing DP039 and designing a biobarrier to address high solvent concentrations in the central portion of the plume and support MNA in the downgradient portion of the plume.
CROSS SECTION COMMENTS		
A.	The cross sections are evolving into a useful tool and incorporating the following revisions will improve their usefulness, however, review of the cross sections has revealed several reoccurring problems that have been grouped together as follows: **Cross Section Location Figure and cross section order**: The accepted convention for presenting geologic cross section location figures and geologic cross sections is to first provide the location maps followed by the actual geologic cross sections, which assists the reader in spatially visualizing the subsurface. The table below demonstrates that all of the cross section location figures are presented after the cross section figures. Please revise the figures in the report so that the cross section location figures precede the cross section figures for all of the sites in their respective sections. **Cross-Section Location Figure** **Cross-Section Figure** Figure 2-5 Section B-B’ FT004/SD031 Figure 2-2 B-B’ Figure 2-6 Section A-A’ FT004/SD031 Figure 2-3 A-A’ Figure 3-4 Section A-A’ LF006 Figure 3-2 A-A’	Based on the following EPA comment received on the Draft 2007-2008 GSAP Annual Report, “Also it would be helpful to include the location of cross section on a plan view map also showing the plume boundaries. Please include the cross section locations in plan view with the associated plume,” it was understood that the EPA preferred the cross section location on the plume map rather than the site map. We added the following note to all of the cross sections “Note: See Figure X for Cross Section Line,” where “X” identifies the specific figure. However, we added the cross section line to the location maps (the first figure of each section) as requested.

No.	Comments	Responses
	Figure 4-6 Section A-A' LF007 Figure 4-2 A-A' Figure 4-5 Section B-B' LF007 Figure 4-3 B-B' Figure 5-4 Section A-A' SS015 Figure 5-2 A-A' Figure 6-4 Section A-A' WIOU Figure 6-3 A-A' Figure 7-4 Section A-A' DP039 Figure 7-2 A-A'	
B.	**Lack of screen interval**: In Figure 6-3 the screen interval is missing for well MWSSBM2X37 on cross section A-A' yet it has a groundwater elevation symbol adjacent to it. Please revise the cross section and either indicate the screen interval or explain in a footnote on the cross section how the groundwater elevation was determined.	We added the screened interval for MWSSBM2x37 to Figure 6-3. Note that a depth to water measurement may still be made at a monitoring well, even if the well screen interval is unknown. The method used to determine groundwater elevations is provided in the Travis AFB *Field Sampling Plan* (CH2M HILL, 2009).
C.	**Missing Groundwater Elevations**: The following table summarizes the wells and their respective figures that are missing groundwater elevation data. Please revise the figures by adding the missing groundwater elevation data adjacent to the wells specified in the table below or explain in a footnote on the cross section why the elevation data is missing. **Figure** **Well** 2-2 MW1000X04, EW576X04, EW580X04, EW621X04, EW623X04 2-3 MW573X31, MW1727X31, EW565X31, EW566X31 5-2 MW237X15, MW315X15, MW625X15 6-3 EW503X33, EW594X36, EW595X36, EW599X37, EW701X37, EW705X37 7-2 EW782X39	All available groundwater elevation data are posted on the cross sections. Groundwater elevation data are not collected at extraction wells (all of the wells listed beginning with "EW") which are actively pumping at the time of the survey. We added groundwater elevations for monitoring wells MW573x31, and MW625x15. We added a note that monitoring wells MW237x15 and MW315x15 have been decommissioned to figure 5-2. We added a note that groundwater elevation 2Q08 groundwater elevation data for wells MW1000x04 and MW1727x31 are not available to figure 2-2, and 2-3, respectively.

No.	Comments	Responses
D.	**Concurrence between boring logs projected onto cross sections with wells/borings shown on cross section location figures:** i. The north end of cross section B-B’ shown on Figure 2-2 includes well MW131X04, but the location for cross section B-B’ on Figure 2-5 does not extend to this well. Please revise Figure 2-5 by extending the cross section line to well MW131X04. ii. The boring/well located at the north end of cross section A-A’ on Figure 3-2 is designated MW01DX35 yet the boring/well located at the north end of the location for cross section A-A’ on Figure 3-4 is MW01DX06. Please resolve the discrepancy and revise Figures 3-2 &/or Figure 3-4. iii. The well/boring located at the east end of cross section A-A’ on Figure 5-4 is MW625X15; 15-SB02 is not located on the cross section line yet at the east end of cross section A-A’ on Figure 5-2 15-SB04 is located west of the MW625X15. Please resolve the discrepancy and revise Figures 5-2 &/or Figure 5-4.	i. The cross section line depicted on Figure 2-5 does extend to well MW131x04. The thin black line connects the well location to the well label and associated TCE concentrations. ii. We corrected the well ID MW01Dx35 shown on Figure 3-2 to MW01Dx06. iii. We revised figure 5-2 to depict MW625x15 in the correct location.
E.	**Two names associated with one well**: The following table summarizes the wells and their respective figure numbers that show two well designations for one well. Please revise the figures and indicate on the cross section figure if the well is a dual completion well. Additionally, if one of the wells is missing from the cross-section, please add that well name to the cross section figure. **Figure** **Well** 3-2 MW01SX06 and MW01DX35 5-2 MW237X15 and MW315X15 6-3 PZ07DX36 and PZ07SX36 7-2 MW783SX39 and MW783DX39	These wells have been labeled as well pairs on the corresponding revised figures and the shallow and deep well of each pair has been identified.
F.	**Bedrock Surface:** The estimated bedrock surface shown on Figure 4-2 has an unusual shape. Please either provide evidence supporting the shape of this geologic feature in a footnote on the cross section or revise the estimated bedrock surface on Figure 4-2.	As described in Section 4.2.1 “On the eastern edge of Site LF007 lies a north-south trending subsurface ridge of Markley Sandstone, resulting in a thinning of the saturated zone towards the east.” The cross section intersects the bedrock ridge. We revised figure 4-2 by adding a label for the bedrock ridge.

No.	Comments	Responses
G.	**Horizontal and Vertical Extent of Contamination:** It would be helpful to include contaminant concentration contours in the subsurface to demonstrate the extent of contamination but also this can aid in calculating the current contaminant mass which should occur prior to the Record of Decision. Please consider contouring the analytical data in the cross sectional view for primary contaminants of concern.	Where COCs exceed IRGs, we added VOC concentration contours to the cross sections
REVIEW COMMENTS – James Chang, EPA Region IX dated May 3, 2010		
SUMMARY COMMENT		
1.	In order for the Natural Attenuation Assessment Report (NAAR) to provide adequate support for the selection of Monitored Natural Attenuation (MNA) the following information is required by EPA. Is should be noted that sites that are considered for MNA but were not presented in the NAAR should have information similarly robust for MNA to be considered for as viable remedial alternative.	MNA or MNA Assessment was selected in two groundwater IRODs as a potential remedy for Travis AFB groundwater plumes or portions of plumes. MNA was selected for evaluation in the IRODs because, given the low permeability of the saturated sediments, low groundwater velocity, diffusion limited desorption, relatively low COC concentrations, and lack of receptors, MNA was regarded as a viable component of a final remedy at these sites. Natural attenuation monitoring networks were consequently established as described in site-specific natural attenuation assessment workplans (NAAWs). These networks, which were agreed upon by the stakeholders, were designed to verify plume stability over the interim period. The purpose of the NAAR is to evaluate the data collected over the interim period from these networks. The NAAR evaluates only the portion of the plume specified for MNA or MNA assessment in the IRODs; it does not extrapolate MNA results to portions of the plume that has been addressed by active remediation over the interim period. However, data collected over the interim period and evaluated in the NAAR will be used to support consideration of MNA as a remedial alternative in the Focused Feasibility Study (FFS). The FFS will also discuss contingency actions for a site if MNA does not perform as designed and the triggers for implementing those contingency actions. Contingency actions may include increased monitoring, applying an enhanced version of MNA, or turning the groundwater extraction and treatment system back on. Triggers may include an increase of COC concentrations in downgradient wells which would indicate that the plume is migrating.
GENERAL COMMENTS		
1.	"Concentration versus Time" plots should be made for each well in as identified in the respective NAAW, Table 4-1 for the *Final FT004/SD031 Natural Attenuation Assessment Work Plan (NAAW) dated July 2001* (FT004/SD031 NAAW), is attached as an example of wells that should utilized. These "Concentration versus Time" plots should be used to	Concentration vs. time plots for the MNA networks described in each site-specific NAAW are included for each site in the draft NAAR that was submitted for review on August 19, 2009. These plots were provided for all site COCs that continue to exceed IRGs in the MNA monitoring network. Concentration vs. time plots of biodegradation daughter products (such cis-1,2-DCE and vinyl chloride) are

No.	Comments	Responses
	Calculate Point Decay Constants as described in *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies, November 2002 (EPA/540/S-02/500)*. A narrative discussing the significance of results including a discussion of attenuation rates for given locations within the plume, and the uncertainty related to these results should be incorporated into the final NAAR. Temporal trends should be discussed in the context of the site conceptual model; review Section 2.6.1.1 of the *Performance Monitoring of MNA Remedies for VOCs in Ground Water, April 2003 (EPA/600 R-04/027)* for more detail. • Please present plots of concentration overtime for the trichloroethene (TCE) and daughter products as appropriate (based on historic and current analytical results). Consider using the format similar to Figures 2-7 and 2-8 presented in the FT004/SD031 NAAW as this is consistent with and supportive of MNA guidance. Note the figure is attached as an example.	provided for sites at which they are prevalent (Sites DP039 and SS015). The MNA networks specified in each NAAW (which have been sampled over the interim period) are identified in each "Status of Interim Remedy" subsection of the NAAR. Table 4-1 of the *Final FT004/SD031 NAAW* is not the list of wells specified for ongoing monitoring during the interim period. Table 4-1 lists the wells that were sampled for natural attenuation parameters during the pre-design investigation. The sample results from the wells listed in Table 4-1 were used to perform a biological screening evaluation as part of the pre-design investigation. Background wells, source wells, plume wells, and distal wells were selected for this screening process. The same process was followed in selecting wells for the biological screening evaluation that was performed in 2008 and documented in the NAAR (under the "geochemical indicators" subheading). The wells included in the interim natural attenuation monitoring network are listed in Table 5-1 of the *Final FT004/SD031 NAAW*; this network agreed upon by the stakeholders. At sites that have had only MNA or MNA assessment as the interim remedy (Sites LF006, LF007B, LF007D, and SS015), the interim monitoring network included wells down the axis of the plume and distal wells. However, at sites where groundwater extraction and treatment (GET) was a component of the interim remedy (Sites FT004, SD031, WIOU, and DP039), the interim monitoring network was selected in the distal portion of the plume, beyond the influence of the GET system. This is because, within the hydraulic capture of the GET systems, decreasing concentration trends are expected to be primarily due to the GET interim remedy rather than natural attenuation. At all sites, evaluation of concentration trends was performed for the wells identified as the interim period MNA network. At Sites FT004, SD031, WIOU, and DP039, the interim MNA network is in the distal portion of the plume because concentration trends from the interior portions of these plumes cannot be used to evaluate natural attenuation due to the active interim remedy. In comments dated October 7, 2009, the EPA requested that the rates of attenuation and time to reach cleanup goals be calculated; citing *Calculation and use of First Order Rate Constants for MNA Studies*, EPA/540/S-02/500, November 2002. In response, using the method recommended for estimating time to cleanup in this EPA paper, the Air Force has calculated a Concentration vs. Time Attenuation Rate constant for all MNA network wells with COC concentrations currently exceeding IRGs and an established decreasing COC trend. We added these calculations into a new Appendix D, and they have been provided for review on our FTP site (ftp://AgenReview:AgencyRe@ftp.ch2m.com/Travis_AgencyReview). We used the calculations to estimate the amount of time to reach IRGs at each site or the portion of the site at which MNA assessment is an IRA. The Air Force performed these calculations for the wells within the interim MNA network, because these wells are in

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		the portion of the plume undergoing MNA or MNA assessment. At sites FT004, SD031, WIOU, and DP039, it is not appropriate to perform these calculations for wells within the interior of the plume that is undergoing an active remedy because it would overestimate the attenuation rate and therefore should not be used to estimate time to cleanup through natural attenuation. • In response to this comment (received on May 3, 2010) we updated the COC plume maps with concentration vs. time plots for wells within the interim MNA network, similar to the figures presented in FT004/SD031 NAAW.
2.	Additionally, Bulk Attenuation Rate Constants should be calculated for each plume with plots of “Concentration versus Distance.” These plots should ideally utilize wells from the areas along the axis of the plume and outside of the source area. A narrative discussing the significance of results including a discussion of bulk attenuation rates specifically as it relates to stability of the plume and the uncertainty related to these results should be incorporated into the final NAAR. Bulk Attenuation Rates also should be discussed within the context of the site conceptual.	In response to this comment (received on May 3, 2010) we calculated the bulk attenuation rates for Site LF006, LF007B, LF007D, and SS015 and provided them in Appendix F. We added a discussion of the bulk attenuation rates to the “Plume Attenuation” subsections for these four sites, along with the Concentration vs. Time Attenuation Rates previously calculated in response to the EPA October 2009 comments. Bulk attenuation rates were not previously calculated in response to the EPA October 2009 comments because these calculations cannot be used for the time-to-cleanup estimates requested by the EPA. In addition, bulk attenuation rates cannot be calculated at sites where GET was part of the interim remedy (Sites FT004, SD031, WIOU, and DP039); the results would overestimate the attenuation at the sites. We added the following generalized text to the “Plume Attenuation” subsections: “In addition to concentration vs. time attenuation (or point attenuation) rates, which were calculated for MNA monitoring wells where COC concentrations continue to exceed IRGs, a bulk attenuation rate may also be calculated for the entire plume. This analysis is performed using a concentration vs. distance plot, ideally using data from wells located along the axis of the plume (EPA, 2002). The bulk attenuation rate provides information on the reduction in dissolved contaminant concentration with distance from the source and can be used to demonstrate that contaminants are being attenuated within the groundwater flow system.” The site-specific text follows the introductory statement above: Sites FT004/SD031 (Section 2.3.1): “Bulk attenuation rates have not been calculated for FT004/SD031 at this time because, due to the recent GET IRA, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site.” LF006 (Section 3.3.1): “A bulk attenuation rate constant of approximately 0.75 per year was calculated for TCE at Site LF006, based on the 2008 distribution of TCE in

No.	Comments	Responses
		groundwater at the site (Appendix F). The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring. The maximum TCE concentration detected at LF006 in 2008 was 8.8 J- µg/L and no TCE source area remains at the site. The travel time for TCE to reach the IRG (5 µg/L) once it leaves the portion of the plume with the highest TCE concentrations (8.8 J- µg/L) is estimated to be approximately 0.75 years. The plume (exceeding the IRG) should extend approximately 63 feet from the portion of the plume with the highest TCE concentrations." LF007 (Section 4.3.1): "A bulk attenuation rate was calculated only for 1,4-DCB because it is the only chemical which was detected at more than 1 monitoring well at the site during 2008. A bulk attenuation constant could only be calculated for the LF007D area. Because no chemicals were detected in the LF007B area monitoring wells a bulk attenuation rate constant could not be calculated for this area. A bulk attenuation rate constant of approximately 1.8 per year was calculated for 1,4-DCB at Site LF007D, based on the 2008 distribution of 1,4-DCB in groundwater at the site (Appendix F). The data set is limited to the two monitoring wells (MW261x07 and MWCx07) where 1,4-DCB is currently detected. The positive bulk attenuation rate constant indicates that attenuation of 1,4-DCB is occurring. The travel time for 1,4-DCB to reach the IRG (5 µg/L) once it leaves the source area (near well MW261x07) is estimated to be approximately 0.96 years. The plume (exceeding the IRG) should extend approximately 85 feet from the source area." SS015 (Section 5.3.1): "Bulk attenuation rate constants for TCE, cis-1,2-DCE, and vinyl chloride (COCs detected at multiple wells at the site) were calculated for Site SS015 (Appendix F). The data set for this analysis was limited to the two wells at which site COCs were detected (MW216x15 and MW625x15). Bulk attenuation rate constants of approximately 8.3 per year (TCE), 9.9 per year (cis-1,2-DCE), and 12 per year (vinyl chloride) were calculated at Site SS015, based on the 2008 distribution of COCs in groundwater at the site The positive bulk attenuation rate constants indicates that attenuation of TCE and daughter products cis-1,2-DCE and vinyl chloride is occurring at the site. The travel times for COCs to reach IRGs upon leaving the source area are estimated to be approximately 0.52 years (TCE), 0.6 years (cis-1,2-DCE), and 0.68 years (vinyl chloride). Based on the travel times for the various COCs, the VOC plume (exceeding IRGs) should extend approximately 205 feet from the source area at Site SS015." WIOU (Section 6.5.1): "Bulk attenuation rates have not been calculated for the WIOU at this time because, due to the ongoing GET IRA, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site."

No.	Comments	Responses
		DP039 (Section 7.3.1): "Bulk attenuation rates have not been calculated for DP039 at this time because, due to the recent GET IRA and ongoing bioreactor and phytoremediation treatability studies, the current bulk attenuation rates would not be representative of natural attenuation conditions. The resulting bulk attenuation rate would be an overestimation of the attenuation rate expected in the absence of the active IRA and treatability studies and thus cannot be used to evaluate the current effectiveness of natural attenuation at the site."
3.	For all sites where active remediation is ongoing or recent, specifically for sites with groundwater extraction, a rebound study should be conducted to demonstrate that plume stability is not dependent on active extraction. And attenuation rates should be recalculated upon the conclusion of the rebound study.	This is not appropriate for inclusion in the NAAR. The NAAR does not assess or draw conclusions about the portions of the plumes that are currently or have recently undergone remedial action other than MNA or MNA assessment. The purpose of the NAAR is to evaluate how MNA has performed over the interim period in the areas specified for MNA or MNA assessment in the IRODs (not in areas undergoing active interim remedies). Many sites at which the interim remedy was GET are currently undergoing rebound studies (FT004, SD031, FT005, and LF008). Available data from these rebound studies will be incorporated into the FFS and used to evaluate alternatives. However, several years of post-active remedy monitoring will be needed to perform the attenuation rate calculations requested by the EPA. Concentration trend data from the period of GET would need to be removed from consideration, and it will require several years to build a data set to perform these calculations. In order to select a remedy in the ROD it is not necessary to prove in advance that the remedy will be effective, particularly when site conditions (e.g., active remediation) preclude the ability to acquire such proof. Rather, the Air Force must show that a preponderance of evidence indicates that it is likely to work and must have a plan for selecting and implementing contingency actions in place in the event that MNA fails to complete the groundwater cleanup at a site. Per Section 6 (Writing the Record of Decision), of *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (EPA, 1999) for a groundwater MNA remedy, the ROD must document: (1) Portions of the plumes that will be treated by MNA, (2) Evidence that MNA is likely to attain cleanup levels (or other remedial objectives) under the specific conditions at the site, (3) Contingency actions that will be used if MNA can not attain aquifer cleanup levels, and (4) Institutional controls that will restrict the use of groundwater until cleanup levels are attained. In many cases, MNA implementation will not take place until the active remedy achieves a designated level of performance. Once initiated, a monitoring program will be established, and a contingency remedy (e.g., enhanced MNA or a return to the active remedy) will be invoked in the event that MNA does not perform as designed. Triggers of the contingency action would include increasing COC

No.	Comments	Responses
		concentrations in downgradient monitoring wells that indicate plume migration. The Basewide Groundwater ROD will contain contingency language that will describe how the Air Force will respond to future plume migration, including MNA Enhancement (in situ treatment), or returning to GET, if appropriate. The performance of the selected remedy will be regularly evaluated under the Travis GSAP, and its protectiveness will be evaluated in 5-Year Reviews. The necessity to perform 5-Year Reviews until RAOs have been achieved will be documented in the Basewide Groundwater ROD. The attenuation calculations requested by the EPA are an appropriate method for evaluating performance of an MNA remedy once it has been implemented. For sites at which MNA is expected to be a component of the final remedy, the FFS will provide: 1. Lines of evidence that MNA is a viable remedy at the site, (based on data collected to date) 2. Methodology for evaluating MNA performance (options include point attenuation rate calculations, bulk attenuation rate calculations, and comparisons of plume dissolved mass, center of mass, and spread of mass over time) 3. Contingency actions to be implemented at the site in the event that MNA does not perform as expected. 4. Triggers for implementing contingency actions (including increasing COC concentrations in downgradient wells and other evidence of plume migration). 5. Documentation and schedule of MNA performance evaluation.

References:

CH2M HILL. 2001. Final FT004/SD031 Natural Attenuation Assessment Work Plan, Travis Air Force Base, California. July.

U.S. Environmental Protection Agency (US EPA). 2002. Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies. November. EPA/540/S-02/500.

Response to Comments on the
Draft Natural Attenuation Assessment Report
Travis Air Force Base, California

Department of Toxic Substances Control

No.	Comments	Responses
REVIEW COMMENTS – Jose Salcedo, P.E., DTSC dated October 29, 2009		
GENERAL COMMENTS		
1.	DTSC has many, if not all, of the same concerns expressed by US EPA in their comment letter dated October 7, 2009 under General Comment section. We will not repeat any of those. DTSC strongly supports US EPA General Comment numbers 1, 2, 4, 5, 7, and 10. Travis AFB should not limit the list of Site COCs to only those contaminants currently being detected at groundwater sites. Assuming that Natural Attenuation is occurring at the groundwater sites, breakdown products are expected to emerge. The NAAR should identify these and provide their MCLs and consider them as COCs. These should also be included in any Contingency Plans or Institutional Control or Land Use Control Plans.	Noted. Please refer to the responses to the US EPA comments on the report. Along with the parent COCs, we have monitored for breakdown products over the interim period, and the NAAR presents detections of both sets of compounds for each site. In most cases, the breakdown products were already classified as COCs during one of four RIs. Of greater importance for the MNA assessment is the inclusion of the daughter products in the biological screening assessment tables, which are used to evaluate the biological component of MNA. However, to evaluate plume stability we focused on a parent compound (usually TCE). Assuming that Monitored Natural Attenuation or an enhanced version is selected as a remedy or part of a remedy at a site, the upcoming Basewide Groundwater ROD will establish cleanup levels for both parent compounds and breakdown products and will describe the appropriate land use controls that will be in effect while the remedy is in operation. All subsequent documentation (designs, action reports, etc) will also include both sets of compounds.
SPECIFIC COMMENTS		
2.	**Sections ES.3 and 1.3, pages ES-2 and 1-3 respectively:** These sections describe interpretation of scores from the AFCEE Wiedemeier et al reference document. The text is verbatim for bulleted items 2-4, however, the first bulleted item is different. Why was the wording changed?	We revised the text to match the AFCEE guidance: "*Inadequate Evidence* for anaerobic biodegradation of chlorinated hydrocarbons".
3.	**Figure ES-4:** There's a typo in the legend it says 200G instead of 2008. Please correct.	We corrected the legend.
4.	**Figure 1-2:** Site LF007C is shown in orange cross-hashing that's not described in the legend. Please correct.	We added a definition of the orange cross hatching, which represents the LF007C easement, in the legend of Figure 1-1.

No.	Comments	Responses
5.	**Section 2.4, first bullet:** The document states that "the upgradient GET system was introducing oxygen into the groundwater, resulting in aerobic conditions in the source area." The GET system has been shut down for a rebound study for almost two years. For how long into the future can the "GET introduced" oxygen be present? Can this variable be eliminated in some of the wells closer to the extraction wells now or in the near future?	The Site SD031 and a portion of the Site FT004 extraction systems were shut down for a rebound study in December 2007; however FT004 extraction wells EW576x04, EW577x04, EW621x04, EW622x03, and EW623x04 continued operation through March 2009. Therefore the GET system was introducing oxygen to groundwater when the 4Q08 samples were collected. Based on low COC concentrations in the former GET area and the low biodegradation rates observed at other sites, it is likely that oxidizing conditions will be present in the short-term future at FT004 and SD031. However, ongoing monitoring will confirm whether physical processes will allow the residual low-level contamination in the former GET area to move downgradient. If so, we will take action to stop the migration. Potential options will include enhanced MNA actions to generate reducing conditions.
6.	**Section 3.5:** There appears to be a discrepancy between the text and Figure 3-10. Monitoring well MW129X07 is identified in the figure as being included as a sampling point for monitoring plume stability, but the text does not describe it as such. Please correct.	Well MW129x07 is a sampling point for monitoring plume stability at neighboring Site LF007, but is also visible on the LF006 Figure 3-10. We added a note to Figure 3-10 that well MW129x07 is in the Site LF007 monitoring network, rather than the one for Site LF006.
7.	**Section 4.3.1 and Figure 4-10:** The text states "Consistent 1,4-DCB detections have been restricted to monitoring wells MW261x07, MWBx07, and MWCx07. 1,4-DCB concentrations continue to exceed the IRG at MW261x07." This implies that at some point in the past monitoring wells MWBx07 and MWCx07 exceeded the IRG. Figure 4-8 does not indicate this. Are data points missing? How was the 1994-95 IRG isoconcentration line drawn in Figure 4-10?	The 1994-95 IRG isoconcentration line was drawn based on in situ and monitoring well data collected during the 1994-1995 RI. The isoconcentration line excludes the area near MWCx07, which has never had 1,4-DCB detections exceeding the IRG. 1,4-DCB concentrations detected in the vicinity of MWBx07 during the RI did exceed the IRG, although concentrations of 1,4-DCB at MWBx07 have been below the IRG since groundwater monitoring began at this well in 1997. We revised the text in section 4.3.1 as follows: "Figure 4-8 shows the current distribution of 1,4-DCB exceeding the IRG and the historical extent of 1,4-DCB contamination in groundwater exceeding the IRG at Site LF007. The historical extent of contamination is based on in situ and monitoring well data collected during the 1994-1995 RI (Radian, 1996)."
8.	**Section 5.2.2, second paragraph:** Figure 5-2 does not present 2Q08 groundwater elevation data as stated in the text. Please correct.	We corrected the text to refer to Figure 5-3, instead of Figure 5-2.
9.	**Section 5.2.3, last paragraph:** The text incorrectly states that the IRG for vinyl chloride is 1µg/L. Please correct.	We corrected the IRG for vinyl chloride so that the text states that it is 0.5 µg/L.

No.	Comments	Responses
10.	**Section 5.3.1, second paragraph:** Please show, in Figure 5-1, the injection point described in the text as “just downgradient of MW216x15”. Seeing this location on the figure would help the reader evaluate whether the decline in VOC concentrations can be attributed to the location of the injection point.	The vegetable oil injection area is shown on Figure 5-1. The vegetable oil was injected through several injection points over this area. We revised the second sentence of the second paragraph of section 5.3.1 as follows: “The vegetable oil injection took place in multiple injection points in an area approximately 20 feet downgradient of MW216x15 (Figure 5-1).”
11.	**Figure 5-9:** Should the areal extent of the vegetable oil injection be depicted in this figure?	We added the areal extent of the vegetable oil injection to Figure 5-9.
12.	**Section 6.1, 1st paragraph:** The text states “Figure 6-1 presents a site map of the WIOU, which illustrates the locations of the WIOU sites and the primary WIOU groundwater TCE plume.” The figure does not show the TCE plume. Please correct.	We corrected the text to state: “Figure 6-1 presents a site map of the WIOU, which illustrates the locations of the WIOU sites.”

Response to Comments on the
Draft Natural Attenuation Assessment Report
Travis Air Force Base, California

Regional Water Quality Control Board

No.	Comments	Responses
REVIEW COMMENTS – Alan D. Friedman, P.E., Regional Water Quality Control Board dated November 3, 2009		
GENERAL COMMENTS		
1.	Water Board staff have reviewed the subject document, dated August 2009, in which an evaluation is made on whether monitored natural attenuation (MNA) is an effective remedy at part or all of eight sites with groundwater (GW) contamination. We have the following comments: MNA is said to be occurring if plumes are stable or reduced in size. We concur only if it also shown that remedial objectives are consistently met within the plume.	Currently, there are only Interim Remedial Action Objectives (IRAOs), which are described in the “Status of Interim Remedy” subsections. MNA assessment was selected as the interim remedy for several sites or portions of sites. We agree that the RAOs that will be presented in the upcoming Groundwater Focused Feasibility Study (FFS) and ROD should be consistently met in order for MNA to be judged successful.
2.	We request an estimate of how long it would take each of these sites to completely attenuate to remedial objectives. The document does not provide strong arguments that they would in reasonable timeframe; only indications that some attenuation is occurring.	There are no RAOs established at this time. COC concentrations in most of the MNA monitoring wells are already below IRGs; therefore IRAOs have already been achieved for the most part. However, we calculated a Concentration vs. Time Attenuation Rate constant for MNA wells with COC concentrations that currently exceed IRGs and with established decreasing COC concentration trends. We added the calculations to the report in a new Appendix D. The calculations have been used to estimate the amount of time to reach IRGs at each site or the portion of the site at which MNA assessment is the IRA. In addition, we will consider the estimated time to cleanup in the upcoming Focused Feasibility Study (FFS).
3.	For most sites, no conclusive evidence of biological degradation was found, and it was concluded that physical processes were therefore responsible for the observed attenuation. We request an evaluation of which specific physical processes are leading to the observed attenuation at each site, and whether these processes are sufficient to fully meet remedial objectives.	We are unsure which physical processes dominate but hypothesize that adsorption, dispersion and volatilization play a major role. Because of varying site conditions, it would be difficult to identify to a high degree of certainty the impact of each physical process on a low concentration solvent plume. For example, seasonal weather variability and man-made caps (asphalt and concrete) would have a significant impact on volatilization rates. However, we believe that the data collected over the last 15 years at Travis AFB demonstrate that these processes in their totality are sufficient to meet the IRAOs at most sites. COC concentrations have declined to below IRGs in most of the MNA wells. For the remaining wells, we estimated times to cleanup to IRGs based on calculated Concentration vs. Time Attenuation Rates.

No.	Comments	Responses
4.	For sites SS015 and DP039, given possible plume migration and GW concentration increases, we do not concur that MNA is a potential remedy absent further study.	We agree that MNA alone would be insufficient at both of these sites. MNA at DP039 can only be successfully applied as a part of a treatment train, which is why we are designing and constructing a biobarrier at DP039 to address higher solvent concentrations and promote MNA by preventing the flow of higher contaminant concentrations into the downgradient portion (the MNA assessment area) of the plume. Additional investigation is also needed at Site SS015. The vegetable oil injection treatability study that was started but not completed at this site as well as subsequent GSAP monitoring suggest it is possible to enhance biodegradation through the addition of an organic substrate, and therefore we will evaluate an enhanced version of MNA as a potential remedy in the FFS.
5.	For several sites, GW extraction and treatment (GET) is employed for the source areas, with MNA proposed as a remedy for the distal portions of the plumes. We request definition of the term distal, and that the distal portions of each plume are shown on each map.	The wells identified in the figure legends as “routinely sampled MNA wells” are those located in the distal portion of the plume where MNA is being evaluated. We labeled the MNA area on each figure. We added the extent of hydraulic capture to figures where GET is part of the IRA at the site. The portion of the site beyond the capture zone is the portion of the plume being evaluated for MNA. We added the following text to Sections 2.5, 6.7, and 7.5: “The distal portion of the plume is defined as the portion of the plume beyond the influence of the source area treatment.” We also added this definition as a note to the bottom of Tables ES-1, ES-2, 1-1, and 8-1.
6.	For the sites using GET in the source areas, we request a study of the relative effect of GET vs. MNA in achieving plume stability, to determine if the observed plume stability is more due to extraction than MNA. If so, the current remedial optimization efforts and rebound studies currently occurring with several of the sites, which involve shutting off selected extraction wells, may have significant effects. Also, since the oxidizing conditions induced by GW extraction are cited as a partial reason why reductive dechlorination is not occurring at many of these sites, we request a study on whether curtailing extraction will aid or hinder MNA.	In some respects, our approach for assessing site-specific rebound conditions in portions of plumes with contaminant concentrations at or below IRGs can be used to compare the abilities of GET and MNA to achieve plume stability. If a portion of or an entire GET system is shut down for a rebound study and the plume is found to be migrating, then the system is brought back online. In this case, contaminant concentrations under these site-specific conditions (hydrogeology features, presence of organic carbon) are too high for MNA to stabilize the plume. If no rebound occurs, then site conditions allow MNA to maintain plume stability and monitoring continues to verify that no plume migration is occurring. Since GET does not reduce the amount of oxygen in local groundwater, it is highly unlikely that extraction aids reductive dechlorination. Because extraction reduces the time that a body of groundwater remains in contact with specific soil layers, GET potentially can reduce the time for oxygen-consuming processes to take place and thus hinder MNA. It may also prevent adsorption from taking place. However, we believe that site-specific subsurface conditions have the greatest impact on the success or failure of MNA, and our current field work focuses on ways to promote reductive dechlorination through the placement of organic material into the local formation. This is the premise behind the DP039 bioreactor and biobarrier as well as

No.	Comments	Responses
		the upcoming injections of an edible oil substrate into 'hot spot' areas where reductive dechlorination is not taking place. The results of this field work will be used to support the selection of groundwater remedies in the upcoming ROD.
7.	It appears that the evaluation of whether biological attenuation is occurring is based on a single quarter's GW data (the 4th quarter 2008). It also appears that the monitoring to verify plume stability is only conducted annually. We request that a larger data set be used to evaluate the attenuation at each site.	As stated in the "Status of Interim Remedy" subsections, MNA assessments were performed at each of the sites following the signing of the IRODs, with the exception of SS015. At this site, a treatability study of enhanced MNA through vegetable oil injection was started but not completed. A summary of the results of the initial biodegradation screening is provided in the "Geochemical Indicators" subsection. No sites showed overall strong evidence of biodegradation in the preliminary assessments, which is consistent with the findings of the 4Q08 assessment. Natural Attenuation Assessment Workplans (NAAWs), prepared for each site following the IRODs and reviewed by the State, specified that routine monitoring at these sites would not include biodegradation parameters, but rather include only site COCs. This is because the stakeholders (Travis AFB, EPA, and the State of California) all agreed at the time that the evidence for biodegradation was unconvincing, and that the ultimate tests of MNA would be plume stability and declining COC concentrations. By these tests, MNA has been generally successful. Since the completion of the initial MNA assessments, plume stability monitoring was performed quarterly for the first year, and reduced to semiannual or annual, using the Groundwater Sampling and Analysis Program Decision Tree. The sampling frequency specified by the Decision Tree is based on the position of the monitoring well relative to the plume and concentration trends at the well. Stable or declining trends resulted in a reduction of the sampling frequency; thus, most monitoring wells in the distal portions of the plume are now sampled annually.
8.	There are many graphs showing the decrease in GW concentrations over time. We request that these graphs are backed up with statistical trend analyses to confirm the significance of the decreases.	We used the Mann-Kendall statistical analysis to evaluate whether decreasing trends observed are statistically significant. We placed the results of the Mann-Kendall analysis into a new Appendix E in the report.