Appendix D

Yermo Annex OU 1 (CAOC 37) – Supporting Information for Five-Year Review of Remedial Systems

D-1 Technical Assessment Report – CAOC 37 (OU 1) Remedial Action Performance Evaluation

D-2 Technical Assessment Report – OUs 1 and 2 Remedial Actions Operations, Maintenance, Repairs, Electrical Costs 2007 – 2011

D-3 Technical Assessment Report – Dissolved Phase Metals at Yermo Annex Justification for Elimination of Aluminum, Antimony, and Thallium as COCs and Optimized Chromium and Nickel Monitoring

APPENDIX D

D-1 TECHNICAL ASSESSMENT REPORT - CAOC 37 (OU 1) REMEDIAL ACTION PERFORMANCE EVALUATION

Technical Memorandum D-1.1 - Yermo Annex Groundwater Plume Evaluation

Introduction

This Technical Memorandum has been prepared to document the evaluation of the Yermo Annex COC Plume. This evaluation was completed in support of the 2012 Five-Year Review. This memorandum was prepared by AIS-TN&A JV (ATJV) for the Department of the Navy under Contract No. N62473-09-D-2610, contract task order 0013.

The contaminants of concern (COCs) consist of dissolved-phase volatile organic compounds (VOCs), primarily trichloroethene (TCE), tetrachloroethene (PCE), and, 1,1-dichloroethene. The Yermo Annex Groundwater COC plume is described in Section 3.4.10 of the main report. The selected remedy for this plume is groundwater extraction, ex-situ treatment of the extracted groundwater, recharge of treated groundwater back into the aquifer, and air sparge/soil vapor extraction (AS/SVE) systems for groundwater and vadose zone VOC mass removal as described in Section 7.2 of the main report.

COC Plume Extent

The interpreted extents of the Yermo Annex PCE and TCE plumes for select years from 1996 to 2006 are presented on Figure D-1.1.1 and for 2007 and 2009 to 2011 on Figure D-1.1.2. Between 1996 and 2006 the Yermo South and CAOC 26 plumes decreased to below the maximum concentration limit (MCL) for each COC. Additionally, the extents of the Yermo North plume also decreased between 1996 and 2006. Between 2007 and 2011, the extents of the Yermo North plume remained relatively stable.

COC Groundwater Concentrations

Groundwater concentrations from four select groundwater monitoring wells used to monitor the Yermo Annex Plume are presented on Graph D-1.1.1. The groundwater COC concentrations presented in this figure show that groundwater concentrations vary significantly from quarter to quarter, reducing the usefulness of well-by-well analyses for understanding overall changes in the plume.

A quantitative analysis of the characteristics of the COC plume was performed to reveal general trends. Graph D-1.1.2, D-1.1.3 and D-1.1.4 show the trends in maximum and average groundwater concentrations across the plume, the area of the plume, and sample counts of the total number of samples and the number of samples exceeding the MCL for TCE, PCE, and 1,1-DCE, respectively. The maximum and average plume concentration for each of the COCs has decreased since 2005. The calculated plume area between 2005 and 2011 indicates a relatively stable plume extent. Although the number of wells sampled has varied from 25 to 39, the number of wells with COC concentrations in excess of the MCL has declined slightly during the same period. To account for the variable total number of samples, the ratio of wells exceeding the MCL to the total number of wells sampled was calculated. For

TCE and PCE, the ratio of wells exceeding the MCL to the total number of wells sampled has remained relatively stable between 2005 and 2011; however, the ratio for 1,1-DCE has been variable.

Remedy Evaluation

Treatment and control of off-base migration of the Yermo North plume is performed through a groundwater extraction and treatment system (GETS) and an AS/SVE system.

Graph D-1.1.5 presents performance metrics for the GETS system. The volume of water treated annually has decreased from its maximum operating year in 1996. However since about 2001, the volume of treated groundwater has varied within a small range. COC concentrations in the influent of the GETS system had been decreasing since 2005, but began increasing again in 2009. The increase in COC influent concentrations is explained by optimization measures that improved extraction well performance and, in 2010, by the addition of GEW-16 which more effectively captured impacted groundwater. Influent concentrations are expected to increase again with the installation of GEW-17 in the central portion of the plume in March 2012.

Cumulative VOC mass removal tracks the changes in influent concentration; long-term trends are shown on Graph D-1.1.5. The rate of cumulative mass removal (calculated from influent concentrations and pumping rates) began slowing in 2005 but improved in 2009 due to increase influent concentrations as discussed above.

Historical CAOC 16 AS/SVE system performance, as indicated by the rate of total VOCs removed and cumulative totals, is presented on Graph D-1.1.6. The rate of COC removal has flattened significantly since start-up. Since about 2006 the extraction rate appears relatively unchanged.

The OU 1 & 2 ROD estimates a cleanup timeline of approximately 30 years (1998 to 2028) for the Yermo North Plume to reach MCLs in all wells (Department of the Navy 1998). Concentration trends for key wells located in the center of the 2011 TCE and PCE plumes are presented on Graph D-1.1.7 and Graph D-1.1.8 respectively. The available data between 2000 and 2011 were included in the trend analysis and trends were assumed to be linear. Two of the three key wells for the TCE plume show an increasing trend while the third shows concentrations falling below the MCL prior to 2028. All three wells in the PCE plume show an increasing trend.

Modeled GETS Capture Zone

The MODFLOW groundwater model presented in the 2010 Annual Groundwater Monitoring Report (Oneida Total Integrated Enterprises [OTIE], 2011) was updated as part of the OU 1 technical assessment. For model documentation, see Technical Memorandum

D-1.2 included in Appendix D-1 of this Five-Year Review report. The update added a newly installed extraction well and calibrated the model to water level data collected in May 2012. The model is used to evaluate the capture zones for the active groundwater extraction wells that are part of the GETS. Particle tracking calculated by ModPath shows that the Yermo plume is being captured by the current GETS extraction wells. Other lines of evidence, including groundwater concentrations in off-site monitoring wells, should be considered to verify capture.

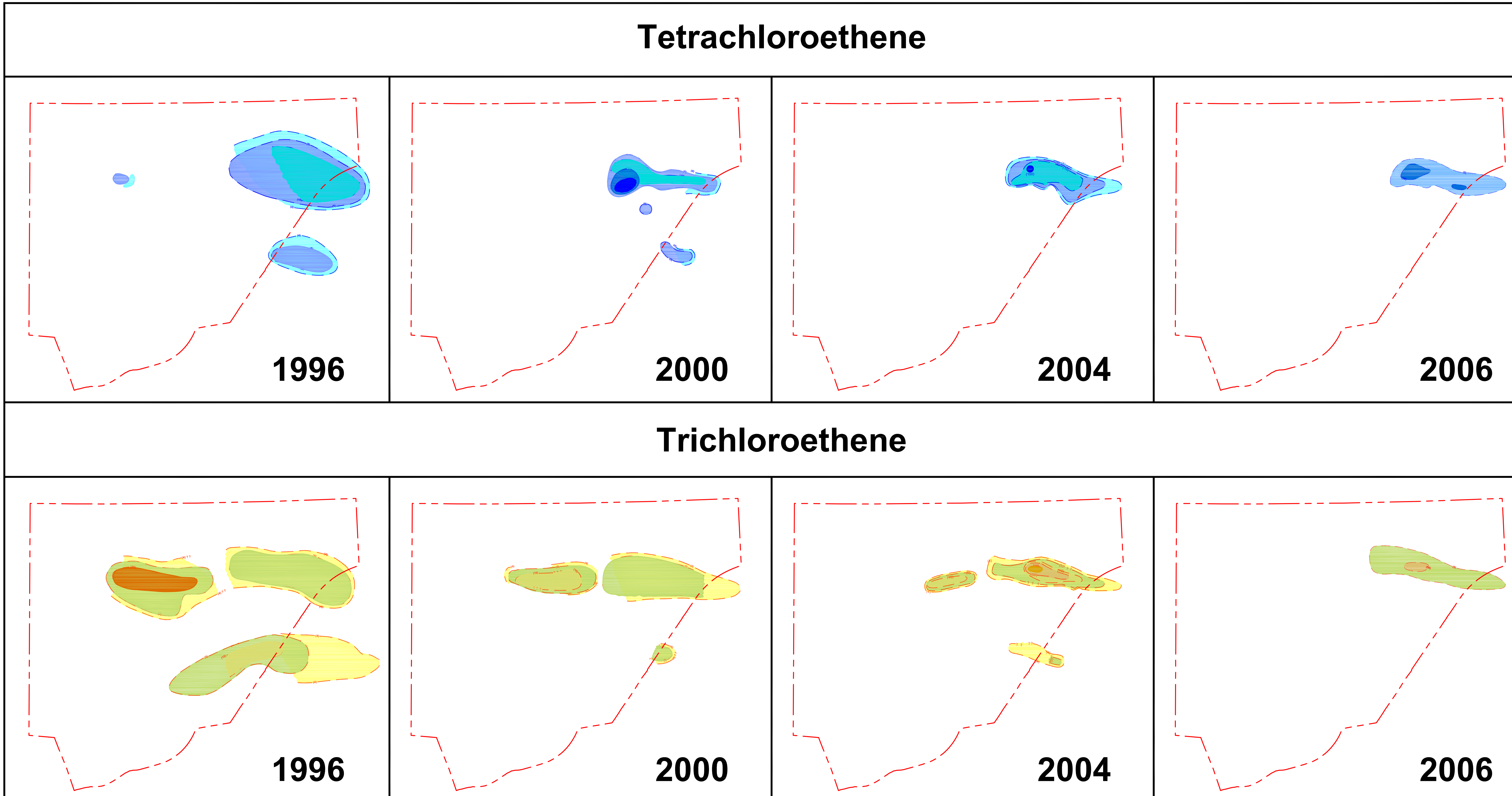
Conclusions

The Yermo North plume had decreased from its historical maximum extent, but has remained relatively stable since about 2005. While the maximum COC concentrations have decreased, the relative number of wells exceeding MCLs has remained about the same compared to the total number of wells sampled. Remedial performance of the remedy has generally declined in recent years; however groundwater model results indicate that the newly installed groundwater extraction well will effectively capture the highest concentration groundwater of the plume. Modeling also indicated that the Yermo North plume should be completely captured on-Base by the GETS. A simple trend analysis shows that PCE and TCE concentrations will not reach MCLs within the 30-year timeframe estimated in the ROD.

References

Oneida Total Integrated Enterprises, LLC. (OTIE). 2011. 2010 Annual Groundwater Monitoring Report Operable Units 1 and 2, Marine Corps Logistics Base, Barstow, California. 25 July.

Department of the Navy 1998. Operable Units 1 and 2, Final Record of Decision Report. April.



Legend

- Yermo Boundary
- 4 ug/L PCE Concentration Area
- 5 ug/L PCE Concentration Area
- 10 ug/L PCE Concentration Area
- 50 ug/L PCE Concentration Area
- 100 ug/L PCE Concentration Area
- 4 ug/L TCE Concentration Area
- 5 ug/L TCE Concentration Area
- 10 ug/L TCE Concentration Area
- 25 ug/L TCE Concentration Area
- 50 ug/L TCE Concentration Area
- 110 ug/L TCE Concentration Area

Notes

1) ug/L = Micrograms per Liter
TCE = Trichloroethene
PCE = Tetrachloroethene

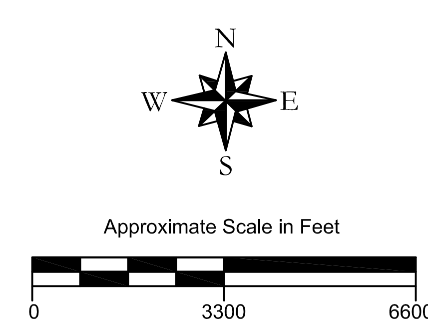
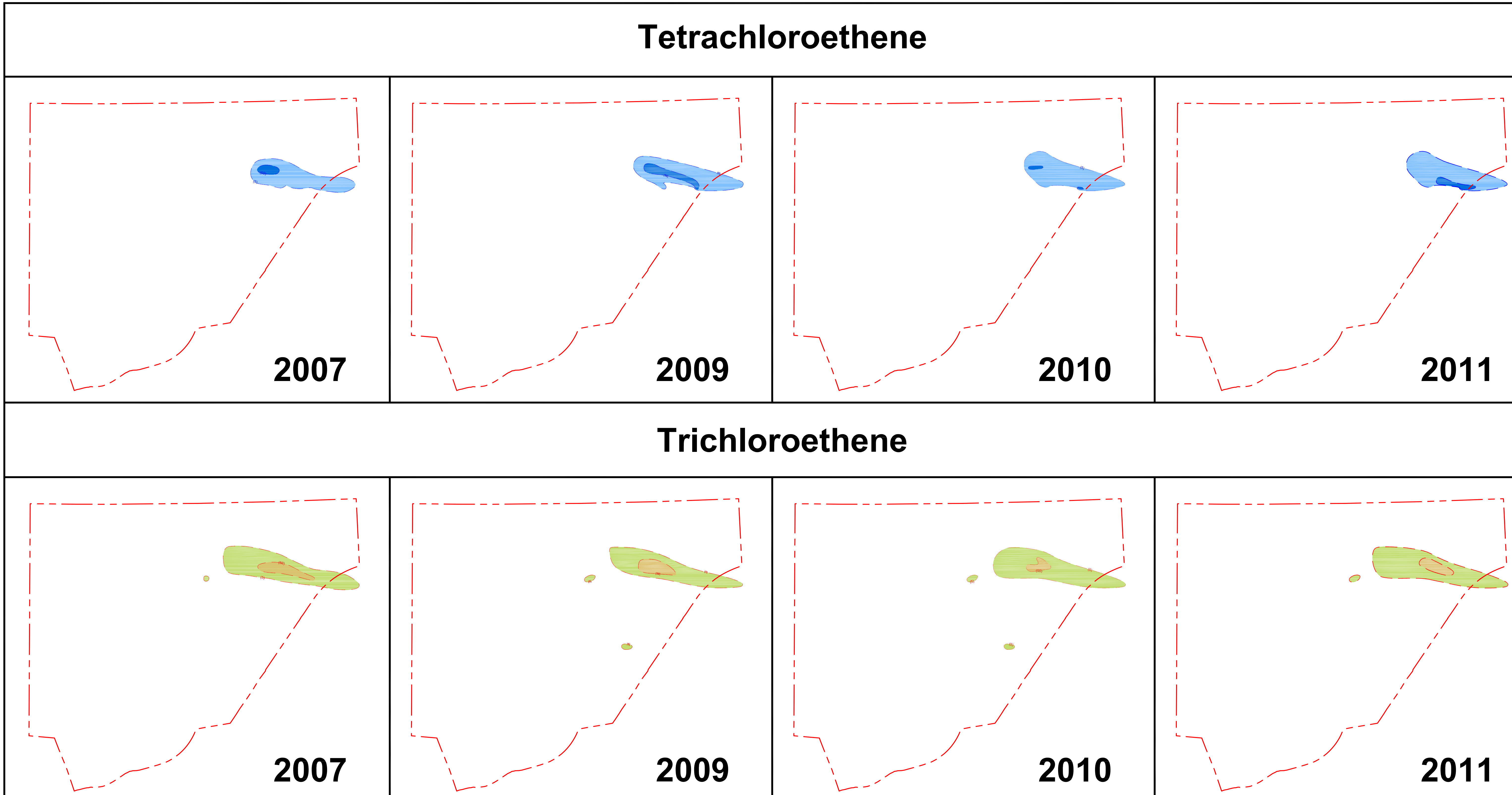


Figure D-1.1.1
Historical Extents of PCE/TCE in Groundwater (Select Years from 1996 - 2006)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: June 8, 2012
File: Barstow_5yrRev.dwg



Legend

- Yermo Boundary
- 5 ug/L PCE Concentration Area
- 50 ug/L PCE Concentration Area
- 5 ug/L TCE Concentration Area
- 50 ug/L TCE Concentration Area

Notes

1) ug/L = Micrograms per Liter
   TCE = Trichloroethene
   PCE = Tetrachloroethene
2) The plume for 2008 (not shown) was essentially identical to the 2007, and 2009 to 2011 plumes.

N
W E
S

Approximate Scale in Feet

0 3300 6600

Figure D-1.1.2
Historical Extents of TCE/PCE in Groundwater (Select Years from 2007 - 2011)

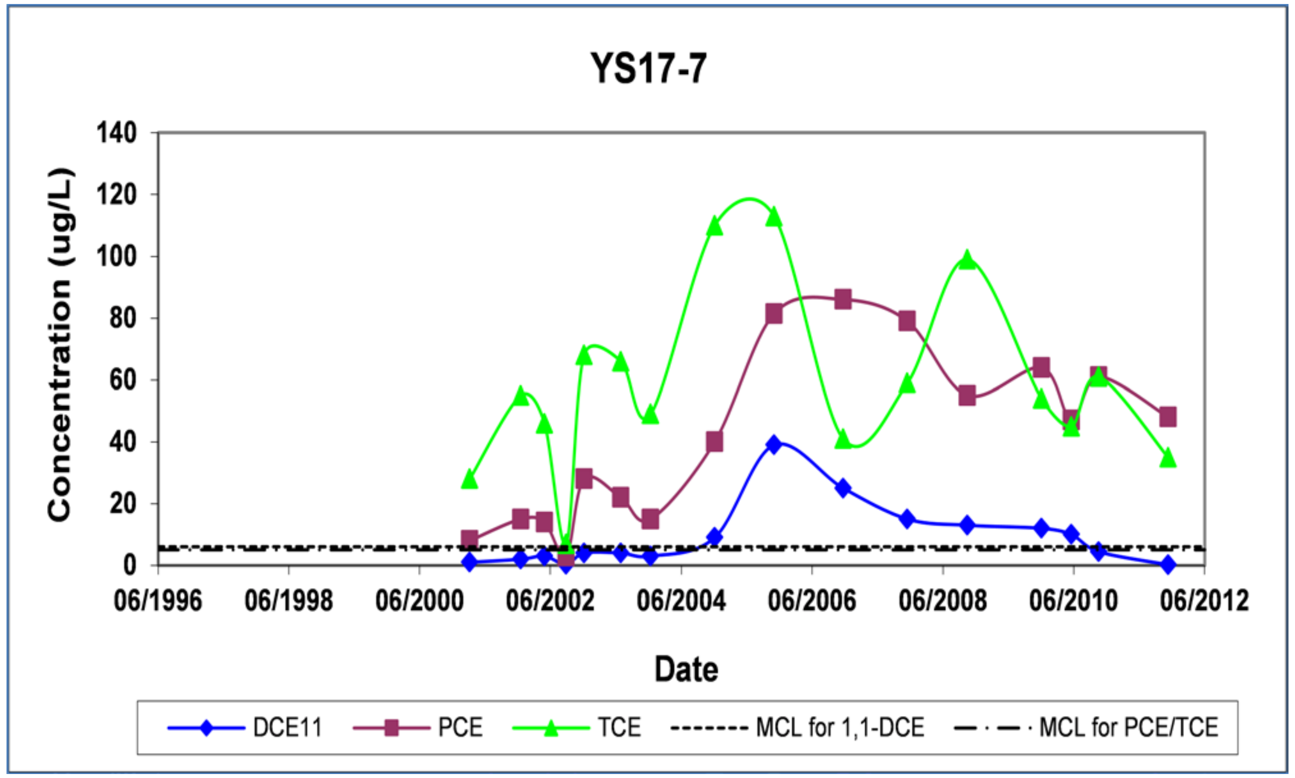
Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

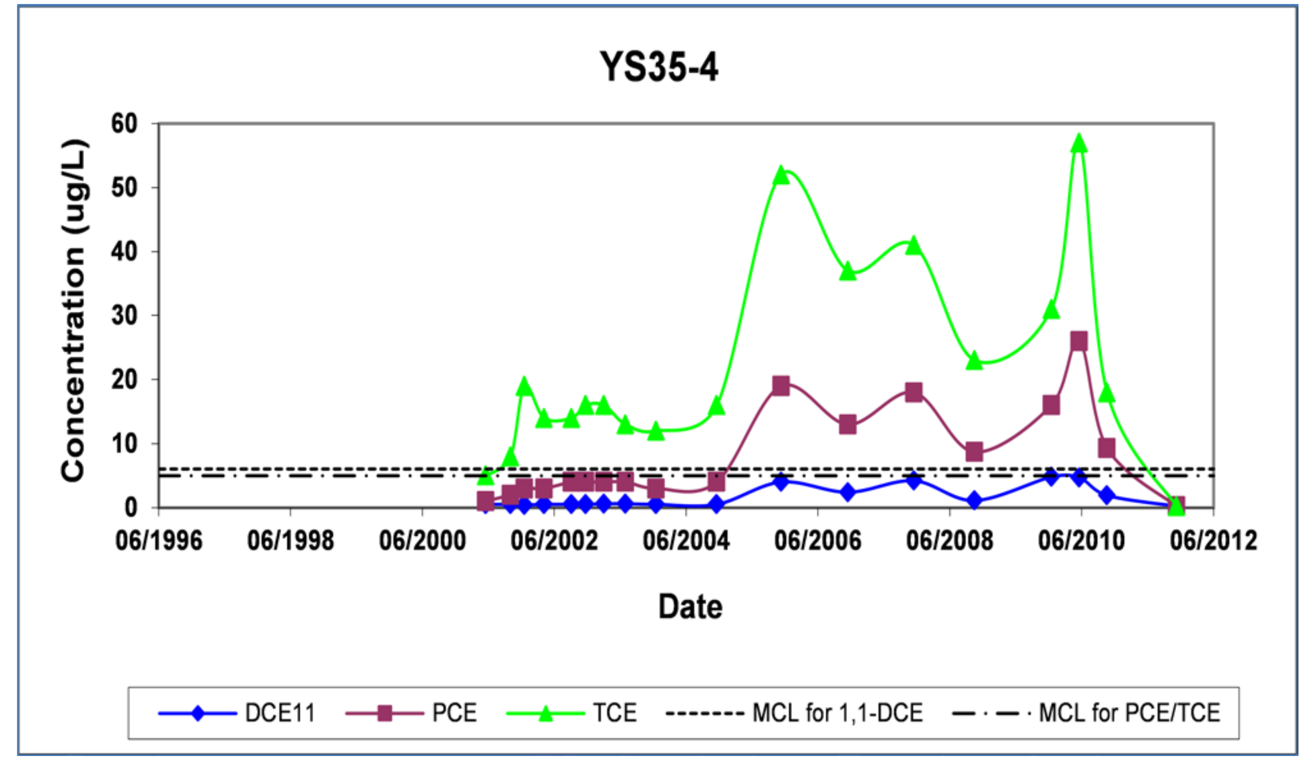
Date: September 4, 2012

File: Barstow_5yrRev.dwg

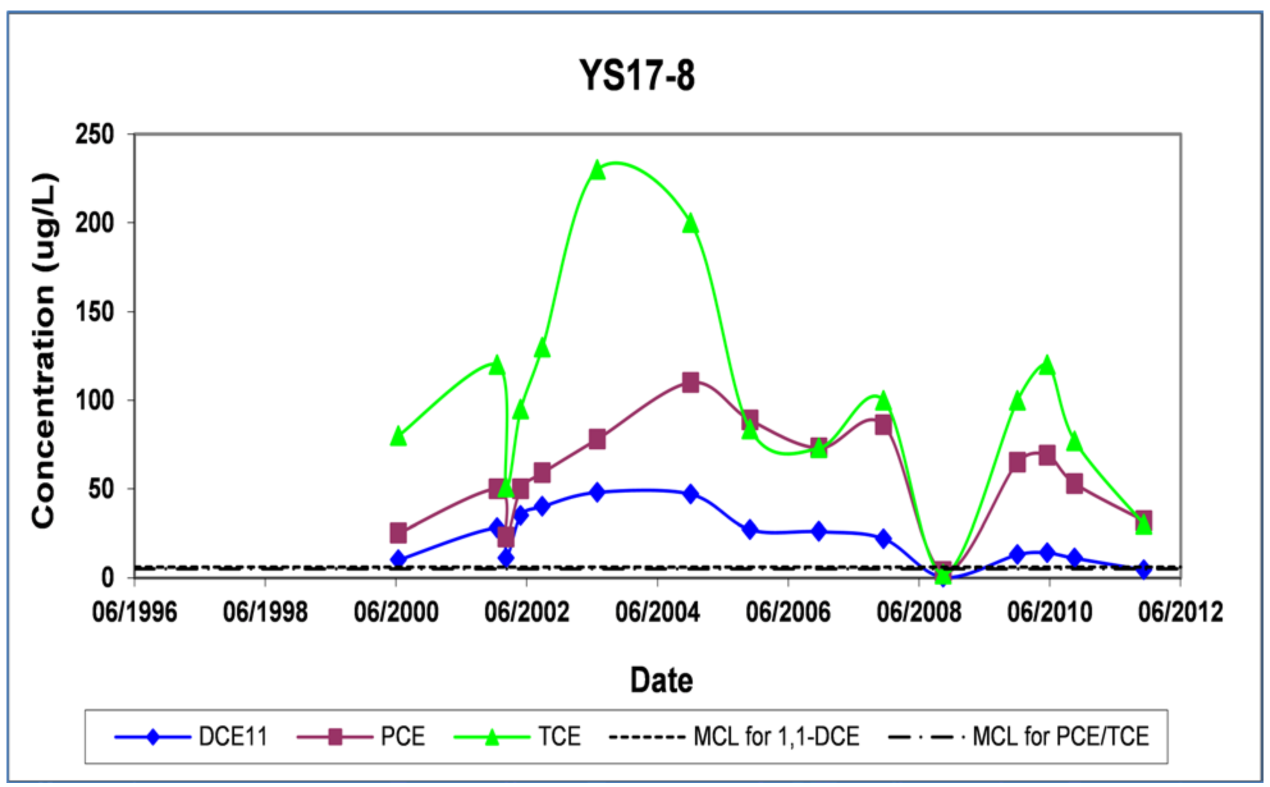
Graph D-1.1.1
Data Trends in Key Downgradient Monitoring Wells for CAOCs 16 and 35
Yermo Annex, MCLB Barstow, CA

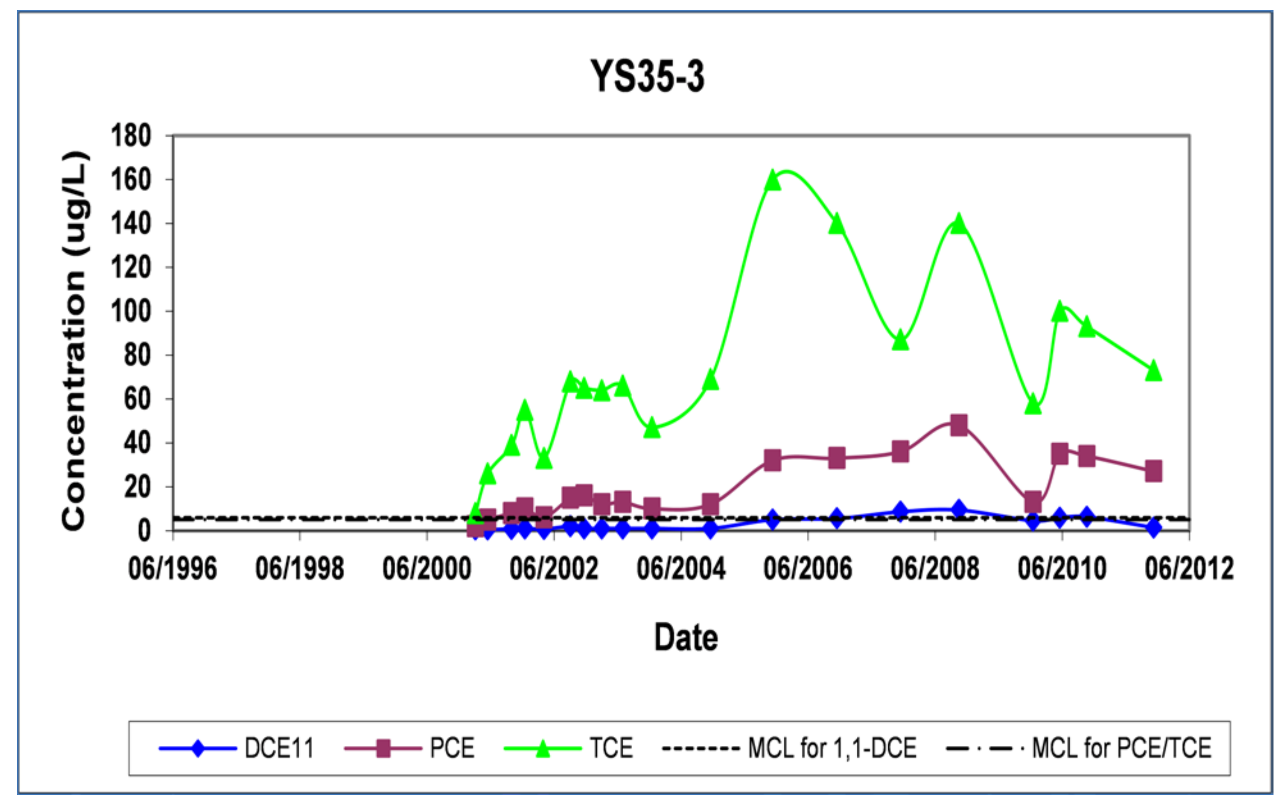


YS17-7 and YS17-18 are downgradient of CAOC 16



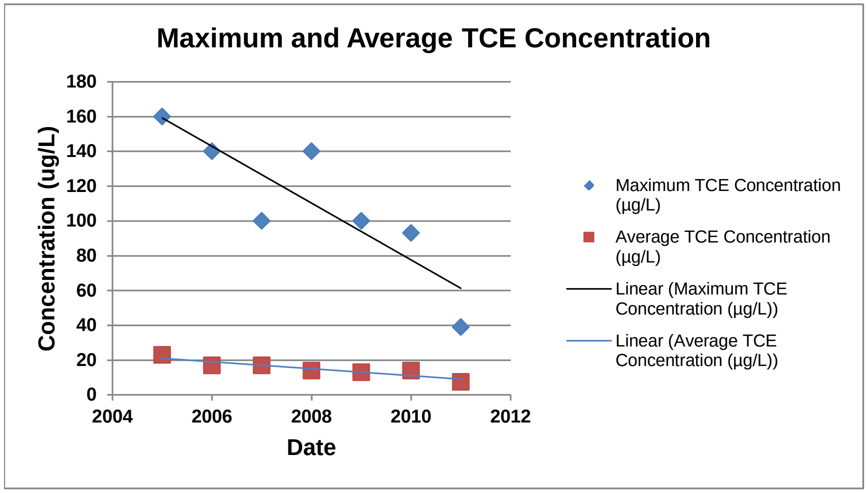
YS35-3 and YS35-4 are downgradient of both CAOC 16 and 35

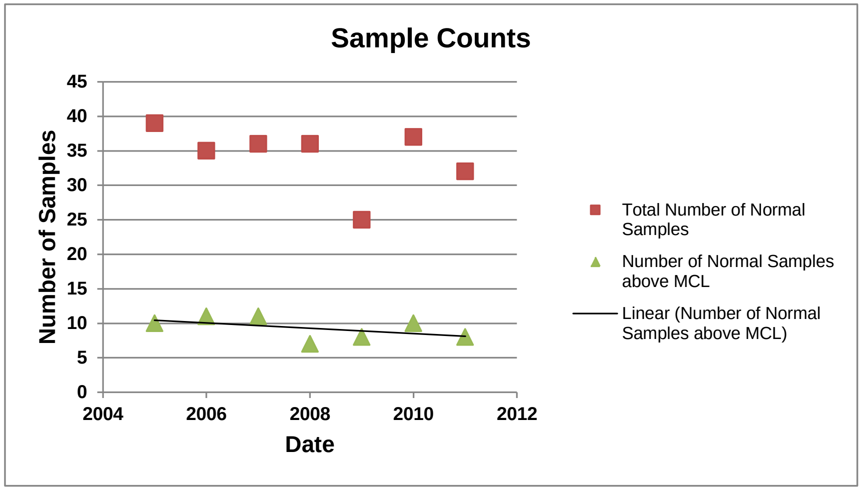


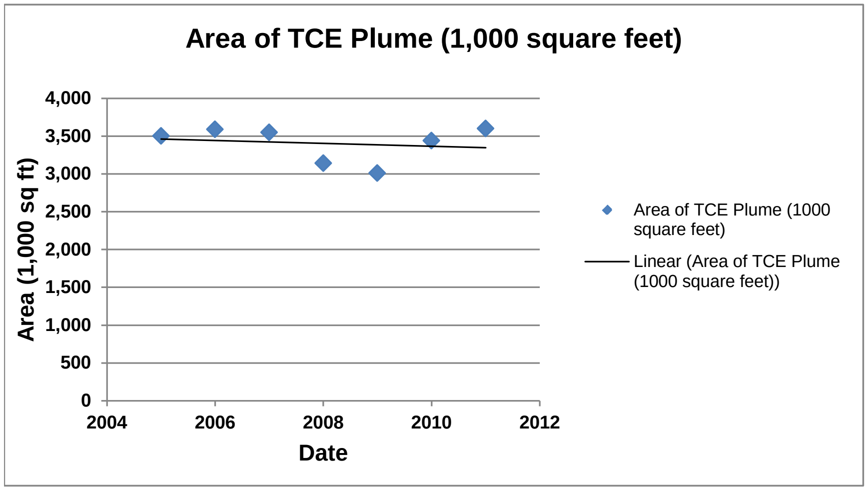


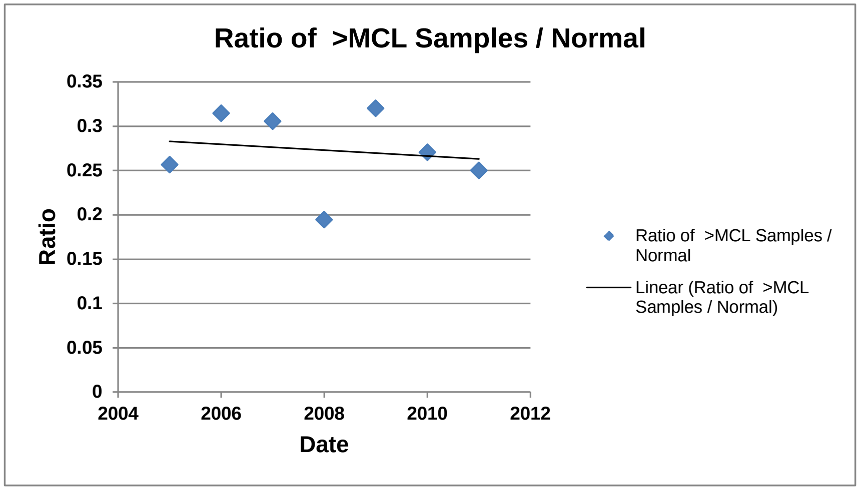
Graph D-1.1.2
Yermo North Plume: TCE Statistics
Yermo Annex, MCLB Barstow, CA

	2005	2006	2007	2008	2009	2010	2011
Maximum TCE Concentration (µg/L)	160	140	100	140	100	93	39
Average TCE Concentration (µg/L)	23	17	17	14	13	14	7.5
Total Number of Normal Samples	39	35	36	36	25	37	32
Number of Normal Samples above MCL	10	11	11	7	8	10	8
Area of TCE Plume (1000 square feet)	3500	3590	3550	3140	3010	3440	3600



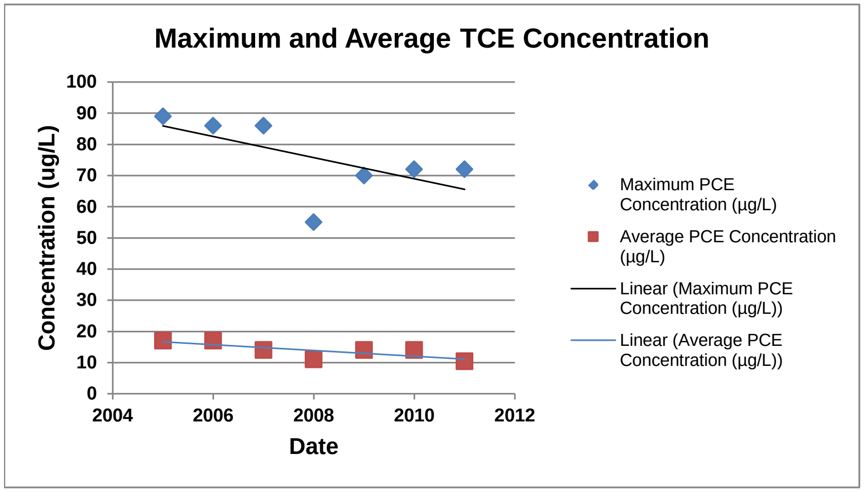


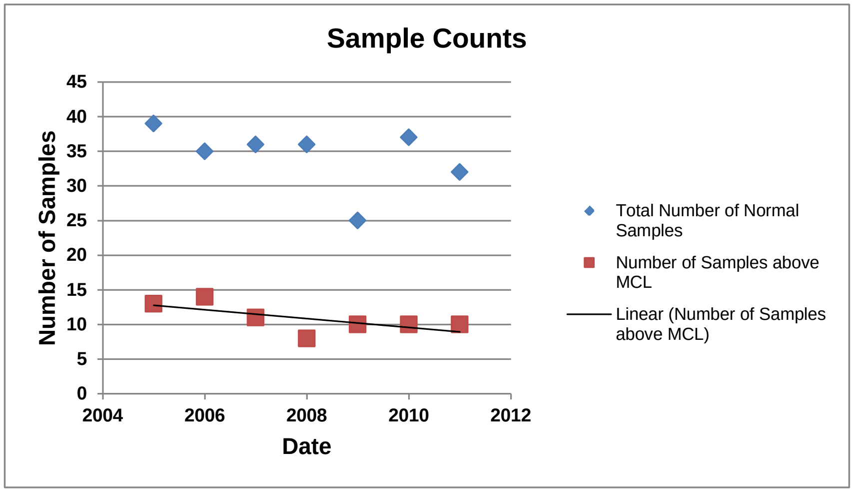


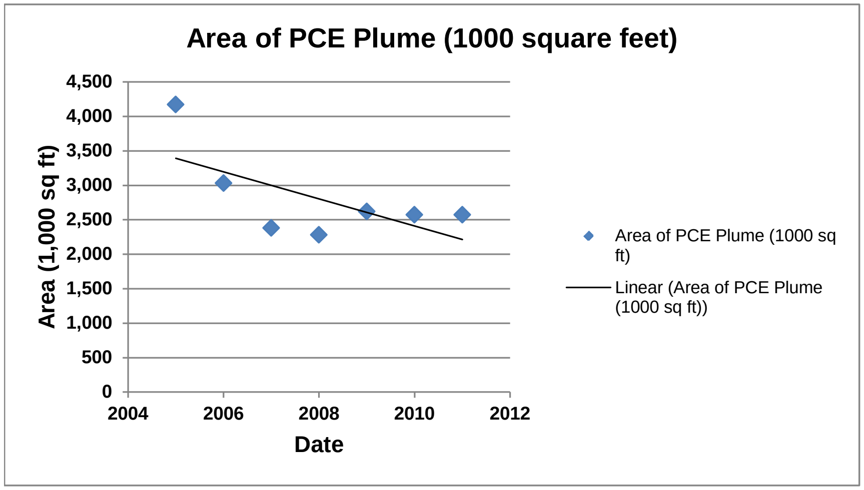


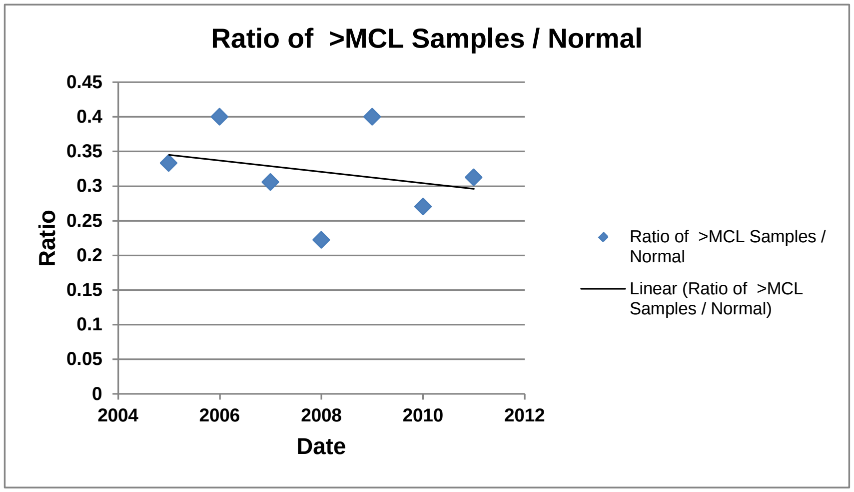
Graph D-1.1.3
Yermo North Plume: PCE Statistics
Yermo Annex, MCLB Barstow, CA

	2005	2006	2007	2008	2009	2010	2011
Maximum PCE Concentration (µg/L)	89	86	86	55	70	72	72
Average PCE Concentration (µg/L)	17	17	14	11	14	14	10.4
Total Number of Normal Samples	39	35	36	36	25	37	32
Number of Samples above MCL	13	14	11	8	10	10	10
Area of PCE Plume (square feet)	4170	3030	2380	2280	2620	2570	2570



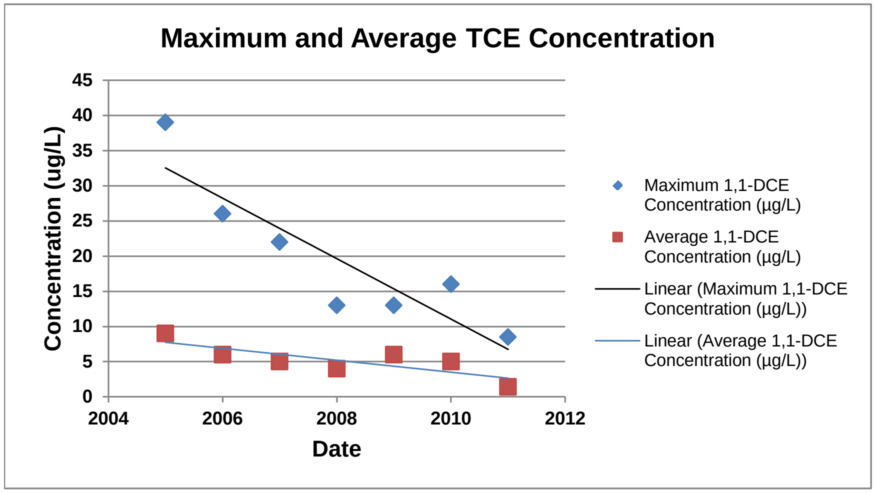


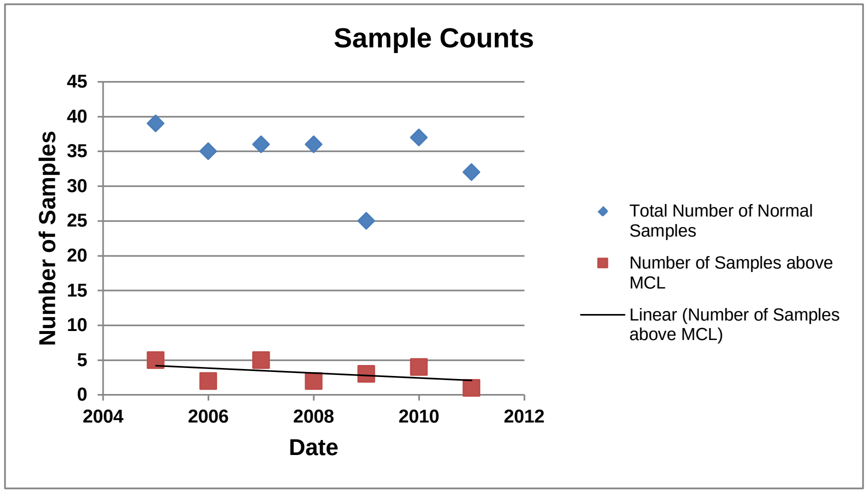


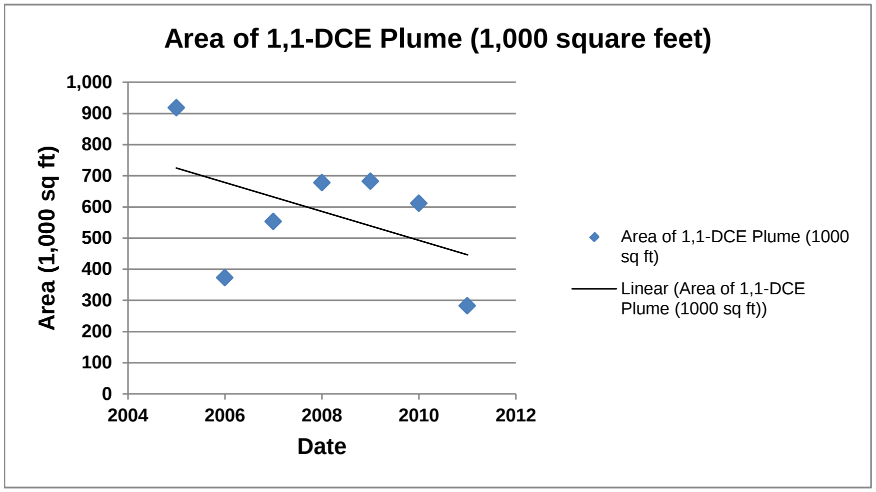


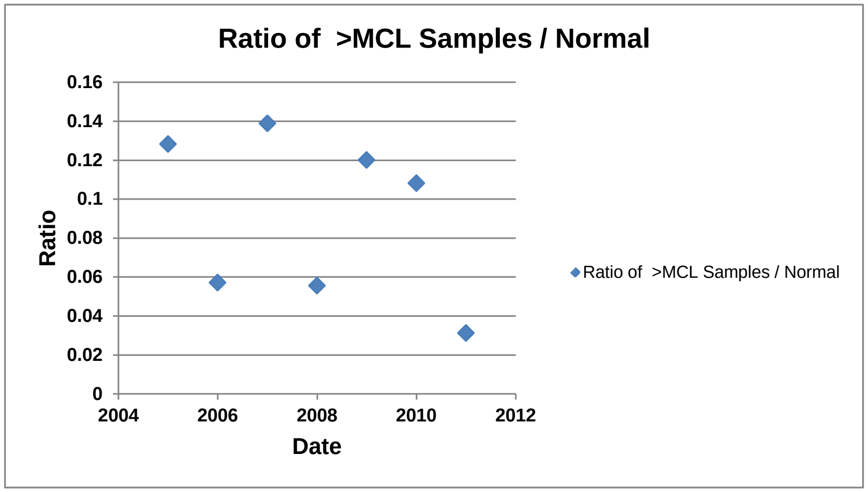
Graph D-1.1.4
Yermo North Plume: 1,1-DCE Statistics
Yermo Annex, MCLB Barstow, CA

	2005	2006	2007	2008	2009	2010	2011
Maximum 1,1-DCE Concentration (µg/L)	39	26	22	13	13	16	8.5
Average 1,1-DCE Concentration (µg/L)	9	6	5	4	6	5	1.4
Total Number of Normal Samples	39	35	36	36	25	37	32
Number of Samples above MCL	5	2	5	2	3	4	1
Area of 1,1-DCE Plume (1000 sq ft)	918	373	553	678	682	611	283



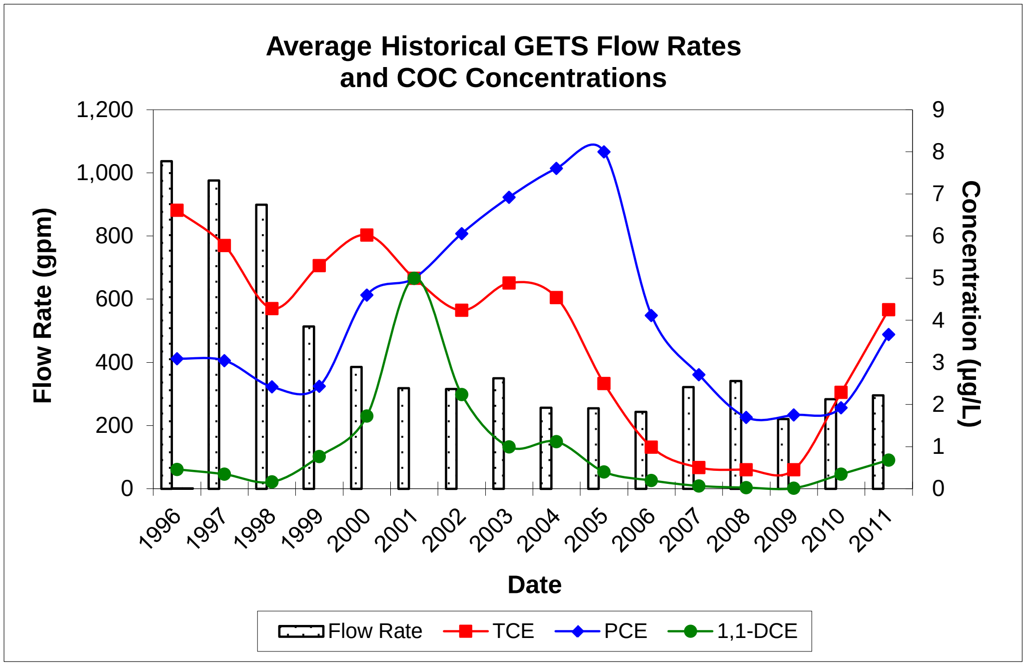


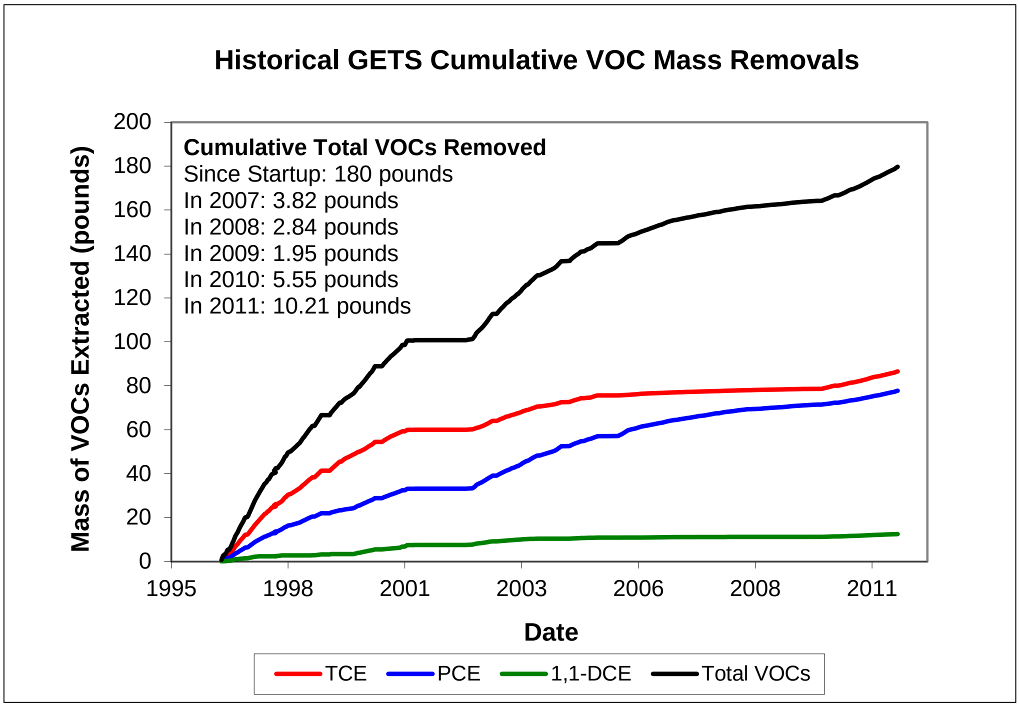




Graph D-1.1.5
Historical GETS System Performance Graphs

Yermo Annex, MCLB Barstow, CA



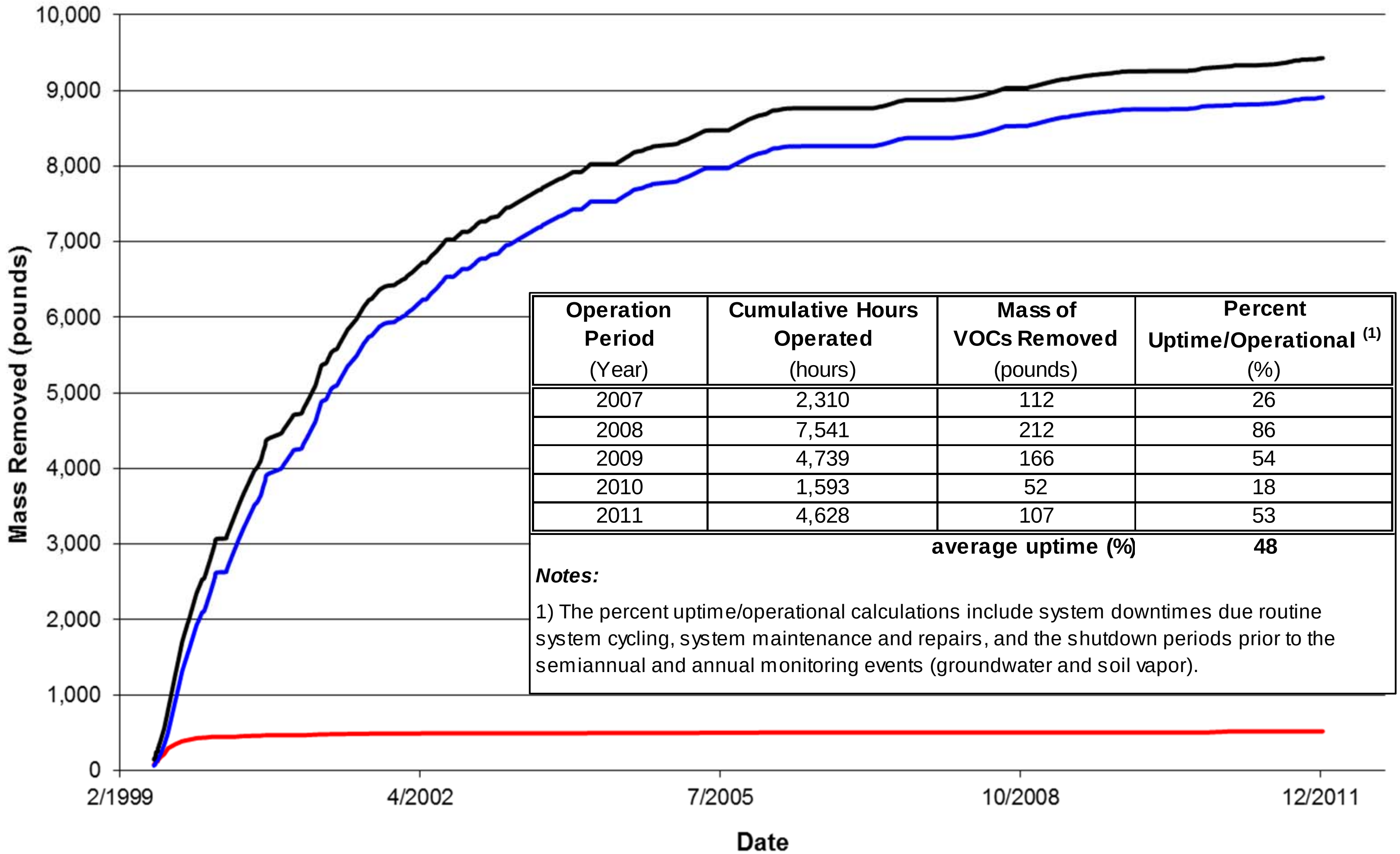


Notes:

GETS = groundwater extraction and treatment system; VOCs = volatile organic compounds
TCE = trichloroethene; PCE = tetrachloroethene; 1,1-DCE = 1,1-dichloroethene
gpm = gallons per minute; µg/L = micrograms per liter

GRAPH D-1.1.6

**HISTORICAL CAOC 16 AS/SVE SYSTEM PERFORMANCE
YERMO ANNEX, MCLB, BARSTOW, CA**



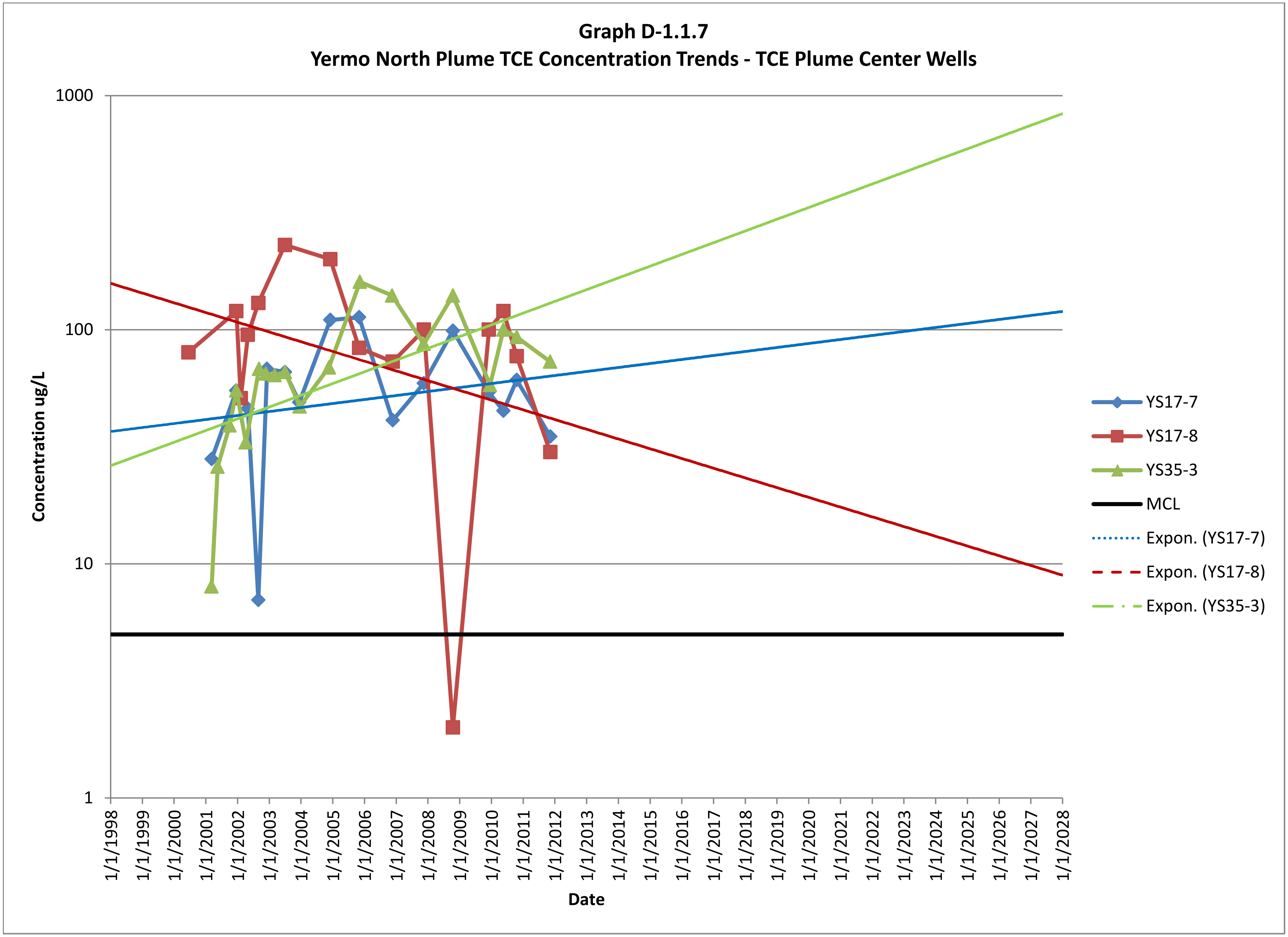
Operation Period (Year)	Cumulative Hours Operated (hours)	Mass of VOCs Removed (pounds)	Percent Uptime/Operational [(1)] (%)
2007	2,310	112	26
2008	7,541	212	86
2009	4,739	166	54
2010	1,593	52	18
2011	4,628	107	53
		average uptime (%)	**48**

Notes:

1) The percent uptime/operational calculations include system downtimes due routine system cycling, system maintenance and repairs, and the shutdown periods prior to the semiannual and annual monitoring events (groundwater and soil vapor).

Notes:
AS/SVE = air sparging/soil vapor extraction
VOCs = volatile organic compounds

Total Freon — Total VOCs — Total Mass



Graph D-1.1.7
Yermo North Plume TCE Concentration Trends - TCE Plume Center Wells
Concentration ug/L
1000
100
10
1
Date
1/1/1998
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
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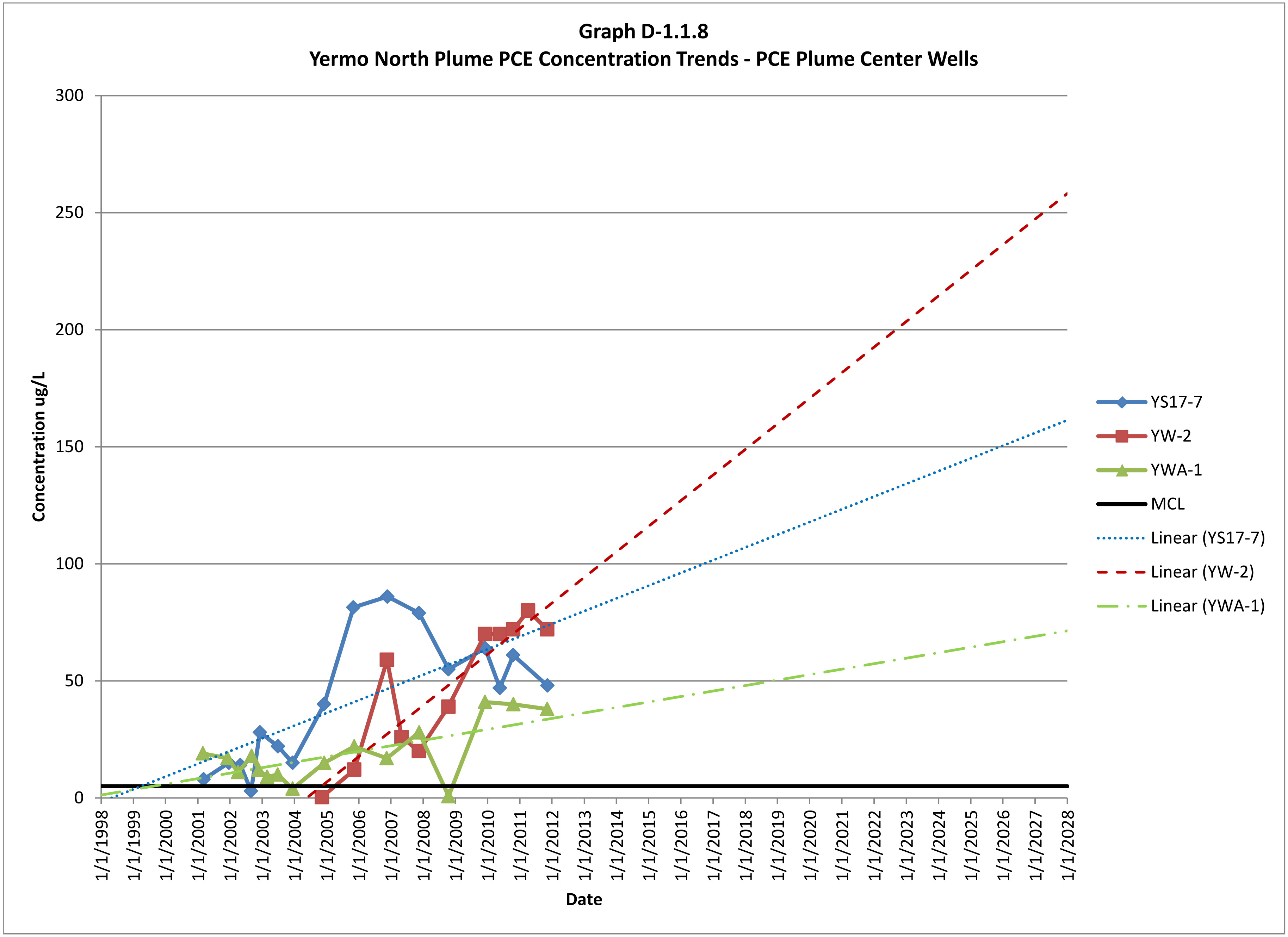
1/1/2025
1/1/2026
1/1/2027
1/1/2028
YS17-7
YS17-8
YS35-3
MCL
Expon. (YS17-7)
Expon. (YS17-8)
Expon. (YS35-3)



Graph D-1.1.8
Yermo North Plume PCE Concentration Trends - PCE Plume Center Wells
Concentration ug/L
300
250
200
150
100
50
0
1/1/1998
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
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1/1/2020
1/1/2021
1/1/2022
1/1/2023
1/1/2024
1/1/2025
1/1/2026
1/1/2027
1/1/2028
Date
YS17-7
YW-2
YWA-1
MCL
Linear (YS17-7)
Linear (YW-2)
Linear (YWA-1)

APPENDIX D

D-1 TECHNICAL ASSESSMENT REPORT - CAOC 37 (OU 1) REMEDIAL ACTION PERFORMANCE EVALUATION

Technical Memorandum D-1.2 - Update of Groundwater Flow Model Based on 2012 May Gauging Event, Yermo Annex

Introduction

This Technical Memorandum has been prepared to document the update of the MODFLOW Groundwater Model that was presented in the 2010 Annual Groundwater Monitoring Report (Oneida Total Integrated Enterprises [OTIE], 2011) by incorporating a newly installed extraction well and calibrating to water level data collected in May 2012. The model is used to evaluate the capture zones for the active groundwater extraction wells that are part of the groundwater extraction and treatment system (GETS) at the Yermo Annex (Operable Unit 1) of the Marine Corps Logistics Base Barstow, California, under Comprehensive Environmental Response, Compensation, and Liability Act Area of Concern (CAOC) 37. This memorandum was prepared by AIS-TN&A JV (ATJV) for the Department of the Navy under Contract No. N62473-09-D-2610, contract task order 0013.

Groundwater Flow Model Development

The groundwater model was developed using the MODFLOW software program, a three-dimensional finite-difference groundwater flow model (McDonald and Harbaugh, 1988). Groundwater flow pathways, based on the resulting simulated flow field, were computed and displayed using MODPATH (Pollock, 1989), a separate software program. For the present version of the model, Groundwater Modeling System (GMS) Version 6.0 (Brigham Young University, 2007), another software program, was used as a pre-processor and post-processor for both MODFLOW and MODPATH. The objectives and detail of the model construction were documented in the 2010 annual groundwater monitoring report (OTIE, 2011).

Updates to the Model Inputs

The 2011 model incorporated extraction well GEW-16 that was installed in 2010. This model incorporates extraction well GEW-17 that was installed in March 2012 (ATJV, 2012).

Some monitoring well locations were refined based on a series of well surveys completed in November 2011 and February 2012. The depth at which the infiltration galleries inject the treated water from the GETS system was updated to reflect their approximate 10-foot depth.

Pumping and infiltration rate inputs into the model for the GETS wells were updated based on the actual active pumping rates recorded between January 2012 and June 2012. The rates used are presented in Table D-1.2.1.

Other model inputs, including infiltration, hydraulic conductivity, geologic layering, etc. remained unchanged.

APPENDIX D

D-1 TECHNICAL ASSESSMENT REPORT - CAOC 37 (OU 1) REMEDIAL ACTION PERFORMANCE EVALUATION

Technical Memorandum D-1.2 - Update of Groundwater Flow Model Based on 2012 May Gauging Event, Yermo Annex

Model Calibration

The steady-state groundwater flow model was calibrated to the data collected during the groundwater gauging event conducted on 9 May 2012. The boundary conditions from the 2010 model run were used as the initial boundary values. The calibrated model groundwater elevations are shown on Figure D-1.2.1. In order to achieve calibration, the boundary elevations upgradient of Yermo Annex in the small valley west of the CalNev site were increased, along with three other locations. The changed values are shown in red on Figure D-1.2.1.

The results of the model calibration are tabulated in Table D-1.2.2 as a comparison of the 9 May 2012 groundwater elevations to those predicted by the model, with the difference between the two referred to as the residual head. Residual heads in the table are color coded by their magnitude. Green bars indicate residuals of less than 0.5 foot and orange indicate residuals between 0.5 and 1 foot. The residual heads listed in Table D-1.2.2 indicate that the simulated on-Base groundwater elevations correspond closely to the May 2012 measured groundwater elevations. 92.3 percent (%) of modeled groundwater elevations for the on-Base wells are within 0.5-foot of the measured groundwater elevations and 7.7% are between 0.5 and 1 foot. The average residual head is -0.04 foot.

The standard deviation of the residual heads was 0.26 foot. The standard deviation of the residual heads for the on-Base wells was about 4.4% of the May 2012 groundwater elevation range. Values less than approximately 10 to 15 percent are generally considered an indication of a good calibration (Groundwater VISTAS, 1998).

Modeled GETS Capture Zone

To illustrate the capture zones, particle flow pathlines were calculated by MODPATH, a software module tied into MODFLOW and interfaced with GMS. MODPATH simulates the pathway of hypothetical particles released from selected cells based on the modeled groundwater flow. Figure D-1.2.2 illustrates the modeled groundwater elevation contours and the particle flow pathlines based on the model inputs. Included on the figures are the estimated extents of the COCs tetrachloroethene, trichloroethene, and 1,1-dichloroethene for the November 2011 Yermo North COC plume.

Model-predicted particle flow pathlines, shown on Figure D-1.2.2, indicate that the Yermo North plume is being hydraulically controlled at the Base boundary by extraction wells GEW-7 and GEW-16. Newly installed GEW-17 is capturing the central portion of the plume. Well GEW-6 is capturing significant clean water from the southwest. Yermo Annex production well YDW-5 may be capturing groundwater from the western-most upgradient edge of the November 2010 plume.

APPENDIX D

D-1 TECHNICAL ASSESSMENT REPORT - CAOC 37 (OU 1) REMEDIAL ACTION PERFORMANCE EVALUATION

Technical Memorandum D-1.2 - Update of Groundwater Flow Model Based on 2012 May Gauging Event, Yermo Annex

Conclusions

The MODFLOW model constructed for the 2010 Annual Groundwater Monitoring Report was updated to reflect the newly installed GETS groundwater extraction wells, current extraction rates, and calibrated to May 2012 groundwater elevations. The model predicted groundwater elevations that were within acceptable tolerances of the May 2012 groundwater elevations. Particle tracking calculated by MODPATH shows that the Yermo plume is being captured by the current GETS extraction wells.

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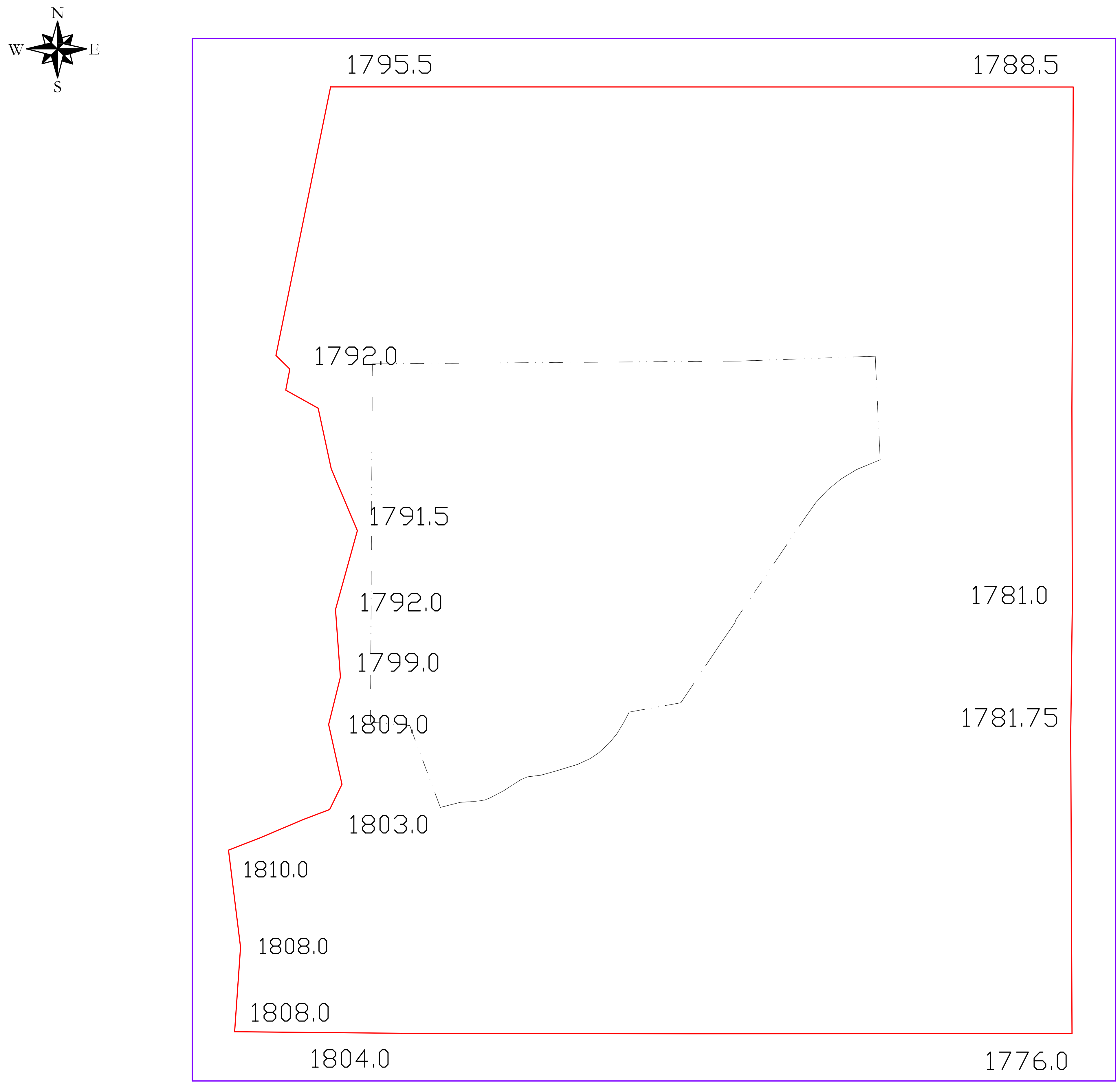


Legend

Yermo Annex Boundary
Constant Head Boundary
Model Boundary
1810.0 Static Head (ft amsl)

Notes

1) ft amsl = feet above mean sea level

Approximate Scale in Feet

0 2,500 5,000

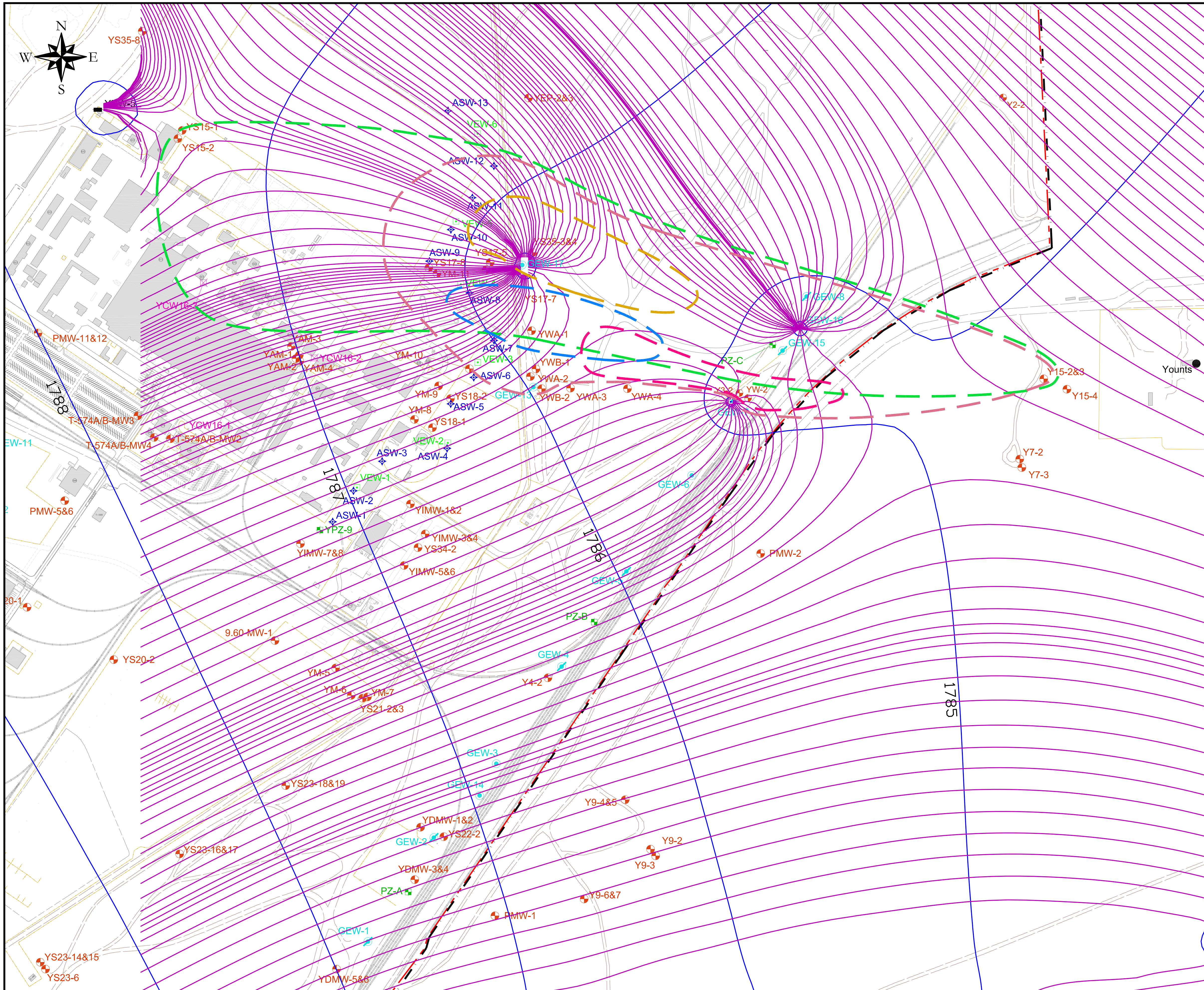
Figure D-1.2.1
Calibrated Boundary Conditions

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: June 6, 2012

File: Yermo_ModUpdate.dwg



Legend

— · —	Yermo Annex Boundary
YMP-2	Groundwater Monitoring Well
YPZ-2	Piezometer
YDW-6	Base Groundwater Supply Well
GEW-3	Groundwater Extraction Well (Active)
GEW-2	Groundwater Extraction Well (Inactive)
VEW-1	Vapor Extraction Well
ASW-1	Air Sparge Well
YCW16-1	Combination Well
Younts	Domestic Well
1785	Model Calculated Groundwater Elevations (ft amsl)
5	Approximate TCE Isoconcentration Contour (ug/L)
50	Approximate TCE Isoconcentration Contour (ug/L)
5	Approximate PCE Isoconcentration Contour (ug/L)
50	Approximate PCE Isoconcentration Contour (ug/L)
6	Approximate DCE Isoconcentration Contour (ug/L)
	Predicted Particle Flow Pathlines

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater Monitoring Event.

2) ft amsl = feet above mean sea level
TCE = trichloroethene
PCE = tetrachloroethene
DCE = dichloroethene

Approximate Scale in Feet

0 500 1,000

Figure D-1.2.2
Model Simulated Groundwater Flow
and Particle Pathways
Upgradient of Plume

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: June 6, 2012

File: Yermo_ModUpdate.dwg

Table D-1.2.1
MODFLOW Well Parameters
Yermo Annex, MCLB Barstow, California

Well Name	Northing (feet) [(a)]	Easting (feet) [(a)]	Pumping Rate (ft^3/Day) [(c)]	Pumping Interval Type	Layer Range		Screen Interval (ft amsl) [(b)]	
GEW-3	6903941.9	2147397.2	0	Screen Interval	NA		1815	1765
GEW-6	6904961.2	2148901.8	0	Screen Interval	NA		1739	1689
GEW-7	6905176.9	2149289.9	-15862	Screen Interval	NA		1740	1689
GEW-13	6904134.8	2149360.9	0	Screen Interval	NA		1812	1762
GEW-14	6903855.0	2147231.5	0	Screen Interval	NA		1771	1721
GEW-15	6905430.6	2149549.9	0	Screen Interval	NA		1787	1737
GEW-16	6905544.1	2149668.6	-22041.25	Screen Interval	NA		1772	1702
GEW-17	6904089.4	2150003.4	-24816.39	Screen Interval	NA		1782.78	1712.78
Hodges	6907772.3	2149770.6	-96.25	Screen Interval	NA		1755	1651
YDW-5	6901885.1	2150799.2	-29799	Screen Interval	NA		1802	1562
YDW-6	6900747.6	2150890.0	0	Screen Interval	NA		1723	1614
YDW-7	6898674.6	2151631.1	-19057.5	Screen Interval	NA		1902	1612
YermoCity1	6908559.0	2154702.0	-125125	Screen Interval	NA		1900	1668
YermoCity2	6908512.0	2154467.0	-125125	Screen Interval	NA		1900	1668
Gallery-01	6899093.3	2151727.5	30787.47	Screen Interval	NA		1843	1803
Gallery-02	6898784.3	2151474.0	30787.47	Screen Interval	NA		1841	1801
Younts	6907605.3	2149488.5	-288.75	Screen Interval	NA		1825	1762
Daggett6	6893915.0	2141800.0	-125125	Screen Interval	NA		1918	1668
Daggett7	6894018.0	2141723.0	-125125	Screen Interval	NA		1918	1668
Domestic1	6902318.0	2153007.0	-192.5	Use layer range	3	4	NA	
Domestic2	6904273.0	2153266.0	-192.5	Use layer range	3	4	NA	
Domestic3	6905545.0	2152912.0	-192.5	Use layer range	3	4	NA	
Domestic4	6906911.0	2153219.0	-192.5	Use layer range	3	4	NA	
Domestic5	6909690.0	2153124.0	-192.5	Use layer range	3	4	NA	
Domestic6	6909973.0	2153148.0	-192.5	Use layer range	3	4	NA	
Domestic7	6910656.0	2152182.0	-192.5	Use layer range	3	4	NA	
Domestic8	6902954.0	2153077.0	-192.5	Use layer range	3	4	NA	
Domestic9	6903378.0	2152677.0	-192.5	Use layer range	3	4	NA	
Domestic10	6903519.0	2152818.0	-192.5	Use layer range	3	4	NA	
Domestic11	6903684.0	2152818.0	-192.5	Use layer range	3	4	NA	
Domestic12	6903849.0	2152842.0	-192.5	Use layer range	3	4	NA	
Domestic13	6904273.0	2152630.0	-192.5	Use layer range	3	4	NA	
Domestic14	6904626.0	2152936.0	-192.5	Use layer range	3	4	NA	
Domestic15	6904909.0	2153289.0	-192.5	Use layer range	3	4	NA	

MCLB - Marine Corps Logistics Base
ft^3/Day = cubic feet per day
ft amsl = feet above mean sea level
a = Datum: NAD83 Horizontal
b = Datum: NAVD88 Elevations
groundwater elevations of MCLB Barstow prior to August 2009 may be based on mixed NAVD88 and NGVD29 data.
c = negative values indicate extraction; positive values indicate injection

Table D-1.2.2
MODFLOW Calibrated Residual Heads
Yermo Annex, MCLB Barstow, California

Well	May 2012 Elevation	Modeled Elevation	Residual Head [(a)]
	(ft amsl)	(ft amsl)	(ft)
GEW-1	1787.55	1787.79	0.24
GEW-10	1788.63	1788.76	0.13
GEW-12	1788.51	1788.55	0.04
GEW-13	1786.17	1785.99	-0.19
GEW-15	1785.01	1784.65	-0.36
GEW-2	1787.24	1787.26	0.02
GEW-5	1785.99	1785.97	-0.02
GEW-8	1784.95	1784.75	-0.20
PMW-1	1786.97	1787.08	0.11
PMW-11	1787.99	1788.01	0.02
PMW-2	1785.49	1785.44	-0.05
PMW-5	1788.17	1788.24	0.07
PMW-7	1788.91	1789.07	0.16
PMW-9	1788.92	1789.06	0.14
Y15-2	1784.49	1784.87	0.38
Y7-2	1784.56	1784.86	0.29
Y9-2	1786.09	1786.28	0.19
Y9-4	1786.22	1786.32	0.10
Y9-6	1786.49	1786.63	0.14
YCW-16-1	1787.63	1787.38	-0.25
YCW-16-2	1787.33	1786.95	-0.38
YCW-16-3	1787.52	1787.29	-0.23
YEP-2	1786.10	1786.31	0.21
YS17-8	1786.29	1786.31	0.01
YS20-1	1788.22	1788.63	0.41
YS20-2	1788.43	1788.38	-0.06
YS23-11	1790.41	1790.44	0.02
YS23-12	1789.41	1789.49	0.08
YS23-14	1789.63	1789.59	-0.04
YS23-16	1788.54	1788.53	-0.01
YS23-18	1787.87	1787.87	0.00
YS26-2	1790.19	1789.68	-0.51
YS28-2	1789.68	1789.48	-0.20
YS35-3	1786.01	1785.14	-0.88
YW-2	1785.26	1784.62	-0.64
YWA-1	1785.90	1785.79	-0.11
YWA-2	1785.98	1785.96	-0.02
YWA-3	1785.83	1785.84	0.01
YWA-4	1785.66	1785.60	-0.06

Average Residual Head	-0.04
Average of Absolute Residual Head	0.18
Standard Deviation	0.26
Root Mean Square	0.26
Minimum May Elevation	1784.49
Maximum May Elevation	1790.41
May Elevation Range	5.92
SD/ER	4.4%

Residual Head Difference Ranges	Percent	Count
Less than 0.5 foot	92.3%	36
Between 0.5 and 1 foot	7.7%	3
Total	100.0%	39

ft - feet
ft amsl - feet above mean sea level
ER - May 2012 Elevation Range
MCLB - Marine Corps Logistics Base
SD - Standard Deviation
(a) (Modeled Elevation) - (May 2012 Elevation)

APPENDIX D

D-2 TECHNICAL ASSESSMENT REPORT
OU 1 and 2 REMEDIAL SYSTEMS O&M COST REVIEW
MCLB BARSTOW

The remedial systems that were operational during the Third Five-Year Review period (2007 – 2012) included:

- Yermo Annex Groundwater Extraction and Treatment System (GETS), CAOC 16 air sparge/soil vapor extraction (AS/SVE) system, and three landfill caps (CAOC 20, 23, and 35)
- Nebo Main Base: "Nebo North" AS/SVE system, "Nebo South" AS/SVE system, and CAOC 7 landfill cap

For a description of the remedial systems and landfill caps please refer to Sections 3.4 and 3.5 of the main text.

The costs reported herein and in Tables 6-2 and 6-3 of the main report were obtained from contractors responsible for operation and maintenance (O&M), monitoring, repair, and upgrades of remedial systems and from the Department of the Navy's (DON's) Remedial Project Manager, Mr. Ralph Pearce.

Definitions:

- O&M refers to regular operations and maintenance tasks, including field inspections, trouble-shooting, minor repairs, data collection, and sampling. These tasks are defined in the related remedy O&M Manuals.
- Repairs and Upgrades refers to major remedial system component repairs or replacements (e.g., repair or replacement of an air compressor, computer system replacements, landfill cap repairs)
- Electrical costs: The DON's Installation Restoration Program (IRP) pays for the electrical cost of running the OU 1 and 2 remedial systems beginning in 2008. Electrical costs prior to the year were not available for this review.

The following page provides a summary table and graphs of trends in costs for the active remedial systems (not including landfills) over the third five-year review period by Yermo Annex and Nebo Main Base. The major O&M expense is the Yermo Annex GETS. As reported in the 2011 Annual Groundwater Monitoring Report (OTIE, 2012), the GETS is extracting approximately 115.5 million gallons of groundwater per year.

The relatively high electrical expense of the CAOC 16 AS/SVE system is demonstrated by the low energy costs experienced shutdown of the system from November 2009 to July 2010. The Yermo GETS was operated during this period.

OU 1 / 2 Remedial Systems

Operation Year	O&M, Monitoring Costs		Repairs & Upgrades		Electrical Costs	
	Yermo	Nebo	Yermo	Nebo	Yermo	Nebo
2007 - 2008	$ 530,841	$ 408,233	$ 221,735	$ 50,000	n/a	n/a
2008 - 2009	$ 560,719	$ 436,477	$ 187,994	$ 85,000	$ 213,390	$ 29,099
2009 - 2010	$ 475,200	$ 316,800	$ 447,300	$ 49,700	$ 221,639	$ 30,223
2010 - 2011	$ 426,000	$ 284,000	$ 200,200	$ 63,800	$ 79,211	$ 10,801
2011 - 2012	$ 381,000	$ 254,000	$ 535,200	$ 44,800	$ 106,656	$ 14,544