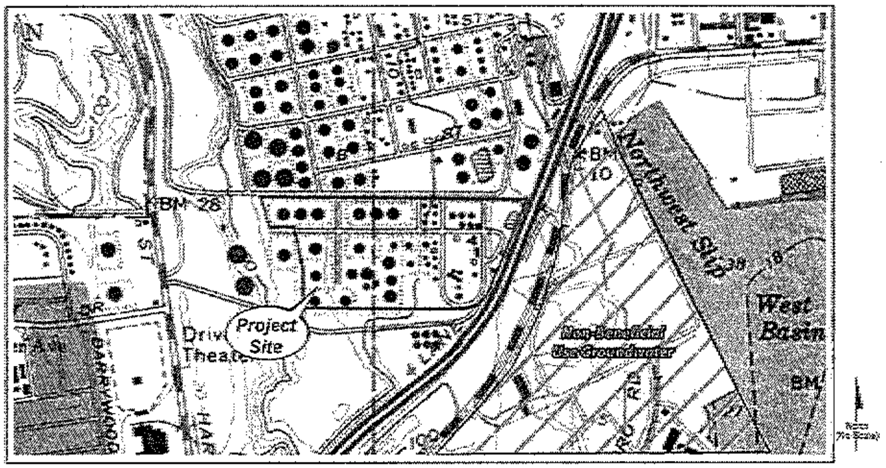
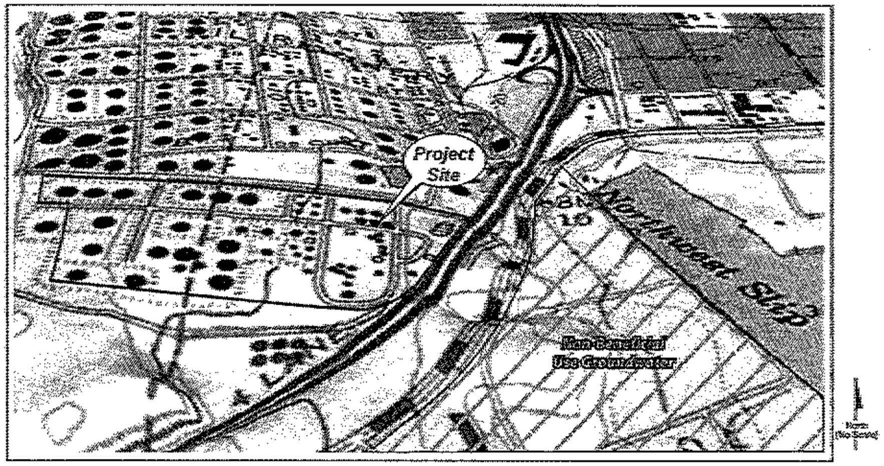
# FIGURES



Reference:
U.S.G.S. 7.5 Minute Quadrangle map
Torrance, California - 1977. Photo revised 1982.

2-DIMENSIONAL SITE LOCATION



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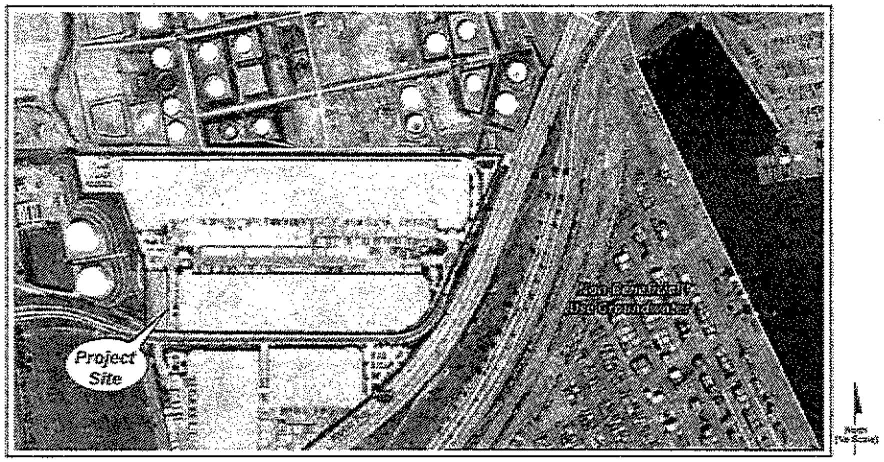
Torrance, California - 1977. Photo revised 1982.

3-DIMENSIONAL SITE LOCATION



Reference:
Google Earth Aerial Photograph
San Pedro, California - 2008

SITE AERIAL PHOTOGRAPH

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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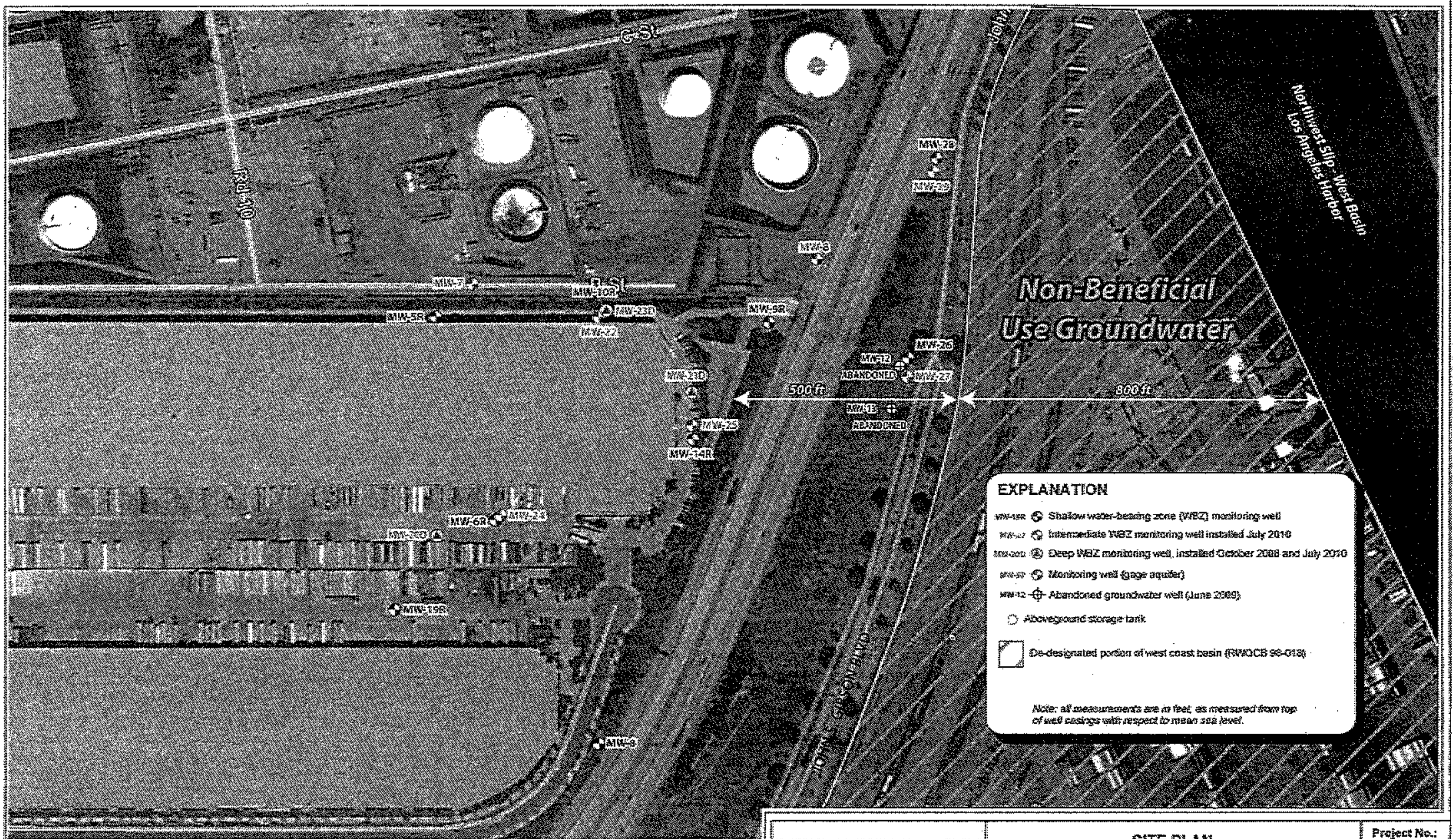
**3-WAY SITE LOCATION MAP**
BlackRock
Port La Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01206525.08

**Figure 1**

Date Drafted:
2/28/14



Reference: Google Earth Aerial Photograph
San Pedro, California - April 2013

0 100 200 300
Approximate Graphic Scale in Feet
1 inch = 200 feet

North

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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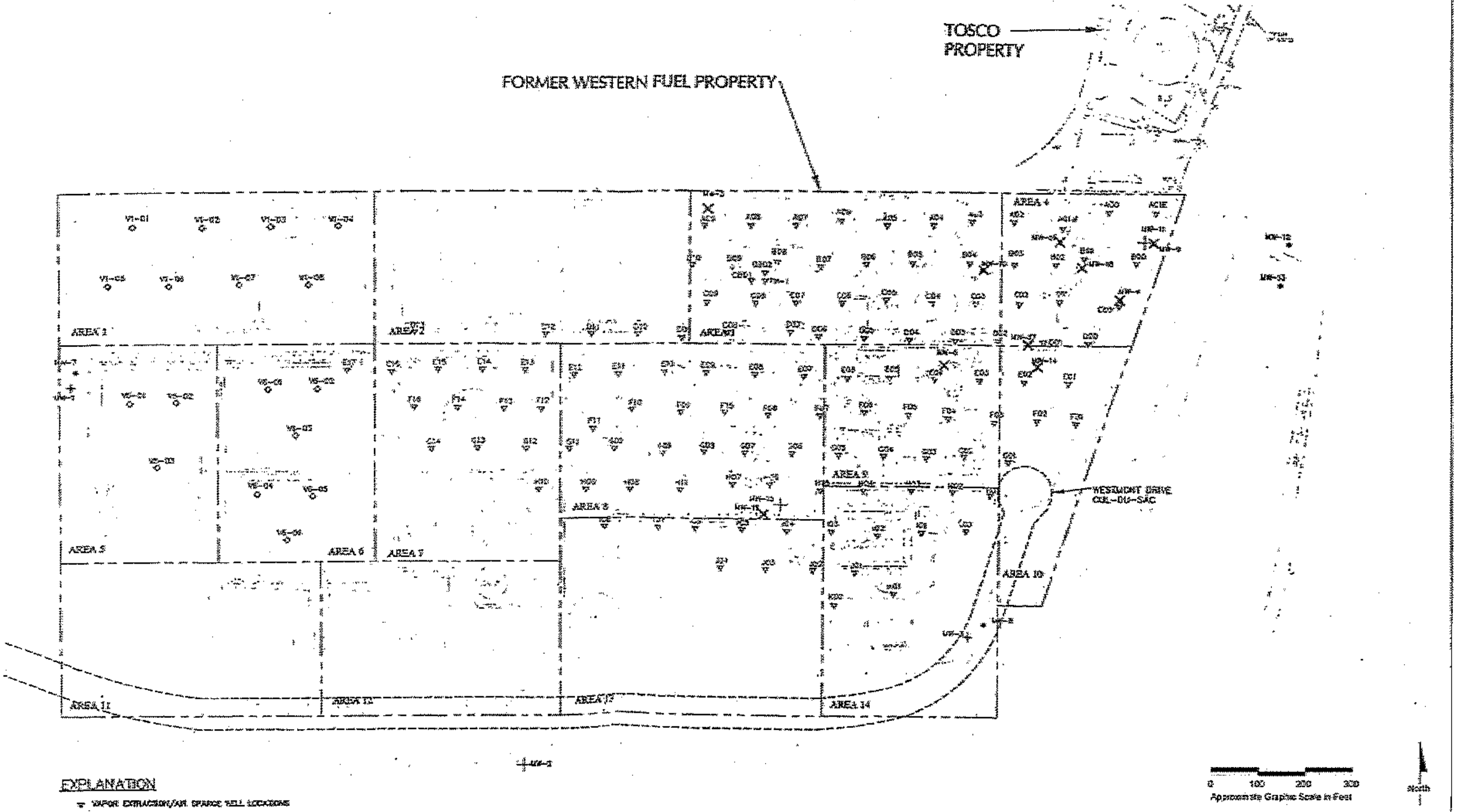
SITE PLAN
BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205525.08

Figure 2

Date Drafted:
2/28/14



EXPLANATION

- VAPOR EXTRACTION/AIR SPARGE WELL LOCATIONS
- VAPOR EXTRACTION WELL LOCATION
- GROUNDWATER MONITORING WELL ABANDONED DURING OCTOBER 2000
- GROUNDWATER MONITORING WELL ABANDONED PRIOR TO 10/2000
- REMAINING GROUNDWATER MONITORING WELL

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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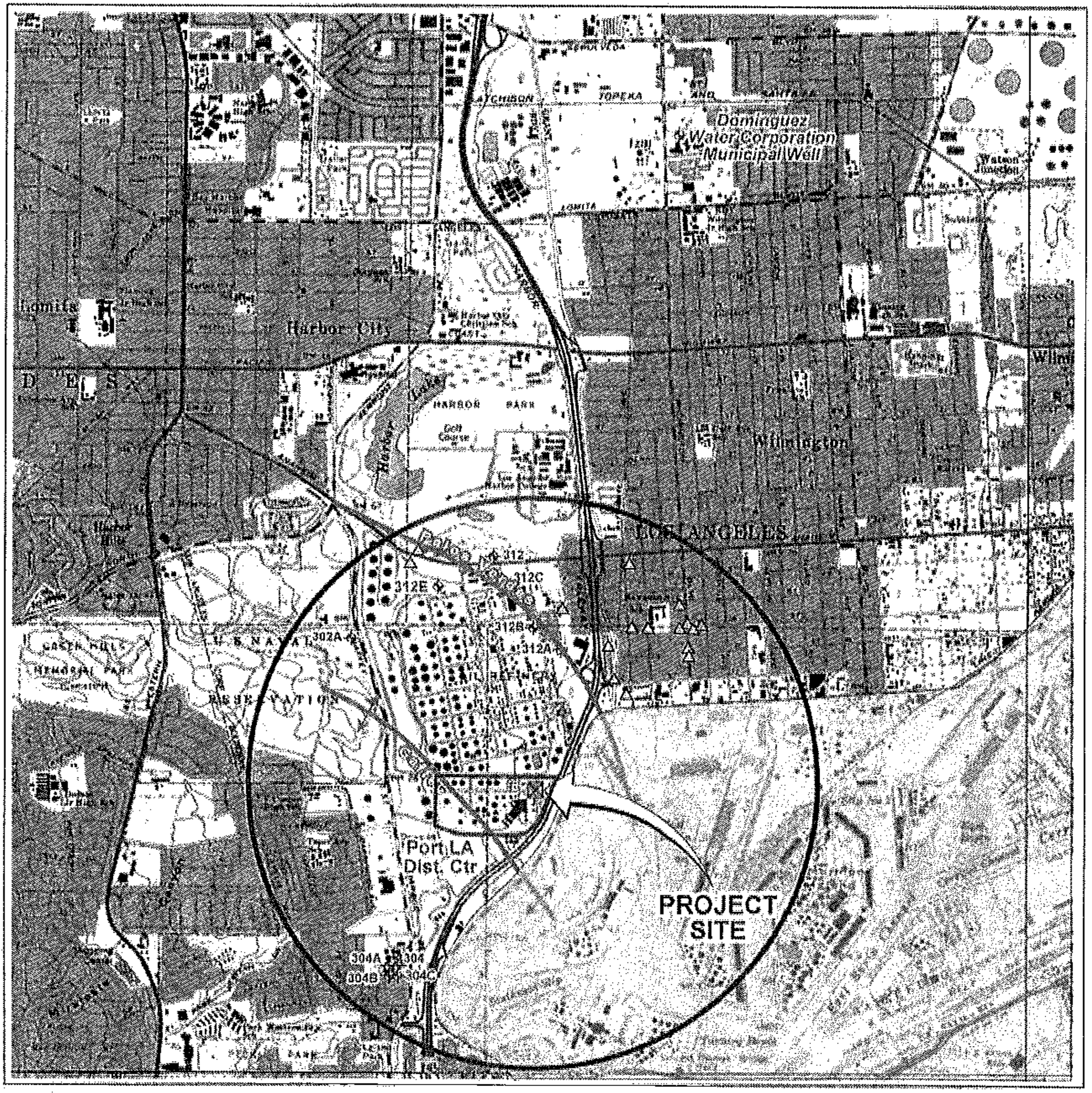
SITE INVESTIGATION DATA
BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.: 01206526.08

Figure 3

Date Drafted: 2/28/14



Reference:
U.S.G.S. 7.5 Minute Quadrangle map
Torrance, California - 1977. Photo revised 1982.

- Active well
- Abandoned well
- △ LACDPW observation or injection wells of Dominguez Gap Barrier Project (DGBP)
- ▨ Site location (Port LA Distribution Center (center of radius))
- Axis of anticline
- Fault: arrows indicate strike slip motion; sawteeth indicate reverse faulting
- Generalized groundwater flow direction
- Area de-designated for MUN beneficial use of groundwater by Resolution No. 98-018

0 1,000 2,000 3,000
Approximate Graphic Scale in Feet

North

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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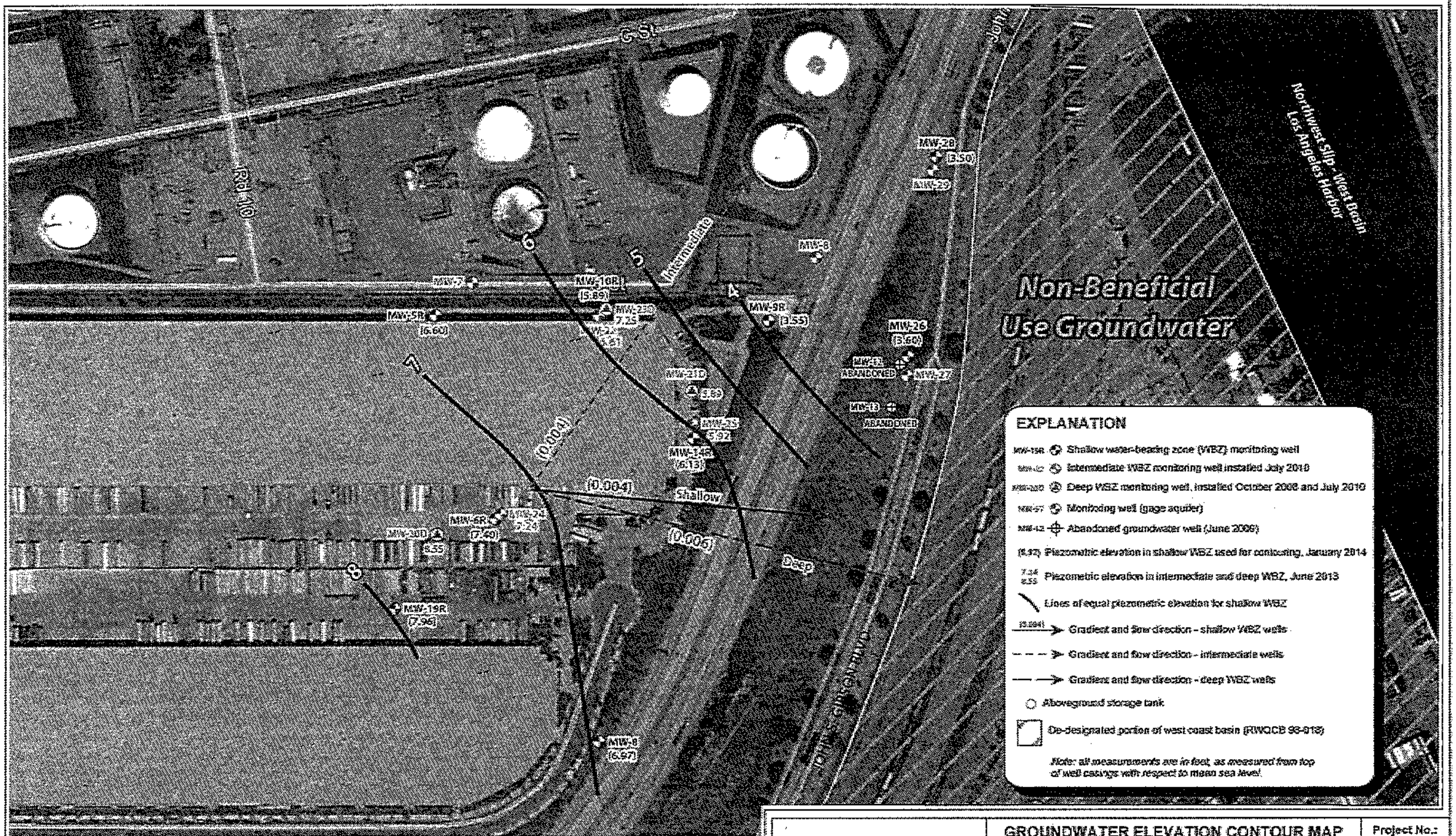
## ACTIVE AND ABANDONED PRODUCTION WELLS
**BlackRock**
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

**Project No.:**
**01205525.08**

**Figure 4**

**Date Drafted:**
**2/28/14**



Reference: Google Earth Aerial Photograph
San Pedro, California - April 2013

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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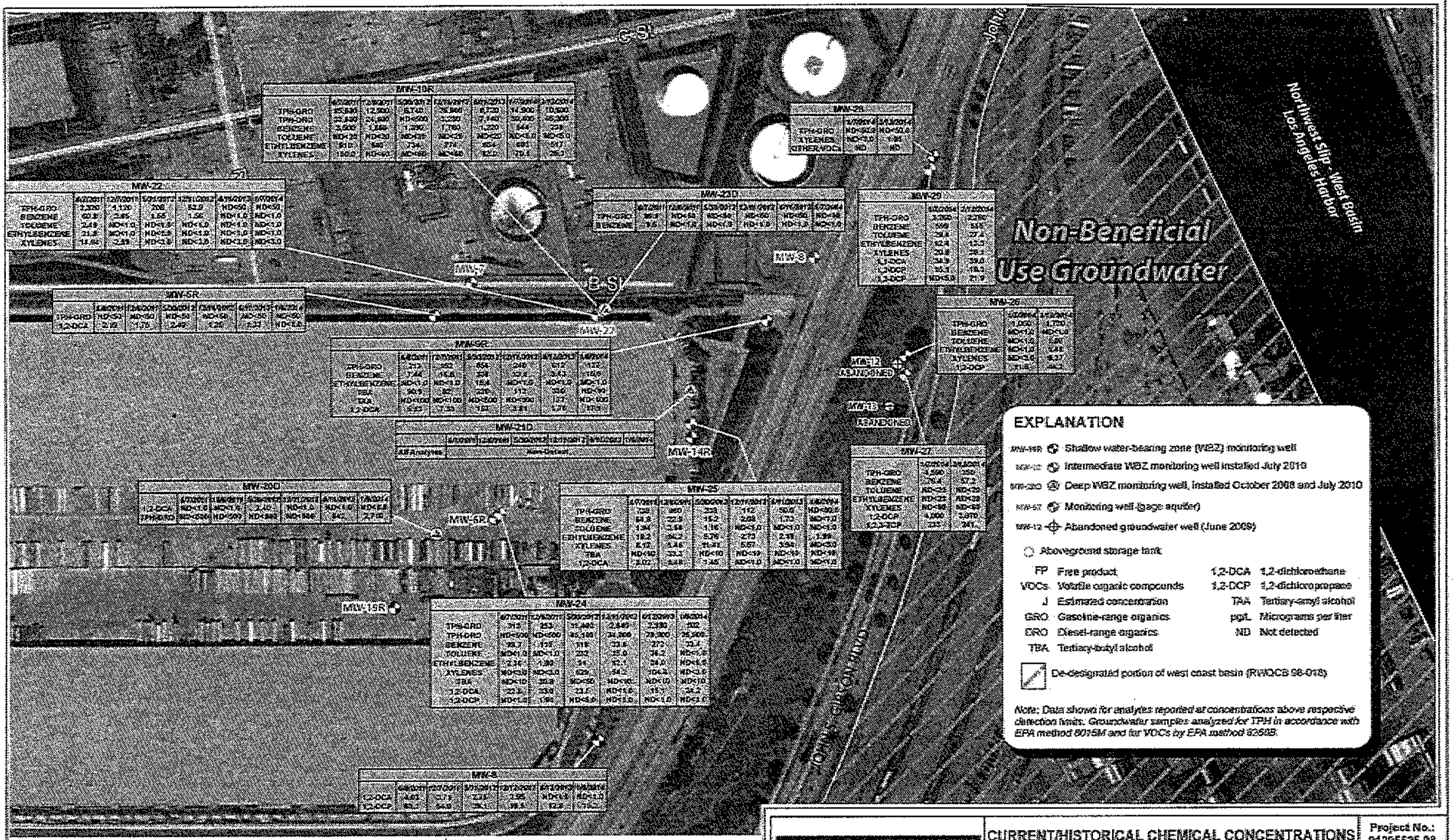
# GROUNDWATER ELEVATION CONTOUR MAP
# SHALLOW WATER-BEARING ZONE, JANUARY 2014

BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.: 01205525.08

Figure 5

Date Drafted: 2/28/14



**EXPLANATION**

MW-19R ◎ Shallow water-bearing zone (WBZ) monitoring well

MW-22 ◎ Intermediate WBZ monitoring well installed July 2010

MW-20D ◎ Deep WBZ monitoring well, installed October 2008 and July 2010

MW-27 ◎ Monitoring well (gage aquifer)

MW-12 ⌖ Abandoned groundwater well (June 2009)

○ Aboveground storage tank

| | | | |
|---|---|---|---|
| FP | Free product | 1,2-DCA | 1,2-dichloroethane |
| VOCs | Volatile organic compounds | 1,2-DCP | 1,2-dichloropropane |
| J | Estimated concentration | TAA | Tertiary-amyl alcohol |
| GRO | Gasoline-range organics | µg/L | Micrograms per liter |
| DRO | Diesel-range organics | ND | Not detected |
| TBA | Tertiary-butyl alcohol | | |

▨ De-designated portion of west coast basin (RWQCB 98-018)

*Note: Data shown for analytes reported at concentrations above respective detection limits. Groundwater samples analyzed for TPH in accordance with EPA method 8015M and for VOCs by EPA method 8260B.*

0 100 200 300
Approximate Graphic Scale in Feet
1 inch = 200 feet

North

Reference: Google Earth Aerial Photograph
San Pedro, California - April 2013

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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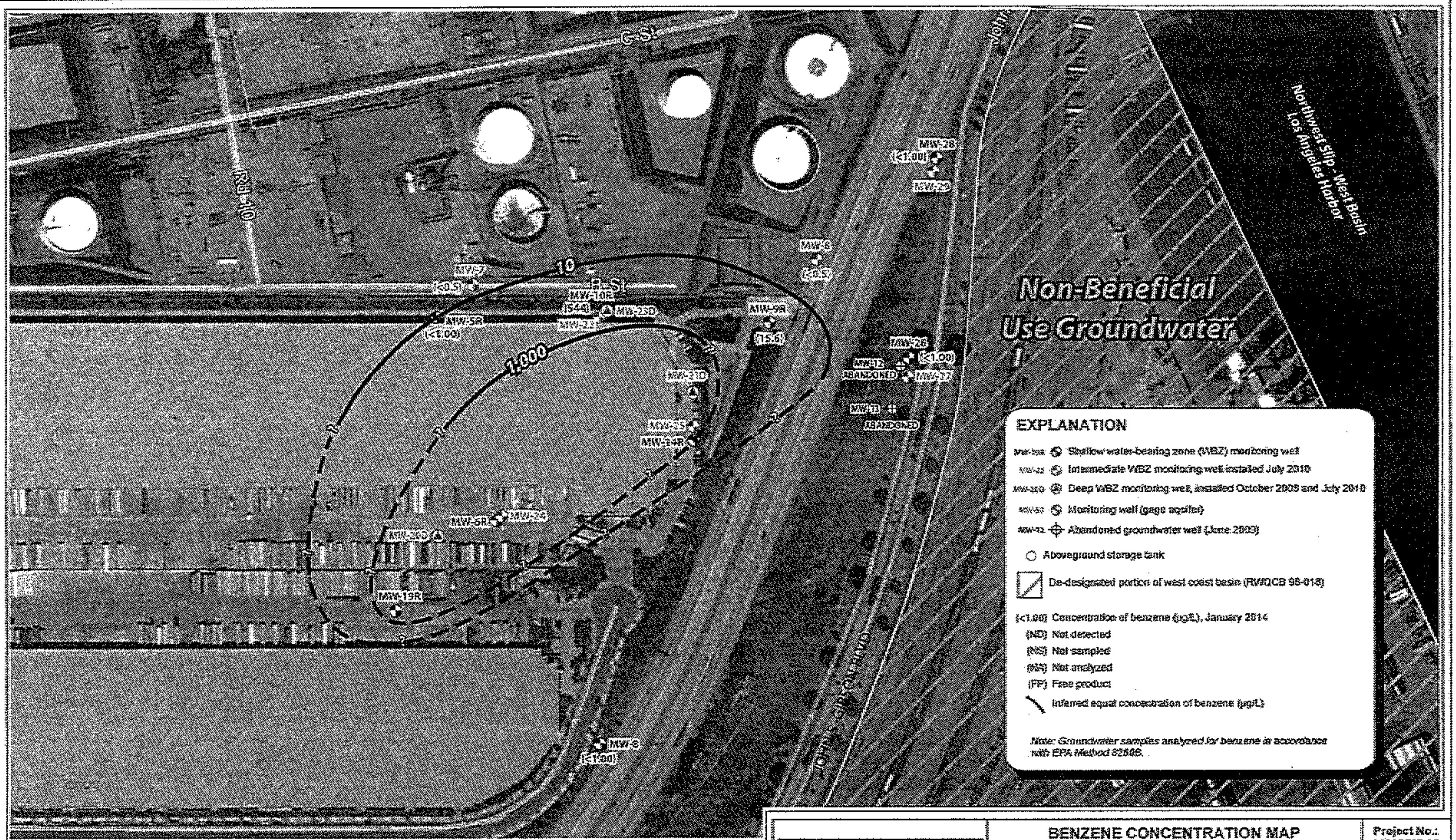
**CURRENT/HISTORICAL CHEMICAL CONCENTRATIONS**
BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205626.08

Figure 6

Date Drafted:
2/28/14



Reference: Google Earth Aerial Photograph
San Pedro, California - April 2013

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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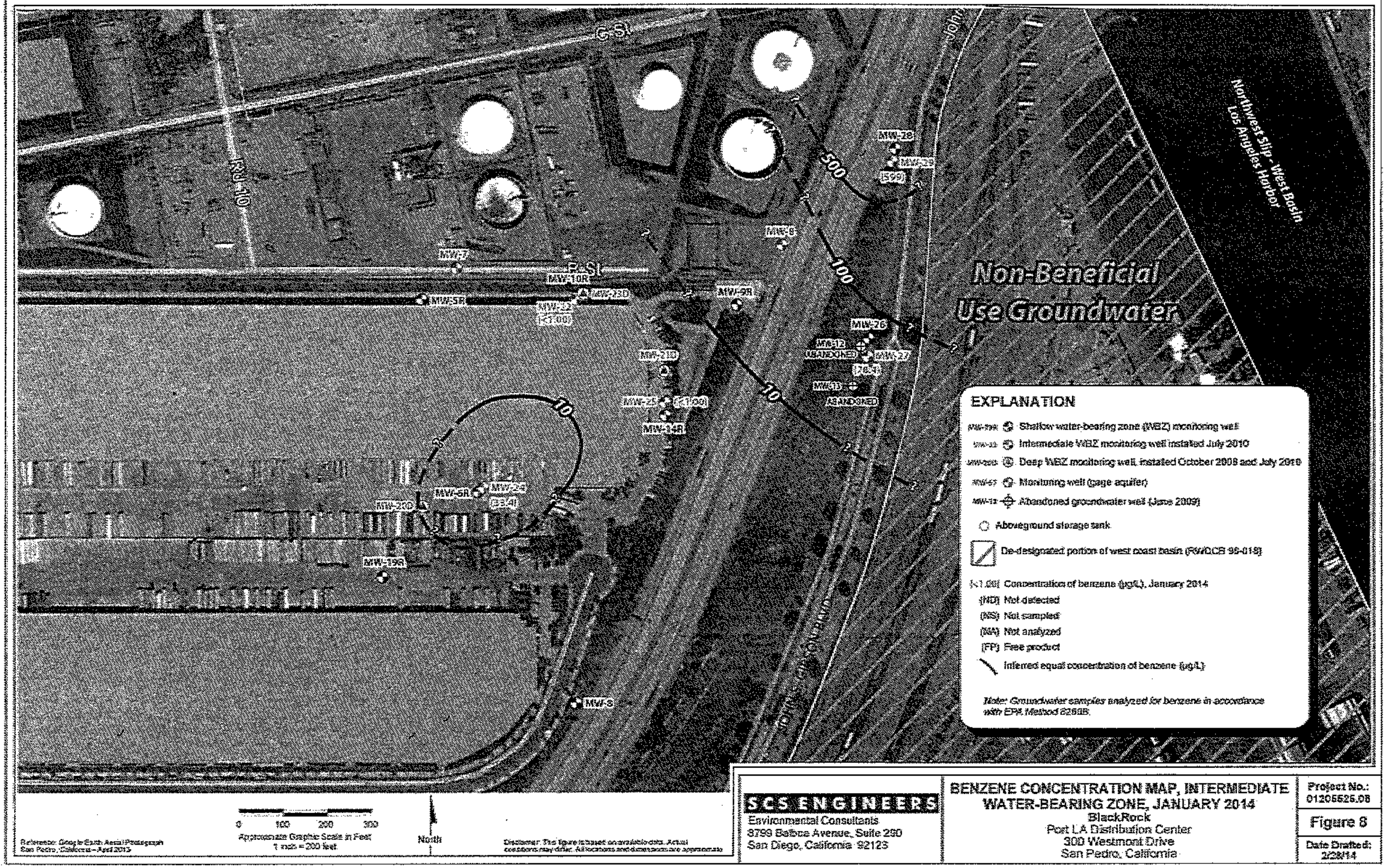
## BENZENE CONCENTRATION MAP
## SHALLOW WATER-BEARING ZONE, JANUARY 2014

BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205525.08

Figure 7

Date Drafted:
3/28/14



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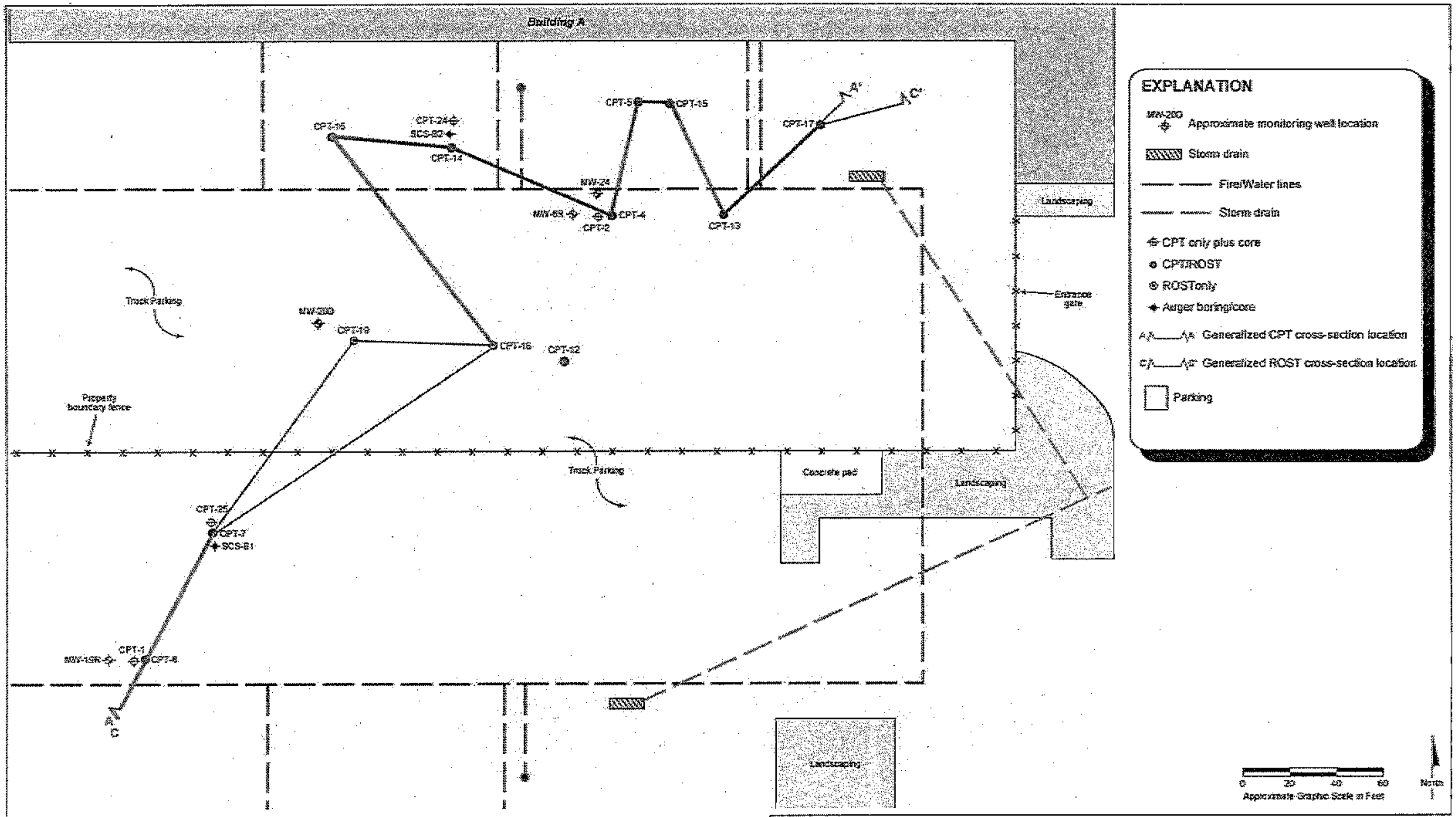
**BENZENE CONCENTRATION MAP, INTERMEDIATE WATER-BEARING ZONE, JANUARY 2014**

BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205525.08

Figure 8

Date Drafted:
2/28/14



Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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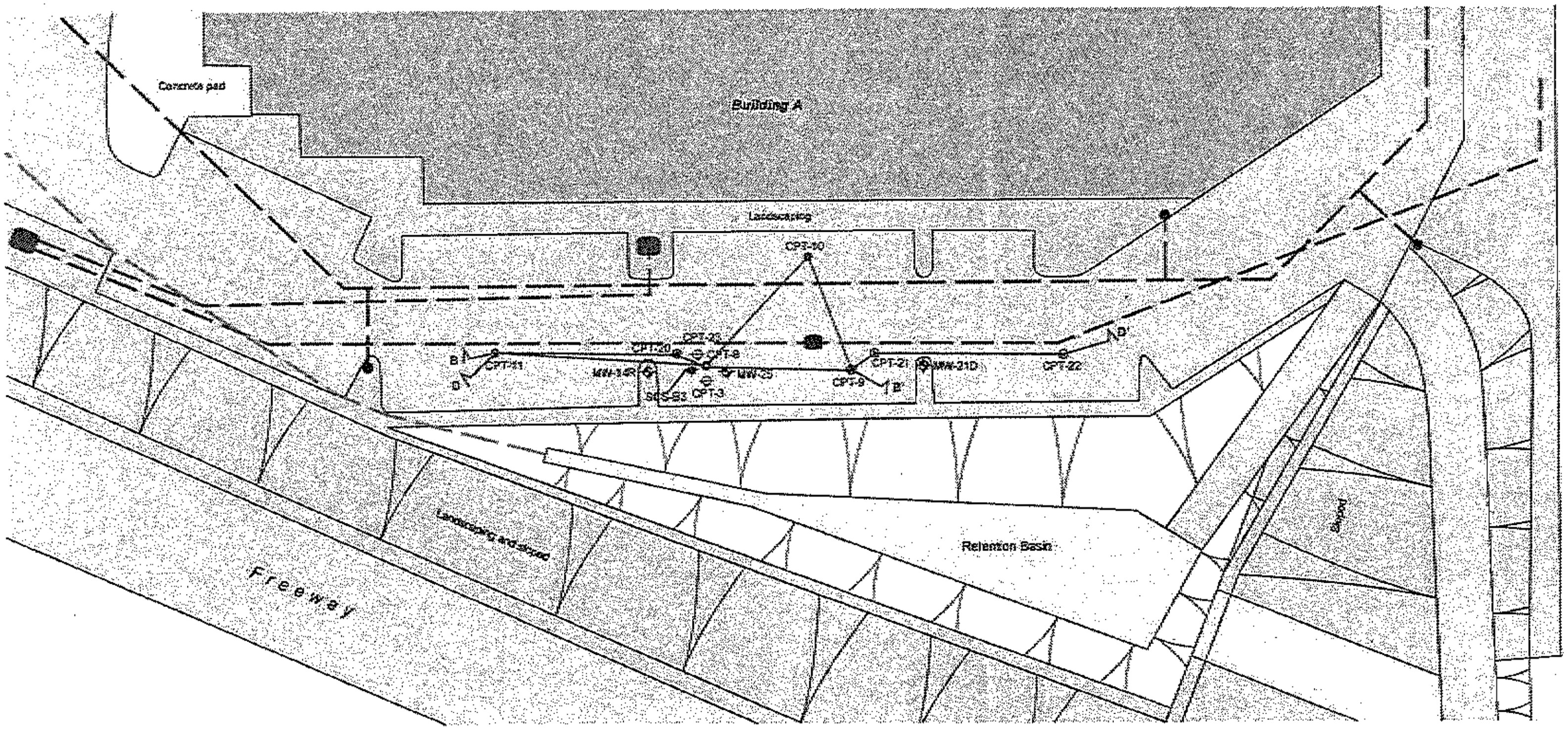
**AREA SOUTH OF BUILDING A**
BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.: 01206525.08

Figure 9

Date Drafted: 2/26/14



Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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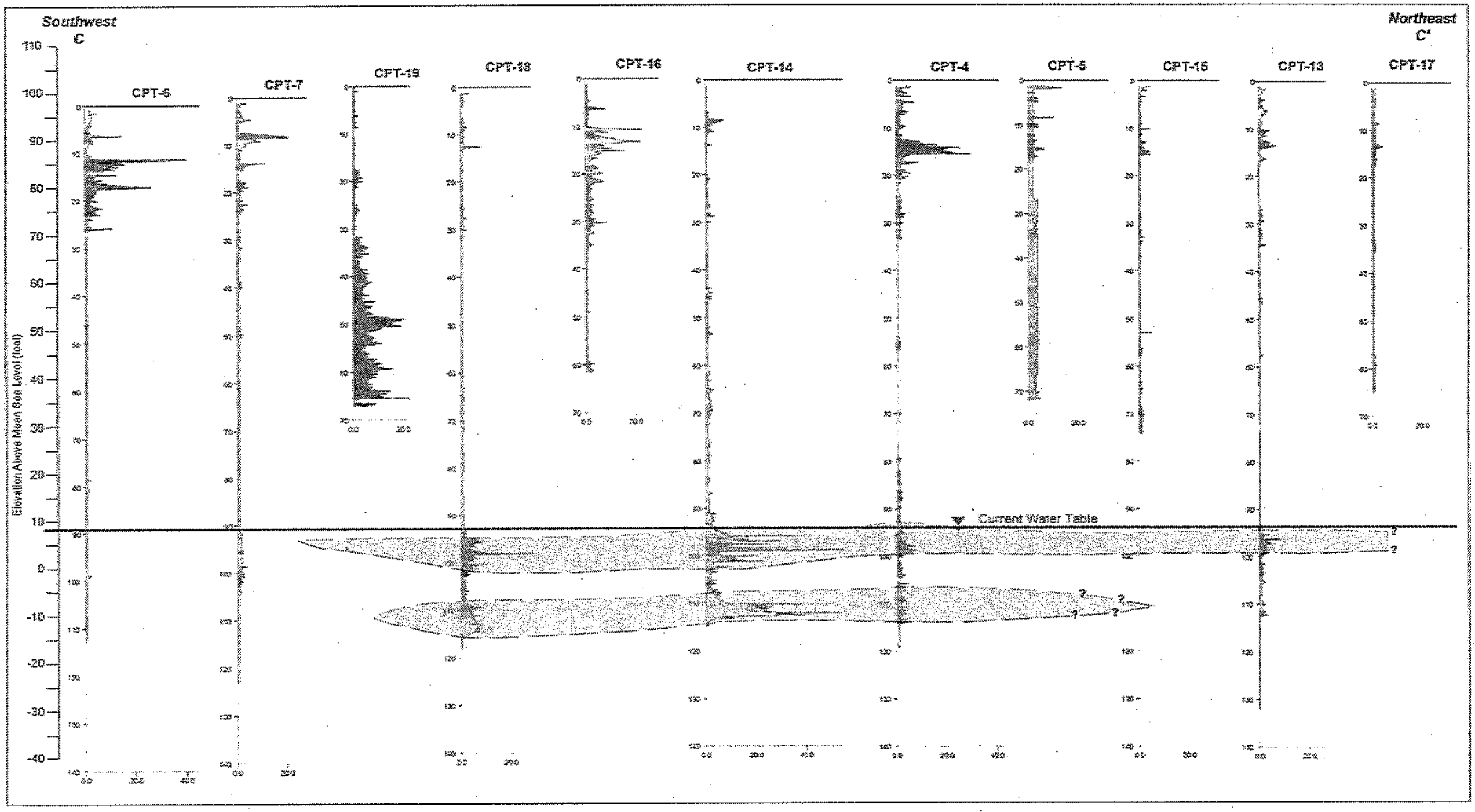
**AREA EAST OF BUILDING A**
**BlackRock**
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

**Project No.:**
**01205525.08**

**Figure 10**

**Date Drafted:**
**2/26/14**



EXPLANATION

▨ Possible zone to LNAPL occurrence (ROST reflectance greater than approximately 3% in shallow WBZ)

0 10 20 30

Approximate Vertical Graphic Scale in Feet
(Horizontal Scale in Percent Reflectivity)

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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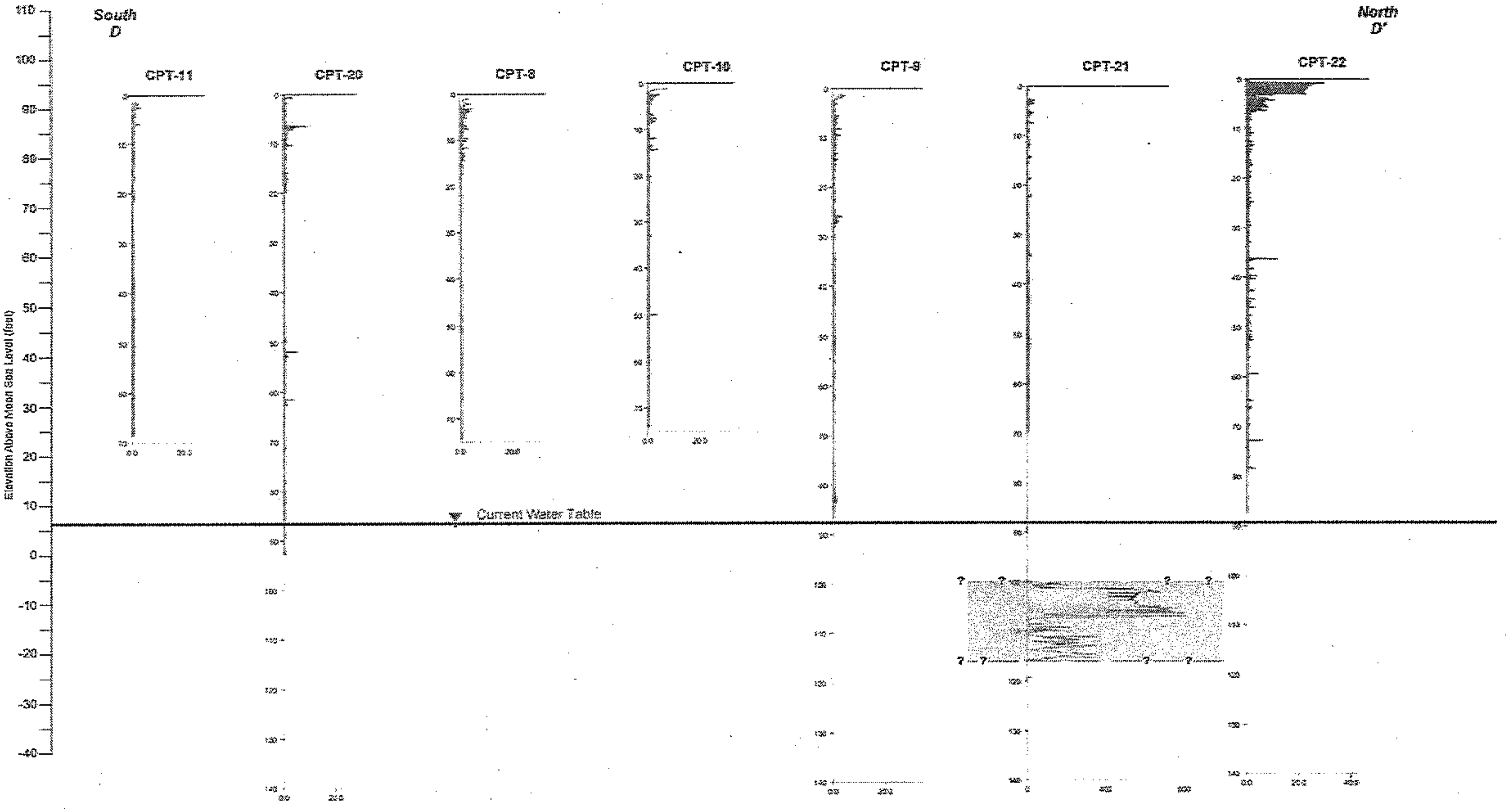
GENERALIZED ROST CROSS-SECTION C - C'
FOR AREA SOUTH OF BUILDING A
BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205525.08

Figure 11

Date Drafted:
2/26/14



EXPLANATION

▨ Possible zone of LNAPL occurrence (ROST reflectance greater than approximately 3% in shallow WBZ)

0 10 20 30
Approximate Vertical Graphic Scale in Feet
(Horizontal Scale in Percent Reflectivity)

Disclaimer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

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## GENERALIZED ROST CROSS-SECTION D - D' FOR AREA EAST OF BUILDING A

BlackRock
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

Project No.:
01205526.08

Figure 12

Date Drafted:
2/26/14

# APPENDICES

# Appendix A

## Dissolved- and LNAPL Plume Stability Evaluations and Discussion of Cleanup Implications

Aqui-Ver, Inc.
August 30, 2011

# DISSOLVED- AND LNAPL PLUME STABILITY EVALUATIONS AND DISCUSSION OF CLEANUP IMPLICATIONS

## FORMER WESTERN FUEL OIL FACILITY
## 300 WESTMONT DRIVE
## SAN PEDRO, CALIFORNIA

August 30, 2011

For:

Mr. Leland Nakaoka
BlackRock Realty Advisors
4400 MacArthur Boulevard, Suite 700
Newport Beach, CA 92660

In Cooperation With:

SCS Engineers
8799 Balboa Avenue, Suite 290
San Diego, CA 92123

AQUI-VER, INC.
*Hydrogeology, Water Resources & Data Services*

# DISSOLVED- AND LNAPL PLUME STABILITY EVALUATIONS AND DISCUSSION OF CLEANUP IMPLICATIONS

## FORMER WESTERN FUEL OIL FACILITY
## 300 WESTMONT DRIVE
## SAN PEDRO, CALIFORNIA

**For:**

**Mr. Leland Nakaoka**
**BlackRock Realty Advisors**
**4400 MacArthur Boulevard, Suite 700**
**Newport Beach, CA 92660**

**In Cooperation With:**

**SCS Engineers**
**8799 Balboa Avenue, Suite 290**
**San Diego, CA 92123**

By:

AQUI-VER, INC.
*Hydrogeology, Water Resources & Data Services*

Principal Authors:

G.D. Beckett, R.G., C.HG., Principal Hydrogeologist

Nathaniel Beal, P.G. Senior Hydrogeologist

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## APPENDICES

# EXECUTIVE SUMMARY

**AQUI-VER, INC.** (AVI) has completed technical evaluations on behalf of BlackRock Realty Advisors regarding dissolved and light non-aqueous phase liquid (LNAPL) plume conditions present beneath the former Western Fuel Oil Site, 300 Westmont Drive, San Pedro, California. The site is presently operating as the San Pedro Business Center, which handles Port-related commerce and transportation.

AVI's evaluations consisted of technical analyses to determine the state of the tert-butyl alcohol (TBA ) and benzene dissolved-phase plumes, and separate evaluations to determine the state of the LNAPL plume remaining beneath the site.

Based on several lines of technical evaluation including mass, flux and trends, the TBA plume is indicated to be stable and is not being transported into the wider aquifer offsite. This, coupled with the marginal quality groundwater beneath the site suggest that this plume meets State standards for presenting no threat to future groundwater use. In addition, potential TBA mass flux evaluations indicate that there is generally no threat to future groundwater use at the Site itself.

Based on several lines of technical evaluation, the LNAPL plume remaining beneath the site has also been determined to be stable. This is due to a number of factors such as time since release, the site specific subsurface parameters, the observed plume morphology, and other facets. Past cleanup actions have also likely contributed to this observed LNAPL stability condition.

A framing of the technical exceptions for further LNAPL cleanup was also developed. Given the site conditions, including past cleanup, there appears to be no net benefit to the waters of the State to additional cleanup measures. Any cleanup measure having any remote chance of further reducing contaminant concentrations in the near term would also severely impede the Port Distribution Facility operations. As a successful Brownfield redevelopment project, the active use of the site is important to the area economy.

Given these findings and conclusions, AVI's work suggests that the site move into a monitored natural attenuation phase, with no further active cleanup, in keeping with the SWRCB Resolution 92-49 and the recent SWRCB update to low-risk groundwater policy (2011).

# 1.0 DISSOLVED PHASE PLUME EVALUATIONS

This chapter discusses dissolved phase plume evaluations with respect to stability, status, and threat to the waters of the State. As discussed below, several techniques were used to evaluate the dissolved phase plumes at the site as related to closure and long-term management considerations.

## 1.1 PURPOSE

The purpose of this analysis is two fold:

1. Evaluate the stability, potential longevity, potential impacts to groundwater utilization, and the potential fate and transport of the tert-butyl alcohol (TBA ) groundwater plume; and

2. Evaluate the stability of the benzene groundwater plume at the site to assist in evaluating the LNAPL plume stability in Chapter 2 of this report.

TBA and tertiary-amyl alcohol (TAA) are currently the chief dissolved phase fuel oxygenates chemicals of concern (COCs) at the Site; however, TAA was not evaluated in this analysis due to the limited data set for this compound. For example, TAA was only sampled in the core of the plume (wells MW-6R, MW-14R, and MW-19R) one time, in August 2007, and site monitoring wells were not analyzed again for TAA until June 2008. In addition, TAA has not been detected more than once in any of the onsite wells. As such, only TBA was analyzed during this evaluation.

The benzene plume was evaluated because it provides insight into the stability of the LNAPL plume. For example, if the benzene plume is not moving downgradient or is contracting then one can infer that the LNAPL plume, which is the source of the benzene plume, is not moving as well. This relationship is described in more detail in Chapter 2 of this report.

All analyses presented herein were performed using data provided by SCS Engineers and from documents on Geotracker (SWRCB, 2011). Data analyses were performed on the data as provided and only reflect the most recent data electronically available (generally through June 2011).

As will be described subsequently, the evaluations conducted herein utilize historic groundwater concentration data, in context with other site characterization information, as a key indicator of the historical and future probable plume state. This focus was developed because groundwater is in contact with residual petroleum hydrocarbons, and understanding the stability, potential plume longevity, potential impacts to groundwater utilization, and potential fate and transport of the TBA plume and the stability of the benzene plume in relation to the LNAPL plume directly affect long-term site care requirements and closure.

## 1.2 METHODS

The basic evaluation methodologies and procedures for the plume longevity estimates, potential impacts to groundwater utilization, and plume stability are provided in Appendix 1-1, and are derived from plume genesis and transport theory. The methodologies are consistent with United

States Environmental Protection Agency (USEPA) recommended protocols for evaluating plume trends (USEPA, 2002).

The fate and transport analysis for TBA was performed using BIOSCREEN (Newell and McLeod, 1996). BIOSCREEN is an analytical groundwater model designed to simulate transport and natural attenuation of dissolved phase hydrocarbons at petroleum release sites. The fate and transport analysis was performed to assess the potential lateral migration of the TBA plume and plume stability based on site data and assumed parameter values from published literature.

## 1.3 DISSOLVED-PHASE MASS ESTIMATES

The mass of TBA dissolved in groundwater was statistically evaluated to estimate the maximum dissolved phase TBA mass observed at the Site based on available site data. This mass estimate was used to estimate plume longevity and to evaluate potential mass flux impacts to future groundwater use at the Site as described in Sections 1.5 and 1.6, respectively. The maximum historical dissolved phase mass was estimated for August/December 2007. This time period represents the most comprehensive data set available for the site and includes onsite wells MW-6R, MW-14R, and MW-19R,which were only sampled one time in August 2007 by collecting discrete samples below the LNAPL layer in the well casing, as well as onsite wells MW-5R, MW-8, MW-9R, and MW-10R and offsite wells MW-12, and MW-13. This data set also includes off-site wells MW-4, MW-7, and MW-8, which are part of the ConocoPhillips site investigation to the north. These wells are shown by Figure 1-1. All of the wells included in this analysis are completed within the shallow water bearing zone characterized at the site, which is part of the Gage Aquifer (SCS, 2011a). Wells completed in the intermediate and deep water bearing zones were not considered for this analysis because the majority of the plume mass is in the shallow water bearing zone.

The first step in calculating the dissolved mass is to constrain the area of integration for TBA, which reflects the maximum plume dimensions historically observed. The TBA groundwater concentration data were compiled, log-transformed, and analyzed using kriging statistical methods. The statistically generated results were reverse transformed to arithmetic values and integrated across the spatial domain to provide a mass estimate based on the estimated impacted aquifer volume.

The impacted aquifer thickness was assumed to be 25 feet thick and the aquifer total porosity is assumed to be 40% based on core data collected by SCS Engineers (SCS, 2011a).

Table 1-1 summarizes the results of the estimated dissolved-phase mass for TBA. The statistically interpolated plume distribution map is illustrated on Figure 1-2. The dissolved phase mass was 405.3 kilograms (kg) in August/December 2007 and this mass is thought to represent the maximum historical dissolved phase mass based on available site data.

## 1.4 ESTIMATION OF CENTER OF MASS THROUGH TIME

An evaluation of the TBA center-of-mass through time could not be conducted due to the lack of available TBA data. Therefore, TBA plume stability was evaluated using a fate and transport screening, as described subsequently. The benzene center-of-mass was evaluated through time; however, there were some limitations to this analysis as described below.

The statistical center-of-mass for benzene was estimated for three time stamps (April 2002, June 2005, and June 2011) using available data from onsite wells MW-5R, MW-8, MW-9R, and MW-10R and offsite wells MW-12, and MW-13. This data set also includes off-site wells MW-4, MW-7, and MW-8, which are part of the ConocoPhillips site investigation to the north. Wells MW-6R, MW-19R, and MW-14R are located within the core of the benzene plume; however, these wells were only sampled twice (April 2002 and August 2007) by collecting discrete samples below the LNAPL layer in the well casing. During the first sampling event in April 2002 it appears that the groundwater samples were emulsified (i.e., mixture of LNAPL and groundwater) based on elevated total petroleum hydrocarbon gasoline range (TPH-GRO) sample results that exceed solubility limits. As such, this data could not be used leaving only one time stamp that is meaningful for these wells. Given that one time stamp is not suitable for estimating the center-of-mass through time, these wells were eliminated from the data set. This results in a plume center-of-mass that is slightly mislocated for all time stamps; however, evaluating the relative change or lack there of in the center-of-mass is the objective of this analysis not finding the exact location of the center-of-mass.

The wells used in this analysis are shown by Figure 1-1 and all of the wells included in this analysis are completed within the shallow water bearing zone characterized at the site, which is part of the Gage Aquifer (SCS, 2011a). Wells completed in the intermediate and deep water bearing zones were not considered for this analysis because the majority of the plume mass is in the shallow water bearing zone. In addition, the submerged LNAPL plume is not present in the underlying water bearing zones.

Plume statistics for benzene were generated using the same mass estimate analysis procedures described in Section 1.3 for TBA. Based on these statistics the location of the statistical center-of-mass was calculated. The center-of-mass calculation is performed by summing the concentrations at the statistical grid intersects across the spatial domain established by the interpreted plume boundary (Anton, 1984). At each grid intersect, a specific northing and easting are associated with a specific concentration. In each coordinate direction, the north or east coordinate is multiplied by its specific concentration and summed across the grid in that coordinate direction. This value is then divided by the sum of concentrations at each grid intersect, leaving the estimated coordinates of the center of mass (east and north, respectively).

The center-of-mass location for each time stamp are illustrated in Figures 1-3. The plume maps used to estimate the center-of-mass location for each time stamp are included in Appendix 1-2. The center-of-mass analyses for benzene demonstrates a stable plume. The relative center-of-mass has actually retracted through time.

## 1.5 PLUME LONGEVITY EVALUATION

Statistical trend analyses of dissolved-phase concentrations of TBA were performed on historical analytical data from site wells with sufficient temporal data. This includes wells MW-9R and MW-10R, as these wells were the only wells at the site with more than one detection of TBA.

The graphical trend analyses were performed with non-detections set to half the laboratory reporting limits, with exceptions. Elevated laboratory detection limits ranging from 100 to 500 ug/L were reported for well MW-10R. Half of the detection limits are greater than or just below historical detections so non-detect data were not used for the trend analysis for MW-10R to avoid biasing the trend by using unconstrained non-detect points. The statistical trends exhibited by MW-9R and MW-10R were decreasing over time and these decreasing trend lines were projected through time until they reached the California drinking water notification level (NL) for TBA, which is 12 micrograms per liter (ug/L).

The exponential trend regression was performed on the time/concentration data using a confidence interval of 95%. Confidence intervals assume a normal distribution about a mean of the predicted regression fit. Then the standard deviation of the samples about the predicted concentration is used to bound the data. Exponential statistical analysis is consistent with the theoretical form of chemical transport and depletion processes. A linear analysis would tend to estimate shorter plume durations and be both less conservative and less reflective of the underlying plume depletion processes.

The statistical trend analysis plots for TBA through time for wells MW-9R and MW-10R are included in Appendix 1-3. Using the statistical regression fit of the concentration data, as shown in Appendix 1-3, the time to reach the regulatory criteria for TBA was estimated for these wells as summarized in Table 1-2. While the trend predicts when the compound will reach regulatory criteria, the actual concentration is expected to range between the upper and lower bounds of the trend line. As summarized in Table 1-2, by using both the curve fit and upper 95% confidence bound, a range of times to regulatory criteria are estimated with the later date providing a more conservative estimate.

Wells MW-9R and MW-10R are generally located on the downstream portion of the plume and are downgradient of the center of mass. Based on the statistical trends in these wells TBA is predicted to reach the NL of 12 ug/L between 2012 and 2015 in well MW-9R and between 2018 and 2024 in well MW-10R. In addition, the decreasing trends in both wells suggest that the leading edge of the TBA plume is stable and has retracted through time. A non-stable or expanding plume would exhibit an increasing trend along the leading edge of the plume. Thus, the TBA plume has likely reached a steady state. This is further supported by the fact that TBA has not been detected in offsite downgradient well MW-8 located on the ConocoPhillips site (Figure 1-2).

## 1.6 FLUX CALCULATIONS

The statistical mass evaluations for TBA described in Section 1.3 can be used to estimate the potential groundwater flux of TBA emanating from the site. The flux estimate is generated from the plume-wide statistical groundwater concentrations developed earlier for the geometry of the plume and the potential groundwater flow rates through the plume. This integrated average concentration (the same as used in the mass calculations), accounts for spatial plume distribution that a simple arithmetic average cannot. The flux estimate is used to estimate the potential worst-case impacts at a hypothetical drinking water production well located onsite. This estimate is conservative and alleviates the need for more extensive modeling evaluations that would show significantly smaller potential impacts. The flux estimate pertains to a hypothetical groundwater production well completed at the site with two different well screen interval scenarios. The first scenario assumes a well screen of 50 feet which is twice that of the assumed impact thickness in the shallow water bearing zone. This scenario is the most conservative of the two. The second scenario assumes a screen length of 100 feet. Scenario two assumes that the production well screen will nearly fully penetrate the Gage Aquifer beneath the site.

Hydraulic conductivity was set at 1 foot per day (ft/day) based on a report from CAPE (2007), the effective porosity was set at 25% based on a report from SCS (2009), and the lateral hydraulic gradient was set at 0.007 feet per foot (ft/ft) based on SCS (2009). The current lateral hydraulic gradient in the shallow water bearing zone is 0.003 ft/ft (SCS, 2011b); therefore, using the higher gradient of 0.007 ft/ft is more conservative. The conceptual groundwater pumping well is assumed to capture 100% of the conservative chemical flux emanating in groundwater from the site. The flux analysis results are summarized in Table 1-3 and estimate potential impacts to a production well at various flow rates. The input and output factors for this flux analysis are provided in Appendix 1-4.

For TBA, there is no predicted impact above the regulatory threshold of 12 ug/L for all scenarios and pumping rates. Furthermore, utilization of groundwater from the Gage Aquifer would require treatment (e.g., reverse osmosis) to remove naturally occurring dissolved phase constituents as indicated by water quality samples collected by SCS (2011b). During this treatment process dissolved phase TBA would most certainly be removed from the produced water. As such, this analysis demonstrates that potential impacts to future groundwater use are unlikely and the TBA plume poses no risk to the waters of the State, especially considering the natural poor groundwater quality in the Gage Aquifer beneath the site.

## 1.7 FATE AND TRANSPORT

To assess the potential lateral migration of the TBA plume existing data collected from the site and assumed parameter values from published literature were used in conjunction with an analytical modeling approach to evaluate plume stability.

The analytical modeling was conducted using the computer program BIOSCREEN (Newell and Mcleod, 1996). BIOSCREEN is specifically designed to simulate transport and natural attenuation of dissolved phase hydrocarbons at petroleum release sites. The software has the ability to simulate advection, dispersion, adsorption, and aerobic decay as well as anaerobic reactions that have been shown to be the dominant biodegredation process at many petroleum release sites. BIOSCREEN includes three different model types:

- Solute transport without decay;
- Solute transport with biodegredation modeled as a first-order decay process (simple lumped-parameter approach); and
- Solute transport with biodegredation modeled as an "instantaneous" biodegredation reaction (approach used by BIOPLUME models).

For this effort, solute transport with biodegredation modeled as a first-order decay process was selected because of the limited amount of data available to support the instantaneous reaction model.

BIOSCREEN is based on the Domenico (1987) three-dimensional analytical solute transport model. The original model assumes a fully-penetrating vertical plane with the source oriented perpendicular to groundwater flow, to simulate the release of organics moving into groundwater. In addition, the

Domenico solution accounts for the effects of advective transport, three-dimensional dispersion, adsorption, and first-order decay.

The source area concentration was set at 18.4 milligrams per liter (mg/L), which is the maximum observed TBA concentration at the site (MW-14R). The size of the source area was conservatively defined using the TBA plume dimensions from August/December 2007, as shown by Figure 1-2. The depth of the source area was set at 25 feet, which is the assumed impact thickness for TBA. A further conservative assumption is that the source area concentration remains constant at its existing concentration indefinitely. This combination of assumptions is likely to produce the most conservative analysis based on available data. The model input parameters are summarized in Appendix 1-5. Where appropriate, model input parameters reported by SCS (2009) for the previously conducted benzene BIOSCREEN modeling were used for the TBA BIOSCREEN modeling. ,

The model was calibrated based on field data from August/December 2007 by adjusting solute half life and the related first order decay coefficient as well as dispersivity until output results fit the field data set. The best fit was based on the parameters shown in Appendix 1-5. Based on this calibration TBA must be naturally attenuating because the modeled plume would not fit the field data unless a decay coefficient was assumed, albeit a low decay coefficient was simulated. The former Western Fuel Oil site ceased petroleum operations in 1995. The facilities that served those operations were demolished between 1997 and 1999 in preparation for redevelopment of the San Pedro Business Center. Therefore, releases likely ceased by 1995 when the operations stopped, excepting the possibility of small releases from left-over product in piping or other ancillary structure. By the end of demolition, that potential residual source was also eliminated. Assuming no natural attenuation TBA would have likely been detected in the furthest most downgradient well (MW-8 at the ConocoPhillips site) by 2007. This well is approximately 500 feet from the source and TBA has never been detected in this well. Thus the TBA plume is likely stable and generally confined to the site by natural attenuation processes.

It should be noted that this approach is not sufficiently rigorous to represent an exact prediction of site conditions. In addition, calibration using the field data was done using reasonable assumptions, but there were some limitations. For example, the defaults for the "distance from source" in the BIOSCREEN model were not exactly equal to the distances observed with the field data, as such the model calibration represents the best fit given these limitations. In addition to the field data limitations, the simulation itself incorporates several limiting assumptions; however, these assumptions do not affect the overall conservative conclusions.

## 1.8 METHOD CONSERVATISM

The plume evaluation methods detailed in Appendix 1-1 and resultant findings summarized in this report provide conservative, worst-case evaluations of site-specific dissolved-phase plume conditions, longevity, and potential impacts to groundwater use. The cumulative consideration of these aspects of plume behavior leads to a conservative, weight of evidence approach using site data.

The underlying premises of the analyses are that observed temporal and spatial groundwater data trends are the actual observed end products of all partitioning and transport phenomena. These methods are derived directly from plume partitioning and transport processes, and are consistent with USEPA recommended protocols for evaluating plume trends (USEPA, 2002). These methods have been applied successfully for State Water Resources Control Board Resolution 92-49 closures in San Diego; Los Angeles; and, Orange Counties. A brief summary of the conservative factors in the analyses is provided in the list below.

- Geographic-based dissolved-phase mass estimates: When the plume masses are estimated at different time stamps, an area greater than or equal to the general maximum historic footprint size of COC for all subsequent plume mass calculations is used as the outer bound of the integration and "Not Detected" (ND) concentrations are expressed as the general detection limit. Therefore, this conservatively overestimates the dissolved-phase mass in depleting plumes.

- Temporal well by well plume longevity evaluation: The upper 95 % confidence bound has been used in predicting time to regulatory criteria which adds conservatism to the estimates. Additionally, the estimates do not account for acceleration of degradation processes as mass decreases and the assimilative capacity of the aquifer and vadose zone increases, resulting in conservative estimates, particularly for wells in the plume core.

- Mass flux calculations: It is assumed that the hypothetical production well (theoretically placed on-site) will capture 100% of the already conservatively over-estimated plume mass discharge. The hypothetical groundwater production rates are assumed without consideration whether the aquifer could indeed sustain production at economically viable rates. When this analysis suggests no risk, it means in effect that a drinking water well could be placed in the center of the plume and net concentrations at that well would be below applicable maximum regulatory levels at various flow rates.

In summary, these various layers of conservatism mirror USEPA risk assessment practices and those of ASTM to provide a direct analysis based on data, rather than models, to assess the safety of site closures under Resolution 92-49. It is estimated that the safety factors involved generate more than 3 orders of conservatism over actual expected conditions.

## 1.9 SUMMARY OF DISSOLVED PLUME CONDITIONS EVALUATIONS

The following summary points provide key observations of dissolved-phase plume conditions at the site based on the data provided:

1. The geospatial mass distributions illustrate the plume stability for benzene (Figure 1-3).

2. No wells were observed to exhibit increasing TBA trends and the wells with sufficient data for a trend analysis exhibited a decreasing trend and reach the regulatory criteria by at the latest 2024 in the wells that are located along the leading edge of the plume (Appendix 1-3). Thus the center of mass of the TBA plume is likely stable and is not moving downgradient.

3. Worst-case scenario predictions using the mass flux from the site to estimate maximum concentrations of TBA at a hypothetical drinking water well result in no impacts above

regulatory criteria for TBA (Table 1-3). Furthermore, utilization of groundwater from the Gage Aquifer would require treatment to remove naturally occurring dissolved phase constituents. During this treatment process TBA would most certainly be removed from the produced groundwater.

4. TBA has not been detected in off-site ConocoPhillips well MW-8 and has not been detected above the NL (12 ug/L) in offsite well MW-12, both of which are located directly downgradient of the source area. MW-8 (ConocoPhillips) and MW-12 have generally been monitored for TBA since it was first detected at the site (2007); although MW-12 was abandoned in 2009.

5. The plume trends and fate and transport analysis suggests that the TBA plume is stable laterally and is attenuating, which is further supported by the absence of detections in downgradient well MW-8 located on the ConocoPhillips site.

6. As discussed in the main body of the Corrective Action Plan (CAP) report, the TBA plume is also contained vertically by predominantly upward vertical gradients in the Gage Aquifer beneath the site.

Based on the summary of findings above, the TBA plume appears to be stable and contained by natural attenuation processes. This, coupled with the marginal quality groundwater beneath the site suggest that this plume meets State standards for presenting no risk, and no threat to future groundwater use.

# 2.0 LNAPL PLUME EVALUATIONS

Various light non-aqueous phase liquid (LNAPL) flow and transport properties have been measured at the site. Coupled with the physics of multiphase flow, the following report sections discuss the parameter values, as well as the implications and findings from those.

## 2.1 OVERVIEW OF MULTIPHASE MECHANICS

Light non-aqueous phase liquid (LNAPL) flow and stabilization (mobility/stability) can be understood through the physics controlling the movement of one fluid phase in the presence of other phases (multiphase flow). Multiphase physics account for the hydraulic interactions and movement of multiple fluids in the pore space, which for these site conditions typically include water, vapor, and LNAPL. These physics control the nature and genesis of LNAPL plume releases. Ignoring compositional reactions, multiphase mechanics are governed by the Continuity Equation for mass conservation (Equation 1), which describes the mass movement of any phase in any direction for a non-deforming coordinate system (Huyakorn et al., 1994; Panday et al., 1994).

$$\frac{\delta}{\chi_i}[k_{ij}\ k_{rp}\ \frac{\rho_p}{\mu_p}\ \frac{\delta\Phi}{\delta\chi_i}] = \frac{\delta}{\delta t}(\theta\ \rho_p\ S_p) - M_p \qquad (1)$$

*Where: "$\partial$" is the differential operator, $\chi_i$ indicates the Cartesian direction of the 3-dimensional differential equation; $k_{ij}$ is the intrinsic soil permeability tensor, $k_{rp}$ is the relative permeability scalar to phase "p", subscript "p" refers to the fluid phase of interest, $\Phi$ is the fluid potential (( $\partial\Phi/\partial\chi_i$ is the fluid potential gradient), "t" is time, $\theta$ is soil porosity, $\rho_p$ is the density of phase "p", $S_p$ is the phase saturation, and $M_p$ is a mass source/sink term.*

Despite the complexity of the continuity equation, the principles it represents are easily described. Movement of any phase (water, LNAPL, or vapor) in any primary Cartesian direction (represented by the left side of the equation) is controlled by the fluid and soil properties and the gradient in that phase at any point in time and space. Net phase movement into or out of an elemental volume must be equaled by a coincident change in mass within that volume (the right side of the equation). If either the phase conductivity or the phase gradient is zero, there is no phase movement or mobility. The fluid potential $\Phi$ includes a gravity term, and for LNAPL, is driven by the head conditions of the LNAPL release, overprinted to varying degrees by the water table gradient.

As a result of these physics, one would expect the development of LNAPL bodies to be highly transient in the early stages of the release due to the nonlinear aspects of the controlling physics. An ideal plume, superimposed on a 0.001 feet per foot (ft/ft) groundwater gradient, would develop through time as shown in the time series sequence of LNAPL saturation distribution in Figure 2-1. One can see from the LNAPL distribution that the LNAPL gradient is initially mounded, with flow in both up- and down-stream directions relative to groundwater flow. The LNAPL gradient dissipates through time, and the mass redistributes laterally, depleting a fraction of the concentrated central mass that was present during the early stages of the release. LNAPL saturations generally remain greatest in the mass centroid area and are lesser in areas distal to the release zones.

As a result of these mechanics, a finite LNAPL release will slow exponentially through time, eventually coming to static equilibrium with the prevailing field conditions. There are 4 key mechanisms that explain this expected stabilization through time, each of which can be amplified by geologic heterogeneity:

1. The LNAPL gradient diminishes through time, as the fluid head created by the release cannot be sustained without an ongoing release;
2. Many porous materials have a pore entry pressure; non-wetting fluids, like LNAPL in most conditions, cannot intrude without a sufficient pressure gradient in that phase;
3. The LNAPL effective conductivity diminishes through time as the finite volume of oil is spread over larger volumes of aquifer materials. As this occurs, the overall LNAPL saturation decreases as a function of spreading and the relative permeability toward oil also decreases exponentially. This is accentuated by water table fluctuations like the overall rise in site area water levels due to the sea water barrier system, acting to redistribute LNAPL over larger volumes of aquifer and vadose zone materials, as well as stranding significant immobile fractions beneath that risen water table;
4. Soil has a capacity to hold oil against drainage as residual. This means that a finite LNAPL release will theoretically be retained as residual at some maximum spreading distance. In practice this final endpoint is not generally observed because of the other facets of stabilization.

Given the factors above, there are several interpretive aspects that can assist in assessing the state of the LNAPL stabilization process at the site. Given the unknowns on release specifics and timing, it is often observed that no single line of evidence is sufficient for the stability evaluation. The evaluation of plume stability/mobility herein uses a weight-of-evidence approach considering all these factors and interpretations. The associated lines of evidence include:

1. Confirmation that the LNAPL releases are finite and not ongoing in the site;
2. Evaluation of the relative age of the LNAPL plumes; the older a plume, the more probable it has reached field static equilibrium;
3. Evaluation of LNAPL gradients;
4. Comparisons of estimated LNAPL to water conductivity values;
5. Evaluation of LNAPL flow;
6. Review of petrophysical properties, including expectations for an entry pressure threshold;
7. Inspection of LNAPL plume distribution to consider whether the morphology is consistent with the form of a stable plume.

The sections that follow present the site data pertinent to the controlling physics described above.

## 2.1 BASIC PETROPHYSICAL PROPERTIES

Basic petrophysical properties are those that have some direct and indirect influences on LNAPL volume, mobility, and transport, but are not the most sensitive of the influencing factors. These are commonly measured parameters for application to a wide spectrum of geological and engineering practices. For this site, they include permeability, porosity, grain and bulk density, moisture content, and grain-size distribution. Reports generated by the petrophysical laboratory are presented in the recent comprehensive site investigation (SCS, 2011a); recall that there have been multiple data collection events, and different sets of parameters were derived during each testing stage. An overview of the results of permeability, grain-size, and porosity results is discussed below. The remaining parameters are less important and are available in the lab reports.

The hydraulic conductivity of the upper aquifer materials has been estimated at about 1 ft/day (CAPE, 2007). This corresponds to a soil permeability in the hydraulically responsive zones of about 0.35 Darcy. Lab testing of 2 soil cores indicated intrinsic permeability ranging from 0.059 - 0.087 Darcy (SCS, 2011a), smaller than the field-derived value. Typically, field values are favored as the hydraulic responses represent flow across a larger domain that is less affected by the scale of the sample than are soil cores.

The grain-size distributions for the soil samples indicates that most of the materials are primarily fine-grained sand with significant silt and some clay. Except for one sample, SCS-B3-91.0 that had about 6.5% fines (silt + clay), the remainder had fines ranging from 20.9 - 62.1%, with a geometric mean of 32.3% and a median of 34.9%. This significant fraction of fines suggests that LNAPL movement/recovery will be limited because of the high expected capillarity; oil moves less readily in materials with small pore dimensions, all other things being equal. Measured capillary properties are discussed below.

Porosity has been measured for several samples, ranging from 24.1 - 47.6%, with a median of 41.9% and a geometric mean of 40.1%. The lower values in the 24% range are low for granular sedimentary materials, but the median and geometric mean values are well within the expected range for predominantly sandy and silty materials.

## 2.2 CAPILLARITY

Soil capillarity controls the saturation of any phase (water, oil, air) as a function of fluid pressures and the pore throat distribution in the sample soil core. Capillary pressure is the difference in pressure between the non-wetting and wetting phase for any couplet (water-air, water-oil, oil-air). The capillary curves are different for each couplet as a function of the interfacial tensions between the fluid pairs. However, because the pore geometry is the same for a given sample core, these curves are scalable to one another by the ratios of interfacial and surface tensions (Farr et al., 1990). That means that a single capillary curve for one couplet, say water-air, can describe the remainder of the system. All three couplets are needed to describe the multiphase conditions of the full system as described in Equation 2-1 earlier in this section.

Following the norms in the multiphase field, air-water capillary curves were measured for two selected cores collected in the 2011 characterization events (SCS, 2011a). Based on the lab data, AVI determined the capillary parameters presented in Table 4-4 (data and curve fits are in Appendix 2-1). Briefly, smaller values of "α" indicate overall smaller pore diameters with a larger capillary rise. Larger values of "n" indicate a more uniform pore geometry. As expected from the grain-size results, these two samples exhibit high capillarity (high water retention, and a low "α" value). The residual water saturation is the asymptotic value of the left side of the curve. Last, the breakthrough pressure is the capillary pressure at which air initially displaces water at 0.5% or more (practical detection limit). This observed air-entry pressure also implies there is an oil-entry resistance as well.

## 2.3 LNAPL SATURATION

Saturation refers to the fraction of the pore space that is filled with any particular fluid phase. For instance, a saturation of 10% within a porosity of 40% would mean a volumetric content of 0.04 for a given fluid. LNAPL saturation is related to volume, mobility and recoverability, as discussed in the multiphase physics overview above. Because it is a bulk physical measurement, saturation results are a relatively simple and direct measurement of oil volume in the pore space and does not have the same limitations as chemical analyses of mass.

In addition to the in situ saturation, residual saturation may also be measured in the lab. Residual saturation refers to the threshold below which physical movement ceases. There are 2 states for residual saturation; 3-phase and 2-phase. Three-phase residual saturation is the threshold of immobility where air is displacing both water and oil. Two-phase residual saturation is the threshold of immobility for saturated conditions where only water and oil are present. Typically, 3-phase saturations are smaller than 2-phase saturations for the same oil and soil types (e.g., Figure 2-2). The summary details of each type of test are discussed in the following subsections.

### 2.3.1 In Situ LNAPL Saturation

In situ LNAPL saturation measurements were conducted using the Dean-Stark method during sampling events from 2005 to present. This method essentially uses weight measurements combined with solvent stripping of all liquids from the sample. Knowing the initial sample weight, the volume of solvent used and recovered, the fraction of water, and the porosity, the LNAPL saturation may then be determined.

LNAPL saturation was measured on 12 soil cores (SCS, 2011a) and ranged from 0 to a maximum of 20.4% in sample SCS-B2-98.0. The median value is 6.1%, and the geometric mean is 2.5%. These samples are purposely biased in that they specifically targeted zones of strongest laser-induced fluorescence (LIF) signals that suggested the presence of relatively more significant LNAPL than in zones of lower signals.

### 2.3.2 LNAPL Mobility/Three-Phase Residual LNAPL Saturation Results

SCS had testing performed on 5 soils cores for what the lab terms a "Free Product Mobility Evaluation", but it is more properly a 3-phase residual saturation test. For this test, native cores are placed in a centrifuge apparatus and a force of 1,000 x Gravity (G) is applied to displace both LNAPL and water. For perspective, 1,000 G = 29, 921 in Hg & 1,033,227 cm water, and is an exceedingly large displacement pressure that drives the fluids to a residual saturation endpoint. The initial and final volumes of fluids in the pore space are measured, that which is left in the core represents the 3-phase residual saturation. The initial saturations represent the native state of a sample core at the time of sampling.

Consistent with the multiphase principles, review of Figure 2-3 indicates that in general, more oil is produced from cores that have a higher initial LNAPL saturation. It is observed that very little oil is produced from cores that have less than about 7% initial LNAPL saturation. The final residual LNAPL saturation values range from 5.9 - 8.2%. Given that the cores are subjected to 1,000 G of force, these results represent a force, gradient, and endpoint saturations that cannot be achieved under ambient or remediation field conditions. A more likely field value would be twice that range, as suggested in an example saturation versus pressure data set from a site with similar aquifer materials (Figure 2-4). The results from these tests will be used subsequently along with data to assist in estimating the hydraulically recoverable fraction of LNAPL.

Further, as shown in LIF cross-section Figure 2-5, the majority of the LNAPL is submerged beneath the water table, and 2-phase residual saturations would apply to that zone, and would be expected to be much greater than the 3-phase results discussed (recall Figure 2-2).

## 2.4 LNAPL PHYSICAL PROPERTIES

The physical properties of the LNAPL include its density, viscosity, and the interfacial tension between the LNAPL, air, and water. These properties together control the physical transport and recovery of the LNAPL. Other things being equal, a high viscosity product will have a lower potential mobility and recoverability than a low viscosity LNAPL, much like viscous paint will pool locally when spilled on the ground, but ethyl alcohol will run out flat. The density, along with capillary properties, controls the amount of oil that penetrates into the aquifer materials as a function of the driving head. Interfacial tensions allow the capillary properties for one phase couplet (air-water in this case) to be scaled to the other capillary couplets (air-oil, oil-water). All 3 couplets are needed to describe a multiphase system from a mechanistic point of view, as discussed previously.

Based on carbon chain characterization work done previously (Jones Environmental, 2002), the LNAPL resembles predominantly kerosene to Jet A ranges of hydrocarbons, which have relatively similar physical properties. The density is expected to be approximately 0.81 g/cc, and the viscosity around 1.5 cP. The interfacial tension for air-water is typically around 72 dynes/cm, the water/oil IFT around 25 (field state) and the oil/air also around 25 dynes/cm. These physical parameters are based on literature ranges published in the API Interactive LNAPL Guide (2004) and its assoicated references.

## 2.5 LNAPL CONDUCTIVITY

As discussed previously, the ability of LNAPL to flow in the subsurface is proportional to the intrinsic and relative permeability, as well as the distribution of LNAPL. Like groundwater, LNAPL has both a hydraulic conductivity and transmissivity based on these factors.

The aquifer permeability was discussed above, with a field value of about 0.35 Darcy representing the higher range as compared to lab values. The LNAPL hydraulic conductivity can be determined by the formula below:

$$K_L = k_{rL}\ k_i \, {\rho_L g}\big/{\mu_L} \qquad (2)$$

*Where "L" denotes the LNAPL phase, and* $K_L$ *is the LNAPL conductivity, the remainder of the parameter being previously defined in equation (1) above.*

$$q_L = K_L i_L \quad V_L = {q_L}\big/{\theta S_{Le}} \qquad (4)$$

$$k_{rL} = (1 - S_{ew})^{0.5} (1 - S_{ew}^{\ 1/M})^{2M}; \; M = 1 - 1/N \qquad (3)$$

*Where N is the van Genuchten capillary fitting parameter discussed previously, and $S_{ew}$ is the effective water phase saturation, where residual saturation values are scaled out as those represent a volume of the pore-space not available to active flow.*

Given these relationships, and the site parameters discussed previously, the hydraulic conductivity toward LNAPL is estimated for each of the soil cores collected in recent work by SCS (2011), and shown in Table 2-1 below. As seen, where there is a value greater than zero, the LNAPL conductivity is quite small, about 100 - 20,000 times less than the groundwater conductivity of about 1 ft/day (discussed above).

**TABLE 2-1: LNAPL HYDRAULIC CONDUCTIVITY ESTIMATES**

| Sample ID | Parameters | | | | | (ft/day) |
|---|---|---|---|---|---|---|
| | $S_n$ | $S_{rL}$ | $S_{rw}$ | $S_{ew}$ | $k_{rL}$ | $K_L$ |
| SCS-B1-99.0' | 10.10% | 6.83% | 20.50% | 95.49% | 3.70E-02 | 1.78E-03 |
| SCS-B2-98.0' | 20.40% | 6.83% | 20.50% | 81.32% | 2.12E-01 | 1.02E-02 |
| SCS-B2-112.0· | 4.90% | 6.83% | 20.50% | 102.65% | 0.00E+00 | 0.00E+00 |
| SCS-B3-91.0' | 8.50% | 6.83% | 20.50% | 97.70% | 1.58E-02 | 7.60E-04 |
| SCS-B3-107.0· | 3.20% | 6.83% | 20.50% | 104.99% | 0.00E+00 | 0.00E+00 |
| SCS-B3-107.0' | 2.70% | 6.83% | 20.50% | 105.68% | 0.00E+00 | 0.00E+00 |
| SCS-B1-99.0' | 7.00% | 6.83% | 20.50% | 99.76% | 8.64E-04 | 4.16E-05 |
| SCS-B2-112.0' | 7.50% | 6.83% | 20.50% | 99.07% | 4.92E-03 | 2.37E-04 |
| SCS-B3-91.0' | 7.70% | 6.83% | 20.50% | 98.80% | 6.86E-03 | 3.31E-04 |
| SCS-B2-98.0' | 14.20% | 6.83% | 20.50% | 89.85% | 1.02E-01 | 4.91E-03 |

$S_n$ = Native LNAPL saturation
$S_w$ = 1 - Sn (fraction of pore filled with water in a saturated system)
$S_{rL}$ = Residual LNAPL Saturation, determined by lab testing
$S_{rw}$ = Residual Water Saturation, determined by lab testing
$S_{ew}$ = Effective water phase saturation in a fully saturated system
$K_L$ = LNAPL conductivity at the particular LNAPL saturation

| | |
|---|---|
| Max | 1.02E-02 |
| Min | 0.00E+0 |
| Geomean | 8.06E-04 |
| Median | 7.60E-04 |

## 2.6 LNAPL VELOCITY POTENTIAL

Using a Darcian approach, the potential LNAPL flow is determined by combining the effective conductivity toward LNAPL with the gradient, porosity and saturation. This results in a potential flow in the LNAPL phase, potential because other plume balancing factors like pore entry pressure, lateral gradient and conductivity decreases, and mass balance among others are not considered by this simple expression (4), where $V_L$ is the average linear pore velocity, and $\Theta$ is the total porosity. These other facets will be considered further in the discussion that follows.

In the sub-chapter above, the LNAPL conductivity range was developed, and the porosity and saturation values were also measured and discussed previously. The remaining factor as yet presented is the LNAPL hydraulic gradient. The LNAPL gradient can be derived in the same manner as the groundwater gradient; it is the slope of the LNAPL head between wells where LNAPL is present, or the adjacent groundwater piezometric surface if LNAPL is not present. The LNAPL gradient was determined for 4 time periods between 2002 and 2011 for wells MW-19R, MW-6R and MW14R, as shown in Table 2-2a and Table 2-2b below.

**TABLE 2-2a; DATA USED TO DETERMINE LNAPL GRADIENTS**

| Well ID | Date | TOC Elev (ft amsl) | DTP (feet BTOC) | FP Elevation (ft amsl) | X | Y |
|---|---|---|---|---|---|---|
| MW-19R | 10/31/2002 | 97.67 | 89.56 | 8.11 | 6474945.511 | 1736943.385 |
| | 6/28/2005 | | 88.7 | 8.97 | | |
| | 12/17/2007 | | 89.76 | 7.91 | | |
| | 6/7/2011 | | 89.34 | 8.33 | | |
| MW-6R | 10/31/2002 | 102.27 | 95.1 | 7.17 | 6475143.96 | 1737134.311 |
| | 6/28/2005 | | 94.15 | 8.12 | | |
| | 12/17/2007 | | 94.7 | 7.57 | | |
| | 6/7/2011 | | 94.45 | 7.82 | | |
| MW-14R | 10/31/2002 | 92.91 | 87.75 | 5.16 | 6475586.769 | 1737298.454 |
| | 6/28/2005 | | 87.52 | 5.39 | | |
| | 12/17/2007 | | 87.59 | 5.32 | | |
| | 6/7/2011 | | 87.06 | 5.85 | | |

**TABLE 2-2b: LNAPL GRADIENT RESULTS**

| Date | Gradient[1] | Degrees from North[1] |
|---|---|---|
| 10/31/2002 | 0.004 | 85.67 |
| 6/28/2005 | 0.008 | 113.4 |
| 12/17/2007 | 0.009 | 128.4 |
| 6/7/2011 | 0.006 | 119.5 |

Notes:
*1: Gradient and Direction calculated using EPA online tools*

Given the LNAPL gradients and other factors discussed, the LNAPL velocity potential relative the the LNAPL saturations measured in each soil core collected by SCS (2011a) are shown in Table 2-3 below for the 2011 gradient. As shown, the maximum potential LNAPL velocity is on the order of 0.35 ft/yr, with the geometric mean being 3.36 x $10^{-2}$, and the median being 1.95 x $10^{-2}$ ft/yr, with 3 of 10 samples having zero mobility (less than residual saturation).

## TABLE 2-3: ESTIMATE RANGE OF POTENTIAL LNAPL LINEAR PORE VELOCITY

| Sample ID | $i_L$ | $\Theta$ | $V_L$ (ft/yr) |
|---|---|---|---|
| SCS-B1-99.0' | 0.006 | 0.013 | 2.89E-01 |
| SCS-B2-98.0' | 0.006 | 0.064 | 3.51E-01 |
| SCS-B2-112.0' | 0.006 | n/a | 0.00E+00 |
| SCS-B3-91.0' | 0.006 | 0.007 | 2.39E-01 |
| SCS-B3-107.0' | 0.006 | n/a | 0.00E+00 |
| SCS-B3-107.0' | 0.006 | n/a | 0.00E+00 |
| SCS-B1-99.0' | 0.006 | 0.028 | 3.21E-03 |
| SCS-B2-112.0' | 0.006 | 0.033 | 1.56E-02 |
| SCS-B3-91.0' | 0.006 | 0.031 | 2.34E-02 |
| SCS-B2-98.0' | 0.006 | 0.066 | 1.64E-01 |
| | | **Max** | **3.51E-01** |
| | | **Min** | **0.00E+00** |
| | | **Geomean** | **3.36E-02** |
| | | **Median** | **1.95E-02** |

$i_L$ = LNAPL gradient
$\Theta$ = LNAPL-filled porosity
$V_L$ = LNAPL linear velocity potential

## 3.0 EVALUATION OF LNAPL PLUME AND CLEANUP CONDITIONS

There are 2 key questions that must be answered to consider what cleanup or plume management actions will be most appropriate at the site: 1) Is the LNAPL plume stable from a management perspective?; and 2) Will additional active cleanup have any net benefit to the waters of the State? The following report sections will consider these questions and related factors to result in a recommended general course for management of the remaining LNAPL beneath the site.

### 3.1 LNAPL STABILITY CONSIDERATIONS

There were several lines of evidence noted in the initial discussion of LNAPL plume genesis that would lead to a determination of LNAPL plume stability or not. The evaluation takes a weight-of-evidence approach, where each factor alone is not as important as all factors in their totality. For convenience, these factors are repeated below:

1. Confirmation that the LNAPL releases are finite and not ongoing at the site;
2. Evaluation of the relative age of the LNAPL plumes; the older a plume, the more probable it has reached field static equilibrium;
3. Evaluation of LNAPL gradients;
4. Comparisons of estimated LNAPL to water conductivity values;
5. Evaluation of LNAPL flow;
6. Review of petrophysical properties, including expectations for an entry pressure threshold;
7. Inspection of LNAPL plume distribution to consider whether the morphology is consistent with the form of a stable plume.

Items 1 and 2 above are straightforward. The former Western Fuel Oil site ceased petroleum operations in 1995. The facilities that served those operations were demolished between 1997 and 1999 in preparation for redevelopment of the San Pedro Business Center. Therefore, releases likely ceased by 1995 when the operations stopped, excepting the possibility of small releases from left-over product in piping or other ancillary structures. By the end of demolition, that potential residual source was also eliminated. Thus, it has been 16 years since any releases of importance have likely occurred. As discussed earlier, LNAPL quickly ceases to move once the gradients induced by the release have dissipated, and that cessation is generally expected in the 3 - 10 year time frame in most cases.

Item 3, the LNAPL gradients, were discussed above and are generally of the same magnitude and direction as groundwater flow. This is typical of confined LNAPL, where the pressure regimes in the LNAPL simply reflect the surrounding hydrostatic pressures. LNAPL is confined in the same way groundwater is confined, by zones of porous materials having low effective hydraulic conductivity, in this case with respect to LNAPL (recall processes discussed above). By way of example, hydrographs for MW-6/6R and MW-14/14R have positive statistical correlations between groundwater head and product thickness (increasing head, increasing thickness; Appendix 2-2). MW-19/19R also has a positive correlation, but only of 0.4. However, this is likely because of the small LNAPL thicknesses in the well, implying less hydraulic continuity in the formation. But as can be seen even in MW-19R, in June 2006 when there is a sharp temporary increase in groundwater head mirrored by a similar increase in LNAPL thickness, indicating fluids in this well are behaving in a confined manner. Increased pressure means higher head or thickness, and vice versa. In summary, it appears the LNAPL has no independent driving head of significance beyond the forces in the groundwater regime. That makes perfect sense given the extensive excavation and cleanup actions taken to date in the shallow portion of the system, effectively cutting off any residual gradients that might have remained from the original releases.

Item 4 has also been discussed above. The analyses determined that, where there is a value greater than zero, the LNAPL conductivity is quite small, about 100 - 20,000 times less than the groundwater conductivity of about 1 ft/day (discussed above). This of course means the potential for LNAPL flow is also approximately 100 - 20,000 times less than groundwater. And in 30% of these cores, the LNAPL conductivity was zero. Given that the coring program by SCS targeted LNAPL-rich zones, if there is a bias in this analysis, it would be expected to be toward the worst-case conditions (i.e., conservative).

The potential velocity of LNAPL (Item 5), was also found to be quite low, well less than 1-ft/yr at a maximum, and less than a few hundreths of a ft/yr in the median and geometric mean case. As mentioned, the velocity potential does not account for a wide variety of real-world factors that cause LNAPL plumes to halt movement in the environment. Therefore these de minimis values of potential mobility are a worst-case screening and indicating the plume is stable.

Petrophysical properties, Item 6, have also been developed above. The combination of high capillarity, a distinct non-wetting entry pressure exhibited in the capillary data, and the relatively high percentage of fines in the majority of soil cores all indicate the LNAPL will not flow easily in this setting absent high pressure gradients. As discussed, gradients are in fact small, and unlikely to mobilize LNAPL beyond its present position in the subsurface now or in the future.

Finally, Item 7, plume morphology, remains to be inspected. There are 2 facets that will be reviewed here. First, the distribution of LNAPL inferred from the LIF investigation, augmented with other data, will be reviewed in map and cross-section views. Second, as discussed in the first part of this report, dissolved benzene concentrations over time will serve as an indirect reflection of LNAPL conditions; the benzene plume was found to be stable and contracting. The concept here is simple; if the LNAPL that is the source of benzene is stable, then the benzene plume should also be stable. Conversely, if the dissolved benzene plume is moving downstream over time, then potential movement of the LNAPL "source" could be one explanation for that observed behavior.

Cross Section A-A' discussed previously (Figure 2-5) shows the inferred LNAPL distribution from the southwest to the northeast. As seen, the submerged LNAPL plume is dominant in the area of CPT-17 and CPT-21, but other constraining data points indicate that the plume pinches out, as expected, toward the northeast. The LIF waveform along the same section (Figure 2-6) shows distinctly different product types in different zones of the plume as reflected in LIF spectral color differences, again consistent with discrete product releases that remained predominantly local to the areas of the original release. The plume has the expected morphology of a stable plume.

In summary, for this particular site, all the factors above point to LNAPL plume stability. While there may be small-scale movement in response to localized gradients, the plume is old enough and displays all the other features of a stable plume relative to site management objectives.

## 3.2 LNAPL CLEANUP CONSIDERATIONS

Given that the LNAPL plume is stable, as discussed above, the plume management options range from managing it in-place to more active engineered cleanup approaches. In this section, the net benefit of various potential actions relative to the waters of the State will be considered. The discussion will also consider the impact of any potential actions on the site operations of the Port Distribution Center that represents an economic positive for the property and surrounding area.

As summarized by SCS, this site has had numerous active cleanup actions taken to date, including pump and treat, extensive soil excavation, air sparge/soil vapor extraction (IAS & SVE), free product recovery and other ancillary actions. As of 2001, it was estimated that approximately 12 million pounds of hydrocarbons were treated by the IAS/SVE system, and another 20,000 yd$^3$ of impacted soil was excavated (Cape, 2001). About 13,000 gallons of water/product mixture have been hydraulically recovered from wells MW-6R and MW-14R, with water typically being the major component of that volume (SCS, 2011a). Certainly all of these past cleanup actions have improved site environmental conditions in that the vapor pathway is now negligible, and the mass recovered helps to further stabilize and reduce the long-term presence of the LNAPL plume. However, as observed in the investigations and discussed previously, LNAPL mass remains submerged below the water table.

As noted in our 2005 Draft Report to the LARWQCB *"Best Practices Study of Groundwater Remediation at Refineries in the Los Angeles Basin (Beckett, Sale, Huntley, & Johnson, 2005)"* the single-most applied remediation technique in the area to address LNAPL is hydraulic recovery. We discuss the limitations of that method, but also why it is used so often in practice. In a nutshell, LNAPL recovery can mitigate the potential for LNAPL transport and it does recover some mass. Whether it recovers enough mass to make a difference in plume management or the longevity of chemicals of concern is the key question often left unaddressed at the majority of release sites. Hydraulics also can typically be installed at site boundaries and not dramatically affect the operations of various petroleum refining and storage facilities. Whereas more aggressive cleanup techniques commonly require a much higher density of cleanup and/or control points to be safe and effective.

The API has developed screening tools to consider the general expect effect of LNAPL recovery and cleanup (API #4715, 2002; API Interactive LNAPL Guide, 2004). These tools are intended to give some framing to the physical and chemical processes at work, and how cleanup may affect the longevity of chemicals of concern in the environment. The petrophysical and fluid parameters discussed above provide the necessary inputs to the screening evaluations. To provide an analogous initial condition to that observed at the site, the initial LNAPL peak saturations are on the order of 20%, as measured by SCS in sample SCS-B2-98.0' (2011). The surrogate chemistry of key compounds in the LNAPL were matched to MW-10R, a well with a history of high TPHg and benzene impacts. The estimate is run in a "type area" context, where we are interested in relative change, not in a precise rendering of site-wide plume conditions; the geometry of the type area includes a depth of 90-ft, and lateral dimensions of 330 x 330 ft (~100 m). A full report of the inputs to the estimates that follow is attached (Appendix 3-1).

Using this screening approach, the baseline condition (natural mass loss scenario) is then compared to hydraulic recovery by skimming and by pump and treat with active groundwater pumping. As seen in Figure 3-1, the expected change in saturation due to hydraulic recovery is quite negligible, as is the associated change in benzene concentration over time for each scenario (Figure 3-2, IAS context will be discussed below). In effect, and consistent with an old, stable, and submerged plume with all the given properties, hydraulics will no longer have any effect on plume management over the long-term. As observed in MW-10 and other locations, the IAS/SVE cleanup initially reduced concentrations significantly, followed by rebound to nearly the same levels as prior to that cleanup action. That observation is completely consistent as well with the fact that submerged LNAPL exists well below the intervals of cleanup targeted by that IAS/SVE action. Again, this site scenario is intended only to point toward reasonable technical expectations; like all screening approaches, the model and method is not designed to be highly site specific (API, 2004).

Taking this a step further, IAS can, in principle, remove the volatile components from the LNAPL as long as the subsurface coverage is sufficient in lateral and vertical dimensions. SVE will capture that vapor stream. Because more volatile compounds partition preferentially into the vapor stream, the remaining LNAPL will in principle become more enriched in less volatile and heavier compounds (e.g., Figure 3-3). As shown then, if coverage and stripping is effectively designed, the ratio of benzene to heavier compounds should decrease through time as benzene is lost more rapidly to the IAS. Figure 3-4 is a chart showing the change over time of benzene to ethylbenzene at MW-10 overlapping the time of IAS/SVE actions. As observed, this ratio is changing prior to the start of cleanup, which is also consistent with natural partitioning processes in groundwater and vapor. It is also seen that the cleanup did not change the overall slope of this ratio, and after IAS/SVE was shut down, there was rebound in this ratio (not shown on the particular plot, but observed in the subsequent well data). These observations are again entirely consistent with not only LNAPL submerged below the zone of cleanup, but also with the limited lateral coverage of the IAS system installed on 100-ft centers.

It is well documented through tank and field scale measurements that the zone of active vapor stripping around an IAS location is quite limited. For instance, Lundegard et al. show an active IAS stripping zone of about 8-ft (2.4 m) in a fine-grained sand (e.g., Figure 3-5). Beckett et al. (1995) demonstrated IAS in the Gage aquifer would have a coverage of about 2 - 3m (~ 6.5 - 10-ft) radially depending on operating conditions (Figure 3-6). So, despite recovering significant mass from the subsurface (12 million pounds), the IAS/SVE system clearly missed existing mass, and thus the observed rebound and persistence of LNAPL and its associated chemical compounds. Given the shallow aquifer materials are similar to the Gage, IAS wells would require a spacing of 10- to 15-ft on center and to a depth of at least 20-ft below the present water table, as indicated by LNAPL saturation impacts at all depth levels investigated to 107 fbg (SCS-B3-107', SCS, 2011).

So, following further hypothetically on what IAS may achieve in principle. If we take the same LNAPL scenario discussed above for hydraulics and assume that stripping at an adequate lateral and vertical distribution of IAS operation could reduce benzene by an order of magnitude (as seen onsite before rebound of the old system), what would be the expected result? Recall in Figure 3-3 above, IAS under these ideal conditions would be expected to reduce the overall concentrations of benzene and other compounds in the near-term, but would not have a significant effect on the long-term presence of the compound or the management of the site.

IAS is in many ways a surrogate for any form of intensive or aggressive cleanup. Cleanup well densities vertically and laterally are intense, particularly at this site, both for control and for the effectiveness of the action. But more to the point, executing such an action at this site has obvious limitations from a feasibility point of view, and again, even if implemented, would have negligible benefit to the environment or the waters of the State. SCS has extensively discussed the poor water quality and the limited value of the resource at this particular location.

Any use of the groundwater in the future at or near the site would require treatment prior to use to remove salt and other man-made impacts besides the petroleum beneath the site. Water treatment would also remove any petroleum hydrocarbons that might reach that hypothetical point of use. As shown in the groundwater analyses earlier in the report, the dissolved-phase plumes are stable, and in the case of benzene, where there are sufficient data to so demonstrate, that plume is contracting. Therefore there are no reasonable or plausible impacts to water use by the remaining LNAPL at this facility.

Given that the site has all risk pathways contained and managed (low-risk), and given that additional cleanup would have no net benefit to the waters of the State, and a high impact to site operations that would need to cease to complete that effort, it is our opinion that no further action is warranted, beyond monitoring plume stability and ongoing natural attenuation. There simply is no additional action that might be taken in the face of these beneficial site commercial operations that would have any benefit, and in a variety of scenarios would have negative net benefits.

In summary, this site meets the concepts of the SWRCB 92-49 Resolution allowing impacts greater than MCLs to remain in-place if they pose no threat to the waters of the State, and if additional cleanup is infeasible or expected to have no net benefit, and if those impacts are stable and naturally diminishing. The site meets all these criteria.

## 4.0 REPORT CLOSURE

The work herein has been conducted based on current scientific principles and the data provided by SCS Engineers and other sources. These site evaluation results depend directly on this information. Changes or corrections to site data may alter interpretations herein, and if such changes are manifest, it is recommended that these evaluations be updated accordingly. Hydrogeologic and multiphase (LNAPL) evaluations have some level of inherent uncertainty in that pore and molecular scale processes are represented by a macroscopic continuum, and results should be viewed accordingly. Similarly, the discrete distributions and effects of geologic heterogeneity at most sites are unknown. The analyses and evaluations herein are intended to set technical scenarios, not to represent highly detailed spatial or temporal variability. This work has been conducted in accordance with scientific principles and the professional standards of the State of California and other states with reciprocal professional standards. No other warranty, express or implied, is provided.

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# Table 1-1
# Dissolved Mass Estimate for TBA
300 Westmont Dr., San Pedro, CA

**Constants and Conversions**

| | | |
|---|---|---|
| Porosity | 0.40 | |
| Impact Thickness | 25.0 | ft |
| Vol | 28.32 | L/cubic ft |

**Mass Estimate Calculation**

| | Integrated Volume | Area of Integration | Ave Conc | Volume of Groundwater | Mass |
|---|---|---|---|---|---|
| | (ug/L) x sqft | sqft | ug/L | L | kg |
| **12/7/2007*** | 1.43E+09 | 8.92E+05 | 1603.95 | 2.53E+08 | **405.3** |

Note: *Samples also collected on 8/9/07

# Table 1-2
# Longevity Estimate for TBA

300 Westmont Dr., San Pedro, CA

| Well ID | Well Location | Constituent | NL [1] (ug/L) | Predicted Range to Reach NL [2] | | | Comment |
|---|---|---|---|---|---|---|---|
| | | | | Earliest | To | Latest | |
| MW-9R | Downgradient | TBA | 12 | 2/15/2012 | - | 5/5/2015 | |
| MW-10R | Downgradient | TBA | 12 | 11/11/2018 | - | 12/25/2024 | |

Notes:

1: California drinking water notification level (NL)

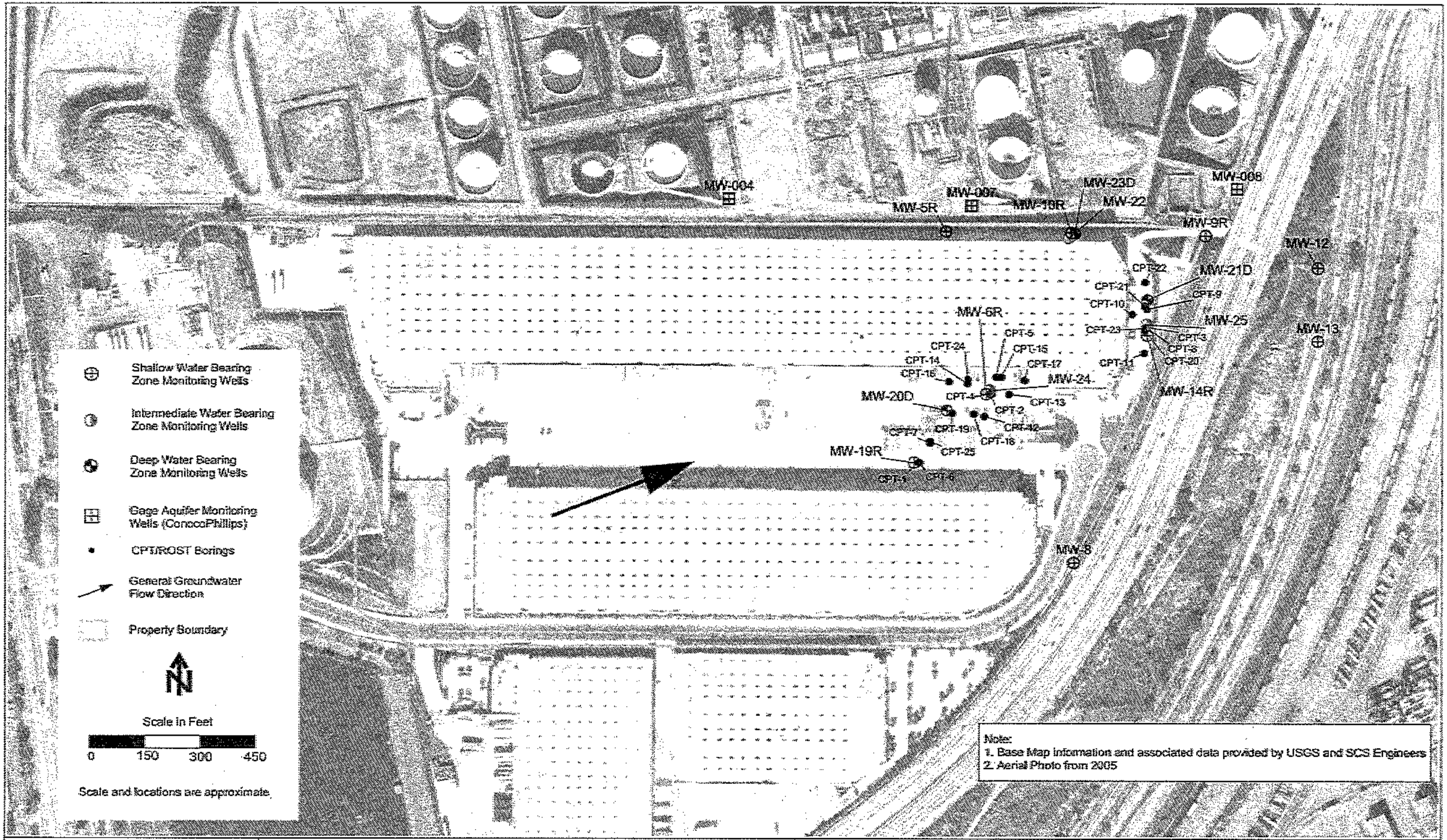
2: Range represents earliest and latest predicted date to reach California drinking water notification level for either the best prediction and/or the 95% CI estimation.

ug/L = micrograms per liter.

TBA = tertiary-butyl alcohol.

# TABLE 1-3
## Potential Flux Impacts to Groundwater Use for TBA

| Puming Zone Thickness (ft) | Compund | Well Production Rates (gpm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Date | K (ft/day) | 100 | 200 | 300 | 400 | 500 | 1000 |
| **50** | **TBA** | December/August 2007 | 1 | 10.72 | 5.36 | 3.57 | 2.68 | 2.14 | 1.07 |
| **100** | **TBA** | December/August 2007 | 1 | 5.36 | 2.68 | 1.79 | 1.34 | 1.07 | 0.54 |
| all concentrations are in units of ug/l | | | | | | | | | |



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2005

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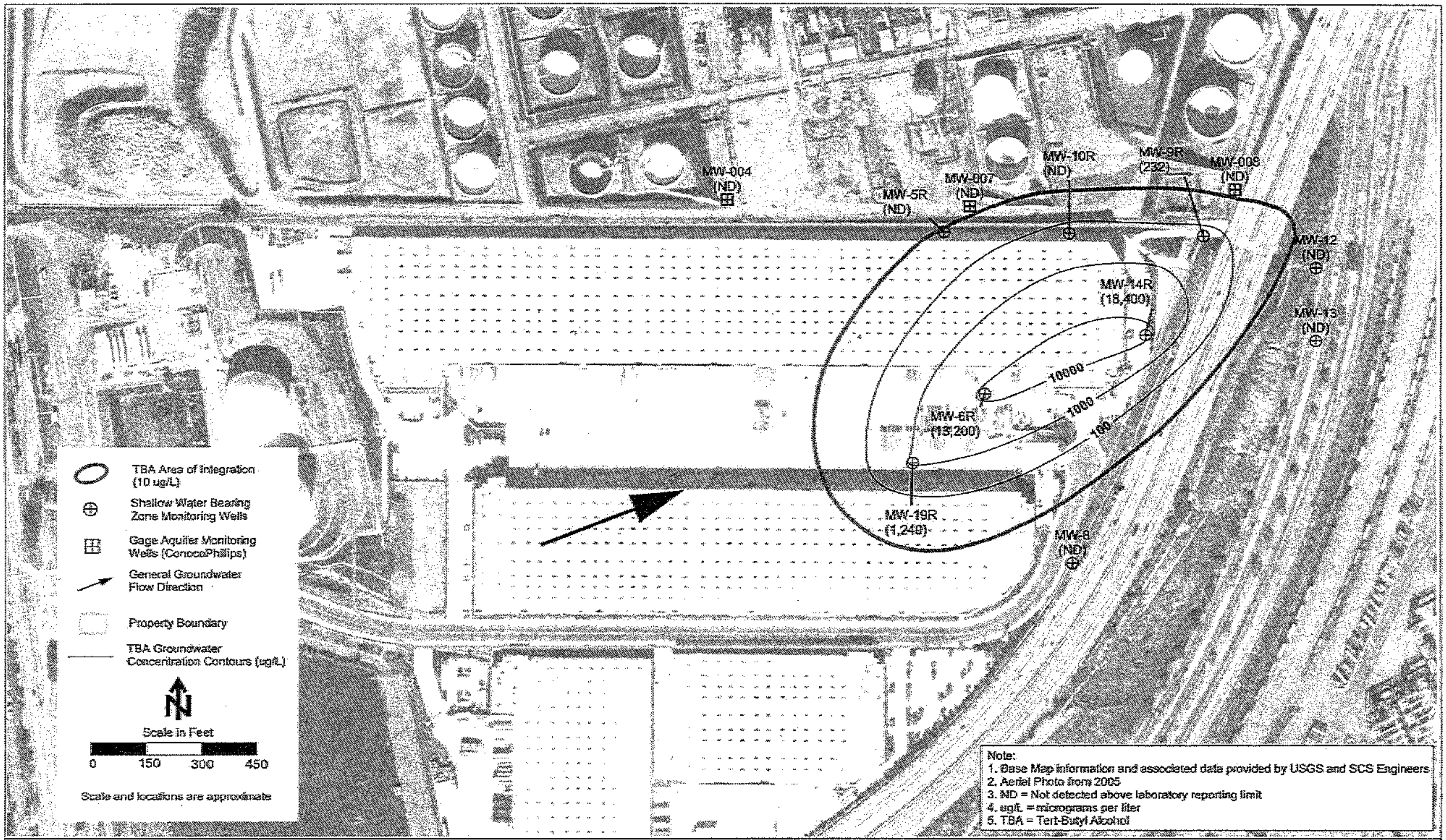
## Site Plan

BlackRock Realty
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

FIGURE:
1-1



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2005
3. ND = Not detected above laboratory reporting limit
4. ug/L = micrograms per liter
5. TBA = Tert-Butyl Alcohol

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**TBA in Groundwater - August/December 2007**

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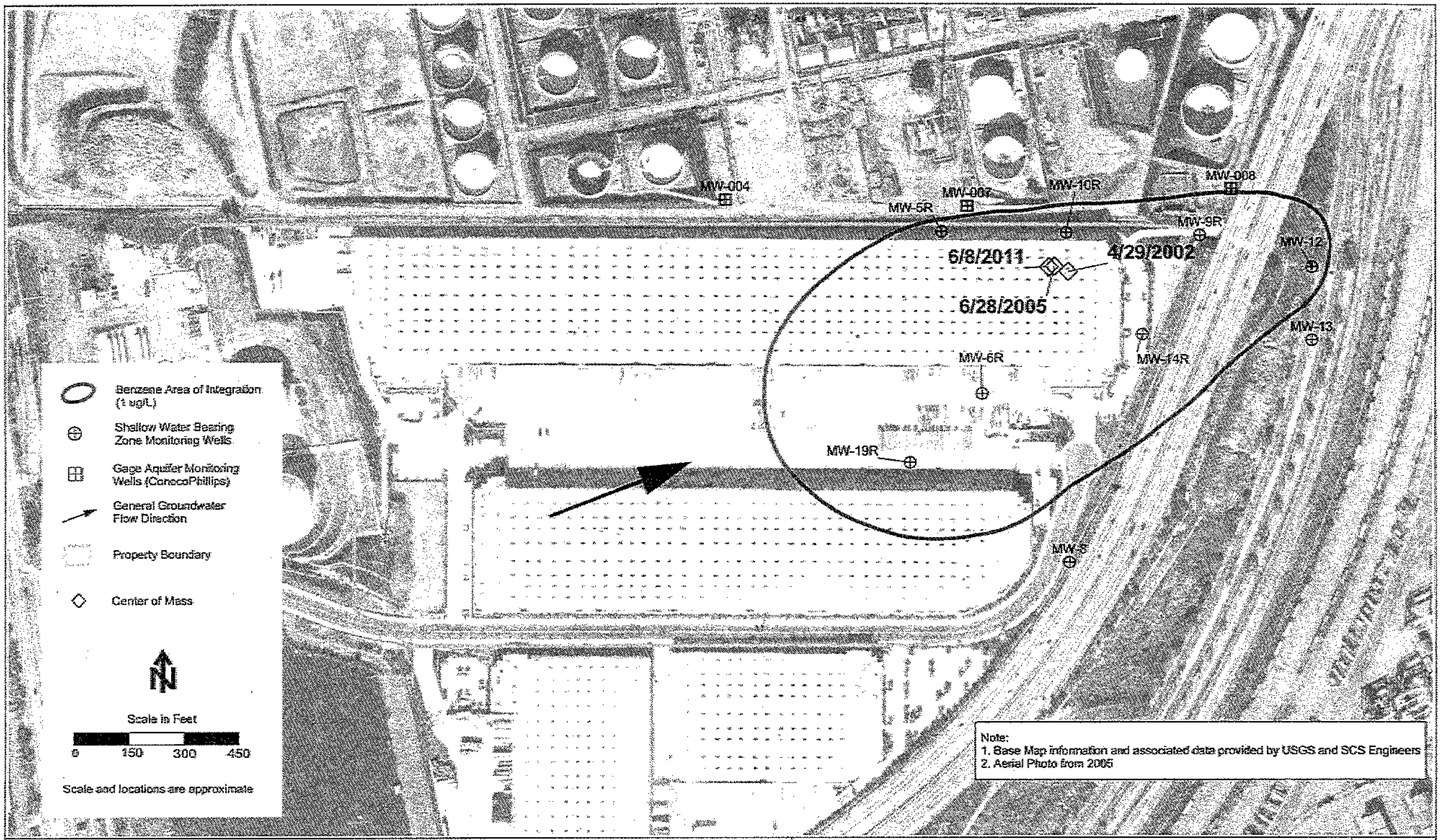
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

FIGURE:

1-2



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2005

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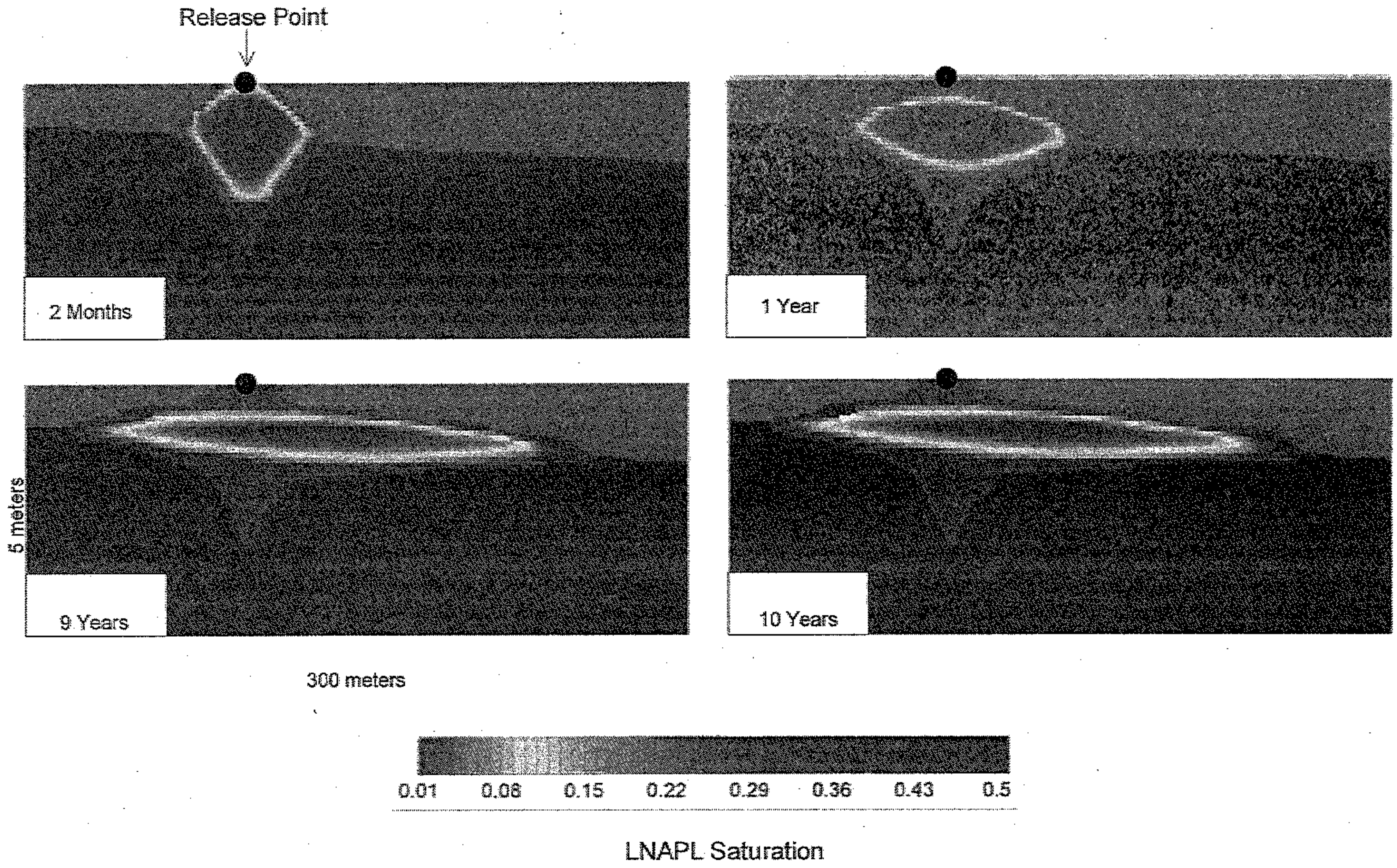
**Benzene Center of Mass Through Time**

BlackRock Realty
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

FIGURE:
1-3



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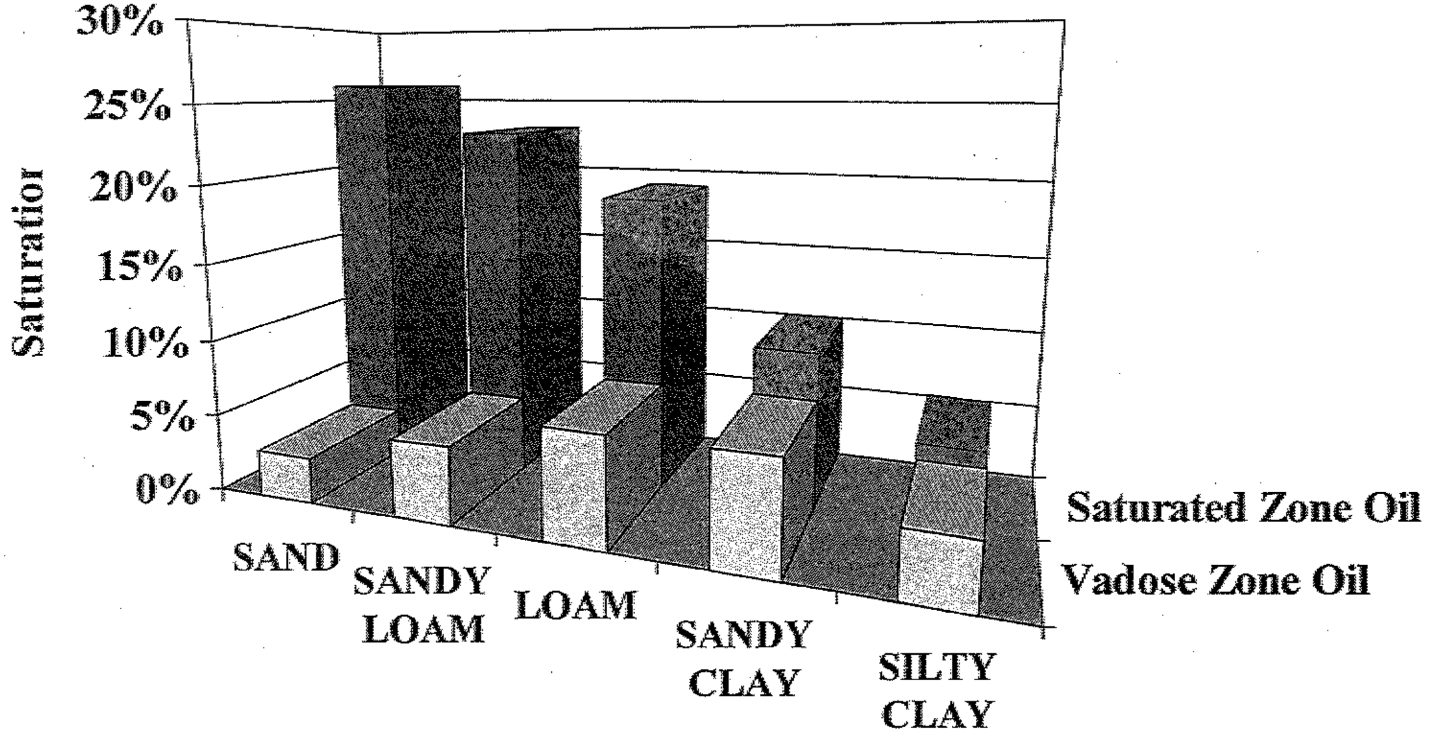
LNAPL Saturations During a Generic Release Simulation

FIGURE:

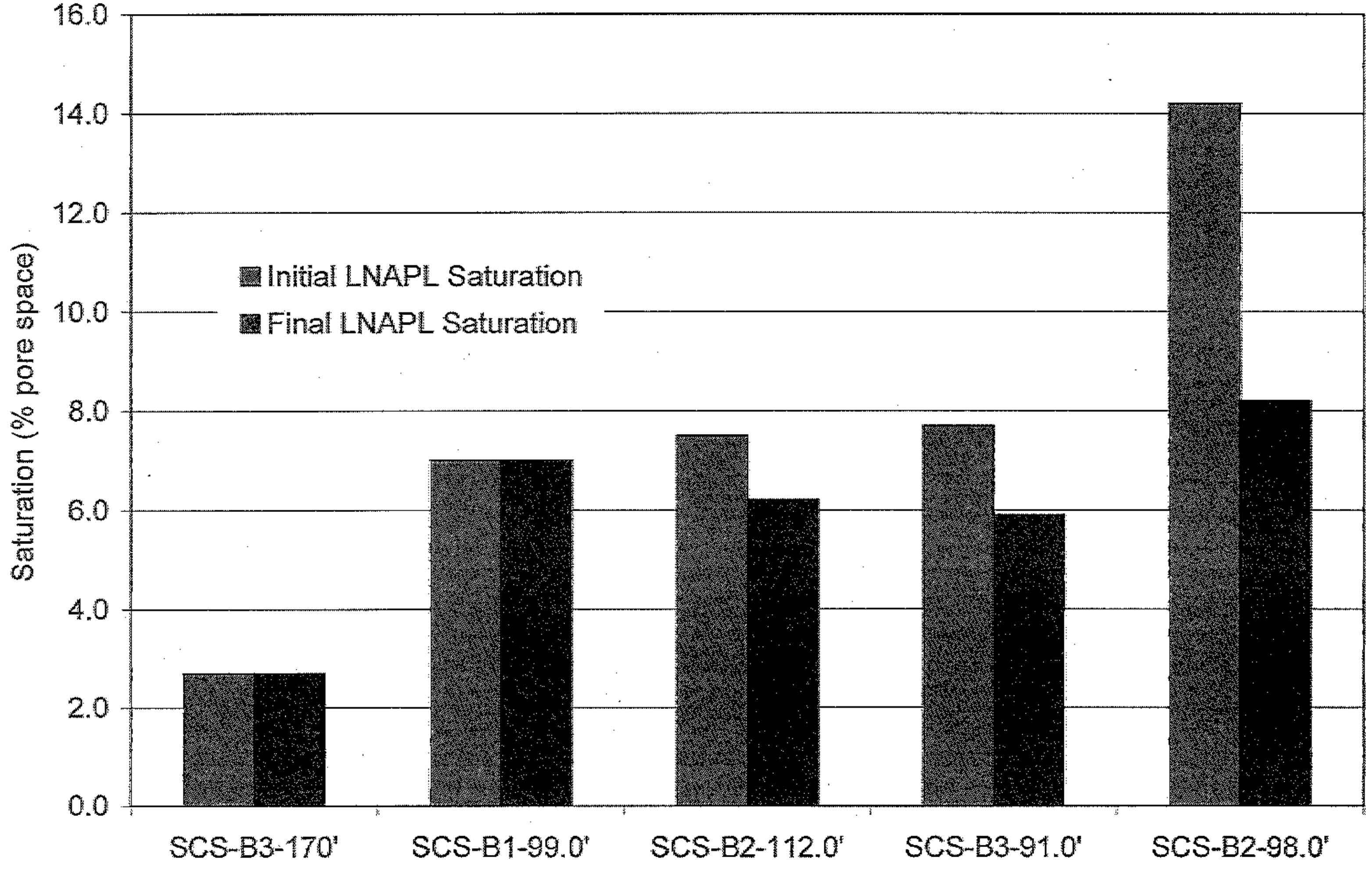
2-1

Figure 2-2
2-Phase Vs. 3-Phase Residual Saturation
***(3-phase is usually much smaller)***

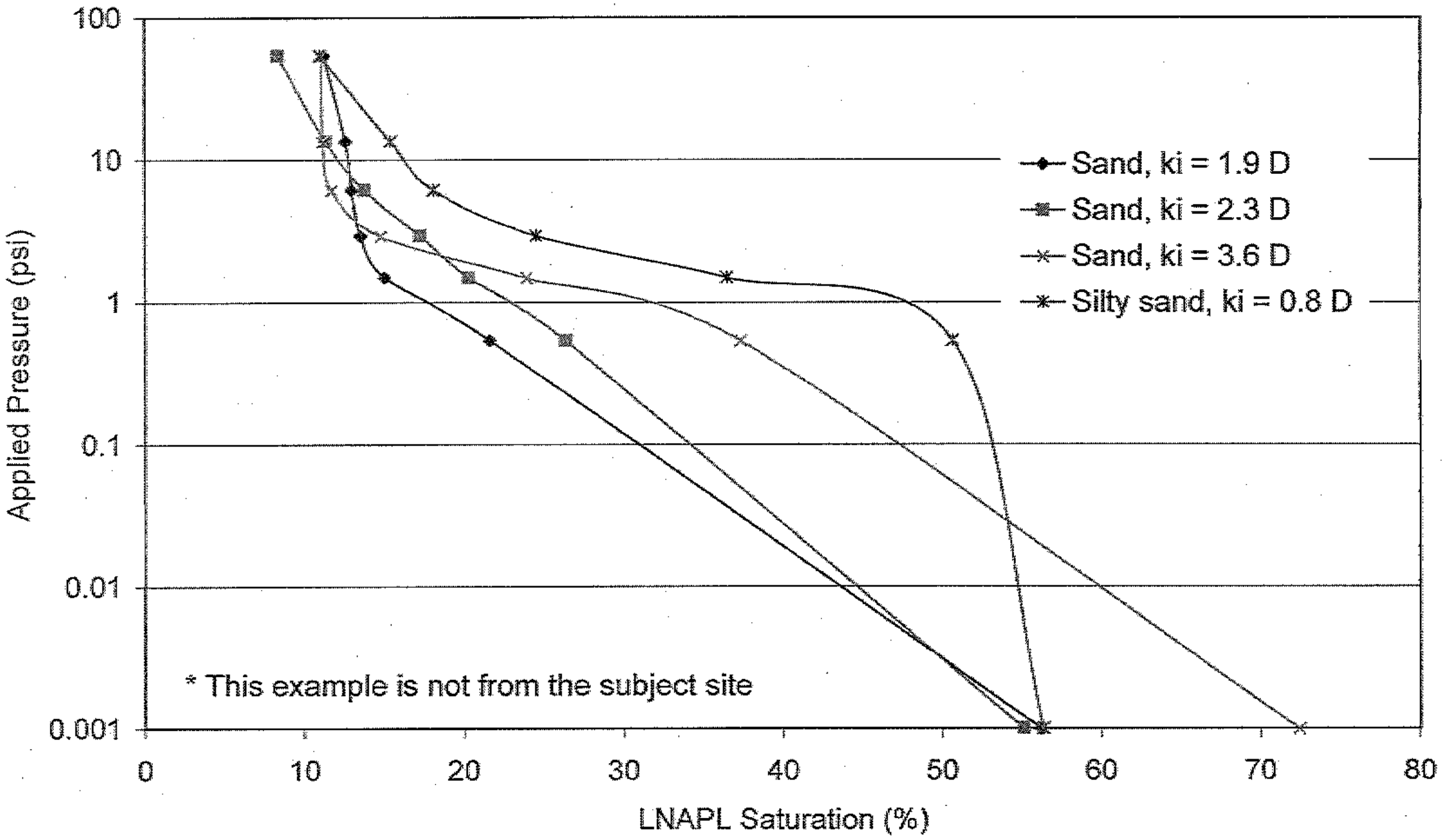


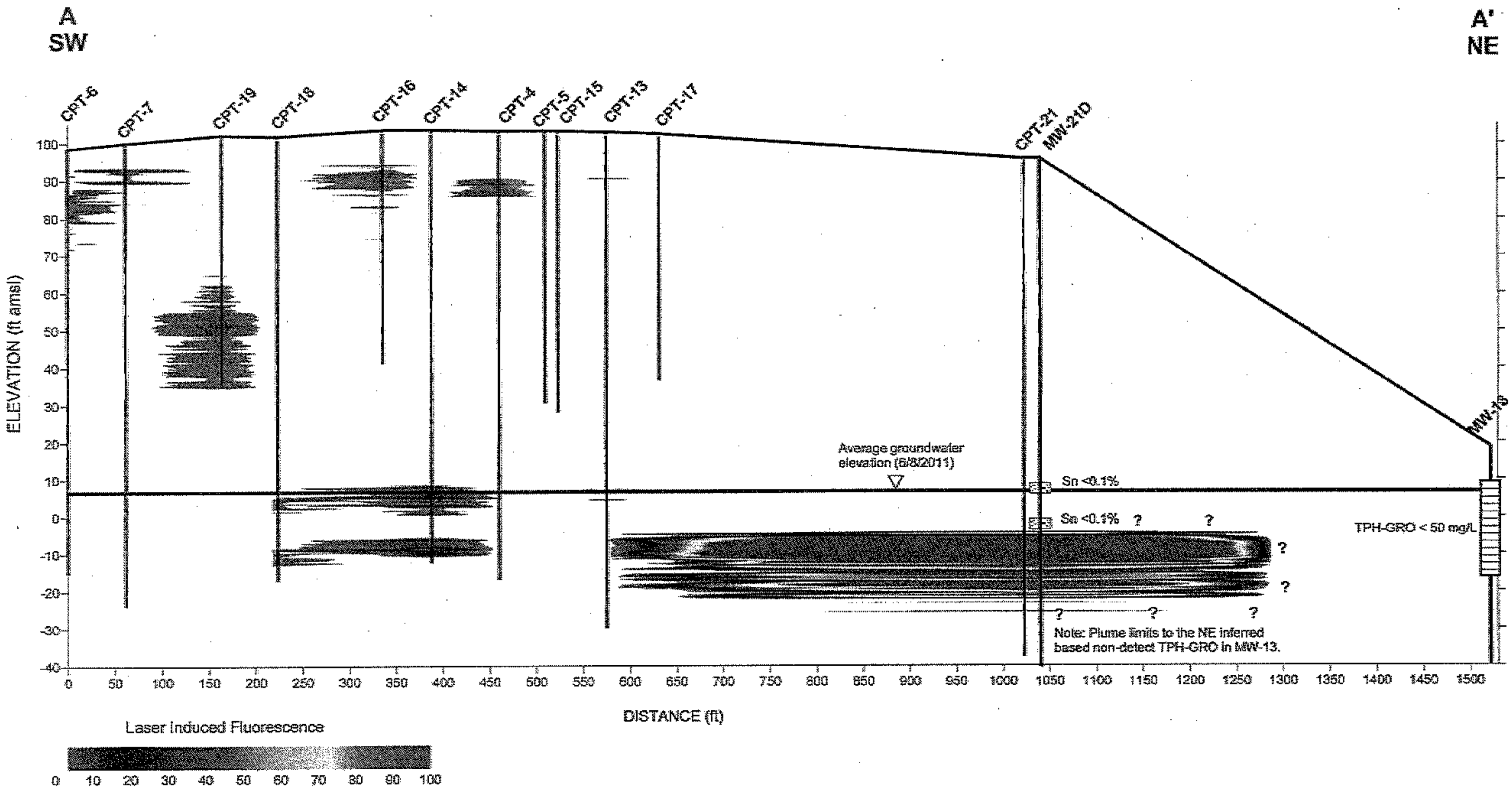
after, J. Parker, 1994

## Figure 2-3
## Initial and Residual LNAPL Saturation Measurements



## Figure 2-4
## Applied Pressure Vs. LNAPL Saturation for 0.8 - 3.6 Darcy Materials





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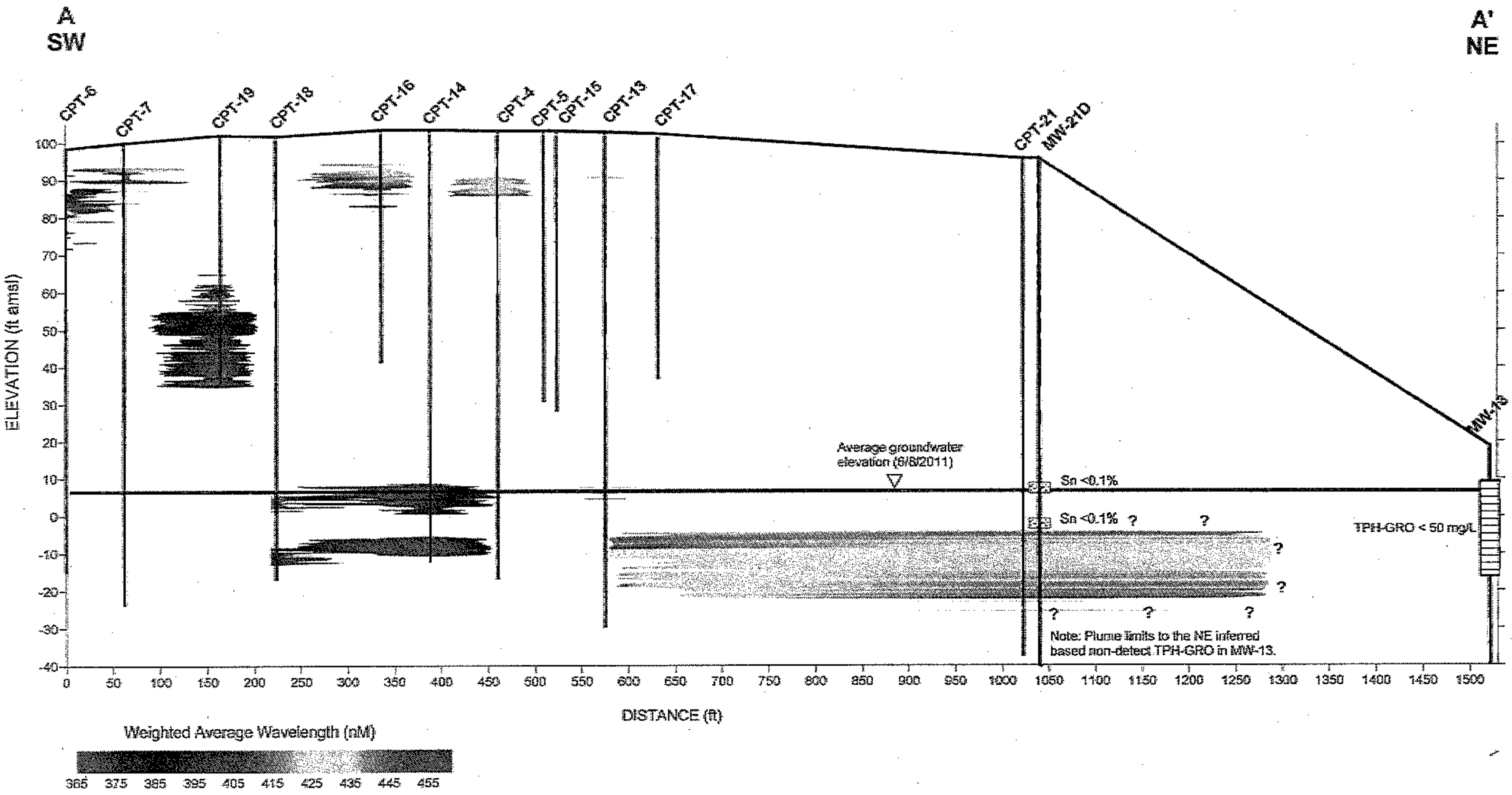
Filename:
LIF_XSec_AA'.srf

**Southwest to Northeast LIF Intensity Cross Section A-A': Laser Induced Fluorescence where Laser Induced Fluorescence is Above Threshold**
BlackRock Realty
Port LA Distribution Center
300 Westmonet Drive
San Pedro, California

FIGURE:
2-5



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Filename:
LIF_XSec_AA'_Wave.srf

**Southwest to Northeast LIF Waveform Cross Section A-A': Laser Induced Fluorescence where Laser Induced Fluorescence is Above Threshold**

BlackRock Realty
Port LA Distribution Center
300 Westmonet Drive
San Pedro, California

FIGURE:
2-6

## Figure 3-1
## Generalized Saturation Profiles Expected Under Cleanup Conditions

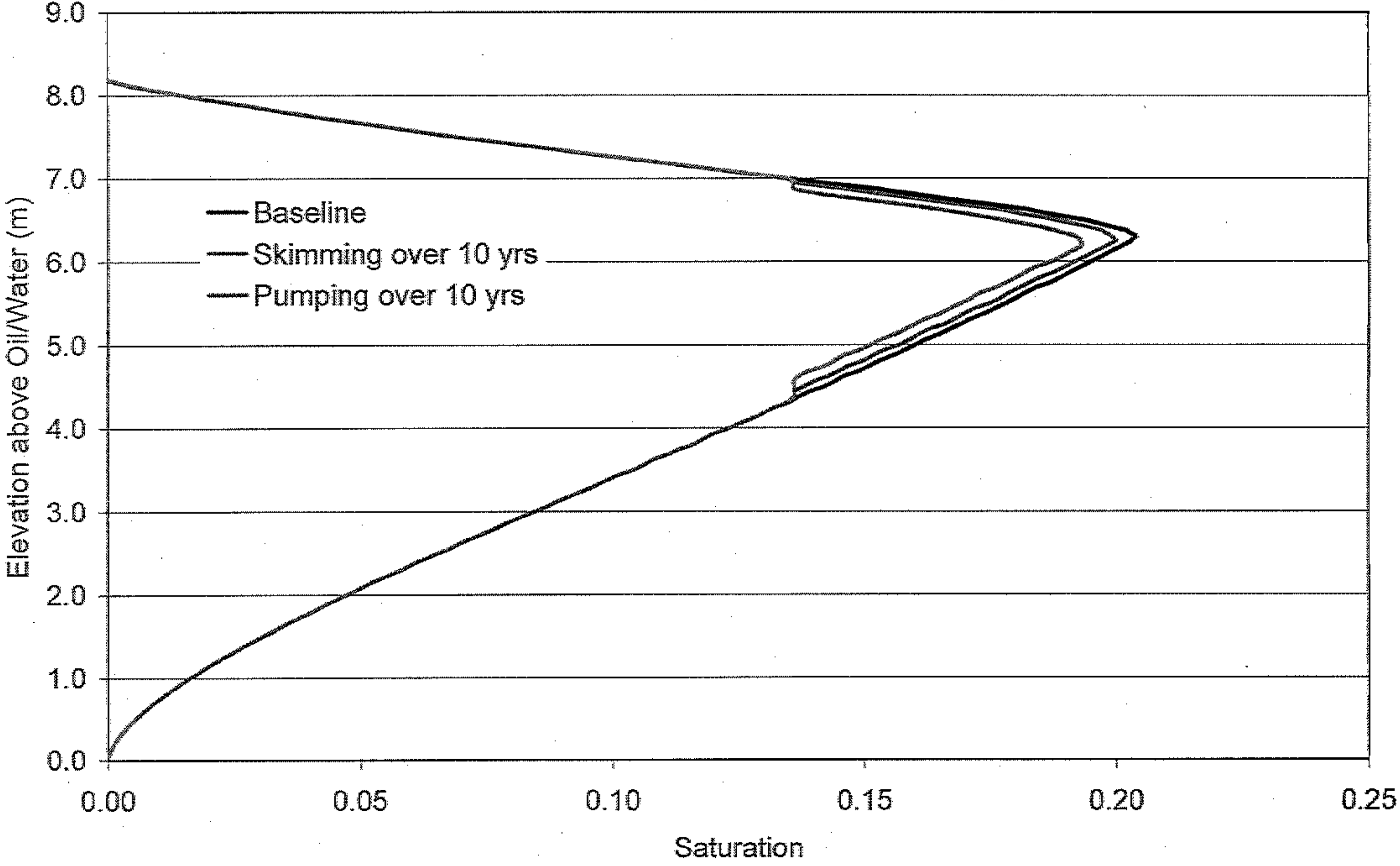


**Figure 3-2**

**Generalized Benzene Change over Time Under Cleanup Conditions**

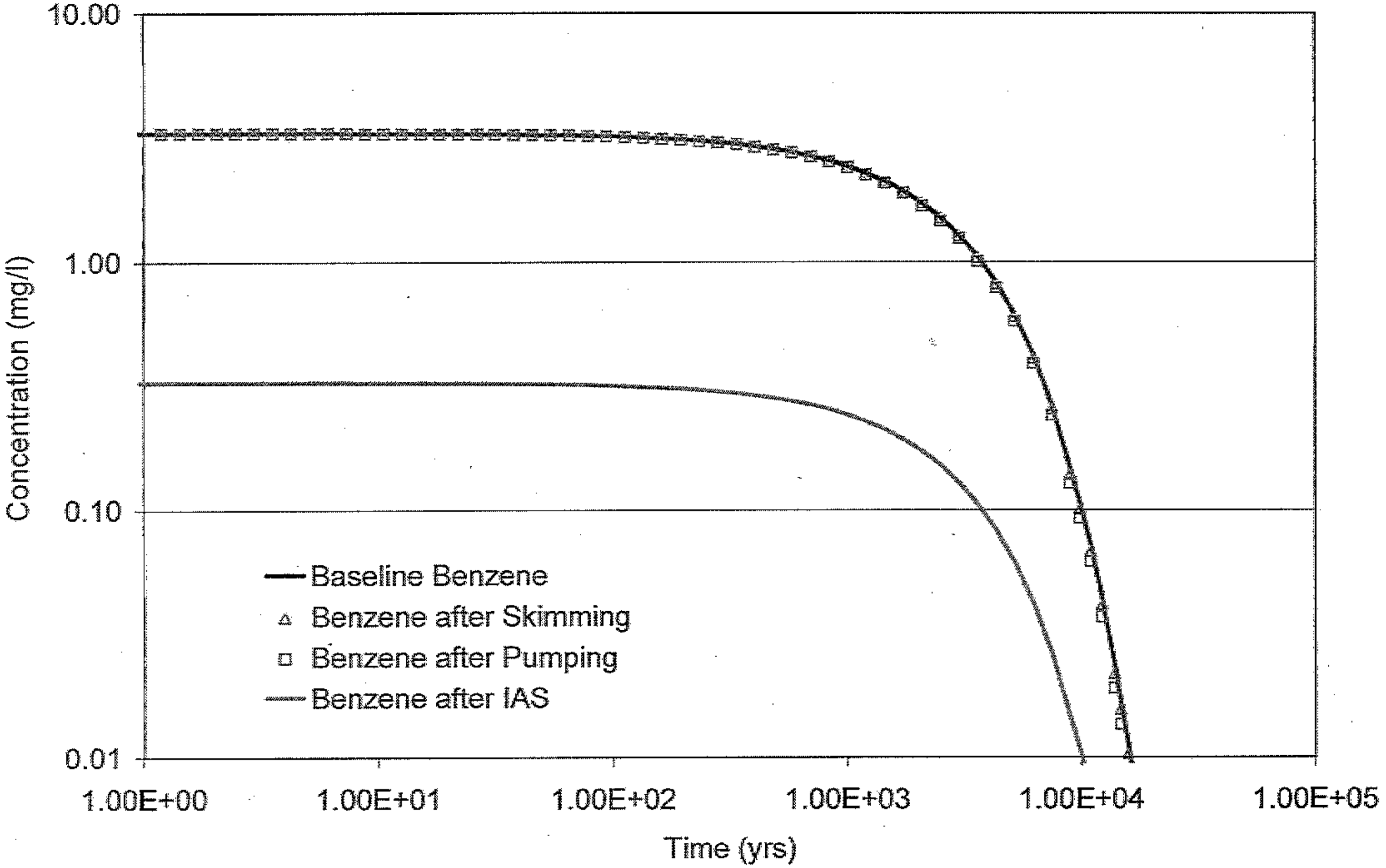
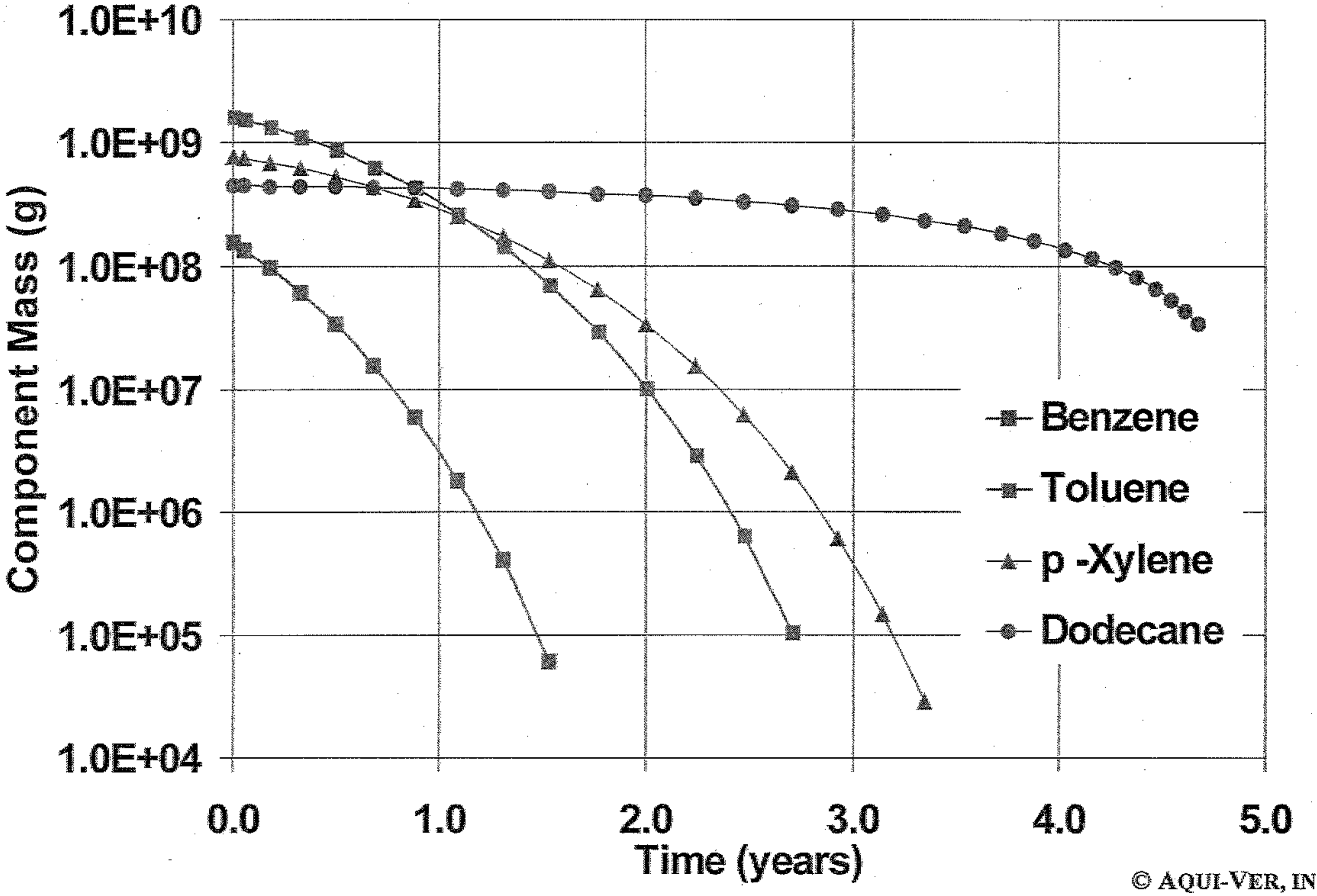


Figure 3-3

Chemical Component Stripping By SVE & IAS



## Figure 3-4

## Ratio of Dissolved Benzene to Ethylbenzene Overlapping IAS/SVE: MW-10

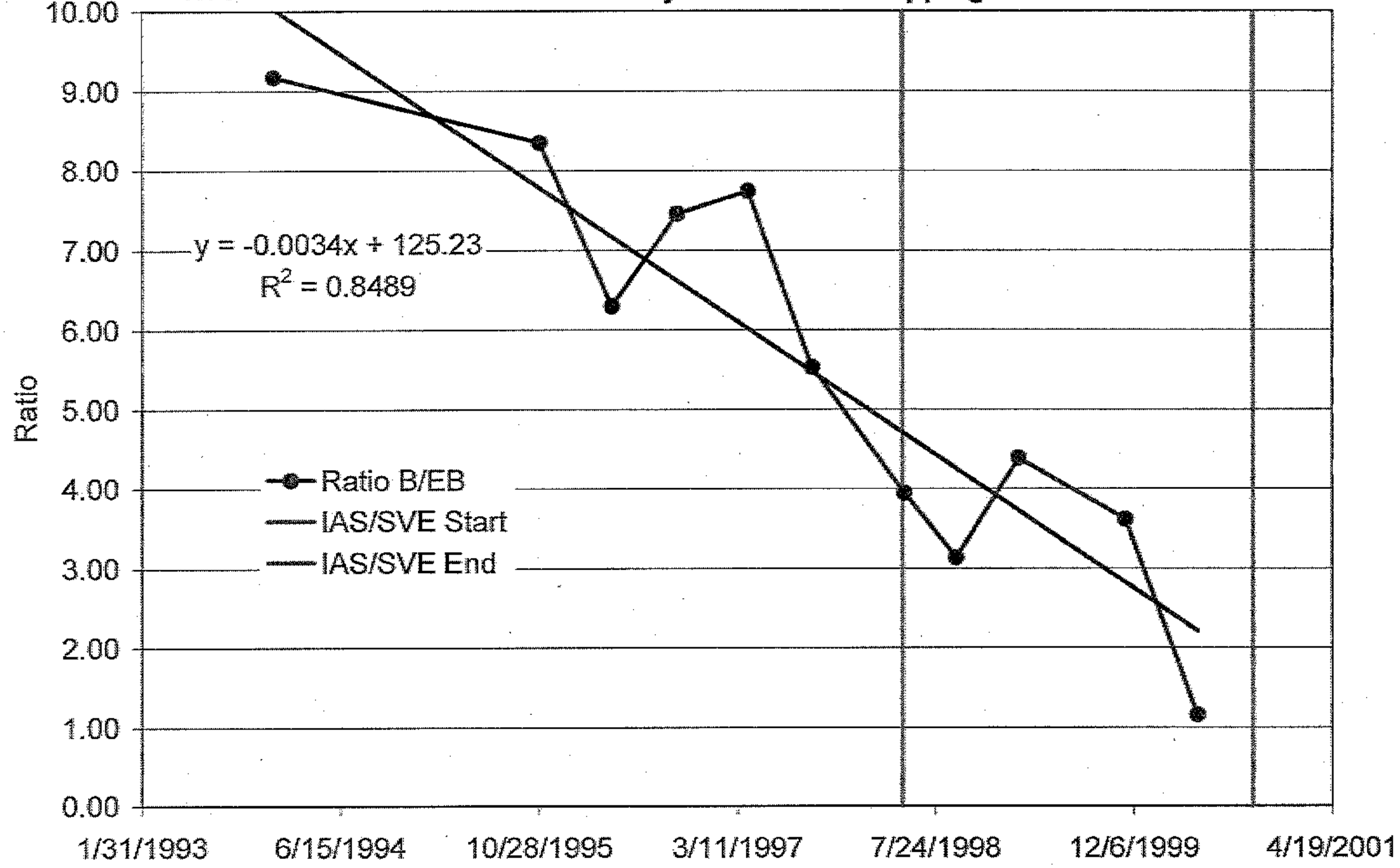
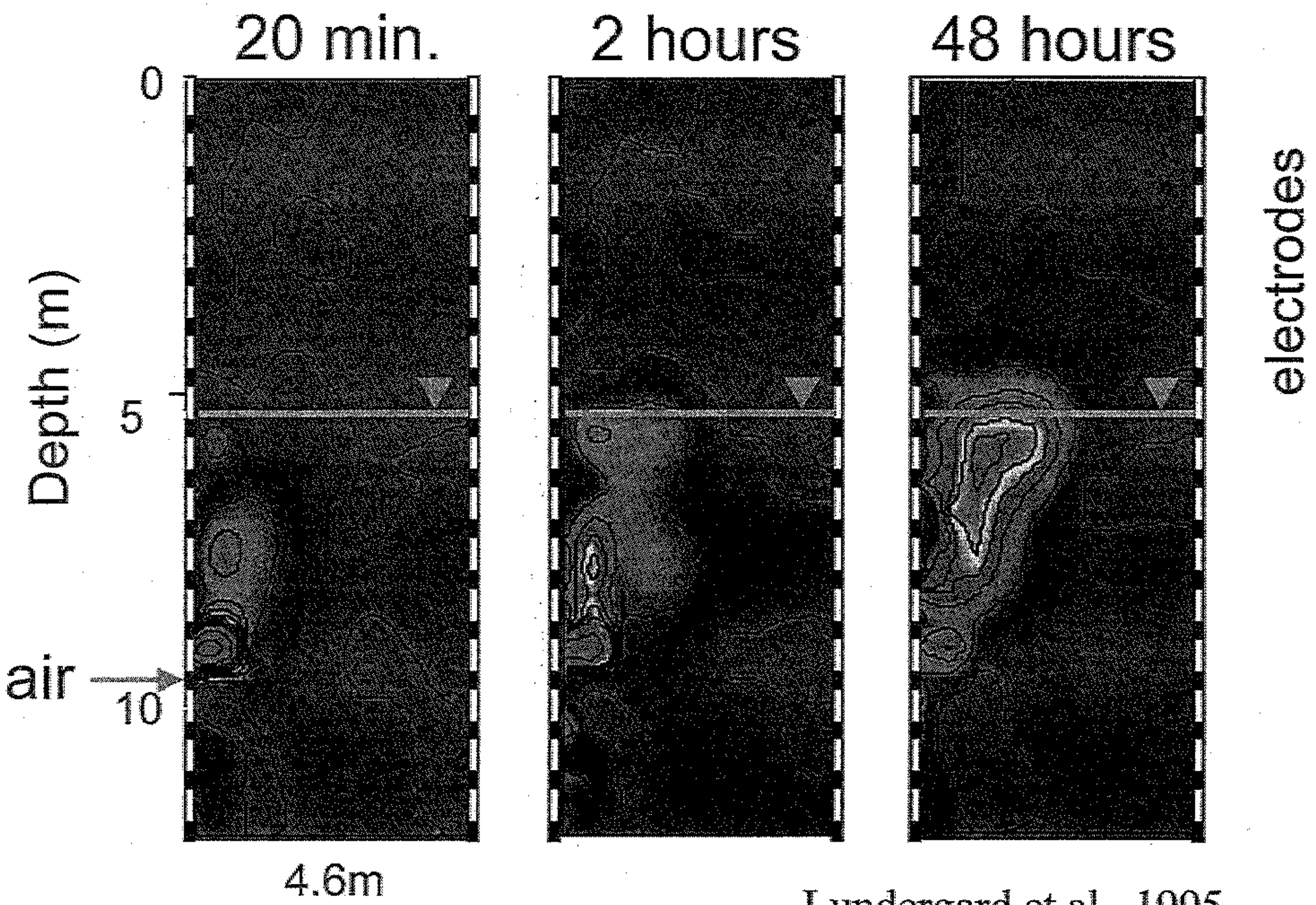


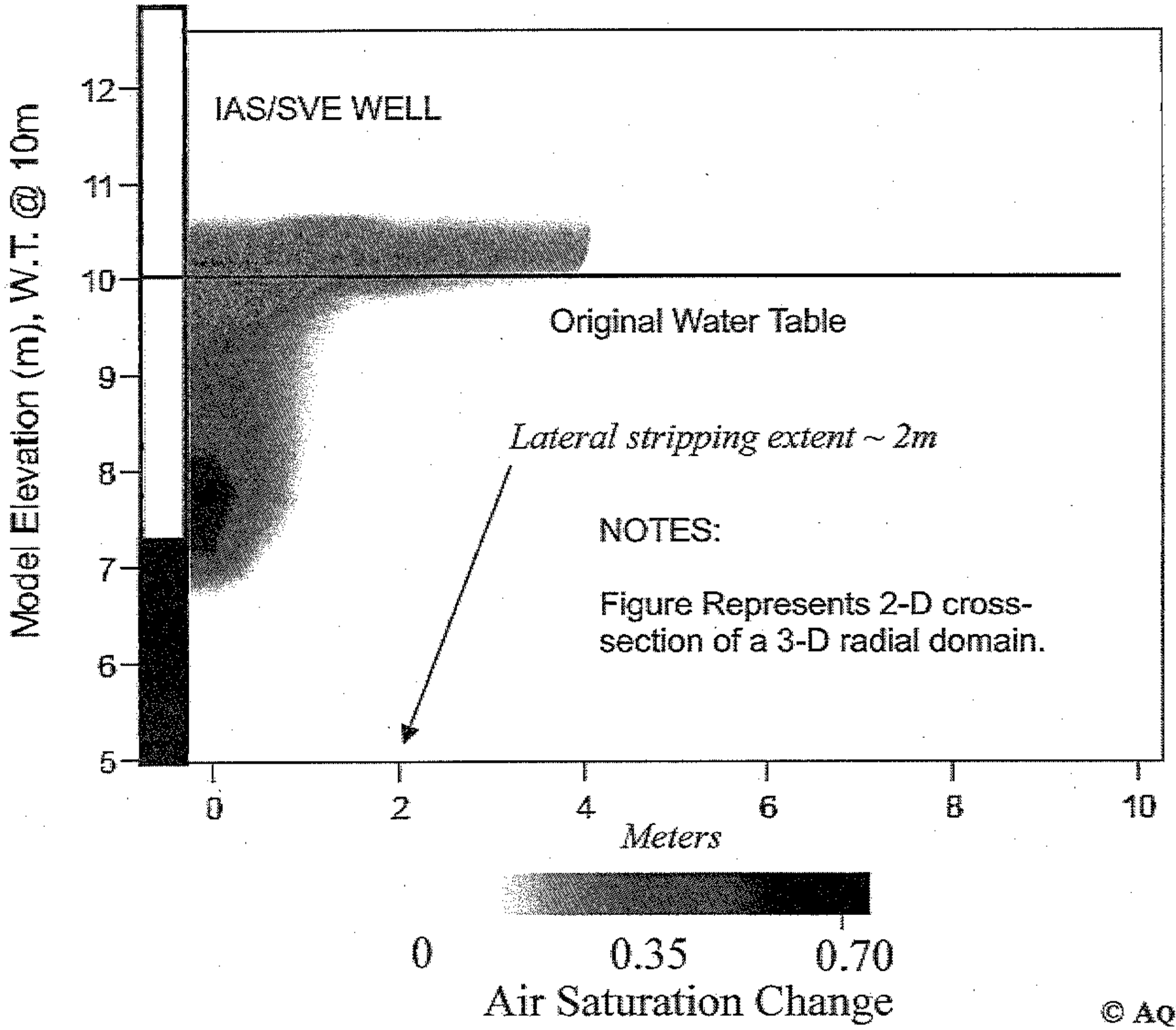
Figure 3-5
Image of IAS In-Situ Stripping Distribution in a Fine Sand
*(by Electromagnetic Tomography)*



Lundergard et al., 1995

# Figure 3-6: IAS Stripping Cone Estimate

(based on field test data, measured parameters, & multiphase calcs)



*Lateral stripping extent ~ 2m*

NOTES:

Figure Represents 2-D cross-section of a 3-D radial domain.

# APPENDIX 1-1
# EVALUATION METHODOLOGY

# GROUNDWATER PLUME ASSESSMENT METHODS

A set of evaluation methods have been developed that use site groundwater data to estimate plume conditions, stability, and longevity. The following sections discuss the approach that is applied to sites affected by petroleum releases under relatively simple and conservative conditions. In summary, the approach includes evaluations of plume stability and attenuation (mass loss). This evaluation process builds extensively on contaminant fate and transport concepts outlined in the 2002 American Petroleum Institute Publication #4715.

## EVALUATION OF PLUME STABILITY & MASS THROUGH TIME

Plume stability refers to a lack of observable geographic spreading through time after some known or unknown period of initial spreading. "Plume" as used here refers to the dissolved-phase footprint of any compound of concern, with different compounds often exhibiting different footprints at a site. When a stable plume condition is present, it provides a static environmental management footprint. Expanding plumes generally require different and more dynamic evaluation and management approach. For the purposes here, geographic stability can also include plume contraction whereby the boundary pertaining to a given dissolved-phase chemical is shrinking through time. A stable or contracting plume allows for simple and conservative estimates of potential impacts to the waters of the State and other receptors, as applicable.

Plume stability or contraction is caused by a variety of attributes in the subsurface hydrogeologic and chemical system. Biodegradation of amenable compounds is often a key facet to stability. Nonlinear sorption of chemicals to certain mineral and organic materials in saturated soil can remove mass from the dissolved-phase plume system. Dispersion and transport of chemicals in aquifer materials will dilute a compound plume to lower concentrations on the plume periphery. Abiotic reactions are also possible (hydrolysis, oxidation, photolysis, etc.) but generally are not important in near-surface aquifer conditions.

Plume stability as a function of all these dynamic transport and attenuation processes can be simply evaluated by spatial statistics. These analyses consider the total relative dissolved-phase mass of a particular compound as observed from monitoring data through time. First, the data are inspected for downgradient migration of the plume front. If the maximum plume boundary is not expanding after some maximum distribution time stamp, the relative plume mass through time can be inspected for mass losses.

If the integrated dissolved-phase mass of the plume is decreasing in the footprint, then it is clearly losing mass with an accordingly diminishing threat to the waters of the State. Related to this analysis is a center-of-mass evaluation. If the center-of-mass is not moving downgradient significantly, then this too is an indicator that the plume center is stable. Often, this stable mass represents a small residual chemical source in diffusion-limited zones, imparting small but persistent mass to clean groundwater that moves into the area from an upgradient direction.

The calculation methodology produces a dissolved-phase mass that is generally conservative, and more importantly, is used to compare mass at different times. The dissolved-phase mass is used as an indicator of plume conditions, while recognizing that there may be additional sorbed or residual mass in soil that feeds this dissolved-plume. The total mass in the system is typically greater than the dissolved-phase mass alone. The maximum volume of impacted groundwater is estimated. The volume is derived from the areal extent of impacts determined through site characterization and dissolved-phase plume tracking through time. The dissolved-phase plume thickness is estimated from site data where available, or conservatively assumed if data are not available. The porosity of the saturated zone is based on site data if available, or estimated from literature values based on the described soil types at a site. The relative dissolved-phase mass is then estimated by integrating the spatial concentrations over the volume of contaminated groundwater. That total dissolved mass, divided by the total water volume in the area of integration, equals the integrated average concentration that can be used in flux estimates. The changes in mass are relative comparisons. The total mass is a function of the volume of groundwater that is impacted. The changes in mass are independent of the total mass.

## ESTIMATION OF TEMPORAL CONCENTRATION DECREASES

In addition to the spatial plume evaluations above, the temporal concentration trends at key wells along the plume axis are determined; the nature and distribution of the site specific plume(s) determine the wells selected for analysis. These temporal trends allow a forward estimate of the time to reach State MCL for any particular compound of concern at a particular location when statistically decreasing trends are present. It is often observed that central "core" wells will exhibit a longer expected chemical lifespan than peripheral wells where transport processes and degradation act to reduce plume concentrations.

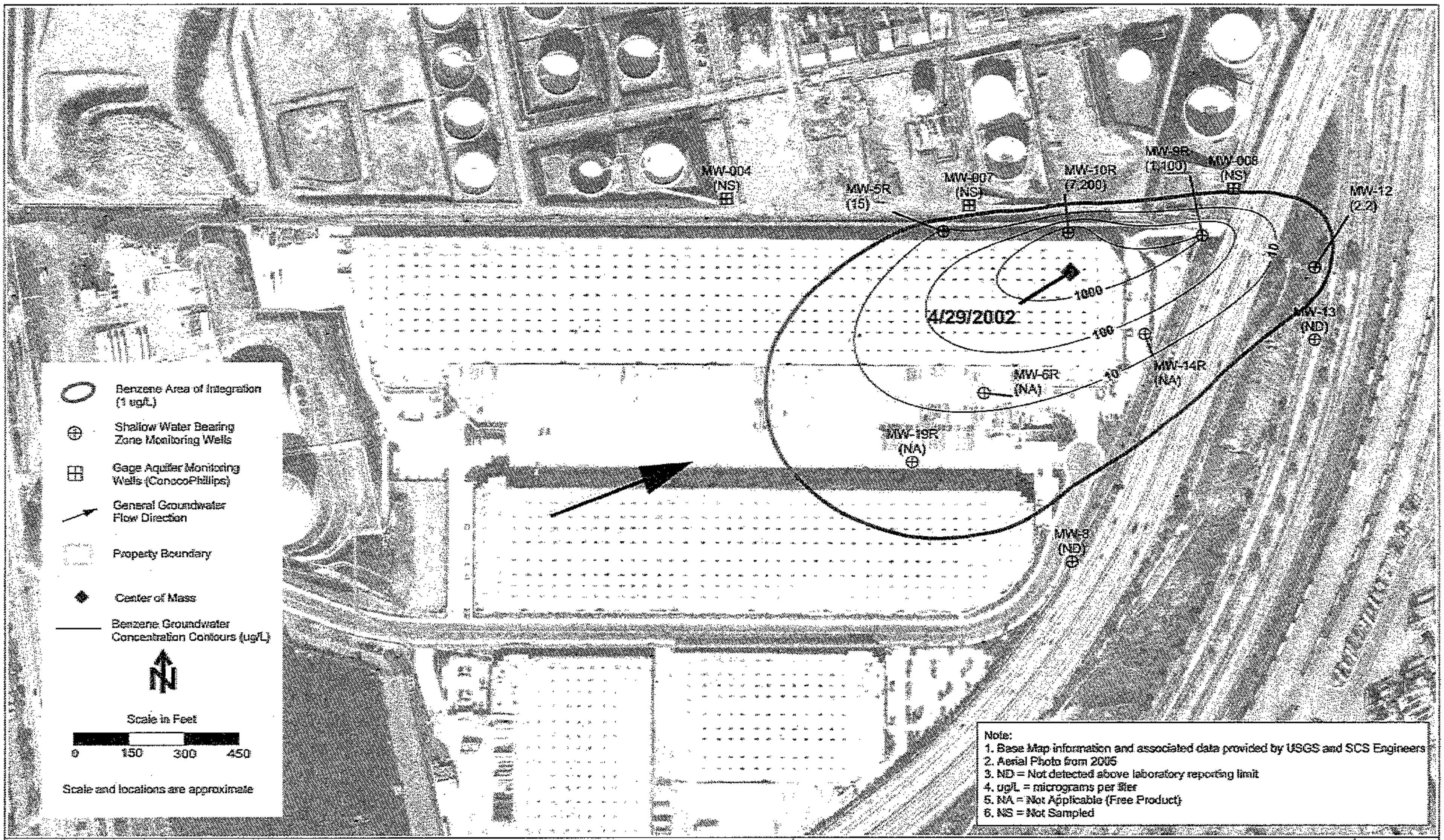
The temporal evaluations for key chemicals of concern are conducted using statistical trend analysis consistent with the form of chemical transport and decay equations (exponential form). The trends are plotted with the associated 95% confidence interval to ensure that a downward, upward, or stable trend at a specific monitoring well is identified in context with the data confidence. Obviously, an increasing or flat trend will not result in estimates of plume longevity, and other analysis methods are then required to derive those estimates and are not part of the work presented herein. Downward trends, when present, are used to estimate the time required to reach MCLs at that location under the implicit assumption that past plume decay processes will continue in the future. In general, this last assumption is conservative as plume decay processes, particularly biodegradation, often improve as chemical loading to the system decreases along with the increasing assimilative capacity of the aquifer and/or vadose zones.

## POTENTIAL IMPACTS TO GROUNDWATER USE

The potential impacts to groundwater use can be assessed using a conservative flux-based analysis for stable or contracting plumes. Using the integrated plume concentrations discussed above for each compound of concern, a potential worst-case chemical flux can be estimated by combining those data with site groundwater flow estimates. In this evaluation, it is conservatively assumed that integrated plume concentration is allowed to propagate into the aquifer system with no attenuation or other mass losses. This results in a conservatively-high mass loading of compounds of concern to the aquifer. That mass loading is then evaluated in context with potential groundwater pumping rates to estimate the maximum potential groundwater concentrations at hypothetical pumping locations. Losses of chemical mass as a result of all forms of natural attenuation are not considered. If a plume is stable or contracting, it is clear that there are actually no relevant mass fluxes into the aquifer system past the non-detection boundary. As a result, the calculation is a highly conservative determination of mass flux from the defined area of impacts and is intended as a conservative screening method, and not as a realistic set of transport or flux conditions. The value used for hydraulic conductivity was 11 feet per day.

The groundwater flow through the aquifer is estimated from Darcy's Law using the measured or assumed aquifer hydraulic conductivity and the average groundwater gradient. That groundwater flow/unit area (Darcian Velocity) is then combined with the integrated concentration data at the most recent plume time stamp to determine the mass flux. Then, using the width and depth of the plume used in the statistical spatial analysis as the cross-sectional area, the total mass loading to the system is estimated. This mass flux is then allowed to be fully captured by a hypothetical groundwater production well pumping at pumping rates ranging from 100 to 1,000 gallons per minute. The calculation results in a value for the concentration of a compound of concern in the pumped groundwater as a function of the applied pumping rate. This maximum potential concentration of the compounds of concern in produced groundwater are compared to State maximum contaminant levels (MCLs) in drinking water, or notification levels where MCLs have not been determined.

# APPENDIX 1-2
# DISSOLVED PHASE BENZENE PLUME MAPS



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2006
3. ND = Not detected above laboratory reporting limit
4. ug/L = micrograms per liter
5. NA = Not Applicable (Free Product)
6. NS = Not Sampled

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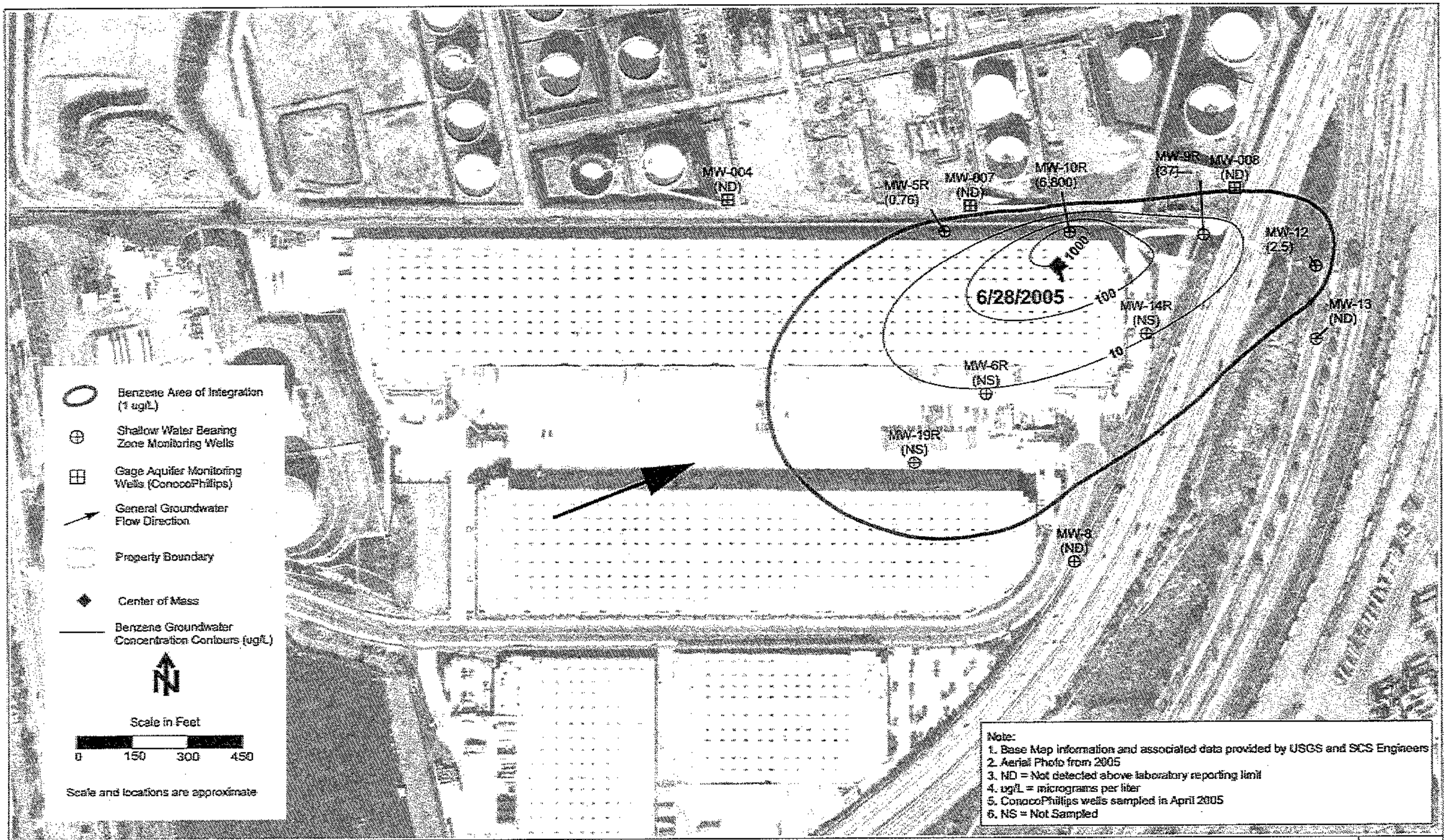
**Benzene in Groundwater- April 2002**
BlackRock Realty
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

APPENDIX:
1-2-1



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2005
3. ND = Not detected above laboratory reporting limit
4. ug/L = micrograms per liter
5. ConocoPhillips wells sampled in April 2005
6. NS = Not Sampled

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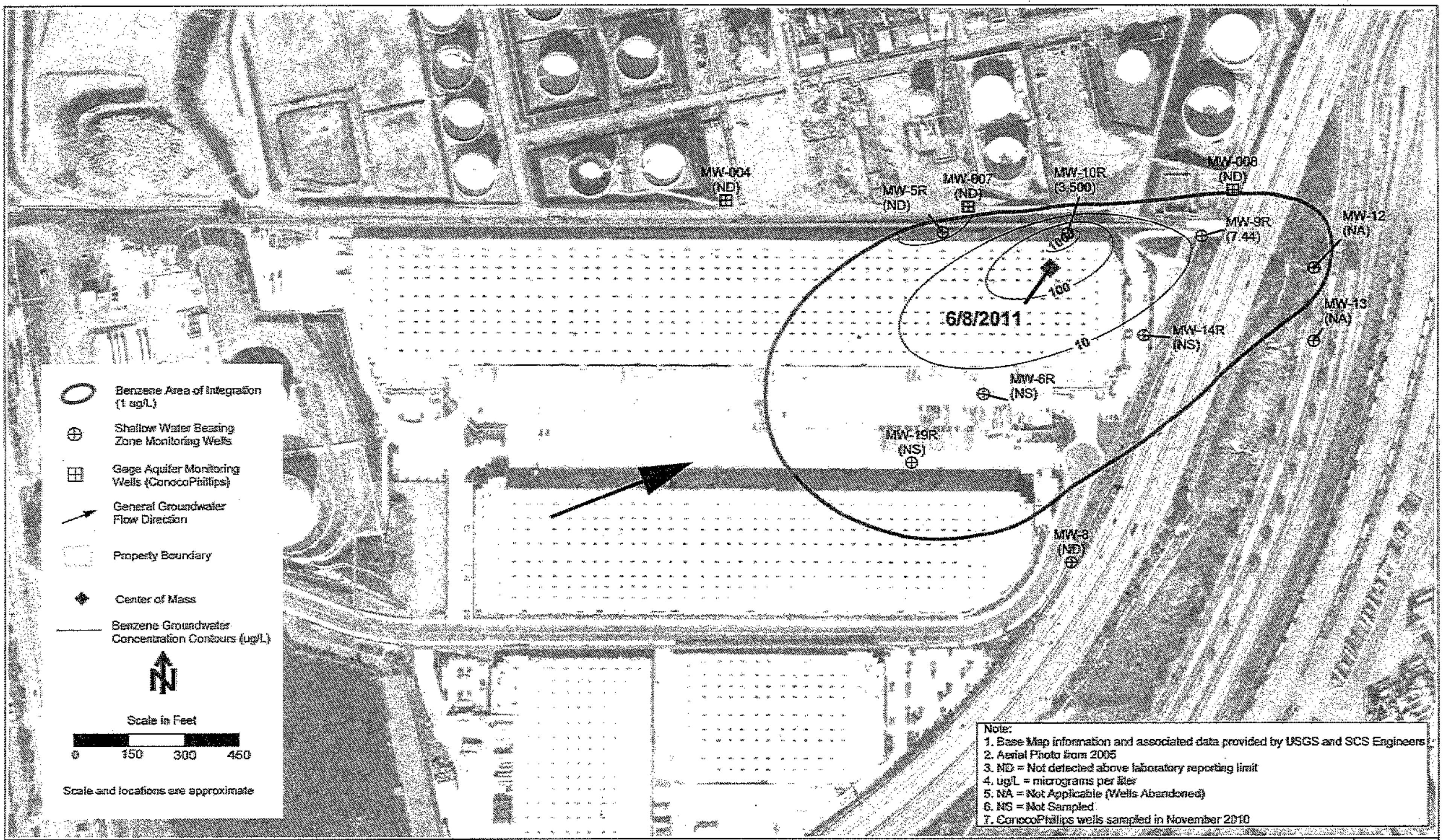
*Hydrogeology, Water Resources & Data Services*

## Benzene in Groundwater- June 2005

BlackRock Realty
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

APPENDIX:
1-2-2



Note:
1. Base Map information and associated data provided by USGS and SCS Engineers
2. Aerial Photo from 2005
3. ND = Not detected above laboratory reporting limit
4. ug/L = micrograms per liter
5. NA = Not Applicable (Wells Abandoned)
6. NS = Not Sampled
7. ConocoPhillips wells sampled in November 2010

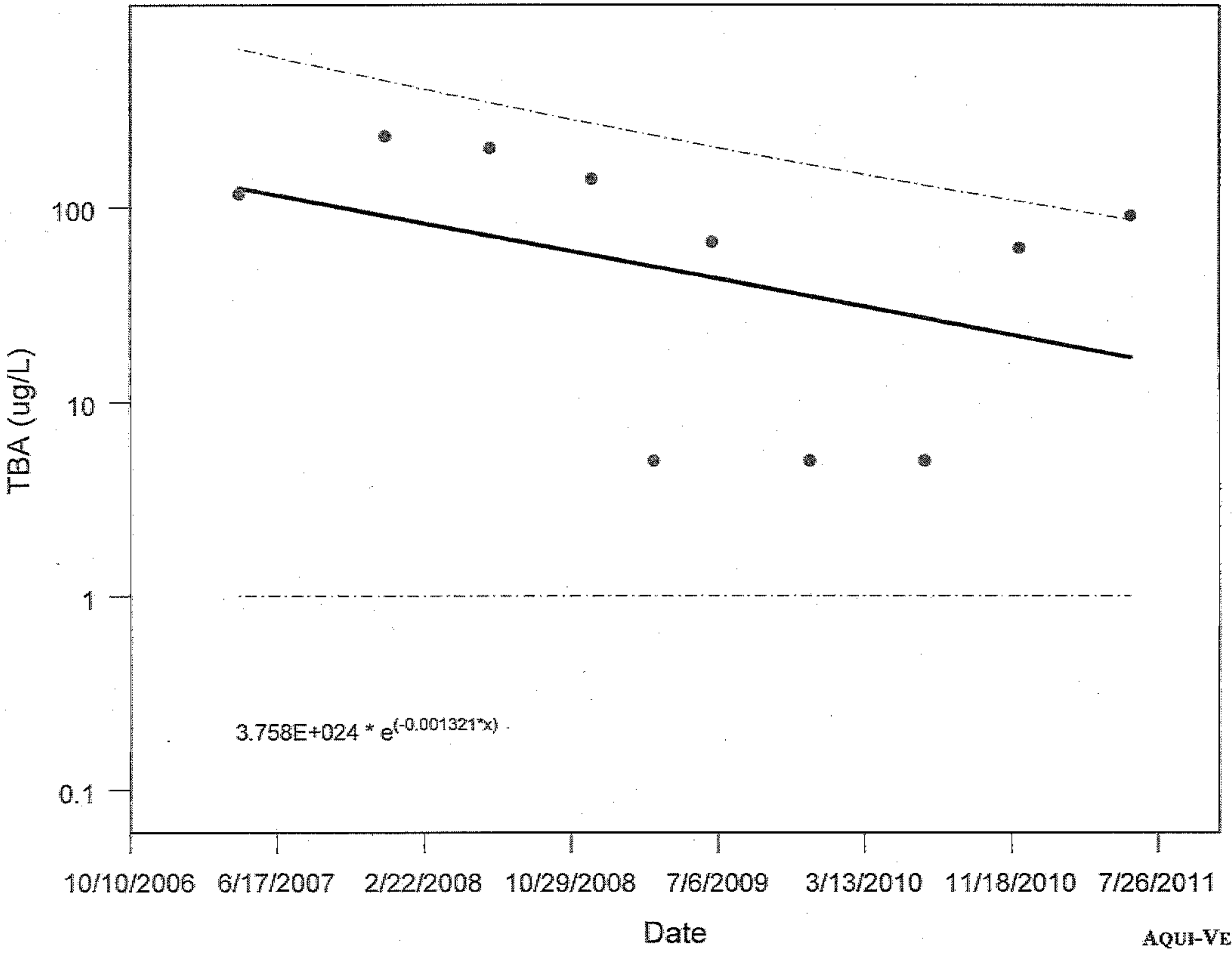
AQUI-VER, INC.
*Hydrogeology, Water Resources & Data Services*

**Benzene in Groundwater- June 2011**
BlackRock Realty
Port LA Distribution Center
300 Westmont Drive
San Pedro, California

APPENDIX:
1-2-3

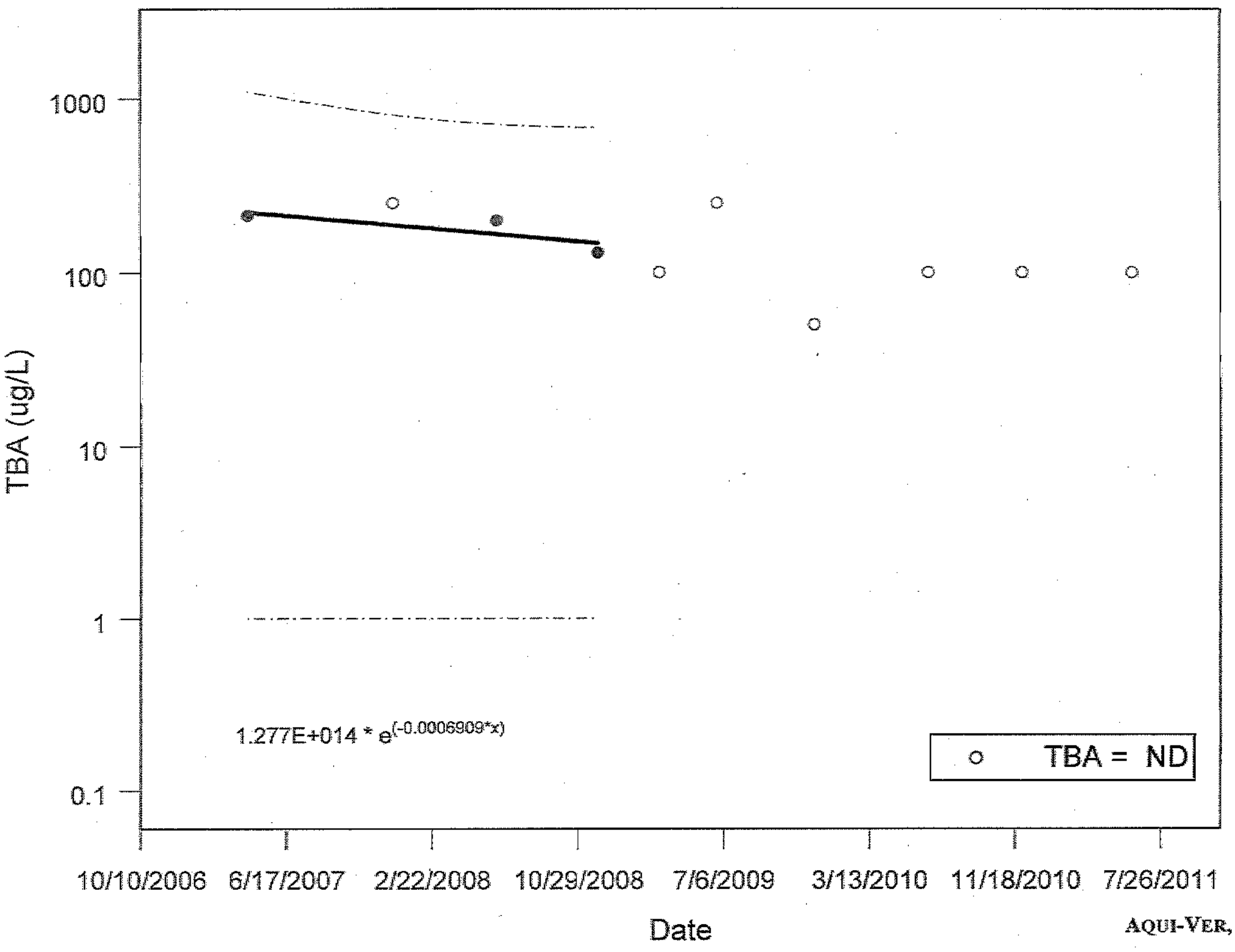
# APPENDIX 1-3
# DISSOLVED PHASE TBA STATISTICAL TRENDS

## 300 Westmont Dr., San Pedro, CA
## TBA vs. Time at MW-9R
with 95% upper confidence bound



AQUI-VER, INC.

## 300 Westmont Dr., San Pedro, CA
## TBA vs. Time at MW-10R
with 95% upper confidence bound



AQUI-VER, INC.

# APPENDIX 1-4
# FLUX ESTIMATE CALCULATIONS

# FLUX ESTIMATE CALCULATIONS

300 Westmont Dr., San Pedro, CA

**Site Condition Inputs**

| | | |
|---|---|---|
| K | 9.92E-01 | ft/day |
| q | 6.94E-03 | ft/day |
| Gradient | 7.00E-03 | |

| | TBA (50 ft) | TBA (100 ft) | |
|---|---|---|---|
| **Zone Length** | 1.48E+03 | 1.48E+03 | ft |
| **Zone Depth** | 2.50E+01 | 2.50E+01 | ft |
| **Zone Area** | 3.70E+04 | 3.70E+04 | ft |
| **Pumping Zone Thickness** | 5.00E+01 | 1.00E+02 | ft |

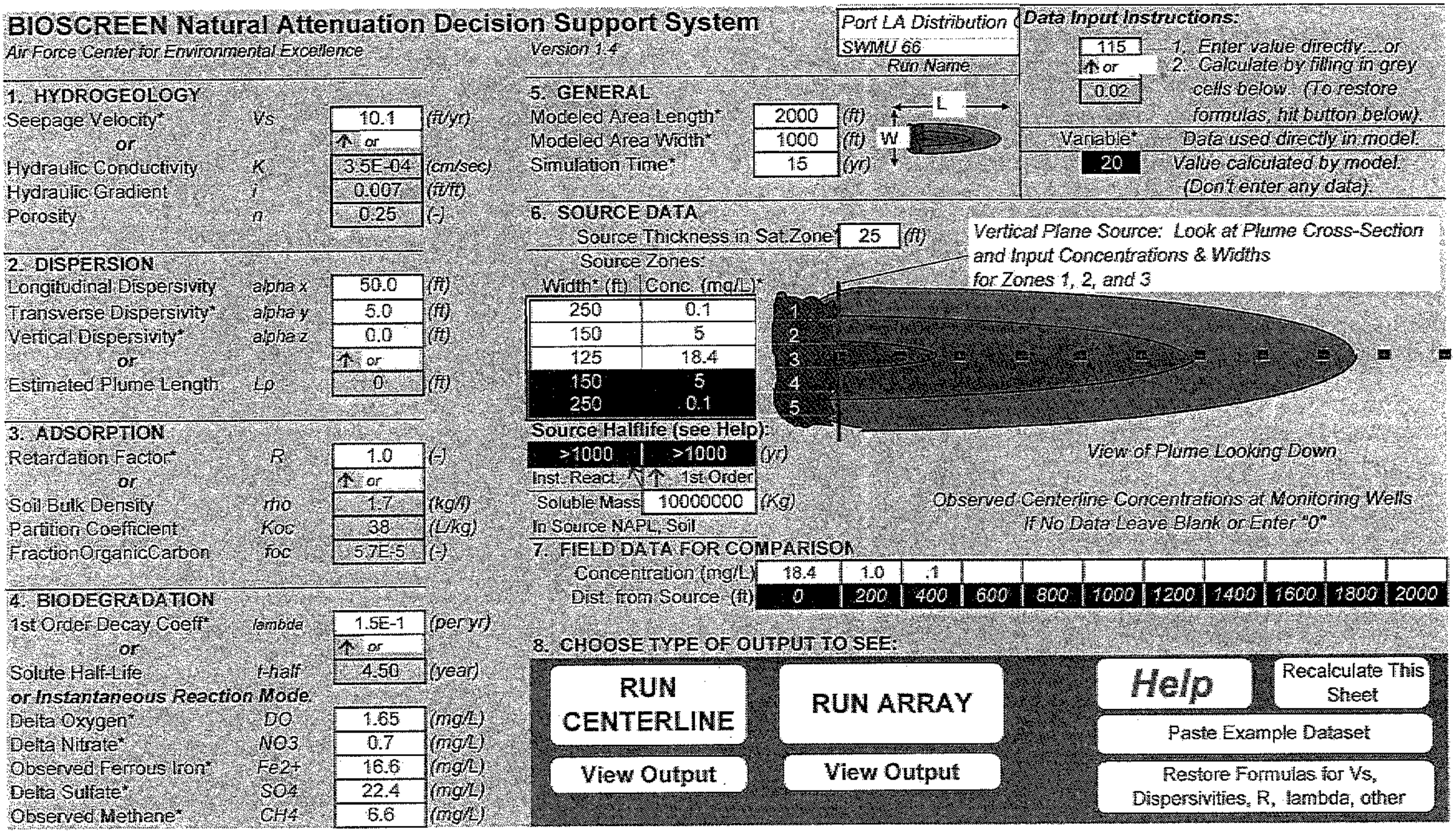
## Flux Calculation Compound Specific Inputs

| Condition | Date | Plume Statistical Concentration (ug/l) | Compound | K (ft/day) | Unit Flux (mg/ft2-day) | Unit Flux (ug/l - ft/day) | Total Flux (mg/day) |
|---|---|---|---|---|---|---|---|
| Plume-wide statistical | December/August 2007 | 1604 | TBA (50 ft) | 1 | 3.16E-01 | 1.11E+01 | 1.17E+04 |
| Plume-wide statistical | December/August 2007 | 1604 | TBA (100 ft) | 1 | 3.16E-01 | 1.11E+01 | 1.17E+04 |

## Flux Calculation Output

| | Well Production Rates (gpm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Date | K (ft/day) | 100 | 200 | 300 | 400 | 500 | 1000 |
| **TBA (50 ft)** | December/August 2007 | 1 | 10.72 | 5.36 | 3.57 | 2.68 | 2.14 | 1.07 |
| **TBA (100 ft)** | December/August 2007 | 1 | 5.36 | 2.68 | 1.79 | 1.34 | 1.07 | 0.54 |
| all concentrations are in units of ug/l | | | | | | | | |

# APPENDIX 1-5
# BIOSCREEN MODEL INPUT AND RESULTS



**BIOSCREEN Natural Attenuation Decision Support System**
*Air Force Center for Environmental Excellence*
*Version 1.4*

Port LA Distribution (
SWMU 66
Run Name

**Data Input Instructions:**
115 — 1. Enter value directly....or
↑ or — 2. Calculate by filling in grey
0.02 — cells below. (To restore formulas, hit button below).
Variable* — Data used directly in model.
20 — Value calculated by model. (Don't enter any data).

**1. HYDROGEOLOGY**
Seepage Velocity* Vs 10.1 (ft/yr)
or ↑ or
Hydraulic Conductivity K 3.5E-04 (cm/sec)
Hydraulic Gradient i 0.007 (ft/ft)
Porosity n 0.25 (-)

**2. DISPERSION**
Longitudinal Dispersivity alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.0 (ft)
or ↑ or
Estimated Plume Length Lp 0 (ft)

**3. ADSORPTION**
Retardation Factor* R 1.0 (-)
or ↑ or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
FractionOrganicCarbon foc 5.7E-5 (-)

**4. BIODEGRADATION**
1st Order Decay Coeff* lambda 1.5E-1 (per yr)
or ↑ or
Solute Half-Life t-half 4.50 (year)
***or Instantaneous Reaction Mode***
Delta Oxygen* DO 1.65 (mg/L)
Delta Nitrate* NO3 0.7 (mg/L)
Observed Ferrous Iron* Fe2+ 16.6 (mg/L)
Delta Sulfate* SO4 22.4 (mg/L)
Observed Methane* CH4 6.6 (mg/L)

**5. GENERAL**
Modeled Area Length* 2000 (ft)
Modeled Area Width* 1000 (ft)
Simulation Time* 15 (yr)

**6. SOURCE DATA**
Source Thickness in Sat.Zone* 25 (ft)
Source Zones:

| Width* (ft) | Conc. (mg/L)* |
|---|---|
| 250 | 0.1 |
| 150 | 5 |
| 125 | 18.4 |
| 150 | 5 |
| 250 | 0.1 |

Source Halflife (see Help):
>1000 | >1000 (yr)
Inst. React. ↑ ↑ 1st Order
Soluble Mass 10000000 (Kg)
In Source NAPL, Soil

*Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3*

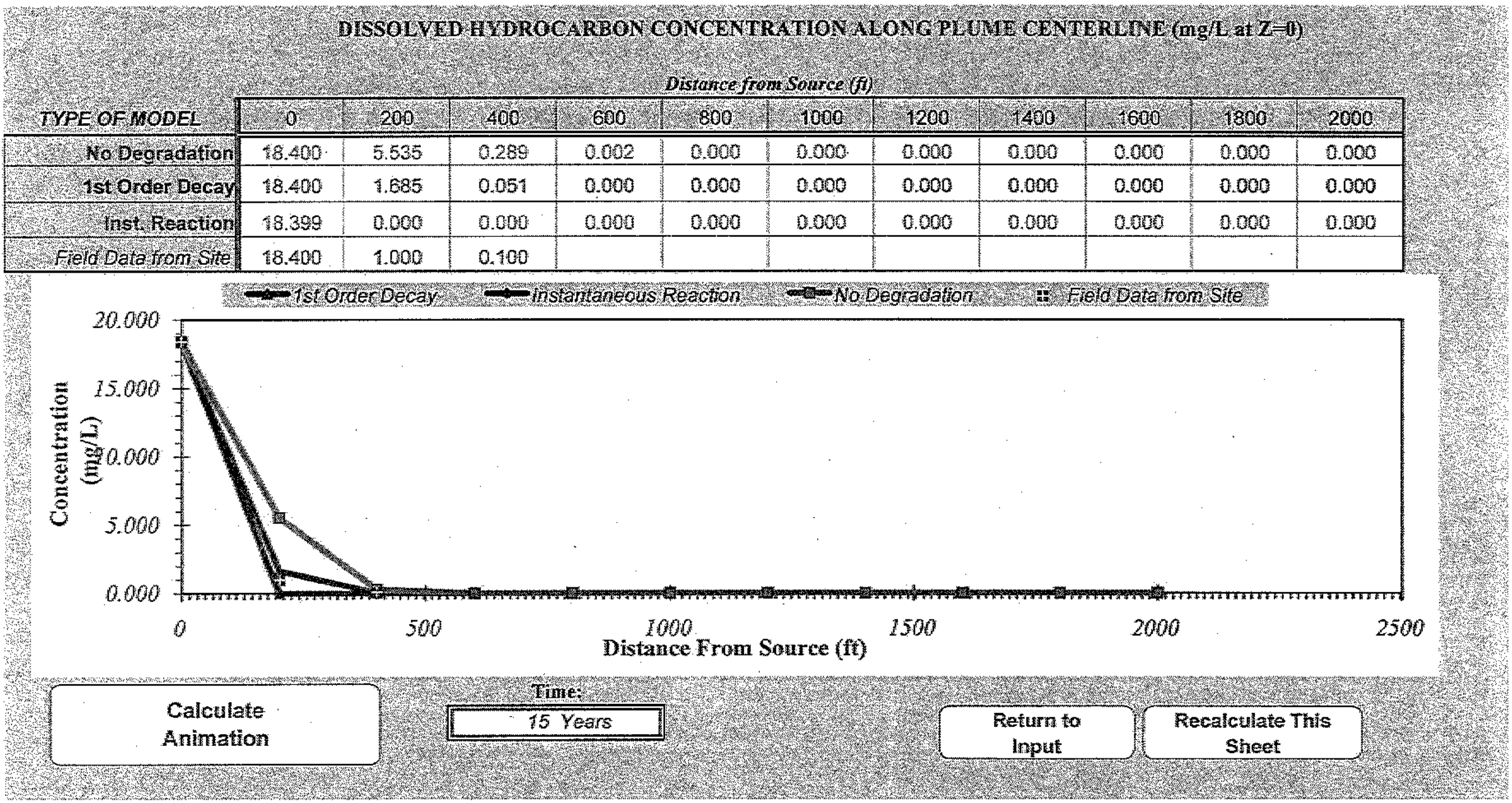
*View of Plume Looking Down*

*Observed Centerline Concentrations at Monitoring Wells*
*If No Data Leave Blank or Enter "0"*

**7. FIELD DATA FOR COMPARISON**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Concentration (mg/L) | 18.4 | 1.0 | .1 | | | | | | | | |
| Dist. from Source (ft) | 0 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |

**8. CHOOSE TYPE OF OUTPUT TO SEE:**



**DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

*Distance from Source (ft)*

| TYPE OF MODEL | 0 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **No Degradation** | 18.400 | 5.535 | 0.289 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **1st Order Decay** | 18.400 | 1.685 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Inst. Reaction** | 18.399 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *Field Data from Site* | 18.400 | 1.000 | 0.100 | | | | | | | | |

Time: 15 Years

# APPENDIX 2-1
# CAPILLARY PARAMETER DERIVATIONS

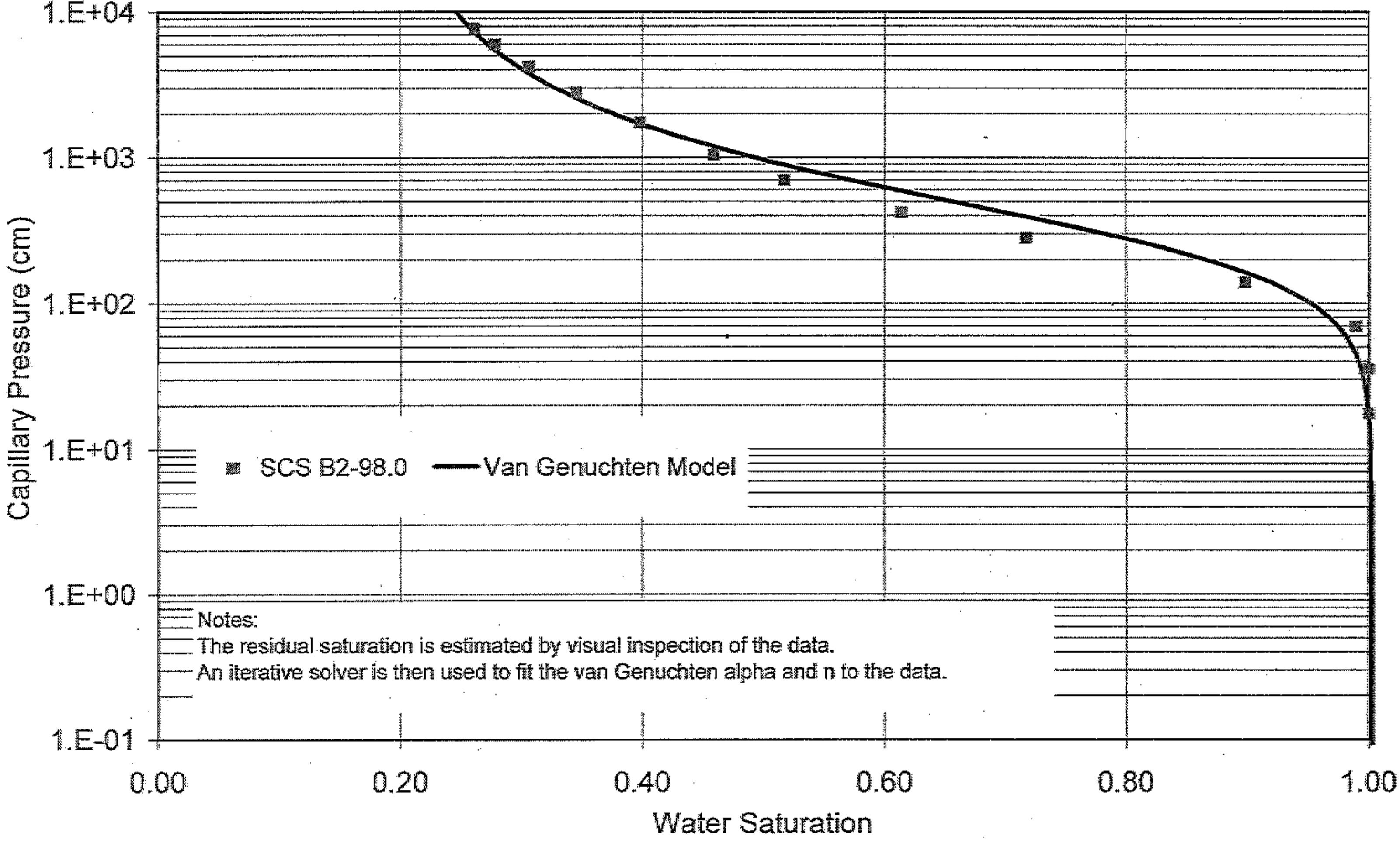
# TABLE 1
# SUMMARY OF CAPILLARY TEST RESULTS

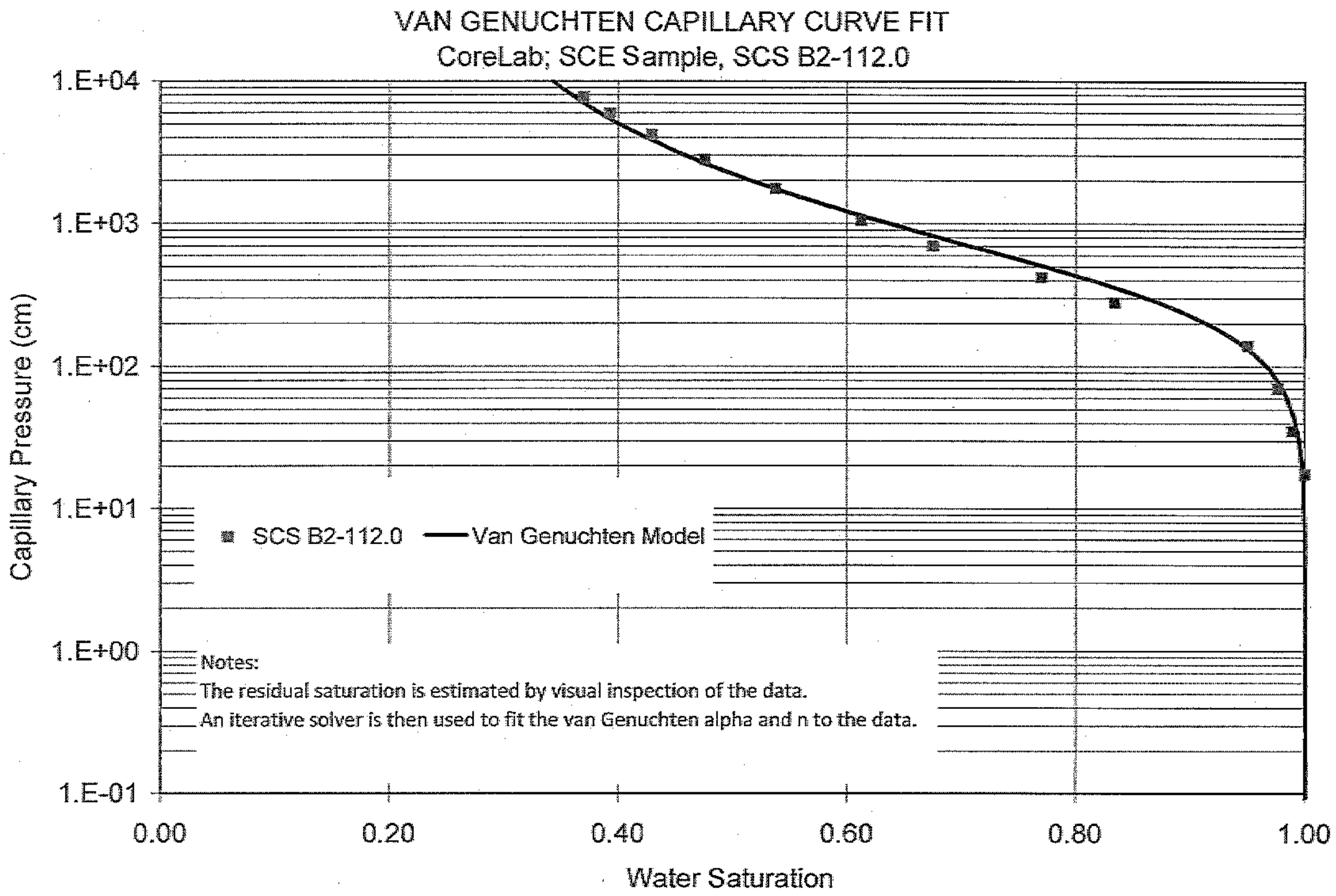
| VAN GENUCHTEN PARAMETERS | | | | | | |
|---|---|---|---|---|---|---|
| Sample ID | alpha α (cm$^{-1}$) | beta n | Residual Water Saturation | Breakthrough (cm) | Curve Fit R$^2$ | Curve Fit SSR |
| SCS B2-98.0 | 3.50E-03 | 1.75 | 0.19 | 70.30 | 0.988 | 1.82E-02 |
| SCS B2-112.0 | 2.70E-03 | 1.56 | 0.22 | 35.20 | 0.996 | 4.33E-03 |

Notes:
alpha ($\alpha$), n, residual water saturation ($S_r$) and saturated (total) water content ($S_s$) are capillary parameters defined by the following equation (van Genuchten, 1980),
with m = 1-1/n, S = water saturation, and h = capillary head (cm):

$$S = S_r + [(S_s - S_r)/(1+(\alpha h)^n)^m]$$

## VAN GENUCHTEN CAPILLARY CURVE FIT
CoreLab; SCE Sample, SCS B2-98.0





VAN GENUCHTEN CAPILLARY CURVE FIT
CoreLab; SCE Sample, SCS B2-112.0

Notes:
The residual saturation is estimated by visual inspection of the data.
An iterative solver is then used to fit the van Genuchten alpha and n to the data.

## Van Genuchten Capillary Model - Air/Water

| SCS B2.08.0 | | |
|---|---|---|
| alpha (α) | [illegible] | 1/cm |
| beta (n) | 1.750 | -- |
| Residual Water ($\theta_r$) | 0.190 | -- |
| Total Water ($S_s$) | 1.003 | -- |
| gamma (m) | 0.429 | -- |
| Specific Permeability to Water | 1.41 | mD |
| Specific Permeability to Air | 0.41 | mD |

| $R^2$ |
|---|
| 0.98753 |

| SSR |
|---|
| 1.83E-02 |

| Raw Data | | |
|---|---|---|
| Measured Capillary Head (cm) | Measured Saturation (% pv) | Measured Saturation (pv) |
| 0.00 | 1.00 | 1.000 |
| 17.60 | 1.00 | 1.000 |
| 35.20 | 1.00 | 1.000 |
| 70.30 | 0.99 | 0.989 |
| 140.60 | 0.90 | 0.898 |
| 281.20 | 0.72 | 0.717 |
| 421.90 | 0.61 | 0.614 |
| 703.10 | 0.52 | 0.517 |
| 1054.70 | 0.46 | 0.460 |
| 1757.80 | 0.40 | 0.398 |
| 2812.40 | 0.35 | 0.345 |
| 4218.80 | 0.31 | 0.306 |
| 5976.40 | 0.28 | 0.278 |
| 7734.10 | 0.26 | 0.261 |

| Van Genuchten Capillary Model - Air/Water | | | | |
|---|---|---|---|---|
| Measured Capillary Head (cm) | Measured Saturation (pv) | Predicted Saturation (pv) | Residuals (Saturation) | Square Residual (Saturation) |
| 0 | 1.000 | 1.003 | 0.0027 | 0.0000074 |
| 18 | 1.000 | 1.000 | 0.000 | 0.0000000 |
| 35 | 1.000 | 0.994 | -0.006 | 0.0000360 |
| 70 | 0.989 | 0.974 | -0.015 | 0.0002105 |
| 141 | 0.898 | 0.919 | 0.021 | 0.0004367 |
| 281 | 0.717 | 0.797 | 0.080 | 0.0064698 |
| 422 | 0.614 | 0.699 | 0.085 | 0.0072461 |
| 703 | 0.517 | 0.572 | 0.055 | 0.0029835 |
| 1055 | 0.460 | 0.483 | 0.024 | 0.0005644 |
| 1758 | 0.398 | 0.394 | -0.004 | 0.0000127 |
| 2812 | 0.345 | 0.335 | -0.010 | 0.0000978 |
| 4219 | 0.306 | 0.297 | -0.009 | 0.0000725 |
| 5976 | 0.278 | 0.273 | -0.005 | 0.0000258 |
| 7734 | 0.261 | 0.258 | -0.003 | 0.0000088 |

| Model Derived Capillary Parameters - For Plotting | | | | |
|---|---|---|---|---|
| Capillary Head (cm) | Calculated Saturation (pv) | Effective Saturation | Effective Water Permeability | Effective Air Permeability |
| | Van Genuchten Model | (scaled for residual) | (Mualem, 1976) | (Mualem, 1976) |
| 0.001 | 1.003 | 1.000 | 1.41E+00 | 3.00E-13 |
| 0.02 | 1.003 | 1.000 | 1.41E+00 | 4.00E-10 |
| 0.04 | 1.003 | 1.000 | 1.40E+00 | 2.40E-09 |
| 0.06 | 1.003 | 1.000 | 1.40E+00 | 4.23E-09 |
| 0.08 | 1.003 | 1.000 | 1.40E+00 | 1.28E-08 |
| 0.09 | 1.003 | 1.000 | 1.40E+00 | 1.71E-08 |
| 1 | 1.003 | 1.000 | 1.37E+00 | 5.20E-06 |
| 1.2 | 1.003 | 1.000 | 1.36E+00 | 8.02E-06 |
| 1.3 | 1.003 | 1.000 | 1.36E+00 | 9.70E-06 |
| 1.5 | 1.003 | 1.000 | 1.35E+00 | 1.30E-05 |
| 2 | 1.003 | 1.000 | 1.34E+00 | 2.70E-05 |
| 3 | 1.003 | 1.000 | 1.32E+00 | 7.05E-05 |
| 5 | 1.002 | 1.000 | 1.27E+00 | 2.38E-04 |
| 7 | 1.002 | 0.999 | 1.24E+00 | 5.28E-04 |
| 9 | 1.002 | 0.999 | 1.20E+00 | 9.60E-04 |
| 11 | 1.002 | 0.998 | 1.17E+00 | 1.54E-03 |
| 15 | 1.001 | 0.998 | 1.11E+00 | 3.21E-03 |
| 20 | 0.999 | 0.996 | 1.05E+00 | 6.32E-03 |
| 25 | 0.998 | 0.994 | 9.90E-01 | 1.07E-02 |
| 30 | 0.996 | 0.992 | 9.30E-01 | 1.64E-02 |
| 35 | 0.994 | 0.989 | 8.86E-01 | 2.34E-02 |
| 40 | 0.992 | 0.987 | 8.30E-01 | 3.10E-02 |
| 45 | 0.989 | 0.984 | 7.94E-01 | 4.19E-02 |
| 50 | 0.987 | 0.980 | 7.62E-01 | 5.33E-02 |

| Model Derived Capillary Parameters - For Plotting | | | | |
|---|---|---|---|---|
| Capillary Head (cm) | Calculated Saturation (pv) | Effective Saturation | Effective Water Permeability | Effective Air Permeability |
| | Van Genuchten Model | (scaled for residual) | (Mualem, 1976) | (Mualem, 1976) |
| 60 | 0.981 | 0.973 | 6.77E-01 | 8.06E-02 |
| 70 | 0.975 | 0.966 | 6.09E-01 | 1.13E-01 |
| 75 | 0.971 | 0.961 | 5.76E-01 | 1.32E-01 |
| 80 | 0.968 | 0.957 | 5.46E-01 | 1.52E-01 |
| 85 | 0.964 | 0.953 | 5.22E-01 | 1.73E-01 |
| 90 | 0.961 | 0.948 | 4.96E-01 | 1.96E-01 |
| 95 | 0.957 | 0.943 | 4.71E-01 | 2.19E-01 |
| 100 | 0.953 | 0.939 | 4.47E-01 | 2.44E-01 |
| 120 | 0.937 | 0.919 | 3.66E-01 | 3.54E-01 |
| 140 | 0.919 | 0.898 | 3.09E-01 | 4.78E-01 |
| 160 | 0.902 | 0.876 | 2.47E-01 | 6.12E-01 |
| 180 | 0.884 | 0.854 | 2.04E-01 | 7.53E-01 |
| 200 | 0.866 | 0.832 | 1.69E-01 | 8.98E-01 |
| 220 | 0.849 | 0.810 | 1.41E-01 | 1.04E+00 |
| 240 | 0.831 | 0.789 | 1.16E-01 | 1.19E+00 |
| 260 | 0.815 | 0.769 | 9.94E-02 | 1.33E+00 |
| 280 | 0.798 | 0.749 | 8.40E-02 | 1.47E+00 |
| 300 | 0.783 | 0.729 | 7.13E-02 | 1.61E+00 |
| 320 | 0.768 | 0.711 | 6.08E-02 | 1.74E+00 |
| 340 | 0.753 | 0.693 | 5.21E-02 | 1.87E+00 |
| 360 | 0.739 | 0.676 | 4.48E-02 | 1.99E+00 |
| 380 | 0.726 | 0.659 | 3.87E-02 | 2.10E+00 |
| 400 | 0.713 | 0.643 | 3.35E-02 | 2.21E+00 |
| 420 | 0.700 | 0.628 | 2.92E-02 | 2.32E+00 |
| 440 | 0.688 | 0.613 | 2.55E-02 | 2.42E+00 |
| 460 | 0.677 | 0.599 | 2.24E-02 | 2.51E+00 |
| 480 | 0.666 | 0.586 | 1.97E-02 | 2.60E+00 |
| 500 | 0.656 | 0.573 | 1.74E-02 | 2.69E+00 |
| 550 | 0.632 | 0.544 | 1.29E-02 | 2.89E+00 |
| 600 | 0.610 | 0.517 | 9.77E-03 | 3.06E+00 |
| 650 | 0.590 | 0.493 | 7.51E-03 | 3.21E+00 |
| 700 | 0.573 | 0.471 | 5.86E-03 | 3.34E+00 |
| 750 | 0.556 | 0.451 | 4.64E-03 | 3.46E+00 |
| 800 | 0.542 | 0.433 | 3.72E-03 | 3.57E+00 |
| 850 | 0.528 | 0.416 | 3.01E-03 | 3.67E+00 |
| 900 | 0.516 | 0.401 | 2.46E-03 | 3.76E+00 |
| 950 | 0.504 | 0.387 | 2.03E-03 | 3.84E+00 |
| 1000 | 0.494 | 0.373 | 1.69E-03 | 3.91E+00 |
| 1050 | 0.484 | 0.361 | 1.42E-03 | 3.97E+00 |
| 1100 | 0.474 | 0.350 | 1.20E-03 | 4.03E+00 |
| 1150 | 0.466 | 0.339 | 1.02E-03 | 4.09E+00 |
| 1200 | 0.458 | 0.330 | 8.74E-04 | 4.14E+00 |
| 1250 | 0.450 | 0.320 | 7.52E-04 | 4.19E+00 |
| 1300 | 0.443 | 0.312 | 6.51E-04 | 4.23E+00 |
| 1350 | 0.437 | 0.304 | 5.67E-04 | 4.27E+00 |
| 1400 | 0.430 | 0.296 | 4.96E-04 | 4.31E+00 |
| 1450 | 0.425 | 0.289 | 4.35E-04 | 4.34E+00 |
| 1500 | 0.419 | 0.282 | 3.83E-04 | 4.38E+00 |
| 1550 | 0.414 | 0.276 | 3.39E-04 | 4.41E+00 |
| 1600 | 0.409 | 0.269 | 3.01E-04 | 4.44E+00 |
| 1650 | 0.404 | 0.263 | 2.68E-04 | 4.46E+00 |
| 1700 | 0.399 | 0.258 | 2.40E-04 | 4.49E+00 |
| 1750 | 0.395 | 0.252 | 2.15E-04 | 4.51E+00 |
| 1800 | 0.391 | 0.247 | 1.94E-04 | 4.54E+00 |
| 1850 | 0.387 | 0.242 | 1.76E-04 | 4.56E+00 |
| 1900 | 0.383 | 0.238 | 1.59E-04 | 4.58E+00 |
| 1950 | 0.380 | 0.233 | 1.43E-04 | 4.60E+00 |
| 2000 | 0.376 | 0.229 | 1.30E-04 | 4.62E+00 |
| 2200 | 0.364 | 0.214 | 9.07E-05 | 4.68E+00 |
| 2400 | 0.353 | 0.201 | 6.51E-05 | 4.74E+00 |
| 2600 | 0.344 | 0.189 | 4.80E-05 | 4.78E+00 |
| 2800 | 0.336 | 0.179 | 3.62E-05 | 4.82E+00 |
| 3000 | 0.328 | 0.170 | 2.78E-05 | 4.86E+00 |
| 3200 | 0.322 | 0.162 | 2.17E-05 | 4.89E+00 |
| 3400 | 0.316 | 0.155 | 1.72E-05 | 4.91E+00 |
| 3600 | 0.311 | 0.149 | 1.38E-05 | 4.94E+00 |
| 3800 | 0.306 | 0.143 | 1.12E-05 | 4.96E+00 |
| 4000 | 0.302 | 0.138 | 9.21E-06 | 4.98E+00 |
| 4200 | 0.298 | 0.133 | 7.63E-06 | 5.00E+00 |
| 4400 | 0.294 | 0.128 | 6.38E-06 | 5.01E+00 |
| 4600 | 0.291 | 0.124 | 5.38E-06 | 5.03E+00 |
| 4800 | 0.288 | 0.120 | 4.56E-06 | 5.04E+00 |
| 5000 | 0.285 | 0.117 | 3.90E-06 | 5.05E+00 |
| 5200 | 0.282 | 0.113 | 3.35E-06 | 5.06E+00 |
| 5400 | 0.279 | 0.110 | 2.90E-06 | 5.07E+00 |
| 5600 | 0.277 | 0.107 | 2.52E-06 | 5.08E+00 |
| 5800 | 0.275 | 0.104 | 2.20E-06 | 5.09E+00 |
| 6000 | 0.273 | 0.102 | 1.93E-06 | 5.10E+00 |
| 6500 | 0.268 | 0.096 | 1.42E-06 | 5.12E+00 |
| 7000 | 0.264 | 0.091 | 1.06E-06 | 5.14E+00 |
| 7500 | 0.260 | 0.086 | 8.15E-07 | 5.15E+00 |
| 8000 | 0.257 | 0.082 | 6.35E-07 | 5.17E+00 |
| 8500 | 0.254 | 0.078 | 5.03E-07 | 5.18E+00 |
| 9000 | 0.251 | 0.075 | 4.02E-07 | 5.19E+00 |
| 9500 | 0.249 | 0.072 | 3.27E-07 | 5.20E+00 |
| 10000 | 0.246 | 0.069 | 2.68E-07 | 5.21E+00 |

# Van Genuchten Capillary Model - Air/Water

| | | |
|---|---|---|
| SCS B2-112.0 | | |
| alpha (α) | 2.70E-03 | 1/cm |
| beta (n) | 1.560 | -- |
| Residual Water ($\theta_r$) | 0.220 | -- |
| Total Water ($\theta_s$) | 1.000 | -- |
| gamma (m) | 0.359 | -- |
| Specific Permeability to Water | 2.43 | mD |
| Specific Permeability to Air | 28.98 | mD |

| $R^2$ |
|---|
| 0.99577 |

| SSR |
|---|
| 4.33E-03 |

| Raw Data | | |
|---|---|---|
| Measured Capillary Head (cm) | Measured Saturation (% pv) | Measured Saturation (pv) |
| 0.00 | 1.0 | 1.000 |
| 17.60 | 1.0 | 1.000 |
| 35.20 | 1.0 | 0.989 |
| 70.30 | 1.0 | 0.976 |
| 140.60 | 1.0 | 0.950 |
| 281.20 | 0.8 | 0.834 |
| 421.90 | 0.8 | 0.770 |
| 703.10 | 0.7 | 0.675 |
| 1054.70 | 0.6 | 0.612 |
| 1757.80 | 0.5 | 0.537 |
| 2812.40 | 0.5 | 0.475 |
| 4218.60 | 0.4 | 0.429 |
| 5976.40 | 0.4 | 0.392 |
| 7734.10 | 0.4 | 0.369 |

| Van Genuchten Capillary Model - Air/Water | | | | |
|---|---|---|---|---|
| Measured Capillary Head (cm) | Measured Saturation (pv) | Predicted Saturation (pv) | Residuals (Saturation) | Square Residual (Saturation) |
| 0.00 | 1.000 | 1.000 | 0.0004 | 0.0000002 |
| 17.60 | 1.000 | 0.998 | -0.002 | 0.0000039 |
| 35.20 | 0.989 | 0.993 | 0.004 | 0.0000195 |
| 70.30 | 0.976 | 0.980 | 0.004 | 0.0000199 |
| 140.60 | 0.950 | 0.947 | -0.003 | 0.0000122 |
| 281.20 | 0.834 | 0.872 | 0.038 | 0.0014377 |
| 421.90 | 0.770 | 0.808 | 0.038 | 0.0012806 |
| 703.10 | 0.675 | 0.707 | 0.032 | 0.0010289 |
| 1054.70 | 0.612 | 0.627 | 0.015 | 0.0002361 |
| 1757.80 | 0.537 | 0.537 | 0.000 | 0.0000002 |
| 2812.40 | 0.475 | 0.467 | -0.008 | 0.0000629 |
| 4218.60 | 0.429 | 0.418 | -0.011 | 0.0001166 |
| 5976.40 | 0.392 | 0.384 | -0.008 | 0.0000696 |
| 7734.10 | 0.369 | 0.362 | -0.007 | 0.0000508 |

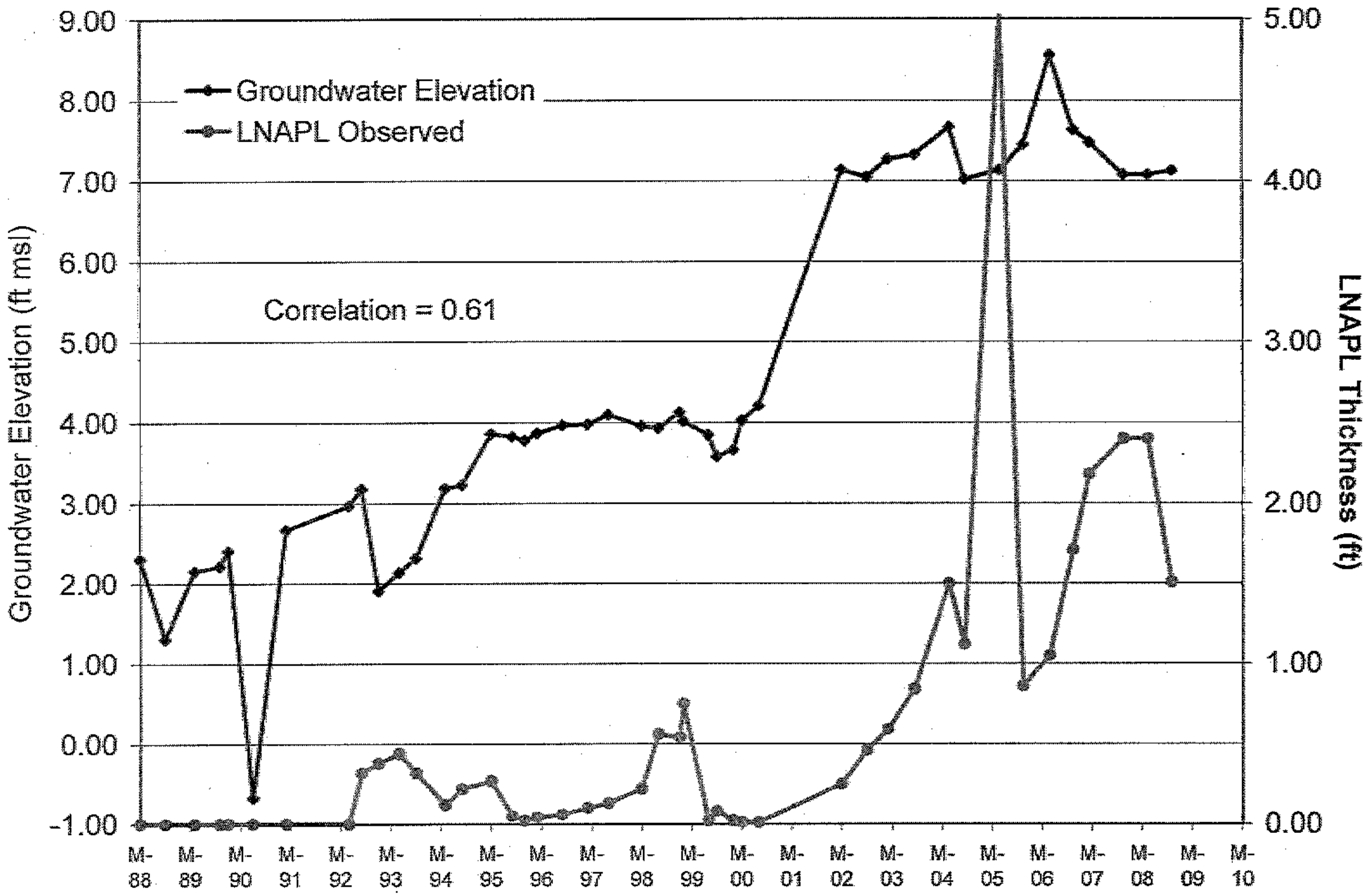
| Model Derived Capillary Parameters - For Plotting | | | | |
|---|---|---|---|---|
| Capillary Head (cm) | Calculated Saturation (pv) | Effective Saturation | Effective Water Permeability | Effective Air Permeability |
| | Van Genuchten Model | (scaled for residual) | (Mualem, 1976) | (Mualem, 1976) |
| 0.001 | 1.000 | 1.000 | 2.43E+00 | 4.56E-10 |
| 0.02 | 1.000 | 1.000 | 2.41E+00 | 1.35E-07 |
| 0.04 | 1.000 | 1.000 | 2.40E+00 | 5.05E-07 |
| 0.05 | 1.000 | 1.000 | 2.40E+00 | 7.71E-07 |
| 0.08 | 1.000 | 1.000 | 2.39E+00 | 1.66E-06 |
| 0.09 | 1.000 | 1.000 | 2.38E+00 | 2.36E-06 |
| 1 | 1.000 | 1.000 | 2.28E+00 | 2.20E-04 |
| 1.2 | 1.000 | 1.000 | 2.24E+00 | 3.23E-04 |
| 1.3 | 1.000 | 1.000 | 2.23E+00 | 3.76E-04 |
| 1.5 | 1.000 | 1.000 | 2.21E+00 | 4.94E-04 |
| 2 | 1.000 | 1.000 | 2.16E+00 | 8.83E-04 |
| 3 | 1.000 | 1.000 | 2.11E+00 | 1.64E-03 |
| 5 | 1.000 | 1.000 | 2.01E+00 | 4.86E-03 |
| 7 | 1.000 | 0.999 | 1.93E+00 | 9.20E-03 |
| 9 | 1.000 | 0.999 | 1.86E+00 | 1.40E-02 |
| 11 | 0.999 | 0.999 | 1.80E+00 | 2.17E-02 |
| 15 | 0.999 | 0.998 | 1.69E+00 | 3.90E-02 |
| 20 | 0.997 | 0.996 | 1.57E+00 | 6.70E-02 |
| 25 | 0.996 | 0.995 | 1.47E+00 | 1.02E-01 |
| 30 | 0.995 | 0.993 | 1.39E+00 | 1.43E-01 |
| 35 | 0.993 | 0.991 | 1.31E+00 | 1.91E-01 |
| 40 | 0.992 | 0.989 | 1.24E+00 | 2.45E-01 |
| 45 | 0.990 | 0.987 | 1.17E+00 | 3.04E-01 |
| 50 | 0.988 | 0.985 | 1.11E+00 | 3.69E-01 |
| 60 | 0.985 | 0.980 | 1.00E+00 | 5.15E-01 |
| 70 | 0.981 | 0.975 | 9.12E-01 | 6.79E-01 |
| 75 | 0.978 | 0.972 | 8.70E-01 | 7.66E-01 |
| 80 | 0.976 | 0.969 | 8.30E-01 | 8.61E-01 |
| 85 | 0.974 | 0.966 | 7.93E-01 | 9.57E-01 |
| 90 | 0.972 | 0.963 | 7.58E-01 | 1.06E+00 |
| 95 | 0.969 | 0.960 | 7.25E-01 | 1.16E+00 |
| 100 | 0.967 | 0.957 | 6.94E-01 | 1.27E+00 |
| 120 | 0.957 | 0.945 | 5.84E-01 | 1.72E+00 |
| 140 | 0.947 | 0.931 | 4.96E-01 | 2.22E+00 |
| 160 | 0.936 | 0.918 | 4.25E-01 | 2.73E+00 |
| 180 | 0.926 | 0.904 | 3.63E-01 | 3.27E+00 |
| 200 | 0.915 | 0.890 | 3.13E-01 | 3.82E+00 |
| 220 | 0.904 | 0.876 | 2.71E-01 | 4.37E+00 |
| 240 | 0.893 | 0.863 | 2.36E-01 | 4.91E+00 |

| Model Derived Capillary Parameters - For Plotting | | | | |
|---|---|---|---|---|
| Capillary Head (cm) | Calculated Saturation (pv) | Effective Saturation | Effective Water Permeability | Effective Air Permeability |
| | Van Genuchten Model | (scaled for residual) | (Mualem, 1976) | (Mualem, 1976) |
| 260 | 0.883 | 0.849 | 2.06E-01 | 5.46E+00 |
| 280 | 0.873 | 0.836 | 1.81E-01 | 6.00E+00 |
| 300 | 0.862 | 0.823 | 1.59E-01 | 6.52E+00 |
| 320 | 0.852 | 0.810 | 1.40E-01 | 7.04E+00 |
| 340 | 0.843 | 0.798 | 1.24E-01 | 7.54E+00 |
| 360 | 0.833 | 0.786 | 1.11E-01 | 8.02E+00 |
| 380 | 0.824 | 0.774 | 9.89E-02 | 8.49E+00 |
| 400 | 0.815 | 0.763 | 8.81E-02 | 8.95E+00 |
| 420 | 0.806 | 0.751 | 7.90E-02 | 9.39E+00 |
| 440 | 0.798 | 0.741 | 7.11E-02 | 9.82E+00 |
| 460 | 0.790 | 0.730 | 6.41E-02 | 1.02E+01 |
| 480 | 0.782 | 0.720 | 5.79E-02 | 1.06E+01 |
| 500 | 0.774 | 0.710 | 5.25E-02 | 1.10E+01 |
| 550 | 0.756 | 0.686 | 4.16E-02 | 1.19E+01 |
| 600 | 0.739 | 0.664 | 3.32E-02 | 1.27E+01 |
| 650 | 0.723 | 0.644 | 2.68E-02 | 1.35E+01 |
| 700 | 0.708 | 0.625 | 2.20E-02 | 1.41E+01 |
| 750 | 0.694 | 0.608 | 1.82E-02 | 1.48E+01 |
| 800 | 0.681 | 0.591 | 1.52E-02 | 1.53E+01 |
| 850 | 0.669 | 0.576 | 1.27E-02 | 1.59E+01 |
| 900 | 0.658 | 0.561 | 1.08E-02 | 1.63E+01 |
| 950 | 0.648 | 0.548 | 9.23E-03 | 1.68E+01 |
| 1000 | 0.638 | 0.535 | 7.93E-03 | 1.72E+01 |
| 1050 | 0.628 | 0.523 | 6.85E-03 | 1.76E+01 |
| 1100 | 0.619 | 0.512 | 5.96E-03 | 1.79E+01 |
| 1150 | 0.611 | 0.501 | 5.21E-03 | 1.83E+01 |
| 1200 | 0.603 | 0.491 | 4.57E-03 | 1.86E+01 |
| 1250 | 0.595 | 0.481 | 4.03E-03 | 1.89E+01 |
| 1300 | 0.588 | 0.472 | 3.57E-03 | 1.92E+01 |
| 1350 | 0.582 | 0.463 | 3.18E-03 | 1.94E+01 |
| 1400 | 0.575 | 0.455 | 2.84E-03 | 1.96E+01 |
| 1450 | 0.569 | 0.447 | 2.54E-03 | 1.99E+01 |
| 1500 | 0.563 | 0.440 | 2.28E-03 | 2.01E+01 |
| 1550 | 0.558 | 0.432 | 2.06E-03 | 2.03E+01 |
| 1600 | 0.552 | 0.426 | 1.86E-03 | 2.05E+01 |
| 1650 | 0.547 | 0.419 | 1.69E-03 | 2.07E+01 |
| 1700 | 0.542 | 0.413 | 1.53E-03 | 2.08E+01 |
| 1750 | 0.537 | 0.407 | 1.40E-03 | 2.10E+01 |
| 1800 | 0.533 | 0.401 | 1.28E-03 | 2.12E+01 |
| 1850 | 0.528 | 0.395 | 1.17E-03 | 2.13E+01 |
| 1900 | 0.524 | 0.390 | 1.07E-03 | 2.15E+01 |
| 1950 | 0.520 | 0.384 | 9.87E-04 | 2.16E+01 |
| 2000 | 0.516 | 0.379 | 9.10E-04 | 2.17E+01 |
| 2200 | 0.502 | 0.361 | 6.67E-04 | 2.22E+01 |
| 2400 | 0.489 | 0.345 | 5.02E-04 | 2.26E+01 |
| 2600 | 0.478 | 0.330 | 3.88E-04 | 2.29E+01 |
| 2800 | 0.468 | 0.317 | 3.02E-04 | 2.32E+01 |
| 3000 | 0.459 | 0.306 | 2.41E-04 | 2.35E+01 |
| 3200 | 0.450 | 0.295 | 1.94E-04 | 2.37E+01 |
| 3400 | 0.443 | 0.286 | 1.59E-04 | 2.40E+01 |
| 3600 | 0.436 | 0.277 | 1.31E-04 | 2.41E+01 |
| 3800 | 0.430 | 0.269 | 1.10E-04 | 2.43E+01 |
| 4000 | 0.424 | 0.262 | 9.24E-05 | 2.45E+01 |
| 4200 | 0.419 | 0.255 | 7.86E-05 | 2.46E+01 |
| 4400 | 0.414 | 0.248 | 6.72E-05 | 2.48E+01 |
| 4600 | 0.409 | 0.242 | 5.79E-05 | 2.49E+01 |
| 4800 | 0.405 | 0.237 | 5.02E-05 | 2.50E+01 |
| 5000 | 0.401 | 0.231 | 4.36E-05 | 2.51E+01 |
| 5200 | 0.397 | 0.226 | 3.84E-05 | 2.52E+01 |
| 5400 | 0.393 | 0.222 | 3.38E-05 | 2.53E+01 |
| 5600 | 0.390 | 0.217 | 2.99E-05 | 2.54E+01 |
| 5800 | 0.386 | 0.213 | 2.66E-05 | 2.55E+01 |
| 6000 | 0.383 | 0.209 | 2.37E-05 | 2.56E+01 |
| 6500 | 0.376 | 0.200 | 1.81E-05 | 2.57E+01 |
| 7000 | 0.370 | 0.192 | 1.41E-05 | 2.59E+01 |
| 7500 | 0.364 | 0.185 | 1.12E-05 | 2.60E+01 |
| 8000 | 0.359 | 0.178 | 8.97E-06 | 2.61E+01 |
| 8500 | 0.355 | 0.173 | 7.31E-06 | 2.62E+01 |
| 9000 | 0.350 | 0.167 | 6.03E-06 | 2.63E+01 |
| 9500 | 0.347 | 0.162 | 5.02E-06 | 2.64E+01 |
| 10000 | 0.343 | 0.158 | 4.22E-06 | 2.65E+01 |

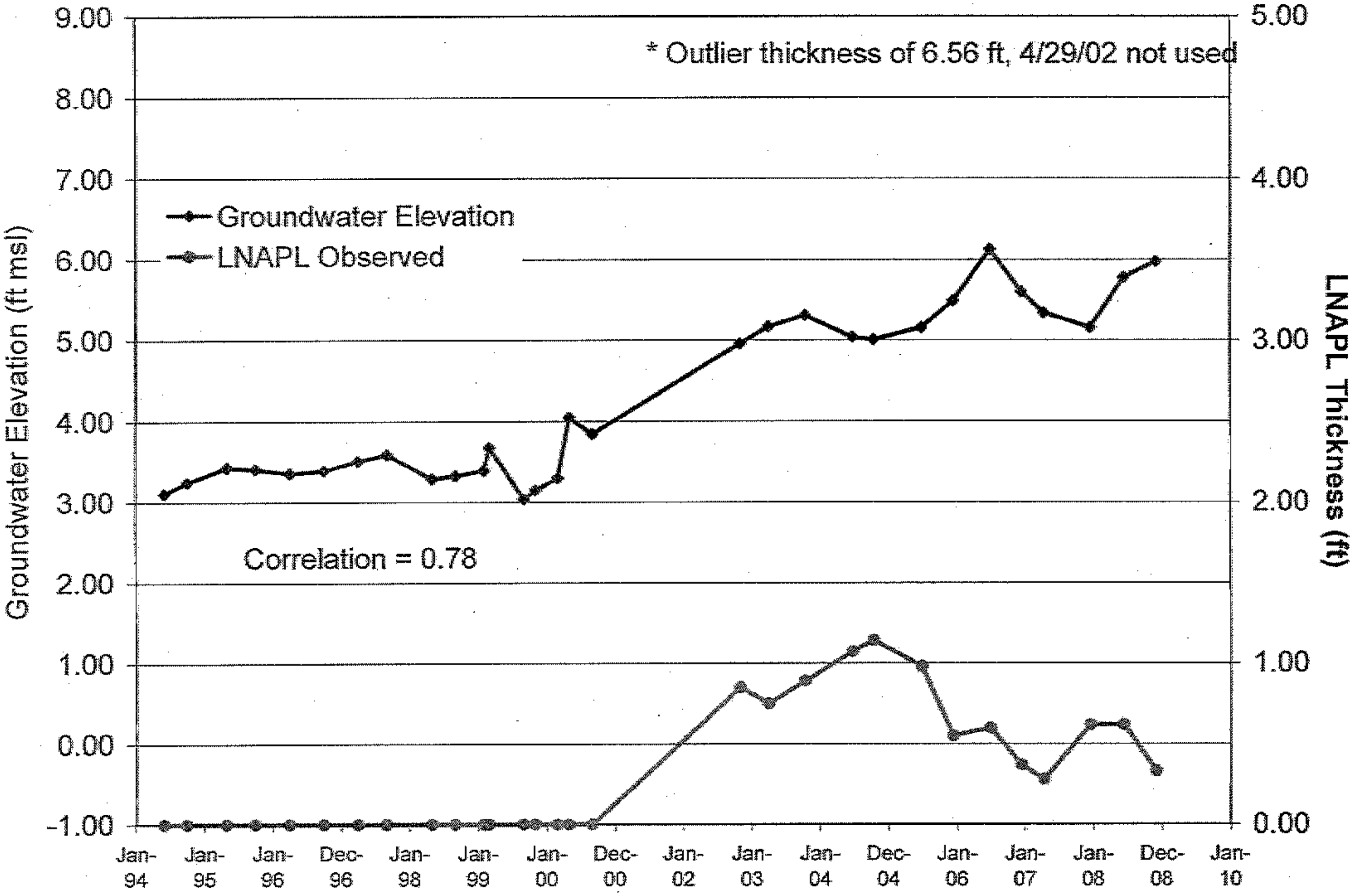
# APPENDIX 2-2
# LNAPL THICKNESS AND GROUNDWATER PIEZOMETRIC HYDROGRAPHS

# APPENDIX 3-1

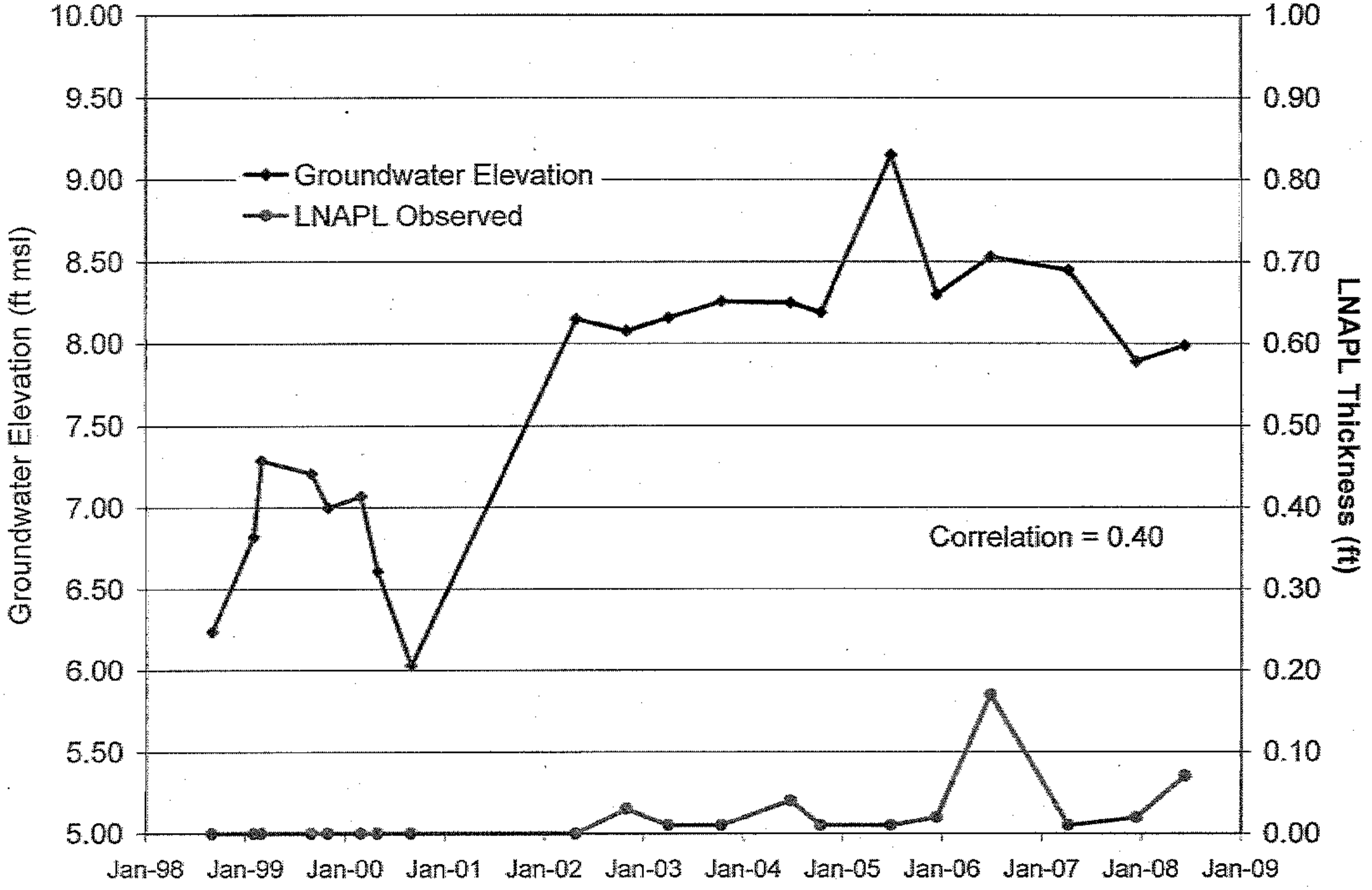
## LNAPL & Corrected Groundwater Elevation Hydrograph: MW-6/6R



## LNAPL & Corrected Groundwater Elevation Hydrograph: MW-14/14R



## LNAPL & Corrected Groundwater Elevation Hydrograph: MW-19/19R



# APPENDIX 3-1
# KEY API LNAPL SCREENING INPUTS AND RESULTS

# Executive Summary - Saturation and Volume

**Site Name:** Port LA Distribution Center

**Project Manager:** SCS Engineers

**Date of Analysis:** 8/26/2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

BASELINE CONDITIONS

## Initial Conditions; Soil & Flow

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | LNAPL Type | LNAPL Zone Thickness (m) | Saturation Condition |
|---|---|---|---|
| 1 | Gasoline | 6.25 | Vertical Equilibrium |

## Results

| Simulation Number | Type Area Volume (cu m) | % Interval Greater than Field $S_{ro}$ | Max $S_o$ | Average $S_o$ | Specific Volume (cu m/m$^2$) |
|---|---|---|---|---|---|
| 1 | 3.13E+03 | 31.82 | 2.04E-01 | 9.48E-02 | 3.13E-01 |

## User Input Parameters

### Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Source Area Input Parameters

BASELINE CONDITIONS

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Equilibrium LNAPL Distribution | Volatilization Included | 8.64E-04 |

# Executive Summary - Source Zone Composition Through Time

**Site Name:** Port LA Distribution Center

**Project Manager:** SCS Engineers

**Date of Analysis:** August 26, 2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

BASELINE CONDITIONS

## Initial Conditions; Soil & Flow

| Simulation Number | Soil Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | Initial VEQ LNAPL Thickness (m) | Initial Peak $S_o$ (%) | Initial Specific Volume (cu m/m$^2$) |
|---|---|---|---|
| 1 | 6.25 | 2.04E-01 | 3.13E-01 |

## Results (Simulation Number 1)

| Compound of Concern | Original Concentration (ug/l) | Concentration at 1 Year (ug/l) | Concentration at 10 Years (ug/l) | Concentration at 20 Years (ug/l) | Concentration at 100 Years (ug/l) |
|---|---|---|---|---|---|
| Benzene | 3.29E+03 | 3.29E+03 | 3.29E+03 | 3.28E+03 | 3.24E+03 |
| Ethyl Benzene | 6.93E+02 | 6.93E+02 | 6.92E+02 | 6.92E+02 | 6.92E+02 |
| Toluene | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.29E+01 |
| Xylene | 1.86E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 |

# User Input Parameters

BASELINE CONDITIONS

## Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Equilibrium LNAPL Distribution | Volatilization Included | 8.64E-04 |

## Solute Transport Properties Input Parameters BASELINE CONDITIONS

| Simulation Number | Effective Porosity | Longitudinal Dispersivity (m) | Horizontal Transverse Dispersivity (m) | Vertical Transverse Dispersivity (m) | Fractional Carbon Content | Vapor Diffusion Efficiency Coefficient |
|---|---|---|---|---|---|---|
| 1 | 0.318 | 3.00E+00 | 1.50E-01 | 1.00E-02 | 3.00E-03 | 2.50E-02 |

# Executive Summary - Saturation and Volume

**Site Name:** Port LA Distribution Center

**Project Manager:** SCS Engineers SKIMMING CONDITIONS

**Date of Analysis:** 8/26/2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

## Initial Conditions; Soil & Flow

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | LNAPL Type | LNAPL Zone Thickness (m) | Saturation Condition |
|---|---|---|---|
| 1 | Gasoline | 6.25 | After Fixed Period of Remediation |

## Results

| Simulation Number | Type Area Volume (cu m) | % Interval Greater than Field $S_{ro}$ | Max $S_o$ | Average $S_o$ | Specific Volume (cu m/m²) |
|---|---|---|---|---|---|
| 1 | 3.11E+03 | 31.06 | 2.02E-01 | 9.41E-02 | 3.11E-01 |

## User Input Parameters

### Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

SKIMMING CONDITIONS

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

# Executive Summary - Source Zone Composition Through Time

**Site Name:** Port LA Distribution Center
**Project Manager:** SCS Engineers
**Date of Analysis:** August 26, 2011
**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

SKIMMING CONDITIONS

## Initial Conditions; Soil & Flow

| Simulation Number | Soil Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | Initial VEQ LNAPL Thickness (m) | Initial Peak $S_o$ (%) | Initial Specific Volume (cu m/m$^2$) |
|---|---|---|---|
| 1 | 6.25 | 2.02E-01 | 3.11E-01 |

## Results (Simulation Number 1)

| Compound of Concern | Original Concentration (ug/l) | Concentration at 1 Year (ug/l) | Concentration at 10 Years (ug/l) | Concentration at 20 Years (ug/l) | Concentration at 100 Years (ug/l) |
|---|---|---|---|---|---|
| Benzene | 3.29E+03 | 3.29E+03 | 3.28E+03 | 3.27E+03 | 3.18E+03 |
| Ethyl Benzene | 6.93E+02 | 6.93E+02 | 6.92E+02 | 6.92E+02 | 6.90E+02 |
| Toluene | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.28E+01 |
| Xylene | 1.86E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 |

## User Input Parameters

### Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

### Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

SKIMMING CONDITIONS

### Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

### LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

### Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

## Solute Transport Properties Input Parameters

| Simulation Number | Effective Porosity | Longitudinal Dispersivity (m) | Horizontal Transverse Dispersivity (m) | Vertical Transverse Dispersivity (m) | Fractional Carbon Content | Vapor Diffusion Efficiency Coefficient |
|---|---|---|---|---|---|---|
| 1 | 0.318 | 3.00E+00 | 1.50E-01 | 1.00E-02 | 3.00E-03 | 1.00E+00 |

SKIMMING CONDITIONS

# Executive Summary - LNAPL Recovery

**Site Name:** Port LA Distribution Center

SKIMMING CONDITIONS

**Project Manager:** SCS Engineers

**Date of Analysis:** 8/26/2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

## Initial Conditions

| Simulation Number | Soil Type | van Genuchten Alpha (1/m) | Recovery Method | Recovery Time (yrs) | Initial VEQ LNAPL Thickness (m) | Selected $S_{ro}$ | Initial Peak $S_o$ | Inital Specific Volume (cu m/m$^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Medium Sand | 0.31 | Skimming Recovery | 5 | 6.25 | 0.136 | 0.20 | 3.11E-01 |

## Results

| Simulation Number | Time to 15% of Recoverable (yrs) | Time to 50% of Recoverable (yrs) | Time to 99% of Recoverable (yrs) | Residual Thickness (m) | 3-Month Rate (cu m/day) | 1-Year Rate (cu m/day) | 3-Year Rate (cu m/day) | Final Specific Volume (cu m/m$^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Na | Na | Na | 6.19E+00 | 5.55E-02 | 5.51E-02 | 5.41E-02 | 4.14E+03 |

## User Input Parameters

### Soil Properties

| Simulation Number | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|
| 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

### Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

SKIMMING CONDITIONS

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

## Skimming Recovery Input Parameters

| Simulation Number | Period of Recovery (yrs) | Number of Wells | Ratio of Radius of Influence / Radius of Well (LNAPL) (m) |
|---|---|---|---|
| 1 | 5.0 | 1.0 | 50.0 |

# Executive Summary - Saturation and Volume

**Site Name:** Port LA Distribution Center

PUMPING CONDITIONS

**Project Manager:** SCS Engineers

**Date of Analysis:** 8/26/2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

## Initial Conditions; Soil & Flow

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | LNAPL Type | LNAPL Zone Thickness (m) | Saturation Condition |
|---|---|---|---|
| 1 | Gasoline | 6.25 | After Fixed Period of Remediation |

## Results

| Simulation Number | Type Area Volume (cu m) | % Interval Greater than Field $S_{ro}$ | Max $S_o$ | Average $S_o$ | Specific Volume (cu m/m$^2$) |
|---|---|---|---|---|---|
| 1 | 3.02E+03 | 27.27 | 1.93E-01 | 9.16E-02 | 3.02E-01 |

## User Input Parameters

### Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

PUMPING CONDITIONS

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

# Executive Summary - Source Zone Composition Through Time

**Site Name:** Port LA Distribution Center

**Project Manager:** SCS Engineers

PUMPING CONDITIONS

**Date of Analysis:** August 26, 2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

## Initial Conditions; Soil & Flow

| Simulation Number | Soil Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | Initial VEQ LNAPL Thickness (m) | Initial Peak $S_o$ (%) | Initial Specific Volume (cu m/m$^2$) |
|---|---|---|---|
| 1 | 6.25 | 1.93E-01 | 3.02E-01 |

## Results (Simulation Number 1)

| Compound of Concern | Original Concentration (ug/l) | Concentration at 1 Year (ug/l) | Concentration at 10 Years (ug/l) | Concentration at 20 Years (ug/l) | Concentration at 100 Years (ug/l) |
|---|---|---|---|---|---|
| Benzene | 3.29E+03 | 3.29E+03 | 3.28E+03 | 3.27E+03 | 3.18E+03 |
| Ethyl Benzene | 6.93E+02 | 6.93E+02 | 6.92E+02 | 6.92E+02 | 6.90E+02 |
| Toluene | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.28E+01 |
| Xylene | 1.86E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 |

# User Input Parameters

## Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

PUMPING CONDITIONS

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

## Solute Transport Properties Input Parameters

| Simulation Number | Effective Porosity | Longitudinal Dispersivity (m) | Horizontal Transverse Dispersivity (m) | Vertical Transverse Dispersivity (m) | Fractional Carbon Content | Vapor Diffusion Efficiency Coefficient |
|---|---|---|---|---|---|---|
| 1 | 0.318 | 3.00E+00 | 1.50E-01 | 1.00E-02 | 3.00E-03 | 1.00E+00 |

PUMPING CONDITIONS

# Executive Summary - LNAPL Recovery

**Site Name:** Port LA Distribution Center

**Project Manager:** SCS Engineers

**Date of Analysis:** 8/26/2011

**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

PUMPING CONDITIONS

## Initial Conditions

| Simulation Number | Soil Type | van Genuchten Alpha (1/m) | Recovery Method | Recovery Time (yrs) | Initial VEQ LNAPL Thickness (m) | Selected $S_{ro}$ | Initial Peak $S_o$ | Inital Specific Volume (cu m/$m^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Medium Sand | 0.31 | Dual Pump Extraction | 10 | 6.25 | 0.136 | 0.19 | 3.02E-01 |

## Results

| Simulation Number | Time to 15% of Recoverable (yrs) | Time to 50% of Recoverable (yrs) | Time to 99% of Recoverable (yrs) | Residual Thickness (m) | 3-Month Rate (cu m/day) | 1-Year Rate (cu m/day) | 3-Year Rate (cu m/day) | Final Specific Volume (cu m/$m^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Na | Na | Na | 5.94E+00 | 1.48E-01 | 1.46E-01 | 1.41E-01 | 3.75E+03 |

## User Input Parameters

### Soil Properties

| Simulation Number | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|
| 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

### Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

PUMPING CONDITIONS

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Distribution After Fixed Period of Remediation | Volatilization Included | 8.64E-04 |

## Dual Pump Extraction Recovery Input Parameters

| Simulation Number | Period of Recovery | Number of Wells | Fluid (LNAPL and Water) Saturated Screen Length (m) | Ratio of Radius of Influence / Radius of Well (LNAPL (m)) | Ratio of Radius of Influence / Radius of Well (Water) (m) | Water Production Rate (cu m/day/well) | Water Production Rate Calculation Method |
|---|---|---|---|---|---|---|---|
| 1 | 10.0 | 1.0 | 10.0 | 50.0 | 500.0 | 9.6 | Program |

# Executive Summary - Source Zone Composition Through Time

**Site Name:** Port LA Distribution Center

SPARGING CONDITIONS

**Project Manager:** SCS Engineers
**Date of Analysis:** August 26, 2011
**Title of Simulations:** Port LA Distribution Center, Former Western Fuel Oil

## Initial Conditions; Soil & Flow

| Simulation Number | Soil Layer | Soil Type | van Genutchen Alpha (1/m) | Selected $S_{ro}$ (%) |
|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 0.136 |

| Simulation Number | Initial VEQ LNAPL Thickness (m) | Initial Peak $S_o$ (%) | Initial Specific Volume (cu m/m²) |
|---|---|---|---|
| 1 | 6.25 | 2.04E-01 | 3.13E-01 |

## Results (Simulation Number 1)

| Compound of Concern | Original Concentration (ug/l) | Concentration at 1 Year (ug/l) | Concentration at 10 Years (ug/l) | Concentration at 20 Years (ug/l) | Concentration at 100 Years (ug/l) |
|---|---|---|---|---|---|
| Benzene | 3.29E+03 | 3.29E+03 | 3.29E+03 | 3.28E+03 | 3.24E+03 |
| Ethyl Benzene | 6.93E+02 | 6.93E+02 | 6.92E+02 | 6.92E+02 | 6.92E+02 |
| Toluene | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.30E+01 | 2.29E+01 |
| Xylene | 1.86E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 | 1.85E+02 |

# User Input Parameters

## Soil Properties

| Simulation Number | Layer | Soil Type | van Genutchen Alpha (1/m) | van Genutchen n | Srw | Sro | K (m/d) | Total Porosity |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Medium Sand | 0.31 | 1.66 | 0.205 | 0.136 | 3.00E-01 | 0.40 |

* Only apply to multiple layer soil conditions

## Groundwater Condition Input Parameters

| Simulation Number | Groundwater Darcy Flux (m/day) | Linear Velocity (m/day) | Groundwater Gradient (m/m) |
|---|---|---|---|
| 1 | 1.98E-03 | 6.23E-03 | 6.60E-03 |

SPARGING CONDITIONS

## Source Area Input Parameters

| Simulation Number | Vertical Formation Thickness (m) | Depth to Top of LNAPL (m) | Length of LNAPL Zone (m) | Width of LNAPL Zone (m) |
|---|---|---|---|---|
| 1 | 6.25 | 27.40 | 100.00 | 100.00 |

## LNAPL Properties

| Simulation Number | Product Type | Oil/Water IFT (dynes/cm) | Oil/Air IFT (dynes/cm) | Oil Density (gm/cc) | Viscosity (cp) |
|---|---|---|---|---|---|
| 1 | Gasoline | 25.00 | 25.00 | 0.81 | 1.50 |

## Method Used to Calculate LNAPL Saturation Input Parameters

| Simulation Number | Method Used To Calculate LNAPL Saturation | Source Volitilization | Criteria For Minimum Mobility (m/day) |
|---|---|---|---|
| 1 | Equilibrium LNAPL Distribution | Volatilization Included | 8.64E-04 |

### Solute Transport Properties Input Parameters

| Simulation Number | Effective Porosity | Longitudinal Dispersivity (m) | Horizontal Transverse Dispersivity (m) | Vertical Transverse Dispersivity (m) | Fractional Carbon Content | Vapor Diffusion Efficiency Coefficient |
|---|---|---|---|---|---|---|
| 1 | 0.318 | 3.00E+00 | 1.50E-01 | 1.00E-02 | 3.00E-03 | 2.50E-02 |

SPARGING CONDITIONS

# Appendix B

# March 14, 2014 Addendum to: Dissolved- and LNAPL Plume Stability Evaluations and Discussion of Cleanup Implications

Aqui-Ver, Inc.

AQUI-VER, INC.
*Hydrogeology, Water Resources & Data Services*

# MARCH 14, 2014 ADDENDUM TO:

# DISSOLVED AND LNAPL PLUME STABILITY EVALUATIONS AND DISCUSSION OF CLEANUP IMPLICATIONS

## PORT OF LOS ANGELES DISTRIBUTION CENTER
## (FORMER WESTERN FUEL OIL FACILITY)
## 300 WESTMONT DRIVE
## SAN PEDRO, CALIFORNIA

**Original issue: August 30, 2011**
**to the:**
**L.A. Regional Water Quality Control Board**
**Attention: Paul Cho**

**For:**

**Mr. Leland Nakaoka**
**BlackRock Realty Advisors**
**4400 MacArthur Boulevard, Suite 700**
**Newport Beach, CA 92660**

**In Cooperation With:**

**SCS Engineers**
**8799 Balboa Avenue, Suite 290**
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STATE OF CALIFORNIA

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### LIST OF FIGURES

### ATTACHMENTS

Attachment #1: Forensic Report of Dr. Alan Jeffrey - Inclusive in SCS Reporting

Attachment #2: Dissolved- and LNAPL Plume Stability Evaluations and Discussion of Cleanup Implications, Former Western Fuel Oil Facility, 300 Westmont Drive, San Pedro, California, August 30, 2011

*..\60300562\doc\final report\Mar2014-addendum.wpd*

## EXECUTIVE SUMMARY

In 2011, **AQUI-VER, INC.** (AVI) performed extensive analyses into contaminant fate and transport, free product stability, recoverability, and the degree of remaining practicable cleanup at the subject site. In that work, we found the dissolved-phase plumes to be stable or contracting, posing no threat to use of groundwater, and expected to reach State maximum contaminant levels (MCLs) in a reasonable time frame. We also found that the LNAPL plume is stable and non-recoverable using commonly available cleanup methods.

In this update, we have reviewed more recent data collected by SCS Engineers over the intervening time and found that conditions remain relatively unchanged and within the range of expectations presented in our 2011 work. That work therefore stands as published (attached hereto).

In total, we determined that the site then met and now continues to meet the requirements of State Resolution 92-49 closure, and that no further action is warranted at the facility. Since our 2011 report, the State Water Resources Control Board (SWRCB) has also further clarified its position on closure of low-risk underground petroleum storage tank sites. That Low-Risk Policy states that it is applicable to petroleum underground storage tank sites and other sites of similar nature, as is the subject former Western Fuel Oil site (currently the Los Angeles Port Distribution Center).

Based on our past and current work, the site meets all the standards of a 92-49 and Low-Risk closure. The plumes are stable and declining, they pose no risk, and they are approaching MCLs in a reasonable time frame. Additional cleanup is impracticable, as has been shown in our work, and regardless would have no benefit to the waters of the State if attempted. Given the extensive cleanup at this site, over many years and many millions of dollars, the non-risk condition, the non-recoverable remaining LNAPL, and the estimated attainment of MCLs in reasonable time, this site should be closed with no further action according to State policies. It is, however, recommended that wells be destroyed and other logistical aspects are dealt with as part of the closure process.

## INTRODUCTION

This is an addendum to our report issued in August 2011, in coordination with SCS Engineers, entitled *"Dissolved- and LNAPL Plume Stability Evaluations and Discussion of Cleanup Implications, Former Western Fuel Oil Facility, 300 Westmont Drive, San Pedro, California, August 30, 2011."* That 2011 report is attached here for convenience. Since that time, additional data have been collected at the facility by SCS, as discussed below, which do not impact the findings and conclusions of our referenced 2011 report, which stands as published. Further, State Policy has changed with the introduction of the Low-Risk Policy for Underground Petroleum Storage Tanks (and applicable to related facilities like the subject site).

The subject site is currently the Port of Los Angeles Distribution Center (PDC), and was formerly the Western Fuel Oil Facility that underwent extensive remediation in preparation to facilitate its present use, as well as post-development remediation actions. As summarized by SCS, this site has had numerous active cleanup actions taken to date, including pump and treat, extensive soil excavation, air sparge/soil vapor extraction (IAS & SVE), free product recovery and other ancillary actions. As of 2001, it was estimated that approximately 12 million pounds of hydrocarbons were treated by the IAS/SVE system, and another 20,000 yd$^3$ of impacted soil was excavated (Cape, 2001). About 13,000 gallons of water/product mixture have been hydraulically recovered from wells MW-6R and MW-14R, with water typically being the major component of that volume (SCS, 2011a). Certainly all of these past cleanup actions have vastly improved the site environmental conditions in that the vapor pathway is now negligible, and the mass recovered stabilized and reduced the long-term presence of the LNAPL and dissolved-phase plumes. However, some residual impacts remain, as discussed in SCS's work (2014) and in our prior efforts (2011).

Stable and declining plume conditions continue to exist today that were demonstrated in our attached 2011 work to be approaching regulatory cleanup levels in a reasonable time-frame. There are no risks from these existing stable and declining plume conditions (SCS, 2009, 2014). It is not anticipated that the groundwater beneath the site would ever be used for drinking water production due to its location within the seawater intrusion protection system, and its location adjacent to non-beneficial use and saline waters. Any conceivable use of these waters in the future would require extensive treatment, which in of itself would make the waters beneath the site usable as well if that were ever to be undertaken. In short, the remaining plumes pose no threat and are approaching regulatory cleanup limits via natural attenuation processes in a time frame reasonable with the site and groundwater setting.

Given the extensive cleanup conducted at the facility over time, the low residual levels of impacts, the contracting plumes, the absence of risk, and the impracticability of further beneficial cleanup, it is my professional opinion that this site should be closed immediately under the Low-Risk Policy or Resolution 92-49, with no further actions excepting well destruction and reporting.

## RECENT DATA COLLECTION

As reported by SCS (2014), additional groundwater sampling, gauging, and well installation has been conducted since AVI's 2011 report. Review of the sampling data indicates that overall conditions have remained in a state of slow plume decay, consistent with prior reporting and analysis (discussed below). Within overall conditions, there were two changes of potential concern in the newer information. First, onsite well MW-24 has experienced an increasing trend in diesel range impacts, while at the same time benzene has continued to decrease at that location. As discussed further below, our interpretation is this represents surface infiltration from the Port Distribution Center operations down the wellbore into the sampling zone.

Second, newly installed offsite well MW-29 (at the intermediate zone level), exhibited petroleum range impacts inconsistent with fate and transport and other site conceptual model aspects. As explained below, several lines of evidence, including advanced chemical forensic analysis, demonstrate that the impacts at MW-29 are related to a release source other than the Port Distribution Center. The adjacent refinery, area pipelines, and historic operations by others are all possible sources for these relatively low impacts at MW-29. However, since petroleum impacts at this well are clearly not connected to the subject Port Distribution Center site, impacts there have no influence on our prior plume and transport evaluations.

## Conditions Since 2011 AVI Reporting

It is important to review updates in overall site plume conditions since our 2011 reporting to ensure expected trends are continuing, which they are as discussed below.

With regard to fate and transport, groundwater gradient conditions reported by SCS (2014) are within the ranges of prior conditions, with an overall upward gradient and lateral gradients between 0.004 and 0.006 ft/ft. The lateral groundwater gradient used in our 2011 transport evaluations was 0.007 ft/ft.

Review of benzene data (SCS, 2014) demonstrates that as of the January 2014 sampling, benzene is either within or below the historical range of concentrations used in our 2011 work. Similarly, forensic and standard analyses for TBA and TAA shows these compounds to also be within or below the historical ranges at that site; again, indicating ongoing downward trends in plume concentration and mass. TBA and TAA were not detected in the most recent standard lab sampling (January 2014), and only detected in MW-10R (85.06 ug/l, February 2014) in the forensic evaluations, which have a lower detection limit than standard laboratory work.

Review of the free product thickness detection data shows that free product continues to be observed at low historic levels at three locations as of the January 2014 gauging even (SCS, 2014); MW-6R (0.47-ft), MW-14R (0.30-ft), and MW-19R (0.05-ft). These free product thicknesses are well within the ranges considered in our 2011 evaluations of free product stability and recoverability.

## MW-24 - Decreasing Benzene & Increasing DRO

MW-24 is an intermediate depth well, located in the truck loading area of the PDC (Figure 1, Site Plan). As seen by the chemical hydrograph for well MW-24 (Figure 2), benzene has been generally decreasing in concentration over time, while there has been a distinct more recent rise in diesel range organics (DRO) concentrations. Benzene is a compound of concern, DRO itself is not, so the key takeaway is the ongoing expected decline in benzene concentrations is consistent with the expectations of our 2011 work.

It is noteworthy that these recent DRO concentrations are well above the solubility limits of diesel fuels (typically less than 6 - 15 mg/l solubility, API 2004), meaning that the results are emulsified and invalid as a quantitative dissolved-phase measure. Therefore the apparent dissolved-phase DRO increases may not in fact be present at concentrations reported by the lab. However, the increasing concentrations do indicate a change in conditions and this is of potential concern given the location of MW-24 within the trucking operations area of the PDC. The most obvious source for a new occurrence of diesel at an intermediate groundwater depth at this location is the surface trucking operations. Given the historic nature of the subject plume beneath the PDC, and the absence of significantly changed hydraulics or other conditions, there is no expectation that this DRO increase is a result of natural fate and transport processes, but rather a new and presumably short-term pulse from surface runoff infiltrating the well box. It is always problematic to have direct conduits to the aquifer under conditions where there are surface sources that can add contaminants, which are fundamentally low mass artifacts imprinted on the broader historic plume.

Given the overarching recommendation of our work, which is for site closure, it is recommended that this well and others within the operations footprint of the PDC be destroyed, as chemical and gauging trends over the years are well controlled, and the risk of having these wells remain is greater than the value of maintaining these locations.

## **Petroleum Impacts at MW-29**

Recent work by SCS (2013/2014) included installation of new offsite and down gradient wells relative to the PDC site. An intermediate zone well furthest down gradient, MW-29, exhibited unexpected petroleum impacts based on the conceptual site model and expected transport conditions (Figure 1, Site Plan).

Advanced forensic evaluations by Zymax Laboratories, and a review by their Senior Geochemist Dr. Alan Jeffrey (attached hereto), show that the impacts at well MW-29 bear no resemblance to, and could not have come from, the PDC area plume. For instance, a diagram of the paraffins, isoparaffins, aromatics, napthenes, and olefins (PIANO; Figure 3) of MW-29 as compared to onsite well MW-10R shows the highly distinct differences in these petroleum products. There is also a poor correlation in the gas chromatographic response between these locations (coefficient of correlation = 0.29; Figure 4). Given these observations, and those of Dr. Jeffrey, it is chemically definitive that MW-29 is unrelated to the PDC site plume.

In addition to that straightforward line of forensic chemistry evidence, there are other supporting observations for this conclusion. First, as shown in Figure 5, the groundwater geochemistry at MW-29 is significantly different from that within the PDC plume. That is, the groundwater at MW-29 is no longer the same as the PDC groundwater, but rather something much different (saltier). If transport was from the PDC to MW-29, groundwater geochemistry would tend to be similar. There is obviously the addition of non-site groundwater to this MW-29 area, and that means that a good portion (or all) of transport to this area is not from the PDC site.

Well-known plume transport principles, coupled with California's plume distribution studies, dictate that contaminant concentrations decrease with distance away from the "source" area. It is not reasonable to have higher concentrations of a degradable compound like benzene at a distal location like MW-29 than is present in near-source locations like MW-10R. This is physically implausible. Further, MW-29 does not contain detectable tert-butyl alcohol (TBA) or tert-amyl alcohol (TAA), the most transportable of contaminants present historically onsite, that will effectively move with the flow of groundwater and be muted by attenuation processes. It is not expected that a degradable compound like benzene would travel preferentially to lesser degradable compounds like TBA and TAA. Further, MW-29 contains diisopropyl ether (DIPE), whereas source area wells at the PDC do not. DIPE was used by some refiners as an anti-knock and oxygen additive from the late 1970s forward, peaking in the mid-1990s during the Reformulated Gasoline era (RFG). Again, the presence of DIPE and absence of TBA/TAA at MW-29 are distinguishing features, along with the other forensics, of a release attributable to a source other than the PDC site. MW-29 also contains chlorobenzene, which has never been detected in PDC plume wells.

In summary, petroleum impacts were discovered at MW-29 that are unrelated to the PDC site, and therefore do not influence past work regarding plume stability, transport, or risk.

In total, given the data reviews above, there have been no changes in overall plume conditions since 2011 that would have an impact on the work and conclusions of our 2011 reporting. That report stands as issued.

## REQUEST FOR SITE CLOSURE

Based on the analysis in our 2011 work, which remains fundamentally unchanged with regard to the newer data collection since, it is my professional opinion that the site meets the closure specifications of the SWRCB Resolution 92-49, as well as the low-risk policy. In specific:

1. The unauthorized release is located within the service area of a public water system; as reported by SCS, the site is serviced with public water, and groundwater flows into a non-beneficial-use zone just offsite. Further, the site is within the sea-water intrusion system whereby changes to these conditions are highly improbable. Plume statistical evaluations and fate and transport analyses confirm that the plumes are stable and pose no risk to beneficial surface or groundwater.

2. The unauthorized release consists only of petroleum; as documented by the data collected by SCS, the subject plume is the direct result of historic petroleum operations predating the PDC operations of today.

3. The unauthorized ("primary") release from the tank system has been stopped; tanks and other operational features of the former Western Fuels were removed in the late 1990s and remediated as part of the extensive work preparing the site for its Brownfield conversion from an impaired property into a viable new business.

4. Free product has been removed to the maximum extent practicable. The present extent is limited to three wells that have had generally decreasing observed thickness trends over the last several years, and low transmissivity values. Despite ongoing vacuum truck recovery, these small isolated occurrences remain; the greatest remaining observed thickness as of last measurement in January 2014 was 0.47-ft at MW-6R, with a declining trend. Part of the

limitation in additional cleanup is that the majority of the plume was already remediated with the property change to the PDC. The other limitation pointed out in our 2011 report is that the LNAPL that remains is submerged below and immobilized by the water table levels, presenting difficult additional remediation targeting.

Site LNAPL transmissivity values (determined with site specific data) are much lower than the 0.1 to 0.8 $ft^2$/day range that the Interstate Technology & Regulatory Council (ITRC, 2009) recommended as a practical endpoint to effective hydraulic LNAPL recovery. Our detailed analysis, using site specific parameters collected by SCS, demonstrates that additional free product recovery will have no measurable beneficial effect. Other remedial options are not viable with the footprint of the PDC business operations, and are not warranted given the negligible expected benefit, as detailed in our 2011 work. At this late plume stage, natural mass losses likely exceed the failingly small remaining recovery possible through hydraulic recovery.

5. A conceptual site model has been developed; SCS along with AVI have completed development of a robust site conceptual model based on 3-dimensional data collection and years of data acquisition (and cleanup) considering petroleum impacts, transport & receptors.

6. Secondary source removal has been addressed; as part of the redevelopment, a substantial portion of surface and subsurface soils were removed to create a "clean" buffer around the new PDC operations. There are no secondary source removal actions remaining.

7. Soil or groundwater has been tested for MTBE and results reported in accordance with Health and Safety Code section 25296.15. The small residual impacts of TBA and TAA have been demonstrated through our work to pose no adverse risk to the waters of the State. MTBE is not present at the subject site.

8. In summary, the site presents no adverse risk to receptors, including the ground and surface waters of the State. The residual site plumes are stable and contracting, pose no risks, and will attain regulatory cleanup thresholds within a reasonable time frame. Given all the cleanup work done to date, the change from a leaky disheveled old refinery/tank farm to a viable Brownfield business redevelopment, and the coincident property improvements thereof, this site is well suited to immediate regulatory closure.

## REPORT CLOSURE

The work herein has been conducted based on current scientific principles and the data provided by SCS Engineers and other sources. These site evaluation results depend directly on this information. Changes or corrections to site data could potentially alter interpretations herein, and if such changes are manifest, it is recommended that these evaluations be updated accordingly. Hydrogeologic and multiphase (LNAPL) evaluations have some level of inherent uncertainty in that pore and molecular scale processes are represented by a macroscopic continuum, and results should be viewed accordingly. Similarly, the discrete distributions and effects of geologic heterogeneity at most sites are defined only on a limited basis. The analyses and evaluations herein are intended to set technical scenarios, not to represent highly detailed spatial or temporal variability. This work has been conducted in accordance with accepted scientific principles and the professional standards of the State of California and other states with reciprocal professional standards.

## REFERENCES

Air Force Center for Environmental Excellence, 2012 (various authors). Low Risk Site Closure.

API, 2004. Interactive LNAPL Guide

ITRC, 2009. Evaluating LNAPL Remedial Technologies for Achieving Project Goals.

SWRCB, undated. Technical Justification for Groundwater Plume Lengths, Indicator Constituents, Concentrations, and Buffer Distances (Separation Distances) to Receptors.

SWRCB, October 1996. Resolution 92-49. Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304

SCS Engineers, 2009. Conceptual Site Model, Port LA Distribution Center (CAO 85-17, SLIC No. 352 Site ID 2040069), 300 Westmont Drive, San Pedro California 90733. May.

SCS Engineers, 2011a. Report of Cone Penetration Testing Investigation, San Pedro Business Center, 300 Westmont Drive, San Pedro California 90733. June.

SCS Engineers, 2011b. Groundwater Monitoring Report, Second Semiannual 2010, San Pedro Business Center, 300 Westmont Drive, San Pedro California 90733. May.

SWRCB, 2012. Low-threat Underground Storage Tank Case Closure Policy, www.swrcb.ca.gov, http://www.waterboards.ca.gov/ust/lt_cls_plcy.shtml.

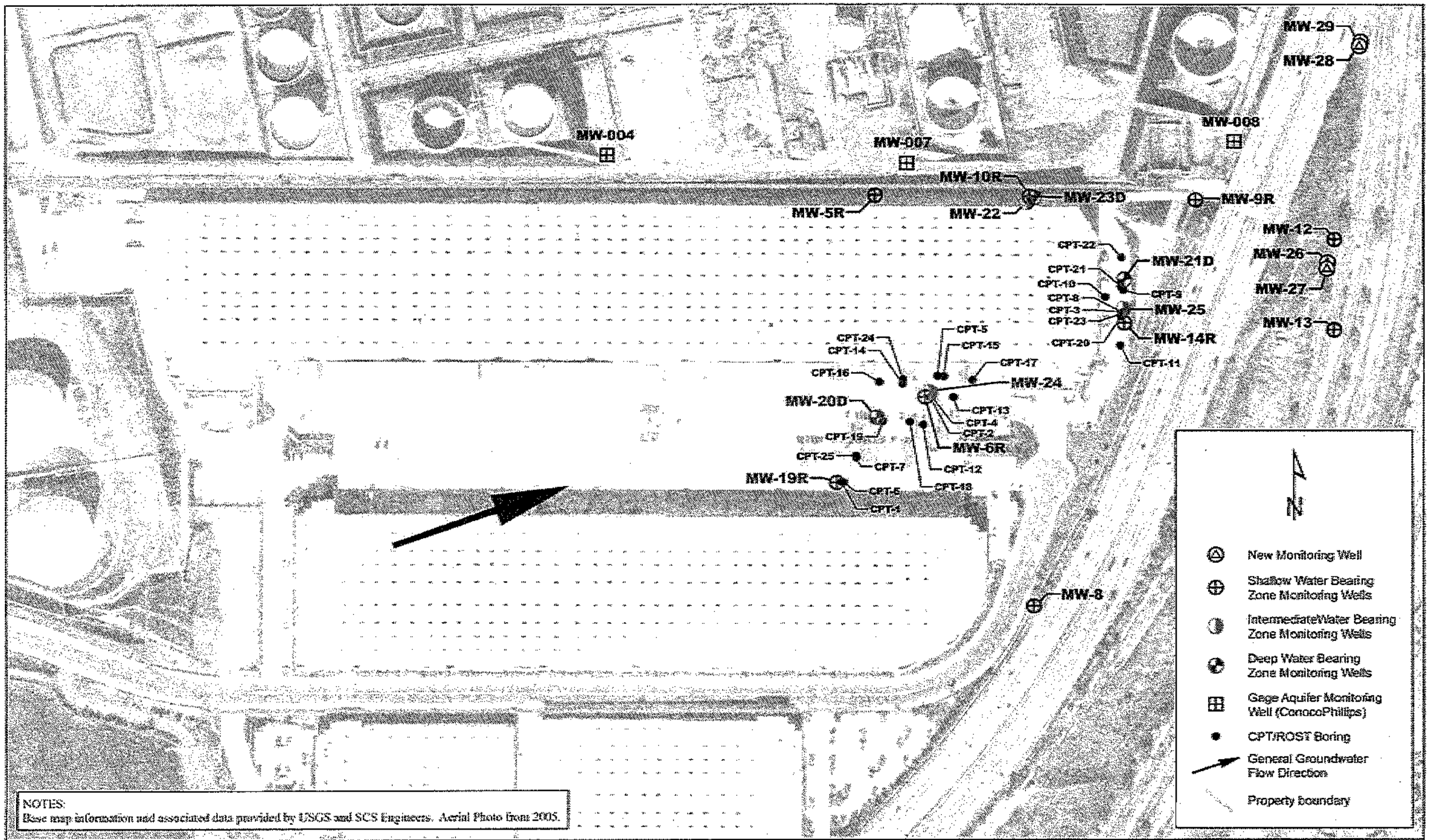
SCS Engineers, 2014; Groundwater Monitoring Report, Second Semi-annual 2013. San Pedro Business Center, 300 Westmont Drive, San Pedro, California

Zymax Forensices, February 2014. Forensic Report of Dr. Alan Jeffrey

Zymax Forensices, February 2014. Forensic Testing Results, MW-10R, MW-26, MW-27, MW-29

** other relevant references are in AVI's 2011 report

C:\AVI\temp\60300562\Doc\Final Report\Mar2014-addendum.wpd



NOTES:
Base map information and associated data provided by USGS and SCS Engineers. Aerial Photo from 2005.

**AQUI-VER, INC.**
*Hydrogeology, Water Resources & Data Services*

0 100 200 400
Feet
1 inch = 200 feet
STATE PLANE NAD 83

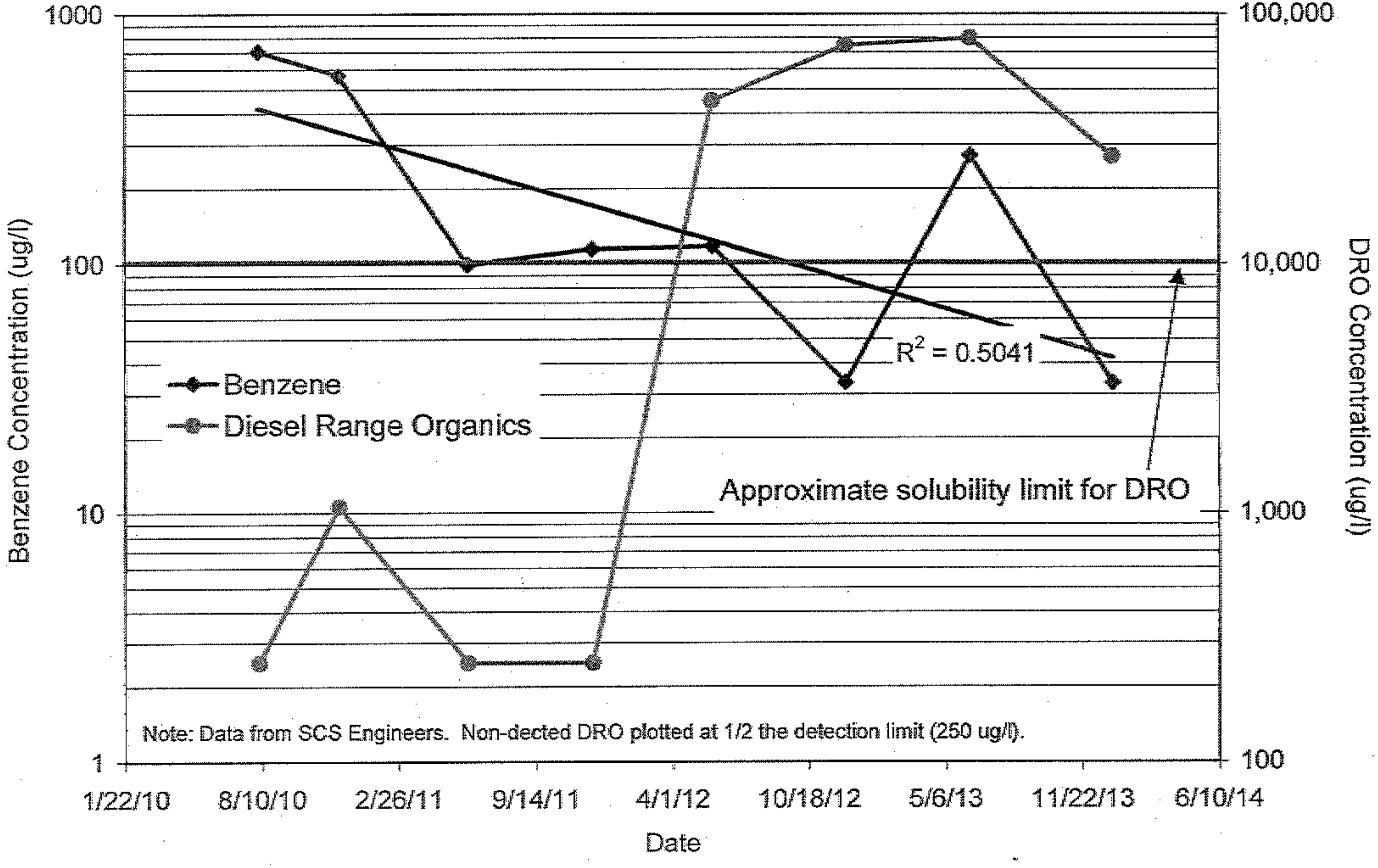
PROJECT 60300562
DATE: 2/27/2014
DRAWN BY: CLIN
REVIEWED BY: GOB
DOCUMENT NAME AND PATH

## SITE PLAN

BLACK ROCK REALTY - PORT LA DISTRIBUTION CENTER
300 WESTMONT DRIVE - SAN PEDRO, CALIFORNIA

FIGURE:
1

## Figure 2
## Benzene & DRO Hydrograph - MW-24 Intermediate Source Zone Well



Note: Data from SCS Engineers. Non-dected DRO plotted at 1/2 the detection limit (250 ug/l).

Figure 3
PIANO Analysis; MW-10R v. MW-29

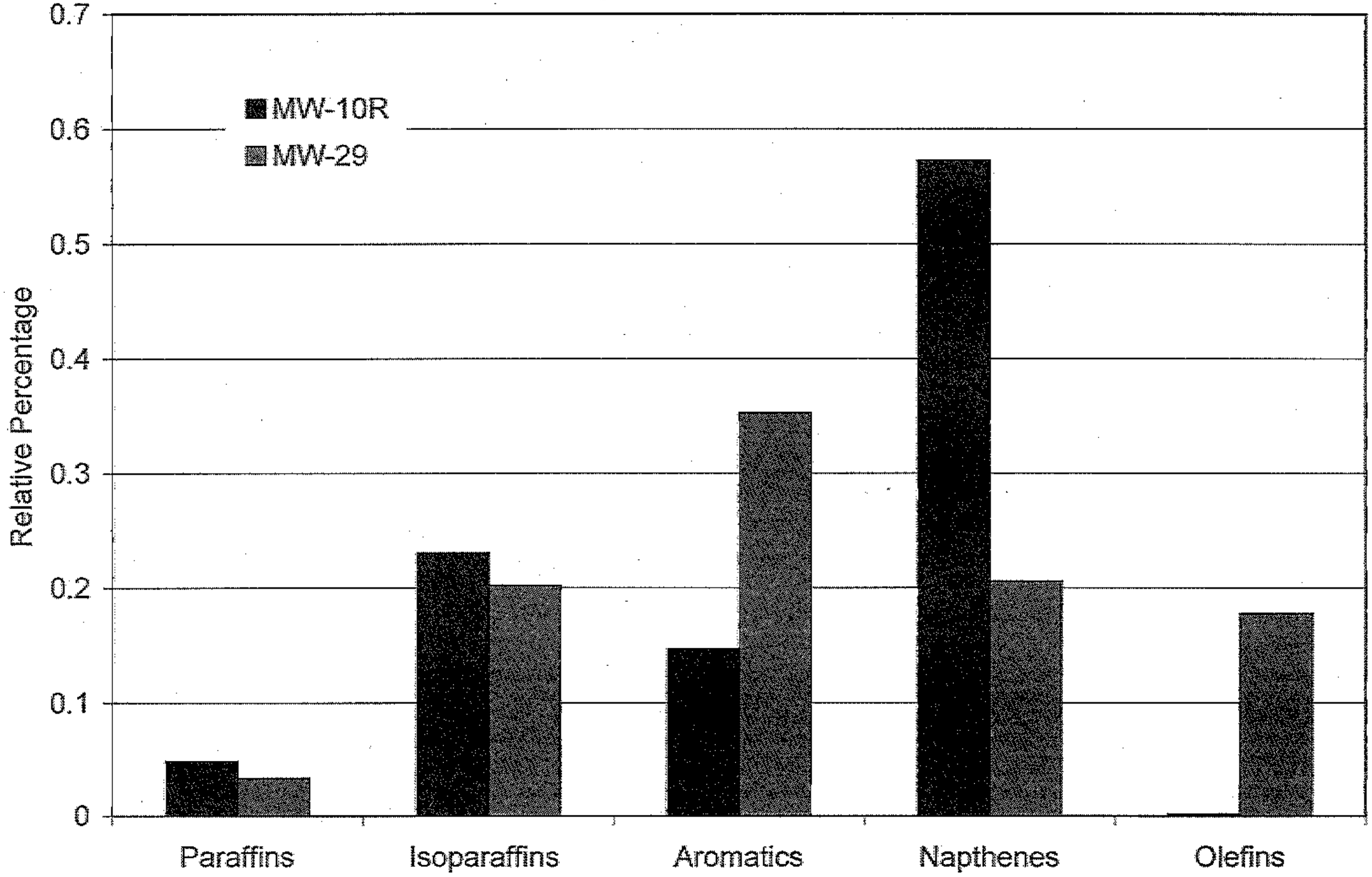
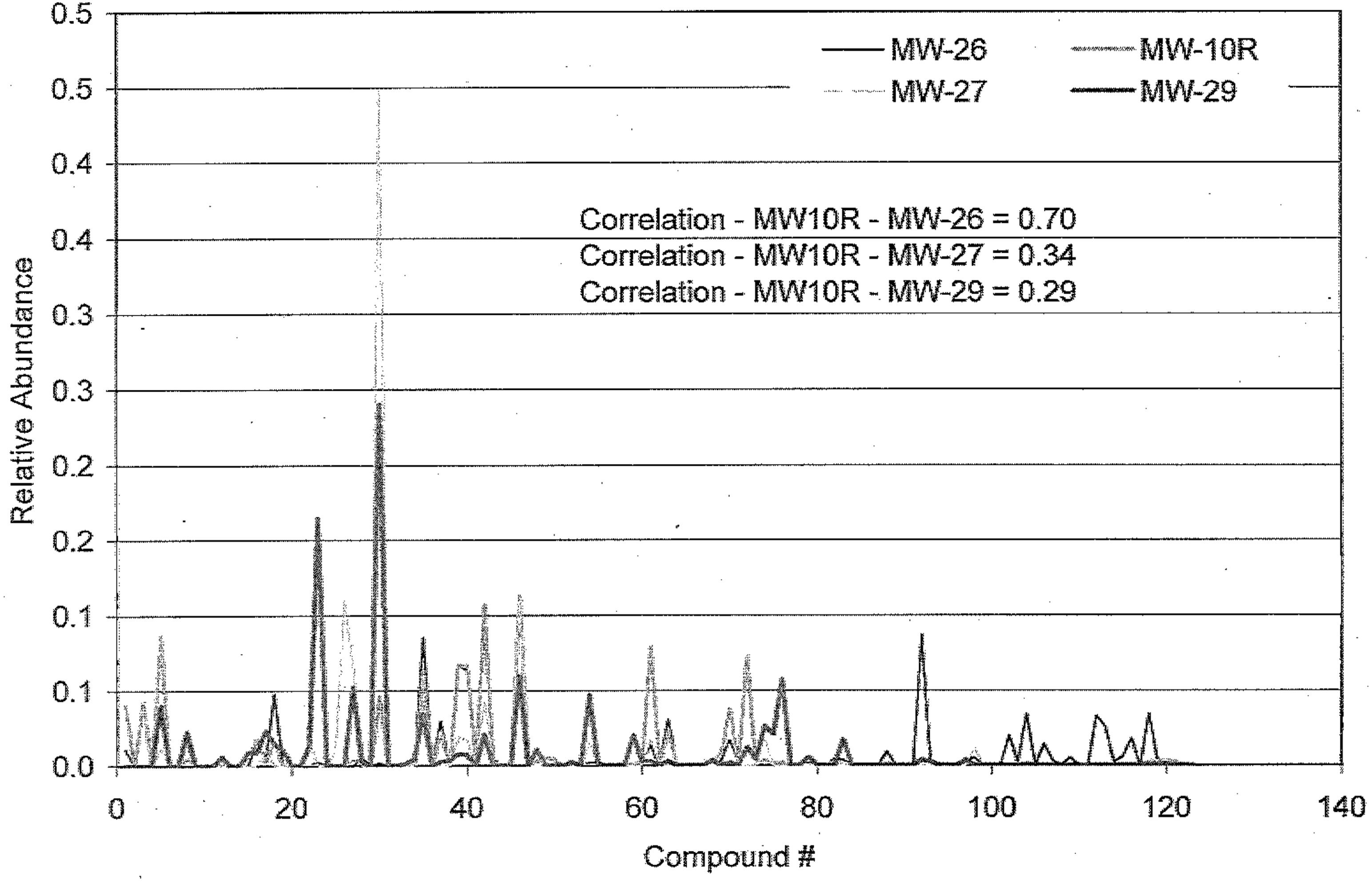
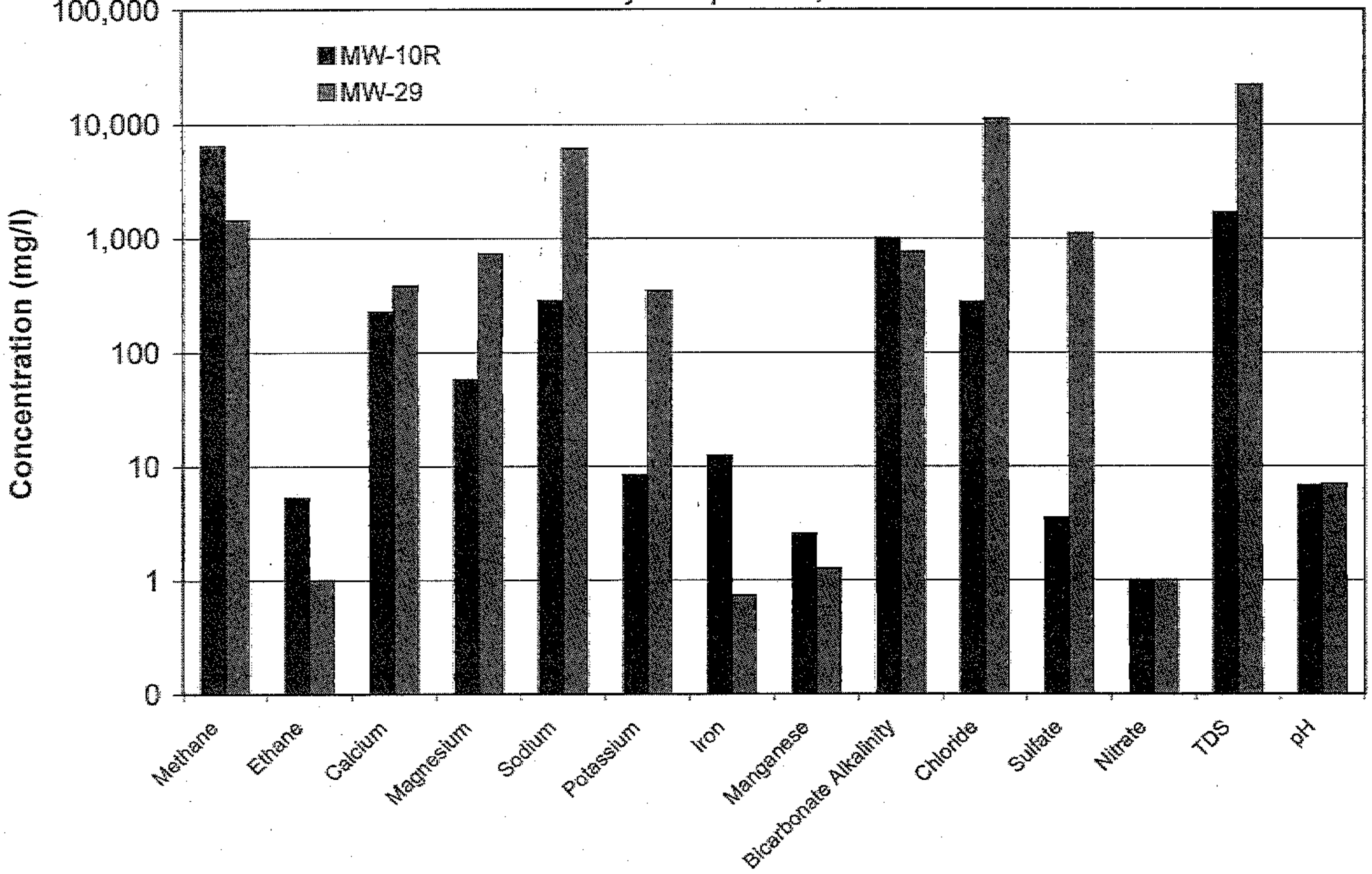


Figure 4
Chromatographic Comparisons; Relative Compound Abunbance



## Figure 5
## General Geochemistry Comparision, MW-10R v. MW-29



# Appendix C

## Zymax Port D. C. Report
## February 28, 2014

ZymaX forensics

# Port D.C.

Report Prepared for:

SCS Engineers
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Long Beach, CA 90806

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**28 February 2014**

TABLE OF CONTENTS

# Introduction

Four water samples, labeled MW-10R, MW-26, MW-27, and MW-29 were received at Zymax on February 13, 2014 for characterization and comparison of petroleum products in the sample. The following analyses were performed:

1. $C_3$-$C_{10}$ gasoline range hydrocarbon concentration by GC/MS
2. Fuel oxygenates by GC/MS
3. $C_{10}$-$C_{40}$ alkane analysis by GC/MS

The complete laboratory data report is presented as an Appendix to this report.

## Methodology

### $C_3$-$C_{10}$ gasoline range quantitation in water and soil samples by GC/MS

Volatile hydrocarbons are purged from water samples by bubbling helium through the sample. The purged sample components are trapped and concentrated on an adsorbent trap. When purging is complete, the sample components are desorbed by heating and back-flushing the adsorbent trap with helium. The desorbed hydrocarbons are cryofocussed on a capillary pre-column. The cryogenic trap is then flash-heated and the analytes are injected into the gas chromatograph (GC) as a tightly focused mass. A 60 meter narrow bore DB5 capillary column is used to separate the hydrocarbon, which are detected with a mass spectrometer (MS) interfaced to the GC. A total of 123 volatile hydrocarbons and sulfur containing compounds are quantified by comparison with authentic standards.

### Fuel oxygenates in water and soil samples by GC/MS

Oxygenates are purged from water samples by bubbling helium through the sample. Soil samples are shaken with methanol, and an aliquot of the methanol extract is injected into distilled water and purged in the same way as water samples.

The purged sample components are trapped and concentrated on an adsorbent trap. When purging is complete, the sample components are desorbed by heating and back-flushing the adsorbent trap with helium. The desorbed hydrocarbons are cryofocussed on a capillary pre-column. The cryogenic trap is then flash-heated and the analytes are injected into the gas chromatograph (GC) as a tightly focused mass. A 60 meter narrow bore DB5 capillary column is used to separate MTBE, TAME, ETBE, DIPE, TBA, and ethanol, which are detected with a mass spectrometer (MS) interfaced to the GC.

### $C_{10}$-$C_{40}$ alkane distribution by GC/MS

Water samples are extracted with methylene chloride solvent and the solvent extract concentrated. Extracts are directly injected into a GC equipped with a 60 meter DB1 column to separate the hydrocarbons, which are detected with a mass spectrometer (MS) in full scan mode, interfaced to the GC. N-alkanes and isoalkanes in the range of $C_{10}$ to $C_{40}$ are identified by comparison with standards, and by MS fragmentation patterns.

## Hydrocarbon Characterization and Comparison

The $C_3$-$C_{10}$ gasoline range concentrations in the samples are shown in the Appendix, and are displayed as bar diagrams in the following pages. MW-10R, shown on p.7, contains a suite of hydrocarbons that is dominated by cycloalkanes, but contains small concentrations of trimethylpentanes, which are alkylate hydrocarbons that are blended into gasoline to increase octane levels. The BTEX components are dominated by benzene and ethylbenzene, which is characteristic of degradation in an anaerobic environment (Chapelle, 2001). The bar diagram of MW-26 on p.7 shows a similar distribution to MW-10R up to C8. Benzene and ethylbenzene, however, are in much lower concentrations in MW-26, which would be consistent with the dissolved hydrocarbon plume migrating into a more aerobic environment, which would promote the degradation of the benzene and ethylbenzene. The concentrations of the C3-benzenes and C4-benzenes are relatively higher in MW-26, and may reflect input from another source.

The bar diagram of MW-29 on p.8 shows a very different hydrocarbon distribution, which is dominated by benzene and a methylpentene. In addition, in comparison with MW-26, the distribution of methylpentanes (identified as horizontal line 1) is different, and the concentrations of the dimethylcyclopentanes (horizontal line 2) are considerably lower. The relative concentrations of the BTEX compounds in MW-29 reflect their solubility in water and represent a relatively undegraded dissolved gasoline plume. MW-29 also contains DIPE (7 ug/L), a fuel oxygenate that was not detected in any other samples. These differences in the hydrocarbon and additive compositions indicate that the gasoline in MW-29 is not sourced from MW-10R.

In the bar diagram of MW-27 on p.9, benzene is dominant, with very small concentrations of other hydrocarbons. Ethylene dichloride (EDC) was also detected, which is probably associated with the other chlorinated solvents, dichloropropane and trichloropropane, that were detected in the sample, as shown in the appendix. Dichloropropane is an intermediate in the production of tetrachloroethene and other chlorinated chemicals (Rossberg et al, 2006). Historically, trichloropropane has been used as a paint or varnish remover, a cleaning and degreasing agent, and in the production of pesticides. Currently, it is also being used as a chemical intermediate in the process of making chemicals such as hexafluoropropylene and polysulfides and as an industrial solvent (Cook, 2009). Tetrahydrofuran, an industrial solvent, was also detected in MW-27. The minor hydrocarbon constituents in MW-27 are in such small concentrations that it is difficult to make any reliable correlation to the other samples. However, the BTEX distribution more closely resembles the distribution in MW-29 than MW-26, suggesting that in MW-27 the BTEX compounds in particular are probably derived from the same source as MW-29.

Chapelle, F.H. (2001) Groundwater Microbiology and Geochemistry, 2nd Edition. John Wiley and Sons Inc, New York, pp.378-379.

Cooke, Mary (2009). Emerging Contaminant--1,2,3-Trichloropropane (TCP) (Report). United States EPA.

Manfred Rossberg, Wilhelm Lendle, Gerhard Pfleiderer, Adolf Tögel, Eberhard-Ludwig Dreher, Ernst Langer, Heinz Rassaerts, Peter Kleinschmidt, Heinz Strack, Richard Cook, Uwe Beck, Karl-August Lipper, Theodore R. Torkelson, Eckhard Löser, Klaus K. Beutel, Trevor Mann "Chlorinated Hydrocarbons" in Ullmann's Encyclopedia of Industrial Chemistry 2006, Wiley-VCH, Weinheim. doi:10.1002/14356007.a06_233.pub2

The $C_{10}$-$C_{40}$ GC/MS alkane chromatograms are shown on pp.7-9. MW-10R contains a suite of hydrocarbons from 20 min to 55 min retention time in the carbon range C10-C24, which is the range of diesel and #2 fuel oil. Isoalkanes are dominant, with no evidence of n-alkanes, which are dominant in fresh diesel and #2 fuel oil, but are the most readily biodegraded hydrocarbons. The peaks up to 20 min retention time represent volatile hydrocarbons. There is no evidence of this diesel/#2 fuel oil in MW-26, MW-27, or MW-29. In MW-26, there is, in addition to the volatile hydrocarbons up to 30 min retention time, unidentified material from 45-50 min and a suite of n-alkanes from nC25 to nC35; this represents a small amount of petroleum wax from an unknown source. In MW-27, the only alkanes identified were from petroleum wax. MW-29 also contained a small amount of petroleum wax. A large peak, identified as $C_{10}H_{15}NO_2S$, probably represents n-butylbenzenesulfonamide, which is widely used as a plasticizer in polyacetals, polyamides, and polycarbonates, and has been found in ground water and effluent from wastewater treatment sites.

## Conclusions

- Water sample MW-10R contains dissolved hydrocarbons that most likely represent degraded gasoline.
- MW-26 contains a similar gasoline, and some heavier aromatic hydrocarbons, probably from another source.
- MW-29 contains a different gasoline with the fuel oxygenate DIPE. This gasoline is from a different source than MW-10R.
- The dissolved gasoline in MW-27 appears to be more similar to MW-29, and is probably from the same source as MW29.
- MW-10R also contains degraded diesel or #2 fuel oil that was not detected in MW-26, MW-27, or MW-29.