WORK PLAN
PHASE 2 GROUNDWATER SITE CONCEPTUAL MODEL
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

Prepared For:

The Boeing Company
The National Aeronautics and Space Administration
The United States Department of Energy

Prepared By:

MWH
1340 Treat Boulevard
Suite 300
Walnut Creek, California 94597

April 2007

REGISTERED GEOLOGIST
JESSE R. WAGNER
#4312
STATE OF CALIFORNIA

Prepared by:

Richard G. Andrachek, P. E.
Project Director

Jesse R. Wagner, R.G. 4312
Professional Geologist

TABLE OF CONTENTS

FIGURES

APPENDICES

MWH

ABBREVIATIONS

Boeing	The Boeing Company
CFC-113	1,1,2-trichloro-trifluoroethane
COPCs	chemicals of potential concern
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DOE	United States Department of Energy
DTSC	Department of Toxic Substances Control
FSDF	Former Sodium Disposal Facility
NASA	National Aeronautics and Space Administration
Panel	Groundwater Advisory Panel
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SCM	Site Conceptual Model
SMMC	Santa Monica Mountains Conservancy
SSFL	Santa Susana Field Laboratory
TCA	trichloroethane
TCE	trichloroethene
VOCs	volatile organic compounds

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan presents activities toward completing the characterization of the Chatsworth formation operable unit[1] of the Santa Susana Field Laboratory (SSFL). In particular, this work plan presents an approach for obtaining field data to be used in evaluating the plume attenuation aspects of the groundwater site conceptual model (SCM). The SSFL is jointly owned by The Boeing Company (Boeing) and the federal government (administered by the National Aeronautics and Space Administration [NASA]) and is operated by Boeing. A portion of the SSFL that is owned by Boeing was operated for the U.S. Department of Energy (DOE). The SSFL is located in the southeast corner of Ventura County, 29 miles northwest of downtown Los Angeles, California. The location of the SSFL and its surrounding vicinity is shown on Figure 1. SSFL site and administrative boundaries are shown on Figure 2. Previous environmental investigations have shown that the Chatsworth formation beneath the SSFL has been impacted by historic releases of various chemicals of potential concern (COPCs) from operational activities. Trichloroethene (TCE) is the compound detected at the highest concentration and with the greatest frequency. This work plan has been prepared by MWH on behalf of Boeing, NASA and DOE and was developed jointly by staff from Boeing, the Groundwater Advisory Panel (Panel)[2] and MWH.

1.1 BACKGROUND INFORMATION

The Panel was commissioned in 1997 to develop a groundwater SCM regarding the movement of COPCs in the Chatsworth formation. At the recommendation of the Panel, new methods including rock coring and crushing were used to characterize COPCs in the fractured sedimentary rock of the Chatsworth formation during the late 1990's. In April, 2000 a Technical Memorandum was submitted that presented the site conceptual model (Montgomery

[1] The Chatsworth formation operable unit consists predominantly of fractured sandstone and includes both the unsaturated and saturated portions of the unweathered bedrock that lies beneath the SSFL.
[2] The Groundwater Advisory Panel consists of Drs. John Cherry and Beth Parker from the University of Waterloo and Dr. David McWhorter, Professor Emeritus from Colorado State University.

Watson, 2000a). The SCM was based on the Panel's understanding of solute transport in fractured sedimentary rock (e.g., Chatsworth formation) and available data as of late 1999.

The site conceptual model of COPC movement in the Chatsworth formation includes the following three key elements:

1. The fractures at the SSFL are small, systematic and interconnected.
2. COPCs dissolved in groundwater flowing through the small, systematic and interconnected fractures are transported into the porous sandstone matrix by molecular diffusion.
3. COPC plume fronts are strongly retarded due to matrix diffusion and the presence of organic carbon, and advance at rates that are orders-of-magnitude slower than the average linear groundwater velocity.

Phase 1 SCM investigations were based on a work plan[3] (Montgomery Watson, 2000b) that was submitted to and approved by the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC, 2000). The Phase 1 work focused on the first two elements of the SCM by:

- Conducting hydraulic and borehole geophysics tests, and inspecting and analyzing rock core to assess the size, nature and interconnectedness of the fracture network. This work was performed at two areas of the site that represent the upper and lower range of Chatsworth formation permeability (the northeast area and the Former Sodium Disposal Facility (FSDF) in the northwest portion of the SSFL, respectively).
- Drilling coreholes at eight source zones located throughout the SSFL to demonstrate that the solutes are transported into the porous sandstone matrix through molecular diffusion.

A report of results from Phase 1 of these intensive investigations in the northeast was issued in September 2004 (MWH, 2004).

[3] The initial methods and concepts of determining whether volatile organic compound (VOC) mass had been transported into the Chatsworth formation sandstone matrix were developed and implemented in 1997 by members of the Groundwater advisory panel and proven by the installation of two coreholes drilled in source areas (RD-35B and RD-46B).

The source zone characteristics identified in the northeast area include a number of elements. Chlorinated solvents were used historically at various locations in the northeast area. The plume that extends to the northeast is believed to be sourced primarily from the former Instrument and Equipment Laboratory (IEL). Historical solvent use areas were discussed and depicted in the aforementioned report of results from Phase 1 (MWH, 2004). These likely solvent input locations were investigated and characterized primarily using soil gas sampling and analysis, and by soil matrix sampling and analysis to a lesser extent (MWH, 2004). Coreholes completed in the northeast area have provided characteristics of the source zone below the water table including the likely penetration of immiscible-phase TCE below the water table, and its subsequent dissolution.

A Phase 2 northeast investigation area work plan was submitted in October 2005 (MWH, 2005) and approved for implementation by the DTSC (2005) and is in progress as of the date of issuance of this work plan. The Phase 2 northeast work plan presented a scope of work focused on both defining the nature and extent of COPCs and on the third element of the SCM, which predicts that solute transport will be strongly retarded relative to the average linear groundwater velocity. This work included installing a corehole[4] near the leading edge of the groundwater plume (RD-39C), installing three coreholes (RD-35C, C-10 and C-11) to assess the nature and extent of the source zone, and deepening an existing well (RD-31) through coring to evaluate the groundwater flow system. These locations are shown on Figure 3. The three coreholes (RD-35C, C-10 and C-11) and the deepening of RD-31, along with data from two previously installed coreholes (RD-35B and C-1) will provide information about the nature and extent of VOC impacts at or near a source zone. This "source zone transect" will serve as a starting point for demonstrating the retardation effect of matrix diffusion on solute plumes at the SSFL. Northeast area source zone transect data are currently being reduced and evaluated to further characterize this source zone. A Technical Memorandum will be prepared that describes the results of these investigations.

[4] Although the scope discussed here refers to corehole installation, the data yielded at these locations is from the collection and analysis of numerous rock core samples, which provide information on the nature and extent of VOC distribution in the bedrock matrix.

This work plan is being prepared in partial fulfillment of the requirement to characterize groundwater that has been established in the corrective action provisions of :

- Areas I and III [Areas owned and operated by Boeing (see Figure 2 for boundaries) Permit No. PC-94/95-3-02, DTSC, 1995] and the November 12, 1992 Stipulated Enforcement Order (DTSC, 1992), and
- Area II (administered by NASA, Permit No. PC-94/-95-3-0, DTSC, 1995), and
- The corrective action provisions established in the hazardous waste operating permit for Buildings 133 and 29 in Area IV of the SSFL (Permit No. 93-3-TS-CAD000629972).

1.2 WORKPLAN OBJECTIVE

The objective of this work plan is to collect field data that can be used to evaluate the magnitude of contaminant attenuation within a groundwater plume due to various physical and chemical processes. One of the key remaining elements of the groundwater SCM that requires field data for validation is the attenuation of COPCs relative to the average linear groundwater velocity. The average linear groundwater velocity is estimated to be on the order of hundreds to thousands of feet per year due to rapid flow through the fracture network in the bedrock. However, the rate of COPC transport at or near the plume front is estimated to be on the order of tens of feet per year (based on two-dimensional transport model runs), reflecting retardation factors between 25 to about 300. The northeast investigation area has been identified as the best location[5] at the SSFL for collecting the necessary data to validate the attenuation aspects of the groundwater SCM. Specifics regarding the field data that will be obtained and its integration into the SCM are described in Section 2 of this work plan.

[5] A number of site features were considered during the transect siting process. Such features included: potential hydraulic effects on COPC transport directions associated with historical groundwater extraction; topography and access; geology, including stratigraphy and structure; and knowledge of source input locations and the occurrence and distribution of COPCs in surficial media. When these factors were considered, the northeast area was chosen as the best location at the SSFL relative to all other areas of COPC-impacted groundwater to evaluate the attenuation aspects of the SCM by drilling a transect.

2.0 APPROACH AND WORK TO BE PERFORMED

The general approach to collecting the data necessary to validate the plume attenuation aspect of the SCM is to install a transect consisting of four coreholes across the width of a groundwater plume down gradient from the source zone transect in the northeast area and includes the following tasks:

1. Collect and analyze rock core, and
2. Consider converting selected coreholes to multi-level monitoring systems

Proposed drilling and coring locations are shown in plan view on Figure 3 and additional descriptions of the work to be performed for these tasks are outlined below.

2.1 COLLECT AND ANALYZE ROCK CORE

The primary method that will be used to achieve the Phase 2 SCM work plan objective will be to collect and analyze rock core samples from the Chatsworth formation for a select set of chemical indicators. The set of chemical indictors to be analyzed for in each core sample includes: tetrachloroethene (PCE), TCE, cis-1,2-dichloroethene (DCE), trans-1,2-DCE, 1,1-DCE, 1,1,2-trichloro-trifluoroethane (CFC 113), chloroform and 1,1,1-trichloroethane (TCA). Such an approach has been effectively used at the SSFL since 1997 (see Montgomery Watson, 2000a and University of Waterloo, 2003 for a presentation of the results from this method). In summary, the Phase 2 SCM work plan objective will be achieved by drilling approximately 2,000 feet of new coreholes from four distinct locations and collecting an estimated 1,200 rock core samples for laboratory analysis. Additional descriptions of the four proposed rock core locations and their purpose are provided below. Drilling, coring and well completion procedures are provided in Appendix A. Rock core crushing and laboratory analytical procedures to be used will be as described in the October, 2005 Phase 2 work plan (MWH, 2005).

2.1.1 Coreholes C-12 through C-15

A series of four coreholes (labeled C-12 through C-15) is proposed for installation off-site within the northeast investigation area. The primary purpose of this series of coreholes is to provide field data to validate the attenuation of COPCs relative to the average linear groundwater velocity as predicted by the matrix diffusion conceptual model (see Montgomery Watson, 2000a or Groundwater Advisory Panel, 2004). These coreholes have been designed as a transect that is perpendicular to the current interpretation of the primary direction of groundwater flow in this portion of the northeast area. The primary direction of groundwater flow has been inferred from the measured COPC concentrations from the existing groundwater monitoring well network, as the COPCs serve as tracers of the flow system. The TCE isoconcentration contours shown on Figure 3 depict the interpreted direction of groundwater flow (i.e., the flow direction is from areas of higher concentration toward areas of lower concentration).

The proposed locations of C-12 through C-15 are shown in plan view on Figure 3 and in cross-section view on Figures 4 and 5. It is important to note that the rock core analytical results from RD-39C, RD-35C, RD-31 deepening and coreholes C-10 and C-11 (i.e., the results from the Phase 2 northeast investigation area work plan) were critical inputs to selecting the locations of the down gradient transect coreholes. In particular, the rock core results from RD-39C were critical in determining how far from the source zone transect this down gradient transect should be located. Coreholes C-12 and C-13 will be used to define the southeastern lateral extent of COPC-impacted groundwater. Corehole C-12 will be installed first, and used to refine the location and target depth of corehole C-13. A road will be built to provide access to the proposed location of corehole C-13. A detailed evaluation of the likely position of the shear zone near the line of the down gradient transect will be performed before selecting the final location of corehole C-15 to reduce the likelihood of this corehole intercepting the shear zone. The proposed locations for all four of these coreholes are off-site on property owned by the Santa Monica Mountains Conservancy (SMMC), and the installation of the coreholes is dependent upon obtaining a site access agreement with the SMMC to perform this work. For planning purposes, the initial estimated total depths of the coreholes are presented on Figure 5. Rock core samples will be collected from the water table to total depth; the estimated water table

MWH

elevations at the four proposed corehole locations are presented on Figure 5. Final siting of corehole locations will be developed in collaboration with the DTSC.

After reaching total depth, each corehole will be sealed to minimize the potential for borehole cross-contamination. A multi-level monitoring system will be designed and installed, if such a system is necessary. The rock core analytical results will be used as the basis for the design of the multi-level monitoring systems. It is important to note that the rock core analytical results are primary data that are needed to validate the attenuation of COPCs relative to the average linear groundwater velocity because these results will indicate if concentrations downgradient of source zones are appreciably reduced.

2.1.2 Corehole Sealing Methods

Previous corehole work performed under the direction of the Panel in 1997 and 1998 has shown that cross-contamination can occur due to intra-corehole flows that develop in an open corehole (see Sterling et al, 2005). Procedures will be put into place to minimize this potential cross-contamination effect during both active coring operations and after completing the corehole and prior to installation of a multi-level monitoring system (or corehole abandonment). Both procedures have been previously used during and after coring operations at the SSFL.

Cross-contamination during active coring operations will be minimized through the placement of a series of up to three packers. The vertical placement of the packers will be dictated by information obtained from field measurements during coring activities. Cross-contamination will be minimized post coring operations through the placement of a blank FLUTe liner in the corehole. The blank liner will remain in place until a multi-level monitoring system is available and ready for installation or until the corehole is ready for permanent abandonment.

2.2 MULTI-LEVEL MONITORING SYSTEMS

Multi-level monitoring systems may be installed at coreholes C-12 through C-15 depending on the data that are produced from all of the rock core analytical results and from any multi-level results at RD-39C, RD-35C, RD-31 deepening, C-10 and C-11. The multi-level monitoring systems would provide both hydraulic head and groundwater chemistry data over time.

The rock core analytical results and the coring logs would be used as the design basis for the multi-level monitoring systems and the designs would be developed in collaboration with the DTSC. Two multi-level monitoring systems (West-Bay and Water FLUTe) would be considered during the design process, both of which have been previously installed as part of the groundwater characterization program at and near the SSFL. The decision as to which of the two systems should be installed at any location would be dependent upon the number of discrete-intervals required[6] and the desired frequency of hydraulic head measurements[7].

[6] The West-Bay system has the capability of using many discrete-intervals within a single corehole while the Water FLUTe is limited to approximately eight discrete-intervals in a 4-inch diameter hole (HQ core) and about 12 discrete-intervals in a 5-inch diameter hole (PQ core).

[7] Alternately, the Water FLUTe has the capability of collecting automated, nearly-continuous hydraulic head measurements, while the frequency of such measurements with the West-Bay system is significantly smaller or much more labor intensive.

3.0 SCHEDULE AND DELIVERABLES

It is anticipated that the field work described in this plan can be completed within about six months of initiation. A schedule including task names and durations and estimated start and completion dates is presented in Figure 6. The schedule assumes that this Phase 2 SCM work plan (and any subsequent modifications and/or revisions) will be approved by DTSC for implementation in early June of 2007. Rock coring operations span the longest duration and cover approximately four months. The corehole schedule logic is described in Section 2 of this work plan and is reflected in Figure 6. The installation of coreholes C-12 through C-15 is contingent upon receiving an access agreement from the SMMC, hence the installation timing of these locations is reflected in the schedule. The overall targeted completion date for the groundwater site conceptual model Phase 2 work is April of 2008.

3.1 DELIVERABLES

A Technical Memorandum is presented in the project schedule (Task 14). The technical memorandum is intended to evaluate and describe the rock core transect results (C-12 through C-15) within the context of the COPC attenuation element of the groundwater site conceptual model. This technical memorandum can also be used to describe the need and/or design of any multi-level monitoring systems that may be placed in the transect coreholes. At this point, the procurement, installation and sampling of such systems are not reflected in the project schedule. A second Technical Memorandum would be issued that describes the installation and completion details of any multi-level monitoring systems that were installed at these locations. All work performed as described in this work plan would subsequently be included in the site-wide groundwater characterization report.

4.0 SUMMARY

This Phase 2 SCM work plan describes investigation activities toward completing the characterization of the Chatsworth formation operable unit of the SSFL. In particular, this work plan presents activities targeted at collecting field data regarding the magnitude of contaminant attenuation in the Chatsworth formation due to various physical and chemical processes.

The Phase 2 SCM scope of work includes collecting and analyzing about 1,200 rock core samples from four corehole locations positioned within the dissolved TCE plume downgradient of TCE sources, and possibly converting some of these four coreholes to multi-level groundwater monitoring systems. The field work is projected to take about six months to complete and will involve an iterative, collaborative approach between the SSFL groundwater team and the DTSC. The field data to be collected during this investigation includes logs of the collected rock core (including fractures), and the results of analysis of rock core samples for a select set of chemical indicators that includes PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, CFC 113, chloroform and 1,1,1-TCA. The rock core analytical results are the primary data that are needed to validate the element of the SCM involving the attenuation of COPCs relative to the average linear groundwater velocity. The comparison of COPC concentrations in rock core collected from the source area with concentrations in downgradient rock core samples will provide direct field evidence of the magnitude of attenuation of COPC concentrations downgradient from source areas.

The work described herein can commence within 10 days of DTSC's approval of this work plan.

MWH

5.0 REFERENCES

Department of Toxic Substances Control (DTSC), 1992. Stipulated Enforcement Order, In the Matter of Rockwell International Corporation, Rocketdyne Division, Respondent, November 12.

DTSC, 1995. Hazardous Waste Facility Post-Closure Permit, Regional Permit Numbers PC-94/95-3-02 and PC-94/92-3-03, Permits for Areas I and III and Area II, effective 11 May 1995.

DTSC, 2000. Letter from Gerard Abrams to Arthur Lenox, Approval of Additional Field Investigations, Chatsworth Formation Operable Unit. September 18.

DTSC, 2005. Letter from Gerard Abrams to David Dassler, Approval of Northeast Area Chatsworth Formation Work Plan, Phase II. November 10.

Groundwater Advisory Panel, 2004. Letter to Mr. James Pappas, DTSC from Dr. John Cherry, Dr. David McWhorter and Dr. Beth Parker, Groundwater Advisory Panel Response to DTSC Letters of February 2 and 3, 2004. March 16.

Montgomery Watson, 2000a. *Technical Memorandum, Conceptual Site Model Movement of TCE in the Chatsworth Formation*, April.

Montgomery Watson, 2000b. *Work Plan for Additional Field Investigations*, Chatsworth Formation Operable Unit. Revision 1. October.

MWH, 2004. Report of Results, Phase 1 of Northeast Investigation Area Groundwater Characterization. September.

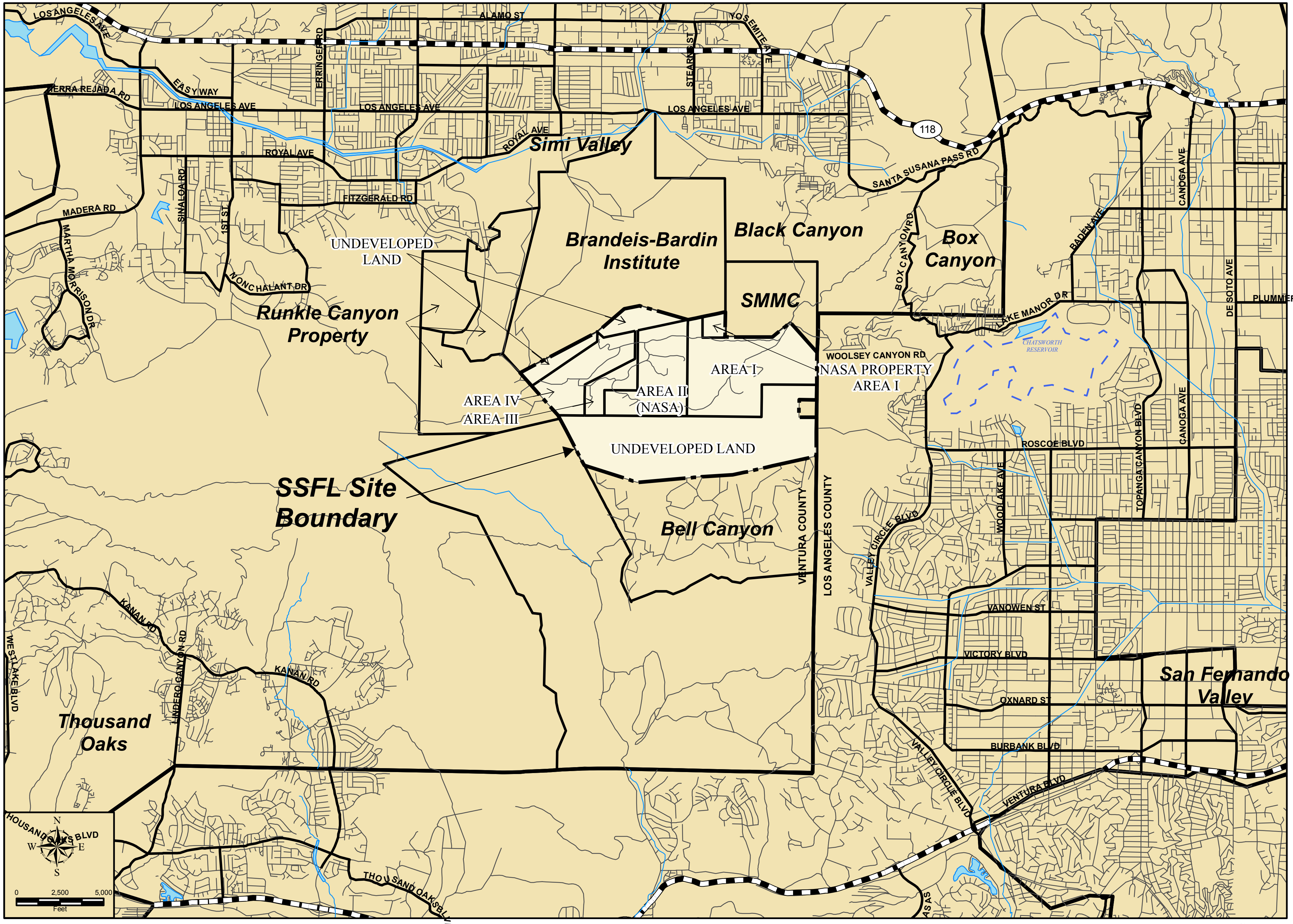
MWH, 2005. Northeast Area Chatsworth Formation Work Plan, Phase 2, Santa Susana Field Laboratory, Ventura County, CA. October.

MWH, 2006. Draft Phase 1 Report of Results, Former Sodium Disposal Facility Groundwater Characterization, Santa Susana Field Laboratory, Ventura County, CA. February.

Sterling, S.N., B.L. Parker, J.A. Cherry, J.W. Lane, J.H. Williams and F.P. Haeni, 2005. Vertical Cross Connection of TCE in a Borehole in Fractured Sandstone. Ground Water, Volume 43, Number 4. July-August.

University of Waterloo, 2003. Source Zone Characterization at the Santa Susana Field Laboratory: Rock Core VOC Results for Core Holes C-1 through C-7, Santa Susana Field Laboratory. December.

FIGURES



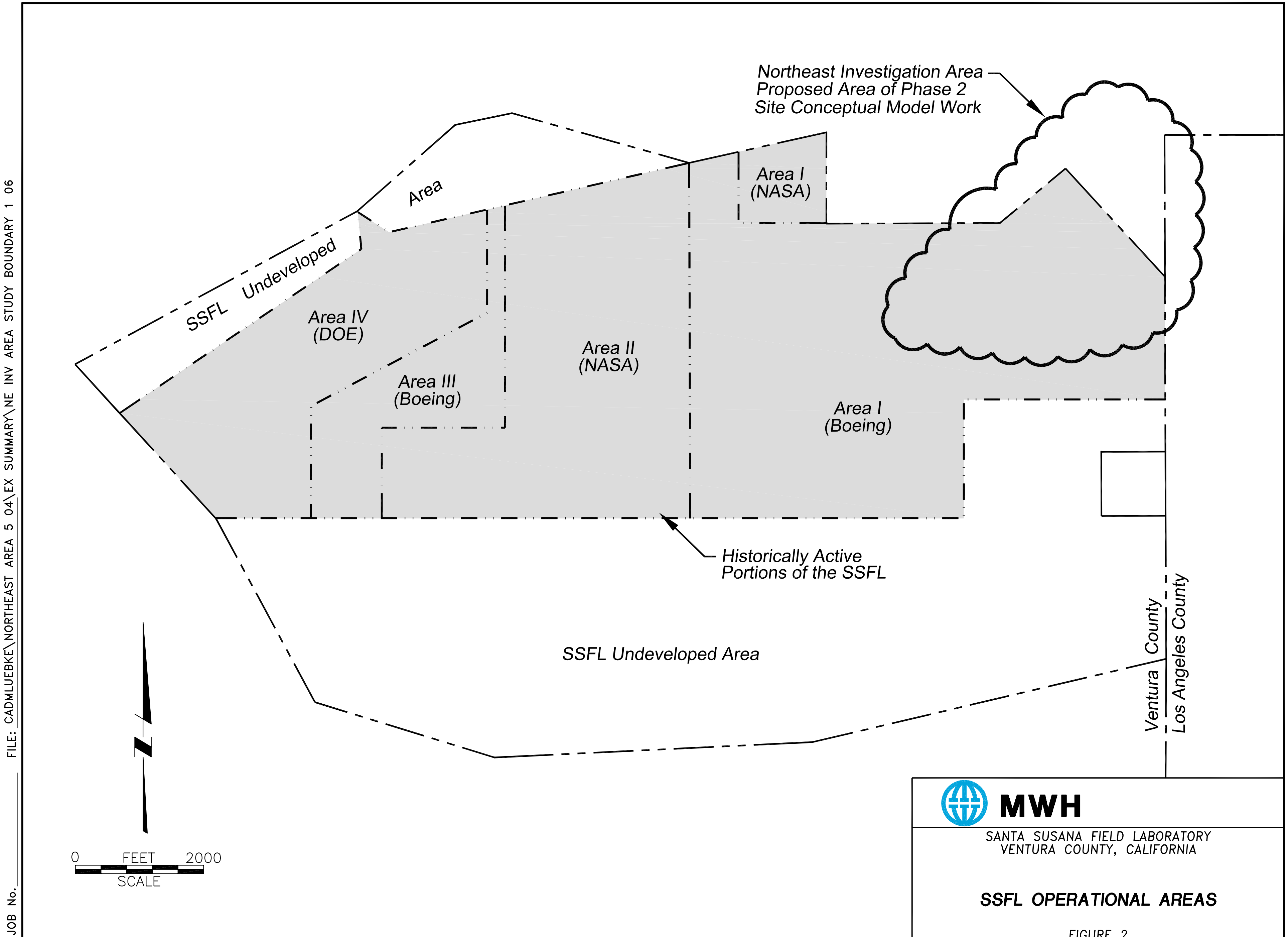
MWH

Santa Susana Field Laboratory (SSFL)
Regional Map

FIGURE
1

r:/rock/plots/arcmap/regional_map.mxd

01/24/06



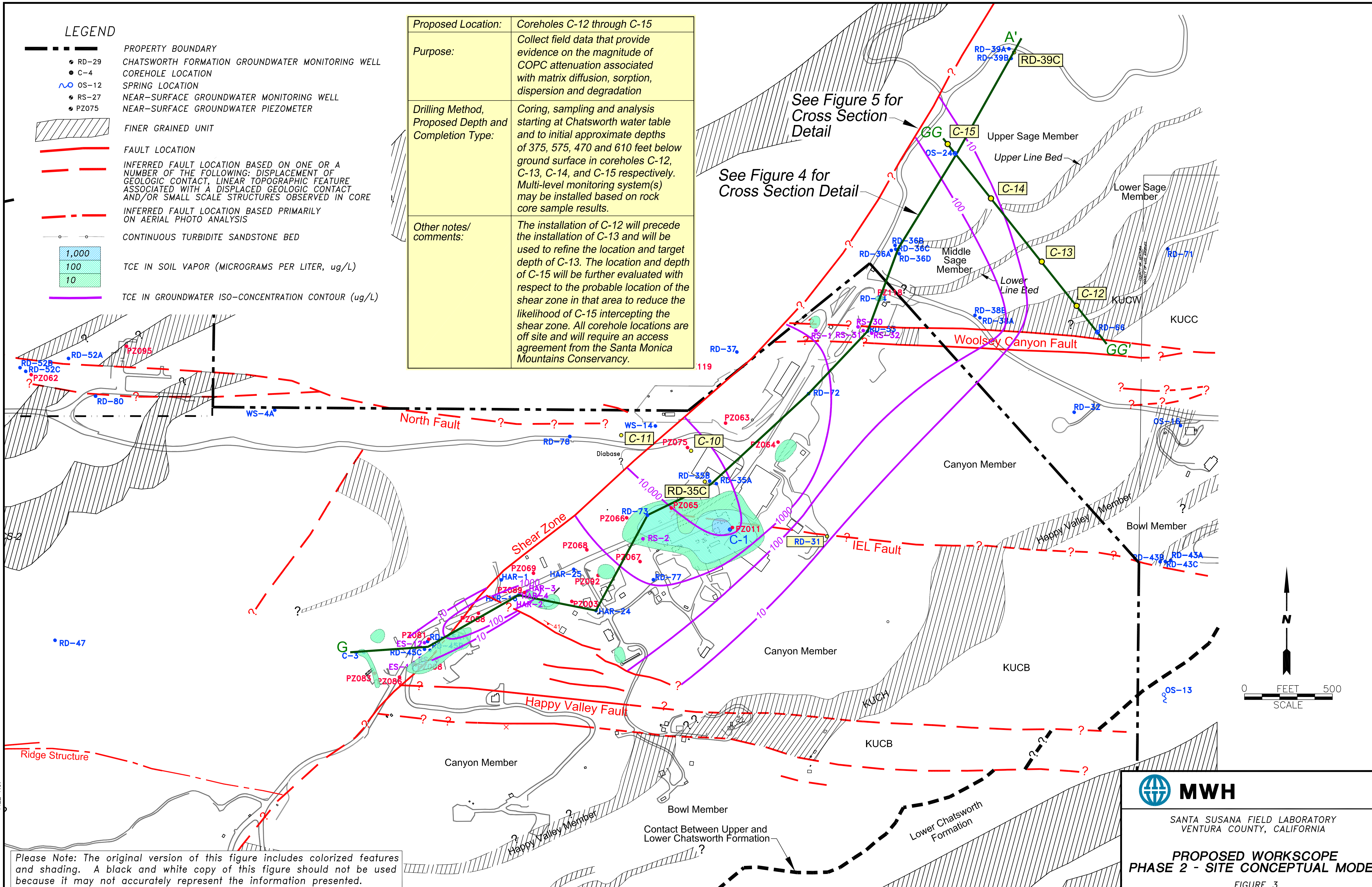
MWH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

SSFL OPERATIONAL AREAS

FIGURE 2

Proposed Location:	Coreholes C-12 through C-15
Purpose:	Collect field data that provide evidence on the magnitude of COPC attenuation associated with matrix diffusion, sorption, dispersion and degradation
Drilling Method, Proposed Depth and Completion Type:	Coring, sampling and analysis starting at Chatsworth water table and to initial approximate depths of 375, 575, 470 and 610 feet below ground surface in coreholes C-12, C-13, C-14, and C-15 respectively. Multi-level monitoring system(s) may be installed based on rock core sample results.
Other notes/ comments:	The installation of C-12 will precede the installation of C-13 and will be used to refine the location and target depth of C-13. The location and depth of C-15 will be further evaluated with respect to the probable location of the shear zone in that area to reduce the likelihood of C-15 intercepting the shear zone. All corehole locations are off site and will require an access agreement from the Santa Monica Mountains Conservancy.



Please Note: The original version of this figure includes colorized features and shading. A black and white copy of this figure should not be used because it may not accurately represent the information presented.

MWH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

PROPOSED WORKSCOPE
PHASE 2 - SITE CONCEPTUAL MODEL

FIGURE 3

CADMLUEBKE\BOEING\SANTA SUSANA\NORTHEAST AREA 5 04\TCE DATA GAPS 9 14 06

FILE No.

JOB No.

Legend

[1548.1] Indicates Groundwater Elevation in Feet msl Before Pumping Began (8/25/03)

TCE Isoconcentration Contour, Chatsworth Formation, Micrograms per Liter (ug/L)

Distribution of TCE in Near-Surface Groundwater (Concentrations ›1,000 ug/L)

Distribution of TCE in Near-Surface Groundwater (Concentrations ›100 ug/L)

Distribution of TCE in Near-Surface Groundwater (Concentrations ›5 ug/L)

Open Port / Sealed Interval — Monitoring Well with FLUTe System

0 FEET 200 SCALE

Please Note: The original version of this figure includes colorized features and shading. A black and white copy of this figure should not be used because it may not accurately represent the information presented.

AREA OF DETAIL

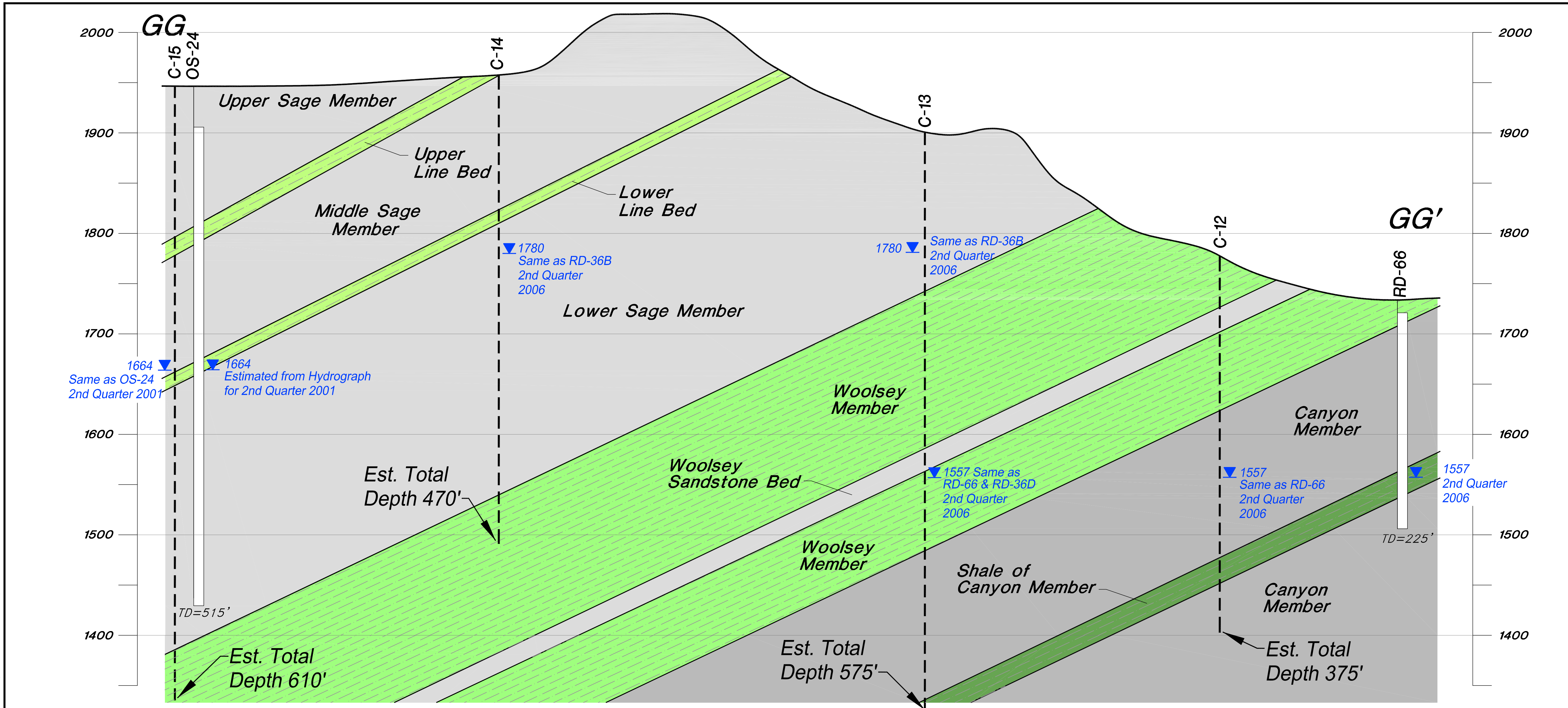
SANTA SUSANA FIELD LABORATORY

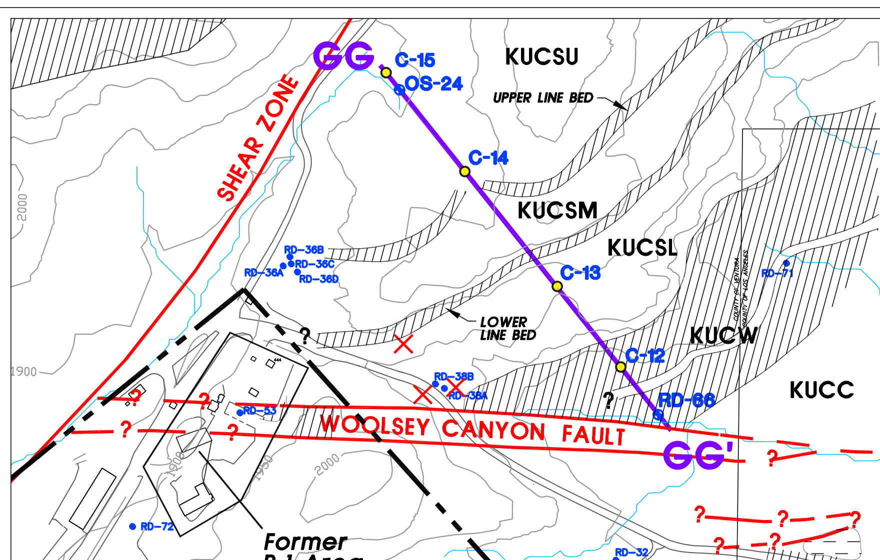
MWH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

CROSS SECTION G-A'

FIGURE 4

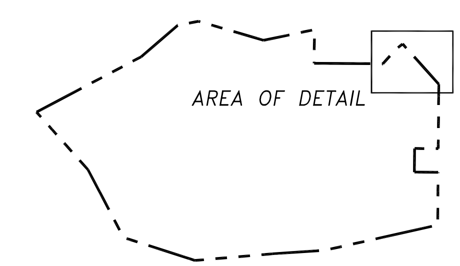




LEGEND

- PROPERTY BOUNDARY
- RD-29 DEEP ZONE GROUNDWATER MONITORING WELL
- OS-12 SPRING LOCATION
- FINER GRAINED UNIT
- FAULT LOCATION
- INFERRED FAULT LOCATION BASED ON ONE OR A NUMBER OF THE FOLLOWING: DISPLACEMENT OF GEOLOGIC CONTACT, LINEAR TOPOGRAPHIC FEATURE ASSOCIATED WITH A DISPLACED GEOLOGIC CONTACT AND/OR SMALL SCALE STRUCTURES OBSERVED IN CORE
- SMALL-SCALE FAULT
- GROUNDWATER ELEVATION

Please Note: The original version of this figure includes colorized features and shading. A black and white copy of this figure should not be used because it may not accurately represent the information presented.



MWH

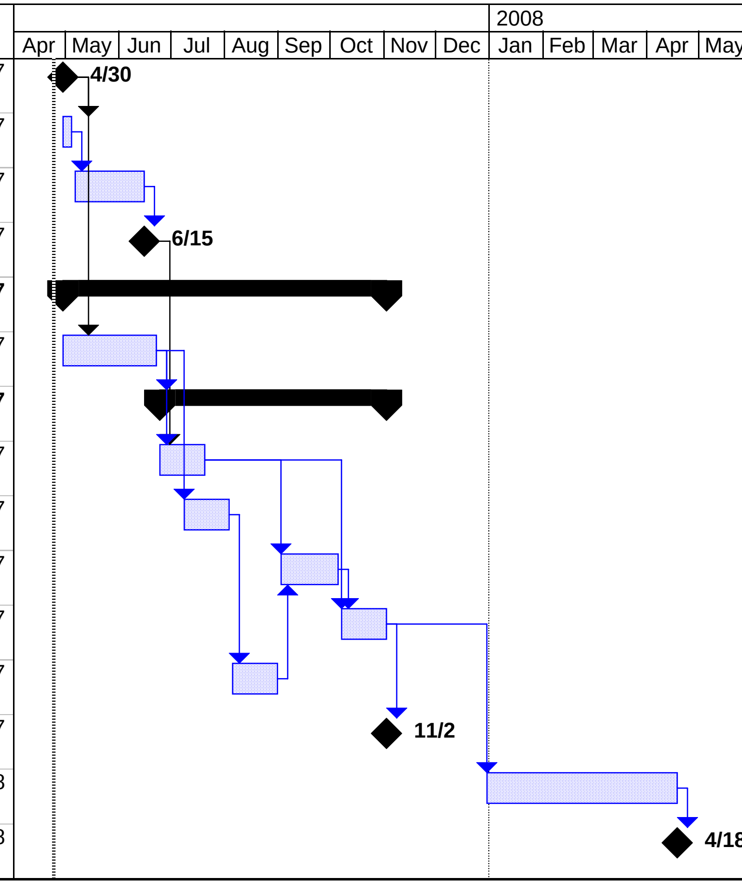
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

CROSS SECTION GG-GG'

FIGURE 5

Project Schedule
Phase 2 Site Conceptual Model Work Plan
Santa Susana Field Laboratory
Ventura County, CA

ID	Task Name	Duration	Start	Finish
1	Submit Phase 2 SCM work plan	0 days	Mon 4/30/07	Mon 4/30/07
2	Request access to drill coreholes	5 days	Mon 4/30/07	Fri 5/4/07
3	Review of access request by SMMC	30 days	Mon 5/7/07	Fri 6/15/07
4	Access agreement in place	0 days	Fri 6/15/07	Fri 6/15/07
5	**Coring Operations**	**135 days**	**Mon 4/30/07**	**Fri 11/2/07**
6	DTSC review, approval of Phase 2 SCM work plan	40 days	Mon 4/30/07	Fri 6/22/07
7	**Planning, Mobilization and Coring**	**95 days**	**Mon 6/25/07**	**Fri 11/2/07**
8	Construct road to C-13 & C-14	20 days	Mon 6/25/07	Fri 7/20/07
9	Drill/core C-12	20 days	Mon 7/9/07	Fri 8/3/07
10	Drill/core C-13	25 days	Mon 9/3/07	Fri 10/5/07
11	Drill/core C-14	20 days	Mon 10/8/07	Fri 11/2/07
12	Drill/core C-15	20 days	Mon 8/6/07	Fri 8/31/07
13	Phase 2 SCM field work complete	0 days	Fri 11/2/07	Fri 11/2/07
14	Prepare TM documenting results of "plume transect"	80 days	Mon 12/31/07	Fri 4/18/08
15	Phase 2 SCM work complete	0 days	Fri 4/18/08	Fri 4/18/08



Task		Rolled Up Milestone	
Split		Rolled Up Progress	
Progress		External Tasks	
Milestone		Project Summary	
Summary		External Milestone	
Rolled Up Task		Deadline	
Rolled Up Split			

Figure 6
April 2007

APPENDIX A

APPENDIX A

PROCEDURES FOR DRILLING, CORING AND WELL COMPLETION PHASE 2 GROUNDWATER SITE CONCEPTUAL MODEL WORK PLAN

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

This appendix to the Phase 2 site conceptual groundwater model work plan presents methods for drilling, coring and completing a series of coreholes at and near the Santa Susana Field Laboratory (SSFL). Descriptions of the coreholes are provided in the main body of this work plan. Methods are presented in this appendix.

Coreholes C-12 through C-15

Coreholes C-12 through C-15 will be drilled to the target depths as described in the main body of this work plan using either HQ- or PQ-size core barrels. A DTSC representative will confirm all new corehole locations in the field. Rock core samples will be collected starting at the water table at an approximate average frequency of one foot. Sample selection is as outlined in Appendix C of the October, 2005 Phase 2 Northeast Area Chatsworth Formation Work Plan (MWH, 2005). The depth to water will be measured each morning during drilling with an electronic water-level indicator prior to commencing coring activities. The coreholes will be drilled to maximize the chance of providing a smooth and vertical well bore. The drilling contractor will be required to provide a vertical corehole that deviates no more than two feet per every one hundred vertical feet.

Each corehole will be initially drilled to 10 or 12 inches in diameter by using air rotary methods from the ground surface, through weathered bedrock and four feet into competent bedrock. A 6-inch or 8-inch diameter schedule 40 low carbon steel conductor casing will then be set. Centralizers will be placed at intervals as shown on Figure A-1. The conductor casing will then be grouted into place from the bottom of the hole and allowed to cure for at least 24 hours before additional drilling is initiated. Air-rotary methods will then be used to reach the approximate depth of the water table. At or near the water table, coring will commence using either HQ- or PQ-size split core barrels. The coring system will be equipped to drill with appropriate surface casing or HQ- or PQ-size conductor to assure that the core drilling rods will maintain maximum verticality of the hole. Corehole verticality will be verified using a borehole deviation tool approximately once per every hundred feet of hole cored. A photograph of each section of core will be taken prior to processing of the core by the University of Waterloo for sampling and analysis or for measuring other physical properties.

2.0 DRILLING FLUID

Water from a specified fire hydrant at the SSFL will be used as the drilling fluid. At a minimum, drilling fluids will be changed at the end of each day and prior to commencing coring activities at the start of each day. Where necessary, a daily record of water usage (volumes, sampling and analysis for VOCs, including results, and replacement episodes) will be maintained. All water entering boreholes either during or after drilling operations will be metered.

A foaming agent may be added to the drilling and coring water (when necessary) to aid in the removal of fine material during drilling. A material safety data sheet (MSDS) describing the contents of the foaming agent will be submitted to Boeing and the DTSC for review and approval prior to using the foaming agent. The minimum required amount of water and foaming agent will be used while advancing the hole to ensure the project objectives are met.

3.0 CONDUCTOR CASING

The conductor casing for the boreholes will consist of either 6-inch or 8-inch diameter. Conductor casing will be installed a minimum of 4 feet into competent bedrock. The conductor casing will be grouted in place using cement grout and will be allowed to cure for a minimum of 24 hours before coring operations proceed. Two centralizers can be used to center the conductor casing in the 10-inch diameter hole when the conductor casing exceeds 15 feet in length. The centralizers will be placed between 2 feet and 4 feet from the bottom of the hole and between 3 feet and 5 feet from the top of the hole. A single centralizer must be used when the conductor casing is less than 15 feet in length and should be placed between 2 feet and 4 feet from the bottom of the hole. A diagram of the completed corehole is provided in Figure A-1.

4.0 GROUT

Portland cement (Type II), mixed with between 5.5 and 6 gallons of water per 94-pound bag of cement, will be used for grouting. If additional water needs to be added, it will be metered in at the site up to the maximum ratio of 6 gallons per sack of cement. Grout shall be emplaced via a rigid grout pipe from the bottom of the conductor casing to the top of the corehole. Cement for conductor casing installation shall conform to the requirements of California Water Well Standards for grouting. No additives or borehole cuttings will be mixed with the grout.

5.0 DECONTAMINATION

A centrally located decontamination area and clean zone will be established at the SSFL for equipment preparation and breakdown. The decontamination area will be large enough to accommodate equipment to be used for invasive work and will allow decontamination rinsate to be pumped off for temporary storage and subsequent treatment and/or disposal. A self-contained decontamination setup will also be utilized at each drilling location.

Before use, and between each drilling location, all sampling, drilling, coring, and down-hole equipment will be pressure washed using hot water or scrubbed with a laboratory-grade, non-phosphate detergent, followed by a rinse with potable water from an approved source. Other equipment that comes in contact with samples will be decontaminated on-site following a four stage process: 1) wash and scrub with a laboratory-grade, non-phosphate detergent, 2) rinse with potable water from an approved source, 3) rinse with a laboratory-grade methanol, and 4) rinse with distilled water. After washing, the equipment will be allowed to air dry. When possible, plastic sheets will be used to cover the equipment.

6.0 COREHOLE DEVELOPMENT

Coreholes will be developed to establish good flow of groundwater between fractured bedrock and the borehole, to eliminate any water added during drilling activities, and remove suspended solids and accumulated cuttings from the bottom of the corehole. Coreholes will be developed using methods that include bailing, swabbing, and pumping or air lifting.

Water quality parameters including temperature, specific conductance, turbidity, and pH will be measured during the air lifting or pumping of the hole. Development will continue until three successive parameter measurements have stabilized within 10 percent where possible. Maximum development time will not exceed two hours but additional development may occur through pumping.

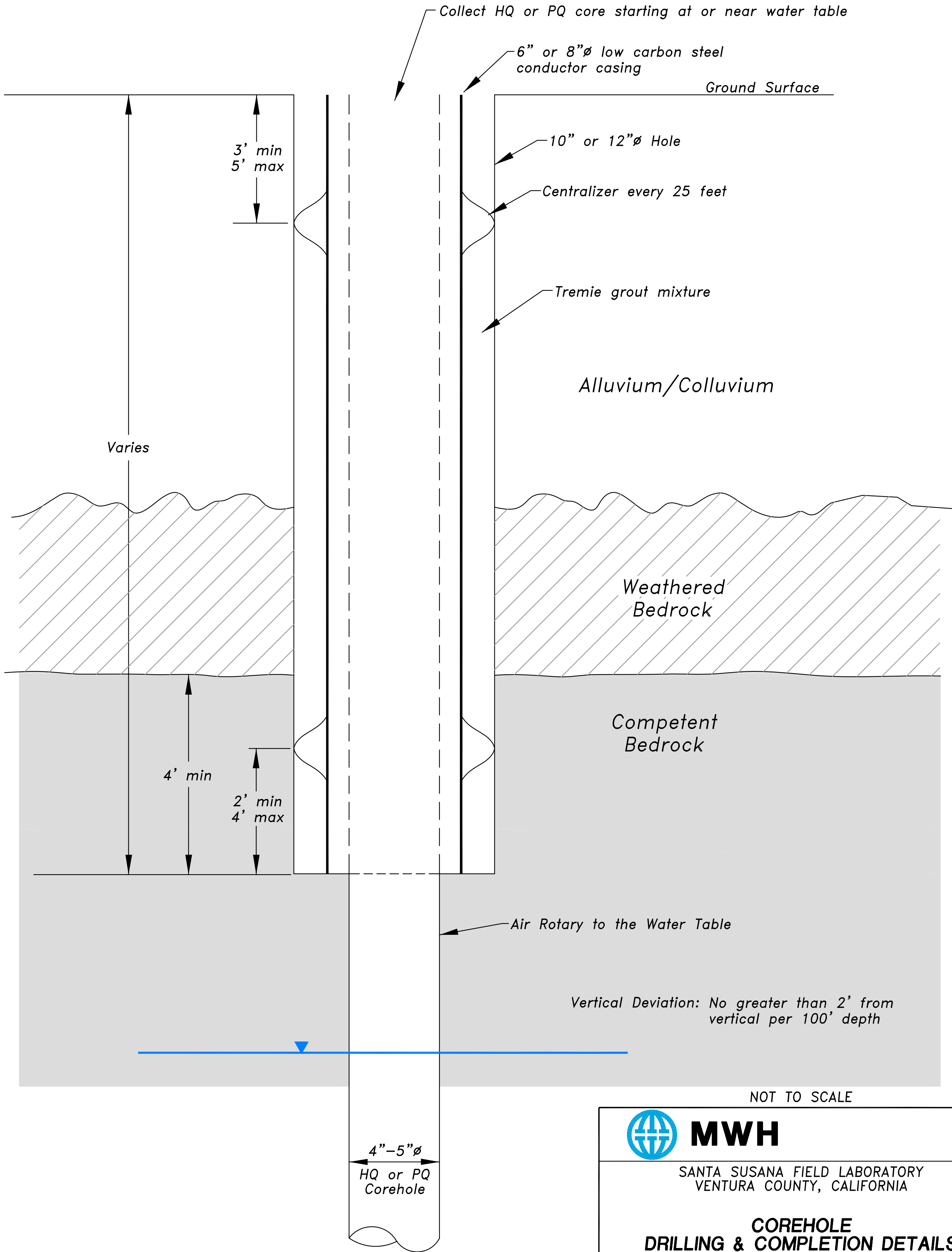
7.0 CONTAINMENT OF DRILL CUTTINGS AND FLUIDS GENERATED

All fluids will be contained in secure, properly labeled portable above ground tanks. All drill cuttings will be contained in tanks or bins. Laboratory analyses (for volatile organic compounds) of the drill cuttings and fluids will determine the appropriate disposal methods. Drill cuttings will be evaluated based on the laboratory analytical results. Based on the analyses, Boeing will dispose of the cuttings in compliance with State and Federal regulations.

8.0 WELLHEAD COMPLETION

The aboveground completions will be contained in well boxes that are grouted in place with a finished height approximately 3 feet above ground surface. The well boxes will be 24-inch by 24-inch square, or equivalent, with locking tops. The well boxes may include standard guard posts for ease of location and protection.

For at-surface completions in high traffic areas, wellheads will be completed in 36-inch by 36-inch by 12-inch deep well vaults. The well vault will have traffic-rated steel plates with bolt-down lids that are watertight.



NOT TO SCALE

MWH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

COREHOLE
DRILLING & COMPLETION DETAILS

FIGURE A–1

JOB No. ________ FILE: D:\PROJECTS\BOEING\SANTA SUSANA\PQ COREHOLE DIAGRAM 6 05