United States Environmental Protection Agency

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Office of Solid Waste and Emergency Response
Office of Superfund Remediation and
Technology Innovation

Optimization Review
State Road 114 Ground Water Plume Superfund Site
(Ground Water Treatment System and
Soil Vapor Extraction System)

Levelland, Hockley County, Texas

OPTIMIZATION REVIEW

STATE ROAD 114 GROUND WATER PLUME SUPERFUND SITE (GROUNDWATER TREATMENT SYSTEM AND SOIL VAPOR EXTRACTION SYSTEM) LEVELLAND, HOCKLEY COUNTY, TEXAS

Report of the Optimization Review
Site Visit Conducted at the State Road 114 Ground Water Plume Superfund Site
September 17, 2013

December 31, 2013

EXECUTIVE SUMMARY

Optimization Background

The U.S. Environmental Protection Agency's definition of optimization is as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."*[1]

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within federal, state, and municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for 1 day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed before the recommendation is implemented. Note that the recommendations are based on an independent review and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

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[1] EPA. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

Site-Specific Background

The State Road 114 Ground Water Plume Superfund Site is located 1 mile west of the City of Levelland in Hockley County, Texas. The site consists of a groundwater plume more than a mile long containing the primary contaminants 1,2-dichloroethane and benzene. The source of the groundwater contamination is a former petroleum products refinery that operated between 1939 and 1954. Environmental contamination of groundwater and soil at the site resulted from the refining operations, associated disposal of wastes, spills, and leaks. The former refinery property is divided into three areas of concern (AOCs): AOC 1 consists of waste disposal units on the far western portion of the property; AOC 2 consists of an area east of AOC 1 that was used to store crude oil and refined products, distillation and cracking of crude oil, and loading refined product; and AOC 3 consists of the area east of Evening Tower Road, which was presumably used for storage and distillation and cracking of crude and possibly mixing additives as well as product loading. Groundwater beneath the site is contaminated with organic compounds and metals; sources of ongoing contamination include a petroleum hydrocarbon layer floating on the water table (light non-aqueous phase liquid [LNAPL]), the soil matrix in the LNAPL smear zone, and a benzene vapor plume in the vadose zone. The groundwater remedy consists of a groundwater treatment system and a soil vapor extraction system.

Summary of CSM

The optimization review focused on current groundwater and soil vapor collection and treatment operations. CSM components key to these operations include the contaminant distribution and plume migration velocity, which are discussed in Section 2.4. The optimization review team believes the presence of LNAPL over a large area, and the large extent of dissolved groundwater impacts, suggest that groundwater will be contaminated at this site for a very long time. Therefore, primary emphasis should be on controlling migration of the most contaminated groundwater to make sure the groundwater plume is not expanding, and keeping annual costs as low as possible given the expected longevity of the remedy.

Summary of Findings

Key findings from this optimization review include:

- The extraction wells pump less than designed. The on-site extraction wells that were intended for mass and LNAPL removal have suffered from significant fouling issues, and the site team is planning to stop on-site groundwater pumping, which will reduce well maintenance costs significantly. Three off-site extraction wells (EW-5 to EW-7) are shallow and are intended to capture the most contaminated off-site groundwater, but those wells also pump at very low rates and have fouling issues. The other off-site extraction wells (north and east of EW-5 to EW-7) have longer screen intervals and pump from deeper intervals, and the extraction rates are highest from the longer-screened wells that have lower average concentrations of volatile organic chemicals (VOCs).

- Water levels have increased beneath the former refinery property, presumably as a result of recharge of treated water at the injection wells and the on-site impoundment (playa) located west of the treatment plant building. Water levels have decreased off site to the east, which may result from a combination of items that include drought, overdraft of water by private irrigation wells, and remedy pumping which extracts the highest rates from the intermediate and deep zone remedy extraction wells furthest to the east (EW-1 to EW-4 and EW-8 to EW-10).

- There have been fouling problems in the reinjection wells related to barium sulfate. About 75 percent of the system discharge is currently reinjected to the eight reinjection wells and the other 25 percent is discharged to the on-site impoundment (playa) west of the treatment system. The site team prefers to not discharge to the on-site impoundment and hopes to optimize extraction and injection so that recharge to the impoundment is no longer needed.

- The target capture zone utilized in the modeling reports is the extent of the dissolved-phase plumes (based on the remedial goal values) in the upper and lower aquifer units. Specific zones of capture are not easily interpreted from the potentiometric surface maps presented in the annual reports, and the effectiveness of the capture zone is based on the particle tracks provided by the groundwater model, using particles started in interior and the edge of the plumes.

- Groundwater modeling was updated in summer 2013 and presented in the November 2013 Draft Groundwater Model Update, which included evaluation of several alternate extraction scenarios. All on-site shallow extraction wells are eliminated for "Scenario 3" in that report; off-site extraction wells EW-5 to EW-7 are replaced by EW-5R to EW-7R with longer wells screens and assumed to pump 25 gallons per minute (gpm) each, EW-8 to EW-9 pump 20 gpm, EW-10 is reduced to 10 gpm, EW-2 to EW-3 pump 30 gpm, and both EW-1 and EW-4 are eliminated. Total extraction is 185 gpm. The modeling results suggest that this scenario provides adequate capture with similar extraction rates to the current system (less than 200 gpm) and also avoids shallow pumping, which is problematic with respect to well fouling. The modeling predicts that the extraction wells with deeper screens will provide adequate capture for contaminants in the shallow zone and suggests the shallow zone in the eastern portion of the plume will dewater over time (such that it does not make sense to keep existing shallow wells EW-5 to EW-7 in addition to the suggested replacement wells).

- The modeling indicates that a significant amount of treated water is recaptured, which increases the extraction rate required for capture. Although the model simulations account for the recapture of treated water, the modeling presented in the report does not illustrate the difference in capture that might result if treated water was not recharged. (The model has not been used to illustrate how much less extraction might be required to achieve similar capture if in absence of treated water being recharged.)

- The groundwater treatment system is effective at removing metals and VOCs. The air stripper off-gas is concentrated with a zeolite wheel and then directed to one of the five cryogenic-cooling and compression (C3) units to recover product. Although the current system meets effluent standards, the groundwater system operates at a very high cost and energy usage (mainly a result of the C3 system that treats air-stripper off-gas). There are likely alternative treatment approaches for the air stripper off-gas that would require significantly less cost and energy usage.

- The soil vapor extraction (SVE) system includes 62 well pairs in the defined LNAPL area. The initial plan was for 6 years of SVE operation, and currently the SVE operation is in year four. The primary mass removal is currently from the deep SVE (10 times higher concentrations in the deep zone), which is resulting in removal of nearly 7,000 gallons of VOCs per month that is sold. The concentrations in the shallow SVE wells have decreased and the site team is planning to operate only the deep SVE wells in the future. Four of the five C3 units are for the SVE system. One is for the shallow SVE system, and three are for the deep SVE system. The C3 system is run on a fixed fee per month contract plus significantly high electricity use.

- The high electricity use for the C3 systems is by far the highest contributor to the environmental footprints of the remedy, and costs these are not offset by the reuse of the recovered product. In addition to the high energy costs that result from the C3 system, the lease/operation of the C3 system represents an extremely large cost of nearly $1.9 million per year. This amount is by far the highest component cost of the remedy. Use of an alternative approach to treat vapors therefore offers the greatest potential for cost savings and environmental footprint reduction for this remedy.

- During the optimization review site visit, it was stated that institutional controls still need to be finalized.

These and other findings are detailed in Section 5 of this report.

Summary of Recommendations

The following recommendations are provided in Section 6 of this report to improve remedy effectiveness, reduce cost, provide technical improvement, and reduce environmental footprints of the remedy.

Improving effectiveness:

- Add sentinel monitoring wells if access allows
- Finalize Institutional Controls (ICs)
- Implement changes to extraction strategy.

Reducing cost:

- Replace or eliminate the C3 systems
- Reduce plant operator level of effort (for simplified system)
- Reduce groundwater monitoring based on a qualitative evaluation
- Reduce project management, support, and reporting (for simplified system)
- Reduce well rehabilitation costs (with elimination of on-site extraction wells).

Technical improvement:

- Operate with only one air stripper (with modified extraction system)
- Accurately record injection rates for each location
- Include injection well screen lengths in well construction table
- Perform simulations with no recharge of treated water.

Site closure:

The site team should make significant efforts to achieve consistent, cost-effective system operation because operation will continue for many years based on the site contaminant mass. The optimization review team does not believe that additional in situ technologies should be considered until cost-effective operation of the current remedy is achieved. Any in situ remedy would be extremely costly because of the large size of the contaminant plume and source area. It is unclear how effective an in situ remedy would be at reducing the time span for remediation.

Environmental Footprint Reduction:

The most significant footprint reductions would be associated with reducing electricity use by replacing the C3 systems as described as part of the cost savings recommendations. Estimated costs and savings associated with these recommendations are provided. In particular, the recommendation to eliminate the C3 systems requires the greatest capital cost, but has a short payback period and results in significant savings with respect to cost and environmental footprints. An evaluation of estimated footprint reductions resulting from elimination of the C3 systems is provided. In total, recommendations with the potential to save more than $2 million per year are suggested, with estimated capital costs of less than $1 million.

NOTICE

Work described herein including preparation of this report was performed by Tetra Tech for the U.S. Environmental Protection Agency under Work Assignment #2-48 of EPA contract EP-W-07-078 with Tetra Tech EM Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the EPA Office of Superfund Remediation and Technology Innovation (OSRTI). The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Chip Love	EPA Construction and Post-Construction Branch U.S. EPA OSRTI Ariel Rios Building Mailstop (5204G) 1200 Pennsylvania Ave., N.W. Washington, DC 20460 love.chip@epa.gov phone: 703-603-0695
Tetra Tech, Inc. (Contractor to EPA)	Therese Gioia	Tetra Tech, Inc. 1881 Campus Commons Drive Suite 200 Reston, VA 20191 therese.gioia@tetratech.com phone: 815-923-2368
Tetra Tech, Inc.	Peter Rich, P.E.	Tetra Tech, Inc. 51 Franklin Street, Suite 400 Annapolis, MD 21401 peter.rich@tetratech.com phone: 410-990-4607

LIST OF ACRONYMS

%	Percent
µg/L	Micrograms per liter
AOC	Area of concern
bgs	Below ground surface
BMP	Best management practices
Btu	British thermal unit
C3	Cryogenic-cooling and compression
ccf	Hundred cubic feet
CCRA	Consumer Cooperative Refinery Association
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents of global warming potential
COC	Contaminant of concern
CSIA	Compound-specific isotope analysis
CSM	Conceptual site model
1,2-DCA	1,2-dicholoroethane
DBSA	Daniel B. Stephens & Associates, Inc.
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
ft^2	Square feet
ft/d	Feet per day
ft/yr	Feet per year
GAC	Granular activated carbon
GEO	Good Earthkeeping Organization, Inc.
GHG	Greenhouse gas
gpd	Gallons per day
gpm	Gallons per minute
HAP	Hazardous air pollutant
HDPE	High-density polyethylene
ICs	Institutional controls
kW	Kilowatts
kWh	Kilowatt hour
lbs	Pounds
lf	Linear feet
LNAPL	Light non-aqueous phase liquid
LTM	Long-term monitoring
MAROS	Monitoring and Remediation Optimization System
MCL	Maximum Contaminant Level
MFC	Motor Fuels Corporation
mg/kg	Milligrams per kilogram
mg/m^3	Milligrams per cubic meter
MMBtu	Million British thermal units
NAPL	Non-aqueous phase liquid

NOx	Nitrogen oxides
O&M	Operation and maintenance
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
OU	Operable unit
PCL	Protective concentration limit
PDB	Passive diffusion bag
ppmv	Parts per million by volume
P&T	Pump and treat
PM	Particulate matter
QAPP	Quality Assurance Project Plan
RAO	Remedial action objective
RC	Restrictive covenant
ROD	Record of Decision
RSE	Remediation system evaluation
SCADA	Supervisory Control and Data Acquisition
scfm	Standard cubic feet per minute
SEFA	Spreadsheets for Environmental Footprint Analysis
SOx	Sulfur oxides
SVE	Soil vapor extraction
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TIFSD	Technology Innovation and Field Services Division
TDS	Total dissolved solids
TSS	Total suspended solids
TVHC	Total volatile hydrocarbons
VOC	Volatile organic compound

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001, independent site optimization reviews called Remediation System Evaluations (RSE) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (that is, those sites with P&T systems funded and managed by Superfund and the states). As a result of the opportunities for system optimization that arose from those RSEs, the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies, as documented in *Office of Solid Waste and Emergency Response (OSWER) Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation-stage activities using Triad Approach best management practices (BMP) during design and RSEs. The EPA's definition of optimization is as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."* [2]

As stated in the definition, optimization refers to a "systematic site review", indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (for example, focus on long-term monitoring [LTM] optimization or focus on one particular operable unit [OU]), but other components of the site or remedy are still considered to the degree that they affect the focus of the optimization. An optimization review considers the goals of the remedy, available site data, the CSM, remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within federal, state and municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (www.cluin.org/greenremediation) and now routinely considers green remediation and environmental footprint reduction during optimization evaluations.

The optimization review included reviewing site documents, visiting the site for 1 day and compiling this report, which includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness

[2] EPA. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

- Technical improvement
- Site closure
- Environmental footprint reduction.

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed before the recommendation is implemented. Note that the recommendations are based on an independent evaluation and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization review recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed on by the site management team and EPA OSRTI.

Environmental contamination of groundwater and soil occurred at the State Road 114 Ground Water Plume Superfund Site as a result of petroleum refining operations and associated waste disposal activities, leaks and spills. The groundwater remedy consists of a groundwater extraction and treatment system and a soil vapor extraction (SVE) system. The groundwater system is intended to achieve hydraulic containment of the contaminant plume and restore the Ogallala aquifer to its beneficial use as a drinking water supply. The SVE system removes light non-aqueous phase liquid (LNAPL) and organic vapors in the vadose zone.

The site was selected by the EPA OSRTI for optimization review based on a nomination from EPA Region 6. The optimization review is focused on current operational effectiveness and efficiency of the remedial systems. The optimization review includes discussion and evaluation of ongoing contamination sources, discharge criteria, and an operating cost breakdown. Other components of the site remedy are considered only as they relate to the remedial systems.

1.2 TEAM COMPOSITION

The optimization review team consisted of the individuals listed in Table 1.

Table 1: Optimization Review Team Composition

Name	Affiliation	Phone	Email
Chip Love	EPA HQ	703-603-0695	love.chip@epa.gov
Peter Rich	Tetra Tech, Inc.	410-990-4607	peter.rich@tetratech.com
Rob Greenwald	Tetra Tech, Inc.	503-223-5388	rob.greenwald@tetratech.com
Carolyn Pitera*	Tetra Tech, Inc.	703-390-0621	carolyn.pitera@tetratech.com

**Did not attend site visit.*

1.3 DOCUMENTS REVIEWED

The following documents were reviewed in support of the optimization review. The reader is directed to these documents for additional site information that is not provided in this report.

- *Technical Memorandum Phase I Remedial Investigation*, Daniel B. Stephens & Associates, Inc., March 2003
- *Draft Technical Memorandum Phase II Remedial Investigation, State Road 114 Ground Water Plume Superfund Site, Levelland, Texas*, Daniel B. Stephens & Associates, Inc., April 2004
- *Analysis of Pumping Test of the Ogallala Aquifer at Area 1, State Road 114 Ground Water Plume Superfund Site, Levelland, Texas*, Daniel B. Stephens & Associates, Inc., May 2004
- *Analysis of Pumping Test of the Ogallala Aquifer at Area 2, State Road 114 Ground Water Plume Superfund Site, Levelland, Texas*, Daniel B. Stephens & Associates, Inc., May 2004
- *Soil Analysis Data Quality Objectives, State Road 114 Ground Water Plume Superfund Site*, Daniel B. Stephens & Associates, Inc., October 2004
- *Final Remedial Investigation Report, State Road 114 Ground Water Plume Superfund Site, Levelland, Texas*, Daniel B. Stephens & Associates, Inc., August 2005
- *Groundwater Modeling for Remediation System Design, State Road 114 Ground Water Plume Superfund Site*, Daniel B. Stephens & Associates, Inc., August 2005
- *Feasibility Study Report, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., January 2008
- *EPA Announces Proposed Plan, State Road 114 Ground Water Plume Superfund Site, Hockley County, Texas*, EPA, January 2008
- *Record of Decision*, *State Road 114 Ground Water Plume Superfund Site*, Superfund Division EPA Region 6, March 2008
- *Final Remedial Design Report–Well Construction, State Road 114 Ground Water Plume Superfund Site, Levelland, Hockley County, Texas*, EA Engineering, Science and Technology, Inc., November 2008
- *Final Remedial Design Report–Ground Water, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., February 2009
- *Superfund Preliminary Close Out Report, State Road 114 Ground Water Plume Superfund Site, Levelland, Hockley County, Texas*, EPA, August 2009
- *Superfund Site Update, State Road 114 Ground Water Plume Superfund Site*, EPA, September 2009
- *Interim Remedial Action Report (Revision 01), State Road 114 Ground Water Plume Remedial Action*, EA Engineering, Science and Technology, Inc., August 2010

- *Superfund Site Update, State Road 114 Ground Water Plume Superfund Site*, EPA Region 6, September 2010

- *Results for SR-114 pH Pilot Test to Resolve Injection Well Failure, State Road 114 Ground Water Plume Superfund Site,* PowerPoint Presentation, EA Engineering, Science and Technology, Inc., October 2011

- *Ground Water Sampling Report, August 2011 Quarterly Sampling Event, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., December 2011

- *Annual Operation & Maintenance Report, 1 September 2010 through 31 August 2011, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., March 2012

- *Ground Water Sampling Report, December 2011 Quarterly Sampling Event, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., March 2012

- *Ground Water Sampling Report, May 2012 Quarterly Sampling Event, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., September 2012

- *Application of Horizontal Air Sparging to the Groundwater Remedy, State Road 114 Ground Water Plume Superfund Site*, Daniel B. Stephens & Associates, Inc., February 2013

- *Evaluation of Changes in Water Levels at the State Road 114 Superfund Site at the State Road 114 Superfund Site*, Daniel B. Stephens & Associates, Inc., February 2013

- *Ground Water Sampling Report, November 2012 Quarterly Sampling Event, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., February 2013

- *Annual Operation & Maintenance Report, 1 September 2011 through 31 August 2012, Long Term Response Action, State Road 114 Ground Water Plume Superfund Site*, EA Engineering, Science and Technology, Inc., May 2013

- Power Consumption Metric for 2010, 2011, 2012, 2013

- Xcel Energy Utility Bills, September 2009 – February 2013

- PowerPoint slides presented by the site team during the September 17, 2013, optimization review site visit

- Draft *Groundwater Model Update, State Road 114 Ground Water Plume*, EA Engineering, Science and Technology, Inc., November 19, 2013

In addition, Luis Vega from EA Engineering, Science and Technology, Inc. (EA), provided remedy cost information for September 2011 to August 2012 and for September 2012 to August 2013 via e-mail after the site visit for the optimization review was conducted.

1.4 QUALITY ASSURANCE

This optimization review utilizes existing environmental data to evaluate remedy performance and to make recommendations to improve the remedy. The optimization review team evaluates the quality of the existing data before the data are used for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data, and the use of the data in the optimization review. Data that are of suspect quality are either not used as part of the optimization review or are used with the quality concerns noted. Where appropriate, this report provides recommendations to improve data quality.

1.5 PERSONS CONTACTED

The following individuals associated with the site were present for the site visit:

Table 2: Persons Contacted During Optimization Review

Name	Affiliation	E-mail
Vince Malott	EPA Region 6	malott.vincent@epa.gov
Alan Henderson	Texas Commission on Environmental Quality (TCEQ)	
Luis Vega	EA Engineering, Science, and Technology, Inc.	
Danny Leaks	EA Engineering, Science, and Technology, Inc. Plant Operator (not including GEO Systems)	
Tim Startz	EA Engineering, Science, and Technology, Inc.	
Stan Wallace	EA Engineering, Science, and Technology, Inc.	
Jay Snyder	EA Engineering, Science, and Technology, Inc.	
Carol Winell	Good Earthkeeping Organization, Inc. (GEO)	
Joe Chwirka	Daniel B. Stephens & Associates, Inc. (DBSA)	
Faraq Botros	Daniel B. Stephens & Associates, Inc. (DBSA)	

EPA retains EA for operation and maintenance of the remedial systems and groundwater monitoring. EA subcontracts Daniel B. Stephens & Associates, Inc. (DBSA) for hydrogeology support and Good Earthkeeping Organization, Inc. (GEO) for the cryogenic-cooling and compression (C3) plant operation that is part of the treatment process. EA also subcontracts other firms for well rehabilitation, maintenance of specific items (electrical, controls, and metals filtration system), and process sample analysis.

2.0 SITE BACKGROUND

This section is a summary based on information in the documents reviewed.

2.1 LOCATION

The State Road 114 Ground Water Plume Superfund Site is located within the Levelland Oil Field along Evening Tower Road, 1 mile west of the City of Levelland in Hockley County, Texas. The site is bordered by State Highway 114, undeveloped land, and a railroad line. The area is relatively flat with topography generally sloping gently to the southeast. Other properties within 1 mile of the site include agricultural, commercial/industrial, recreational, and residential areas. The site location is shown on Figure 1 included in Appendix A.

2.2 SITE HISTORY

2.2.1 HISTORICAL LAND USE AND FACILITY OPERATIONS

The source of the groundwater contamination is a 64-acre former petroleum products refinery with a production capacity of 5,500 barrels/day of gasoline, tractor fuels, diesel, distillate products, and fuel oils. It was operated from its construction in 1939 to 1945 by Motor Fuels Corporation (MFC) and by the Consumers Cooperative Refinery Association (CCRA) from 1945 to 1954. Prior to 1939, the refinery property was undeveloped farm and grassland. The refinery facilities were dismantled or demolished between 1954 and 1958. Subsequently, the property was divided into various parcels and sold in 1958. Currently, most of the site area is occupied by Farmers Co-Op Elevator Association offices, warehouses, and grain storage facilities constructed prior to 1987 in the central and eastern portion of the site.

The former refinery property is divided into three areas of concern (AOCs). AOC 1 is located on the far western portion of the property and includes the playa (15-acre basin), the central, northern, southern, and southeastern impoundments, five tar pits, and a large excavated area. The playa basin, impoundments and pits received brine water, waste oil, off-specification refined fuel, and runoff. AOC 2 includes the area east of AOC 1 and west of Evening Tower Road and was used to store crude oil and refined product, distill and crack crude oil, and load refined product. AOC 3 consists of the east side refinery (east of Evening Tower Road) and was used for storing, distilling, and cracking crude oil and presumably for storing and mixing additives and loading refined product. Reported leaks from process equipment and spills throughout the refinery area resulted in comingling of crude oil and off-specification petroleum products with wastewaters and other liquid wastes disposed of in the disposal units, pits, and excavated area.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

Predecessors of the Texas Commission on Environmental Quality (TCEQ) (Texas Water Commission and Texas Natural Resource Conservation Commission [TNRCC]) began groundwater contamination investigations at the site in 1990. TNRCC investigations conducted from 1997 through 2000 with involvement of the EPA indicated elevated groundwater concentrations for 1,2-dichloroethane (1,2-DCA), benzene, arsenic, manganese, vanadium, and other contaminants of concern (COCs) in several residential and commercial wells, one irrigation well and several municipal wells in the vicinity of the site. The TNRCC investigated the Farmers Co-Op and oil field service-related businesses, including Edward’s Transport, Inc. and Well-Co Oil Service, Inc. along the south side of State Highway 114 as potential sources contributing to the groundwater plume, along with the former refinery. No conclusive evidence was identified for confirming one or more sources.

The TNRCC and EPA installed and maintained point-of use groundwater filtration systems to address the COCs in the affected private and public water supply wells. Subsequently, the TCEQ completed the remedial investigation in 2005; the EPA completed the feasibility study and supplemental investigation, ecological assessment, and additional groundwater sampling in 2008, and issued the Record of Decision (ROD) for the site on March 31, 2008. The site-wide remedy specified in the ROD included excavation of surface soil contaminated with copper and zinc (completed in April 2009), installation of a new municipal water supply system (completed in July 2009 followed by removal of the filtration systems), and installation of a groundwater extraction and treatment system and soil vapor extraction system. The current remedial systems began operation in September 2009. The EPA is currently operating the groundwater and SVE systems and anticipates transferring operation and maintenance of the groundwater system to the TCEQ in September 2020. (The SVE system operation, if it is still ongoing, will not be transferred.)

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

Groundwater comprises approximately one-third of the City of Levelland's drinking water supply. In addition, some businesses and residences in the plume area obtain drinking water, irrigation water, or both from private wells. The Ogallala aquifer is the only source of high-quality drinking water in the site area. Benzene, 1,2-DCA, arsenic, and 1,2-dibromoethane in groundwater present a risk to human receptors who may use unfiltered groundwater from private wells. However, all residences and businesses with affected water wells have been connected to the municipal water supply line installed in 2009, and groundwater is no longer used for potable purposes in the area.

With regard to soil contamination, a 2006 human health risk assessment indicated that since current land use is commercial/industrial (that is, non-residential), human health exposure to existing COCs in soil is considered acceptable, and current and future commercial/industrial carcinogenic risks do not present an unacceptable risk to on-site workers. A 2006 ecological risk assessment (ERA) indicated a potential unacceptable risk to ecological receptors in areas within AOC 1 (abandoned drum hot spot) and AOC 2 (west side hot spot) based on copper and zinc concentrations in soil above the ecological screening criteria of 61 milligrams per kilogram (mg/kg) for copper and 120 mg/kg for zinc in soil. The ERA did not identify any unacceptable risk to waterfowl and mammals and aquatic wildlife receptors that may come in contact with the playa sludge.

2.4 EXISTING DATA AND INFORMATION

2.4.1 SOURCES OF CONTAMINATION

Sources of ongoing contamination at the site include LNAPL (petroleum hydrocarbon layer floating on the water table), the soil matrix in the LNAPL smear zone, and a benzene vapor plume in the vadose zone.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

Local geology is composed of the following units, from top to bottom:

- Fine-grained sand and clay (approximately the upper 20 feet)
- Caliche-bearing fine sand (approximately 70 feet thick)
- Sandstone (approximately 10 feet thick)
- Sands that increase in coarseness with depth (approximately 75 to 120 feet thick)
- Clay aquitard that is encountered at approximately 175 to 215 feet below ground surface (bgs).

The water table or saturated zone of the Ogallala aquifer is encountered at approximately 140 feet bgs, and the saturated thickness varies across the site from approximately 40 to 80 feet. Direction of groundwater flow is to the east-northeast.

The Remedial Design Report (EA, February 2009) indicates the following with respect to aquifer parameters:

- Hydraulic conductivity - After two aquifer tests at the SR 114 site were completed using test wells screened across the entire saturated thickness (that is, both the shallow and deep zones), the average hydraulic conductivity of the aquifer was determined to be 14 feet per day near the leading edge of the plume and 20 feet per day near the mid-plume. However, based on the location of paleochannels and the general thickening of course-grained sediments, the average aquifer hydraulic conductivity probably increases east of the plume front.
- Storage coefficient – Values for storage coefficient of 0.005 and 0.034 in the plume front and mid-plume areas were calculated based on the results of the two aquifer tests conducted at the site.

The storage coefficient values reported based on the aquifer tests indicate semi-confined conditions. The area is quite arid and very little net recharge from precipitation is anticipated. The Remedial Design Report indicates that groundwater recharge in the Levelland area may be greater as a result of infiltration of imported Canadian River Municipal Water Authority water and infiltration of focused storm runoff, as has been observed to the east within the City of Lubbock.

The Annual Report for September 2011-August 2012 states that "The magnitude of the gradient is approximately 0.004 ft per ft." but is not clear if that value is pre-remedy or post-remedy. Based on potentiometric maps in the Annual Report for September 2011 to August 2012, the observed hydraulic gradient appears to be higher, and a value of approximately 0.0067 appears to be more representative of current conditions.

- Assuming a hydraulic conductivity of 14 to 20 feet per day (ft/d) from the aquifer tests, an approximate hydraulic gradient magnitude of 0.0067 (from recent potentiometric surface maps), and porosity of 0.2 to 0.3, the groundwater flow velocity under current conditions would be expected to be on the order of 100 to 250 feet per year (ft/yr).
- Assuming a hydraulic conductivity of 14 to 20 ft/d from the aquifer tests, an approximate hydraulic gradient magnitude of 0.004 (assumed for pre-remedy conditions), and porosity of 0.2

to 0.3, the pre-remedy groundwater flow velocity would be expected to be on the order of 70 to 150 ft/yr.

Higher hydraulic gradients under current conditions (relative to pre-remedy conditions) are consistent with higher water levels beneath the former refinery property and lower water levels off site that have been observed in recent years, which is reportedly a combined result of the remedy (recharge of treated water on the former refinery property and remedy extraction off site) and regional factors (drought and off-site, non-remedy irrigation pumping) that are discussed in the Annual Report for September 2011-August 2012.

2.4.3 SOIL CONTAMINATION

The September 2009 Superfund Site Update states the following: "The soil remedy was completed in April 2009. Soil contaminated with copper and zinc from the former refinery was excavated and buried on-site to eliminate potential ecological risks in the area." The optimization review did not focus on soil contamination.

2.4.4 SOIL VAPOR CONTAMINATION

Soil vapor contamination is expected because the site contaminants include volatile organic compounds (VOC) (for example, benzene) and the site remedy includes soil vapor extraction.

2.4.5 GROUNDWATER CONTAMINATION

The groundwater contaminant plume is approximately 1.2 miles long and extends approximately 0.7 mile to the east-northeast beyond the edge of the eastern boundary of the site. Specific COCs in groundwater include benzene, 1,2-DCA, arsenic and manganese. A defined arsenic plume is not evident at the site. The manganese plume is caused by reducing conditions in the aquifer that results from the VOC contamination. The benzene plume attenuates within a shorter distance than the 1,2-DCA plume. The 1,2-DCA plume is the driver of groundwater remediation because it has migrated the greatest distance in the shallow, intermediate and deep zones and the plume extends downgradient under residences. Figures showing the extent of the groundwater impacts are included in Appendix A.

The facility operated as early as 1939, so groundwater could have been contaminated as long ago as 64 years. The plume transport distance is approximately 6,000 feet for 1,2-DCA, which is a conservative VOC constituent because it does not strongly sorb to aquifer material and therefore is transported at velocity close to that of groundwater. Groundwater flow velocities of 70 to 150 ft/yr (presented earlier for pre-remedy conditions) are consistent with a plume 6,000 feet long that developed from sources starting as early as 1939.

2.4.6 SURFACE WATER CONTAMINATION

The closest surface water bodies are a 15-acre playa basin and associated sludge pits on the western portion of the site. Surface water generally flows along natural drainage channels from the perimeter of the former refinery property toward the 15-acre playa. Surface water discharges to the surrounding environment are not indicated by the off-site drainage patterns. The nearest stream is Yellow House Draw, which is located approximately 7.5 miles northwest.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

3.1 EXISTING REMEDIES

The purpose of the groundwater extraction and treatment system and the SVE system is to address groundwater and soil contamination by reducing LNAPL and organic vapor in the source area and providing hydraulic containment of the plume. Institutional controls (IC) are intended to prevent exposure of potential receptors to contaminants. The ultimate objective for the remedial systems is to restore the Ogallala aquifer to its beneficial use as a drinking water supply. The remedial systems consist of groundwater extraction wells, an oil/water separator, a coagulation/filtration process, air strippers, groundwater re-injection wells, soil vapor extraction wells, C3 technology, and granular activated carbon (GAC) to treat off-gases from the air strippers and soil vapor extraction system.

The C3 systems, manufactured by GEO, combine cryogenic-cooling and compression processes with regenerative adsorption to recover VOCs from a vapor stream as a non-aqueous phase liquid (NAPL). The C3 system equipment includes a series of air/air heat exchangers and refrigerated heat exchangers, automatic drains and a proprietary regenerative adsorber, as well as electrical service panels, gauges, and control systems, housed in enclosed trailers. The C3 system equipment lowers the temperature of the vapors to approximately -45°F, resulting in condensation of the contaminants in the vapors into a NAPL product. The NAPL is temporarily stored in in two 6,500-gallon fiberglass reinforced plastic tanks (same as those used for the oil/water separator that treats extracted groundwater from on-site wells) for periodic removal to a licensed fuel recycler or re-blender. Effluent vapors from the C3 system are then conveyed to vapor GAC vessels (two 5,000-pound vessels in series) for final polishing and discharge to the atmosphere.

The process configuration is shown in the Process Flow Schematic included in Appendix A. The C3 technology is implemented with five separate units, as follows:

- One unit (C3 System 21) is for treatment of off-gas from the air strippers associated with groundwater treatment, after those vapors are concentrated by a Munters zeolite wheel.
- One unit (C3 System 22) is for treatment of vapors from the shallow SVE system.
- Three units (C3 Systems 23A, 23B, and 23C) are for treatment of vapors from the deep SVE system.

The following sections describe the components of the remedial systems and operations in more detail.

3.1.1 GROUNDWATER EXTRACTION

The groundwater extraction network consists of 11 on-site wells and 10 off-site wells. Of these 21 extraction wells, 14 are shallow extraction wells (bottom of screen interval from 158 to 164 feet bgs), four are intermediate extraction wells (bottom of screen interval from 185 to 200.5 feet bgs), and three are deep extraction wells (bottom of screen interval from 205 to 210 feet bgs). The intermediate and deep extraction wells have long screens that include a portion of the screen in the shallow zone. (Top of screen is typically on the order of 150 feet bgs for the intermediate and deep extraction wells.)

The 11 on-site wells were located for source containment and mass recovery, whereas the 10 off-site wells were located between 800 and 2,000 feet northeast of the site to contain the leading edge of the groundwater plume. All extraction wells are equipped with electric submersible pumps, vaults, downhole pressure transducers, pressure gauges, valves, magnetic flow meters, totalizers, control panels with Supervisory Control and Data Acquisition (SCADA) controls, and radios to transmit water level data, operating pressure, instantaneous and totalized flow data to the control station in the treatment building.

Total system extraction design flow rate was anticipated to be 281 gallons per minute (gpm) with 66 gpm from the shallow on-site wells and 215 gpm from the off-site wells, but the actual groundwater extraction rate has been close to 200 gpm total as a result of fouling issues in the shallow on-site wells and the three shallow off-site wells.

3.1.2 GROUNDWATER TREATMENT

3.1.2.1. LNAPL Removal

Groundwater from on-site extraction wells flows to an oil/water separator, which recovers LNAPL from the influent water. The recovered LNAPL is stored in two 6,500-gallon fiberglass-reinforced plastic tanks located outside the treatment building for periodic removal to a licensed fuel blender. Water from the oil/water separator is combined with water from the off-site wells in a 12,500-gallon equalization tank (Tank T-1) and is then directed for treatment.

3.1.2.2. Metal Coagulation and pH Adjustment

Groundwater is treated for the removal of metals (arsenic and manganese) using (1) a coagulation process by chemical addition, followed by (2) flocculent removal in two parallel filtration vessels using adsorptive media filters, and subsequently (3) pH adjustment. The treated water is then directed to the air strippers for removal of benzene and 1,2-DCA.

Chemicals used for the coagulation of metals and pH adjustment include sodium hypochlorite and sulfuric acid (replaced in September 2013 by carbon dioxide [CO_2]). A 12.5 percent sodium hypochlorite solution is used to oxidize arsenic, iron, and manganese in the influent groundwater. Sulfuric acid (recently replaced by CO_2) is added to lower the pH of the water after air stripping. Sodium hydroxide would be used if necessary (it has not been needed) to adjust the pH of the water entering the air strippers for organics removal. All chemicals are metered using automated control systems.

3.1.2.3. Filtration

The flocculent is removed in two parallel filtration vessels using an adsorptive media filter. The two flocculent filtration vessels are backwashed with water from the system effluent tank (Tank T-4) approximately every 8 hours using a 4-minute backwash cycle. The resulting backwash water is transferred to a 20,000-gallon reclamation tank (Tank T-3) for settling. The minimal waste sludge volume is collected and managed as nonhazardous solid waste, and a sump pump returns the remaining water back to the equalization tank (Tank T-1).

3.1.2.4. Organics Removal via Air Stripping

Groundwater from the metals treatment is split into two streams and an anti-scaling chemical is injected into each stream before flow enters two low-profile seven-tray strippers to remove benzene, 1,2-DCA, and other organic constituents. Off-gases from the air strippers are routed to a Munters zeolite wheel concentrator. The zeolite wheel concentrator is located on a covered reinforced-concrete slab located adjacent to the treatment plant building. The unit is designed to handle 2,600 to 7,000 standard cubic feet per minute (scfm) of VOC-laden air and uses a corrugated mineral fiber substrate permanently bonded with a proprietary mix of hydrophobic zeolite and other inorganic compounds to adsorb VOCs from the air stream. The concentrated vapors from the zeolite wheel are sent to one of the cryogenic-cooling and compression units (C3 System 21). Any other vapors from the zeolite wheel are discharged to the atmosphere.

3.1.2.5. Bag Filters and Reinjection of Treated Groundwater

Treated groundwater from the air strippers is directed to a 10,000-gallon effluent storage tank, pumped through bag filters (four vessels, 25 microns), and then pumped through a high-density polyethylene (HDPE) line to eight injection wells for re-injection into the full thickness of the aquifer. The eight injection wells are located approximately 2,000 feet due north from the on-site extraction wells. Initially, there were four injection wells (as indicated on the process schematic in Appendix A), but as a result of flow limitations an additional injection well was added adjacent to each of the original injection wells in late 2010. It was explained during the optimization review site visit that the new injection wells share panels with the original injection wells in the SCADA system, and as a result the individual flow rates for injection wells are not reported by the SCADA system. Excess water not re-injected is discharged to the playa, an on-site impoundment west of the treatment plant that functions as a recharge basin.

3.1.3 SOIL VAPOR EXTRACTION AND TREATMENT

SVE wells were installed to remove VOCs from the vadose zone and reduce LNAPL extent in the source zone beneath the former refinery property. The SVE wells operate in conjunction with the on-site groundwater extraction well network, which in concept lowers the water table and increases the effective interval for vapor collection (which may be offset at this site by recharge of treated water).

3.1.3.1. Soil Vapor Extraction

The SVE well network consists of 62 shallow well/deep well pairs (for a total of 124 SVE wells). The shallow wells are screened from 70 to 90 feet bgs and the deeper wells are screened from 110 to 140 feet bgs. Vacuum is applied to the SVE wells to extract soil vapor and direct it to the SVE manifold located within the treatment plant building. The SVE manifold is composed of 12 deep-zone vapor conveyance circuits and 12 shallow-zone vapor conveyance circuits, for a total of 24 connection points. As designed, the SVE treatment system will treat up to 1,250 scfm from the deep zone and 417 scfm from the shallow zone.

3.1.3.2. Soil Vapor Treatment

Soil vapors from the shallow and deep circuits are treated in separate, parallel treatment trains consisting of knockout tanks to remove entrained moisture, followed by the C3 system (C3 System 22 for the shallow SVE wells and C3 Systems 23 A/B/C for the deep SVE wells) and then vapor GAC for off-gas treatment. Condensate from the knockout tanks is transferred to the groundwater treatment system. Effluent vapors from the knockout tanks are compressed with air compressors, then stored in a receiver vessel, and then passed through a heat exchanger to lower the temperature to near-ambient temperatures.

After the heat exchanger, the vapors are transferred to the C3 system and subsequently to the GAC vessels for final polishing before discharge to the atmosphere.

3.2 REMEDIAL ACTION OBJECTIVES AND STANDARDS

The March 2008 ROD identifies the following remedial action objectives (RAOs) for groundwater at the site. (The numerical criteria used to measure progress toward meeting the groundwater RAOs are presented in Section 3.4.)

- Prevent human exposure to the contaminated groundwater above acceptable risk levels within the organic contaminant plume;

- Prevent or minimize further migration of the organic contaminant plume exceeding the remedial goals (plume containment);

- Prevent or minimize further migration of contaminants from source materials (such as LNAPL) to groundwater (source control); and,

- Return groundwater within the organic contaminant plume to its expected beneficial uses wherever practicable (aquifer restoration).

The RAO for soil at the site is:

- Prevent exposure of ecological receptors to COCs above acceptable limits in the AOC 1 abandoned drum hot spot; specifically the remedial goals for soil are 61 mg/kg for copper and 120 mg/kg for zinc.

3.3 MONITORING PROGRAMS

3.3.1 TREATMENT PROCESS MONITORING

The process monitoring program consists of process water and process air sampling, as follows:

- The process water sampling includes system influent and system effluent. Samples are collected twice per month and are analyzed for VOCs and metals.

- The process air sampling includes influent from the shallow SVE network, influent from the deep SVE network, influent to the vapor GAC (that is, combined sample from after the C3 systems), and effluent from the vapor GAC. Samples are collected twice per month and are analyzed for total volatile hydrocarbons (TVHC) and VOCs.

Process monitoring samples are analyzed by Trace Analysis, Inc., in Lubbock, Texas.

3.3.2 LONG-TERM MONITORING (LTM) FOR GROUNDWATER

Groundwater monitoring is performed at different types of wells on a somewhat irregular basis. Table 3 summarizes the different types of sampling locations, and the number of sampling locations in the three recent events described in the Annual Report for September 2011-August 2012. It was stated during the optimization review site visit that the conceptual plan is to sample three times per year, but funding has limited the sampling to two or three events per year.

Table 3: Number of Long-Term Monitoring Locations (Three Recent Events)

Type	December 2011	May 2012	August 2012
Monitoring Wells	46 total PDBs at 39 locations (VOCs only)	Low flow sampling at 38 locations (VOCs and total metals) 3 PDBs (VOCs only)	47 total PDBs at 39 locations (VOCs only)
Extraction Wells	15 operating EWs (VOCs only)	19 operating EWs (VOCs and total metals)	19 operating EWs (VOCs and total metals)
Private Water Supply Wells	2 wells from tap, pre-filtration (VOCs only)	22 wells from tap (VOCs and total metals) + 2 wells from tap, pre- and post- filtration (VOCs only)	2 wells from tap, pre- and post- filtration (VOCs and total metals)
Injection Wells		micropurge sampling at 3 wells (total metals only)	

EWs = Extraction Wells PDB = Passive Diffusion Bag VOCs = Volatile Organic Compounds

The routine groundwater monitoring samples are analyzed at an EPA-approved Contract Laboratory Program (CLP) laboratory currently at no cost to the project. However, in the future when the groundwater treatment system transfers to the state, laboratory costs will be incurred; therefore, equivalent commercial laboratory costs are estimated in Section 5.2.

The Annual Report for September 2011-August 2012 indicates that the May 2012 event also included non-routine sampling for general chemistry analysis and compound-specific isotope analysis (CSIA), as follows:

- Groundwater samples for general chemistry analyses from 20 extraction wells and three injection wells

- Groundwater samples for CSIA from 11 monitoring wells and five extraction wells.

Groundwater samples for the general chemistry analysis were collected to better evaluate water quality and aquifer conditions that may be altering the performance of the injection well and extraction well pumps. General chemistry parameters included alkalinity, sulfate, hardness, total dissolved solids (TDS), and total suspended solids (TSS), and these samples were analyzed at Trace Analysis, Inc., in Lubbock, Texas. CSIA samples were collected from 16 wells transecting the 1,2-DCA plume to evaluate the degradation of 1,2-DCA in the shallow water-bearing zone and were analyzed by Isotope Tracer Technologies, Inc., in Waterloo, Ontario, Canada, to perform carbon compound-specific stable isotope ratio measurements for 1,2-DCA in groundwater.

3.4 AIR AND WATER DISCHARGE STANDARDS

Treatment system influent and relevant discharge limits are included in Table 4 (water) and Table 5 (air) for selected parameters that have influent concentrations that typically exceed the discharge limit and therefore require treatment. (Note that arsenic influent concentration for groundwater has only sporadically exceeded the discharge limit.) System operation consistently meets the discharge limits.

Table 4: Water Discharge Limits for Selected COCs

Parameter	August 24, 2012 Influent	Discharge Limit
1,2-Dichloroethane (1,2-DCA)	57.8 µg/L	5 µg/L[1]
Benzene	1,040 µg/L	5 µg/L[1]
Arsenic	<10 µg/L	10 µg/L[1]
Iron	360 µg/L	300 µg/L[2]
Manganese	1420 µg/L	1,100 µg/L[3]

[1] Maximum Contaminant Level (MCL)
[2] Secondary MCL (not a discharge criterion)
[3] TCEQ protective concentration limit (PCL) for residential drinking water

Table 5: Air Discharge Limits

Parameter	August 24, 2012 Influent[2]	Discharge Limit[1]
Benzene	7.9 lbs/hr	0.056 lbs/hr
Total Volatile Hydrocarbon (TVHC)	389 lbs/hr[3]	1.0 lbs/hr

lbs/hr – pounds per hour
[1] Discharge criteria for benzene are based on 30 Texas Administrative Code (TAC) 106.262 and TVHC is based on 30 TAC 106.533.
[2] Calculation of influent air in lbs/hr assumes 1,200 standard cubic feet per minute (scfm) of soil vapor extraction (SVE) flow from deep wells, 400 scfm from shallow wells, and 400 scfm from air stripper concentrate, and used influent results in milligrams per cubic meter (mg/m^3) for the shallow and deep SVE systems (Table 2 of Annual Report for September 2011-August 2012). For groundwater, influent mass flux is based on the mass per month calculated to be removed by the air stripper (Table 5 of Annual Report for September 2011-August 2012).
[3] Typical influent mass is about 80 lbs/hr based on reported 7,000 gallons/month light non-aqueous phase liquid (LNAPL) recovery.

4.0 CONCEPTUAL SITE MODEL

The optimization review focused on current groundwater and soil vapor collection and treatment operations. CSM components key to these operations include the contaminant distribution and plume migration velocity that were discussed in Section 2.4. The optimization review team believes the presence of LNAPL over a large area, and the large extent of dissolved groundwater impacts, suggest that groundwater will be contaminated at this site for a very long time. Therefore, primary emphasis should be on controlling migration of the most contaminated groundwater to make sure the groundwater plume is not expanding and keeping annual costs as low as possible given the expected longevity of the remedy.

5.0 FINDINGS

The observations provided below are the interpretations of the optimization review team and are not intended to imply a deficiency in the work of the system designers, system operators, or site managers; rather, they are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based on operational data not available to the original designers. Furthermore, it is likely that site conditions and general knowledge of treatment have changed over time.

5.1 GENERAL FINDINGS

5.1.1 GROUNDWATER PUMPING, GROUNDWATER FLOW, AND PLUME CAPTURE

Eleven of the extraction wells (EW-11 to EW-21) are on-site wells that are pumped primarily for mass removal of VOCs in the shallow zone source area. The on-site extraction wells have well screen lengths of 15 to 20 feet and were designed to pump approximately 6 gpm each, for a total on-site design extraction rate of 66 gpm. However, these wells actually pump at much lower rates than the design rate (typically 20 gpm or less in total) and also remove only a small volume of LNAPL each year (less than 100 gallons per year). These wells extract groundwater with high dissolved concentrations of 1,2-DCA and benzene. The 1,2-DCA concentrations typically exceed 100 micrograms per liter (µg/L) and in some cases 500 µg/L, and the benzene concentrations typically exceed 5,000 µg/L and in some cases 20,000 µg/L. The on-site well pumps are plagued with fouling problems because of the high levels of TDS in the upper unit; the current practice is to replace pump ends approximately three times per year. The site team is planning to stop on-site groundwater pumping, which will reduce well maintenance costs significantly.

The remaining 10 extraction wells are located off site and were designed to extract a total of 215 gpm. These 10 off-site extraction wells include the following:

- Three of the off-site extraction wells (EW-5, EW-6, and EW-7) are shallow zone wells with 15-foot screen intervals and are located just north of SR 114 and approximately 1,200 feet east of the closest on-site extraction well (EW-11). These wells were intended to intercept the shallow plume in the vicinity of these wells, where concentrations are relatively high, so that portions of the aquifer that are deeper or further downgradient would clean up over time. These wells were designed to pump 10 gpm each (30 gpm total) but actually only pump several gpm each or less. Similar to the on-site extraction wells, the 1,2-DCA concentrations typically exceed 100 µg/L at EW-5 to EW-7 and in some cases 500 µg/L, and the benzene concentrations typically exceed 5,000 µg/L at EW-5 to EW-7.

- Four of the off-site extraction wells (EW-4, EW-8, EW-9, and EW-10) are intermediate zone wells with 40-foot screen intervals.

    - EW-8, EW-9 and EW-10 are located north of EW-5 to EW-7, and were designed to pump at 25 gpm each. When operating, EW-8 and EW-9 achieve a rate on the order of 15 to 25 gpm, but EW-10 achieves lower rates (generally less than 15 gpm). These intermediate zone wells have much lower VOC concentrations than the shallow extraction wells to the west (on site) or to the south (off site). The 1,2-DCA concentrations at EW-9 and EW-10 are typically less than 50 µg/L, and benzene concentrations are generally below the

Maximum Contaminant Level (MCL) of 5 μg/L. The 1,2-DCA concentrations at EW-8 have been increasing from generally less than 50 μg/L in 2009 and 2010 to 72 μg/L in May 2012 to 110 μg/L in August 2012. Similarly, the benzene concentrations at EW-8 have been increasing from "non-detect" in 2009 and 2010 to 40 μg/L and 27 μg/L in 2011 to 200 μg/L and 870 μg/L in 2012. This increasing trend could indicate the plume is being pulled down by relatively deep extraction at this well and the three deep extraction wells (EW-1 to EW-3).

EW-4 is located farther northeast than EW-9 and EW-10. EW-4 was designed to pump at 30 gpm, and it generally pumps when operational at 20 to 40 gpm. EW-4 has even lower VOC concentrations than EW-9 and EW-10. The 1,2-DCA concentrations at EW-4 are typically less than 10 μg/L, and benzene concentrations are generally below the MCL of 5 μg/L. Pumping from this well was stopped in 2013.

- Three of the off-site extraction wells (EW-1, EW-2, and EW-3) are deep zone wells with 50- to 60-foot screen intervals located approximately 1,000 to 1,500 feet east of EW-5 to EW-10. These wells were designed to pump 30 gpm each, and they generally achieve rates of 20 to 30 gpm or higher. These wells have concentrations similar to intermediate zone wells EW-9 and EW-10 that are located farther upgradient, with 1,2-DCA concentrations typically less than 50 μg/L and benzene concentrations generally below the MCL of 5 μg/L.

The site team indicated that the plume is deeper east of EW-5 to EW-10 because a slight clay layer may be absent to the east of those extraction wells, or because there are private irrigation wells with deeper well screens to the east of those extraction wells. The intermediate and deep zone wells were intended to provide containment of the leading edge of the plume, with the hope that other remedy items — such as SVE to remove mass and shallow extraction from farther upgradient to contain the highest concentrations in groundwater — would allow for the leading edge of the plume to clean up over time. This downgradient portion of the plume is in an area of houses and irrigation, so it is preferable that the downgradient portion of the plume be remediated as quickly as possible.

Monitoring wells to the east of extraction wells EW-5 to EW-10 are sparse as a result of access limitations, and the downgradient extent of impacts is not fully delineated by site monitoring wells for this reason. For instance, MW-30I is located downgradient of extraction well EW-3 (see Figure 2 in Appendix A) and has slightly elevated concentrations of 1,2-DCA, typically on the order of 10 μg/L. The site monitoring wells are, however, augmented by sampling at private wells, which are also illustrated on Figure 2 in Appendix A. The private wells located downgradient of the easternmost extraction wells typically have VOC concentrations below standards, with the exception of well Smith-01, located adjacent to MW-30I discussed above, which has slightly elevated concentrations of 1,2-DCA, typically on the order of 15 μg/L. It cannot be stated with certainty if VOC impacts above standards extend much farther east than MW-30I and Smith-01.

The Annual Report for September 2011-August 2012 documents changes in water levels that have occurred since 2008. Water levels have increased on the former refinery property, presumably because of recharge of treated water at the injection wells and the on-site impoundment located west of the treatment plant building. Water levels have decreased off site to the east, which may result from a combination of items that include drought, overdraft of water by private irrigation wells, and remedy pumping, which extracts the highest rates from the intermediate and deep zone remedy extraction wells farthest east (EW-1 to EW-4 and EW-8 to EW-10).

The target capture zone utilized in the modeling reports is the extent of the dissolved-phase plumes (based on the remedial goal values) in the upper and lower aquifer units. Specific zones of capture are not easily interpreted from the potentiometric surface maps presented in the annual report, and the effectiveness of the capture zone is based on the particle tracks provided by the groundwater model, using particles started in the interior and the edge of the plumes. Groundwater modeling was updated in summer 2013 and presented in Draft Groundwater Model Update (November 2013), which included the following:

- Addition of a fourth model layer to represent the clay that separates the shallow zone from the intermediate/deep zones at the site. (Where the clay is not assumed to be present, the properties of the layer above and below are assigned for that model layer.)

- Use of remedy extraction rates more consistent with observed rates, particularly at shallow extraction wells.

- Evaluation of scenarios where some or all of the shallow on-site extraction is eliminated.

- Evaluation of scenarios that include different configurations for remedy pumping (and changes to the injection rates based on changes to the total extraction rate), as follows:

    - <u>Scenario 1</u>: On-site extraction wells EW-11 through EW-16 are shut off and EW-17 through EW-21pump 2 gpm. Off-site extraction wells EW-5 to EW-7 pump 2 gpm, EW-8 to EW-10 pump 20 gpm, and EW-1 to EW-4 pump 30 gpm. Total extraction is 196 gpm.

    - <u>Scenario 2</u>: All on-site shallow extraction wells are eliminated. Off-site extraction wells EW-5 to EW-7 pump 2 gpm, three additional shallow wells near EW-5 to EW-7 are also added at 2 gpm, EW-8 to EW-10 pump 20 gpm, EW-1 to EW-3 pump 30 gpm, and EW-4 is eliminated. Total extraction is 162 gpm.

    - <u>Scenario 3</u>: All on-site shallow extraction wells are eliminated. Off-site extraction wells EW-5 to EW-7 are replaced by EW-5R to EW-7R with longer wells screens and assumed to pump 25 gpm each, EW-8 to EW-9 pump 20 gpm, EW-10 is reduced to 10 gpm, EW-2 to EW-3 pump 30 gpm, and both EW-1 and EW-4 are eliminated. Total extraction is 185 gpm.

The modeling presented in the November 2013 Draft Groundwater Model Update suggests that Scenario 3 provides adequate capture with similar extraction rates to the current system (less than 200 gpm) and also avoids shallow pumping, which is problematic with respect to well fouling. The modeling predicts that extraction wells with deeper screens will provide adequate capture for contaminants in the shallow zone and suggests the shallow zone in the eastern portion of the plume will dewater over time (such that it does not make sense to keep existing shallow wells EW-5 to EW-7 in addition to the suggested replacement wells).

The modeling indicates that a significant amount of treated water is recaptured, which increases the extraction rate required for capture. This recapture makes it difficult to use a simple calculation to estimate the extraction rate required for capture, and use of a numerical model for evaluating capture is more appropriate given that a lot of the treated water is recaptured. Although the model simulations account for the recapture of treated water, the modeling presented in the report does not illustrate the difference in capture that might result if treated water was not recharged. (The model has not been used to illustrate how much less extraction might be required to achieve similar capture if in absence of treated water being recharged.)

5.1.2 GROUNDWATER TREATMENT

The groundwater treatment system is effective at removing metals and VOCs. There have been fouling problems in the reinjection wells related to barium sulfate. The injection wells require maintenance and have required rehabilitation at a frequency of approximately once per year. The site team began testing CO_2 instead of sulfuric acid in September 2013 for adjusting pH down after air stripping to see if the fouling is alleviated. About 75 percent of the system discharge is currently reinjected to the eight reinjection wells and the other 25 percent is discharged to the on-site impoundment west of the treatment system. The site team prefers to not discharge to the on-site impoundment and hopes to optimize extraction and injection so that recharge to the impoundment is no longer needed. The site team has met with the City of Levelland to review the option of providing the treated water to the city as a further means to supplement its existing water supply, potentially which would mitigate the issue of recharge to the impoundment.

The air stripper off-gas is concentrated with the zeolite wheel and then directed to one of the C3 units to recover product. This C3 system includes a 150-horsepower compressor. The air stripper off-gas is very dilute, so the unit cost to recover product is extremely high. The site team has been considering treating the off-gas with vapor GAC instead of the C3 system.

With the current flow of less than 200 gpm and future flow likely less than 200 gpm (per Scenario 3 of the modeling described above, which has total extraction rate of 185 gpm), it is possible that one stripper could be taken off-line. The site team reports that the stripper effluent pumps might have to be replaced to allow the stripper to be taken off line.

Chemical use in the groundwater treatment system includes about 13 gallons per day (gpd) of 12.5 percent sodium hypochlorite and about 18 gpd of 93 percent sulfuric acid. As stated above, the sulfuric acid was replaced by carbon dioxide in September 2013 (one180-liter size CO_2 bottle every 2.5 days). The sand filter backwashes (4-minute cycle) occur every 8 hours automatically. Sludge disposal has been only one truck of wet sludge in 4 years. Decant water is bled back into the system influent.

Although the current system meets effluent standards, the groundwater system operates at a very high cost and energy usage (mainly because of the C3 system that treats air-stripper off-gas). There are likely alternative treatment approaches for the air stripper off-gas that would require significantly less cost and energy usage. These options are discussed in subsequent sections of this report.

5.1.3 SOIL VAPOR EXTRACTION

The SVE system includes 62 well pairs in the defined LNAPL area. The initial plan was for 6 years of SVE operation, and currently the SVE operation is in year four. The primary mass removal is currently from the deep SVE, which is resulting in removal of nearly 7,000 gallons of VOCs per month. The combined concentration from the shallow SVE system is generally less than 100 milligrams per cubic meter (mg/m^3) of benzene and less than 7,000 mg/m^3 of TVHC, whereas the combined concentration from the deep SVE system is generally more than 1,000 mg/m^3 of benzene and more than 70,000 mg/m^3 of TVHC (10 times higher concentrations in the deep zone). The concentrations in the shallow wells have decreased and the site team is planning to operate only the deep SVE wells in the future. The site team indicated that the state pays 10 percent of the SVE system cost, but the total cost of the SVE system would not be turned over to the state (TCEQ) after 10 years (unlike operation of the groundwater extraction and treatment system). Some deep SVE wells have also been shut down based on an informal criterion of approximately 100 parts per million by volume (ppmv) total VOC shutdown level. Additional SVE wells are being considered on the west and northeast sides of the SVE network.

Four of the five C3 units are for the SVE system. One is for the shallow SVE system, and three are for the deep SVE system. The C3 system is run on a fixed fee per month contract plus electricity. These units are not concentration dependent, but they require high power use. The site team has considered purchasing a generator or fuel cell to convert the recovered product to electricity for use on site or sale to the local utility company. While this idea could slightly improve long-term operation and maintenance (O&M) costs, the capital costs would be high and could be avoided altogether if a better alternative to the C3 systems was implemented (discussed in subsequent sections of the report).

5.1.4 GROUNDWATER MONITORING

The current monitoring plan includes on-site and off-site wells sampled at somewhat irregular intervals, with at least two events per year. There is a mixture of sampling techniques at monitoring wells, such as passive diffusion bags (PDBs) in some events (for VOCs only) and annual low flow sampling events (for VOCs and total metals). The site team indicated it plans to use PDBs in the future. Although some metals are constituents of concern at the site, elevated metals (manganese, iron, and arsenic) are all likely caused by reducing conditions caused by the VOCs. Continuing laboratory analysis of metals in monitoring well samples on an annual basis does not appear to be critical for site cleanup, and analysis for metals could be reduced in frequency to every 5 years. Thus, use of PDBs for monitoring of VOCs only in monitoring wells may therefore be practical. When analyses for metals are required (perhaps infrequently as suggested above), samples could be collected with low flow sampling or with alternative techniques that can include metals. Total metals could still be sampled for analysis at residences and extraction wells at any frequency desired, since those locations are not sampled with PDBs.

It was stated during the optimization review site visit that there are access restrictions that prohibit additional monitoring in some areas. For instance, the site team indicated that additional monitoring between extraction wells EW-1 to EW-3 is not likely to be feasible because of access restrictions. These restrictions could hamper the ability to further delineate the plume extent to the east and to add sentinel monitoring wells (rather than relying on private wells).

5.1.5 INSTITUTIONAL CONTROLS (ICS)

The remedy defined in the ROD includes ICs. The Annual Report for September 2011-August 2012 indicates the following with respect to ICs:

> "*In order to protect human health and prevent future groundwater use from the shallow aquifer on site, EPA will implement institutional controls at the site. This will consist of a Consent Decree with the current landowner that will include a restriction on the installation of wells for withdrawing water from the shallow aquifer. The Consent Decree will also require the landowner to execute and record an easement running with the land that will grant right-of access for activities related to implementing the remedy. A restrictive covenant will be used to restrict future property use at the former refinery to non-residential uses, and thus eliminate the potential for indoor vapor issues in a future residential use scenario. The restrictive covenant may also impose restrictions on unauthorized drilling, excavating, digging, trenching, or any other activities that might otherwise expose contaminated soil, which may result in potentially unacceptable risks to receptors. A deed notification for the site will be filed with the appropriate land records office. The deed notification will state that the property is located within a Superfund site, identify the types of contaminants present, and describe activities that should not be conducted at the site. During the performance of routine groundwater monitoring activities at the site, a site evaluation will be conducted to verify that contaminated groundwater is not being used*."

During the optimization review site visit, it was stated that ICs still need to be finalized, and some unit costs for those efforts were provided by the site team (discussed in Section 6.1.2).

5.1.6 SUGGESTIONS BY SITE TEAM FOR POTENTIAL SYSTEM MODIFICATIONS

The site team has put forth suggestions for system improvements in the Annual Report for September 2011-August 2012 as well as during the optimization review site visit. Some of these suggestions by the site team have previously been noted in this optimization review report, but a brief listing of some of these suggestions by the site team is provided below.

- Reduce number of C3 units from five to three and eliminate the zeolite wheel concentrator. This action would be accomplished by eliminating shallow SVE (eliminates one C3 system) and by treating the air stripper off-gas with vapor GAC (which eliminates the zeolite wheel concentrator and another C3 unit). Air stripper off-gas is currently concentrated by the Munters zeolite wheel concentrator and treated in the C3 unit. This approach is extremely inefficient for the low mass (2.4 pounds/day benzene) in the vapor stream. A booster blower (or reconfiguration of the air stripper to suction blower) would likely be needed to run the off-gas from the stripper to the vapor GAC. The site team is already working on this change. In addition to cost savings, this change would likely decrease system downtime substantially because the zeolite wheel concentrator has had many maintenance issues.

- Consider reducing the number of air strippers from two to one if the extraction flow rate can be reduced.

- Use CO_2 in place of sulfuric acid for lowering pH in the treatment process, to reduce fouling at the injection wells (implemented in September 2013).

- Assuming three on-site C3 units remain, purchase a generator or fuel cell to produce on-site energy from the recovered product and use the resulting electricity on site or sell the electricity to the grid.

- Drill replacement wells EW-5R to EW-7R near existing shallow zone extraction wells EW-5 to EW-7, with long well screens, to improve extraction rates in this critical area and eliminate some of the well fouling issues observed at EW-5 to EW-7.

- Potentially add a new extraction well (shallow/intermediate) between EW-1 and EW-2.

- Consider additional injection wells.

Recommendations by the optimization review team are provided in Section 6 of this optimization review report and differ somewhat from the suggestions by the site team.

5.2 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Ongoing annual costs for this remedy are approximately $3.2 million per year. Table 6 provides a breakdown of the approximate annual cost estimates for operating this remedy based on total costs provided by the site team and general averaging by the optimization review team.

Table 6: Summary of Annual Operating Costs

Item	Notes	Approximate Annual Cost
Plant Operator	One full-time employee + 15 hrs/week overtime + truck + approx. 20 hrs/month additional support	$286,000
Project Management/Tech Support/Reporting		$305,000
Groundwater Monitoring	Based on two passive diffusion bag (PDB) events and 1 low-flow event in a year	$139,000
Groundwater Analysis Equivalent	CLP- no cost to site; approximately 240 VOCs and 80 total metals, plus QA/QC samples	$40,000*
Process Sampling	Four water samples and eight air samples per month	$24,000
Well/Pump Rehab	To be reduced in future if on-site extraction wells are eliminated	$122,000
Chemicals	Antiscale and filtration	$71,000
Supplies	Includes $4,000 for bag filters and $5,000 for stripper intake filters	$57,000
Granular Activated Carbon	None spent in FY13	$4,000
Sludge Disposal	None spent in FY13	$1,000
Electric	Approximately 509 kilowatt (kW) connected or 4,500,000 kWh/yr	$308,000
C3 System Lease	Includes on-site O&M	$1,883,000
Additional Maintenance (not C3)	Electrical contractor, PLC support, metals filtration O&M support,	$33,000
Misc. Utilities/Service	Phone/Internet/Trash	$5,000
Fuel Recovery	Credit	($55,000)
TOTAL		**$3.2MM**

**No current lab costs incurred by site, but that will change after transfer to the state, so a rough estimate is provided for approximate annual costs for an off-site lab (not including special sampling events)*

A more detailed discussion of specific cost items is presented below.

5.2.1 LABOR AND TRUCK

The site team reports combined operating labor and management (including reporting) requirements of approximately 55 hours per week, plus additional support of approximately 20 hours per month. The truck costs are likely on the order of $1,000 per month. It is possible the labor costs could be reduced if the system were simplified in the future such that there is less fouling and fewer systems to operate (no zeolite wheel and no C3 systems).

5.2.2 GROUNDWATER SAMPLING

The combined $139,000 sampling cost for approximately 240 sample locations translates to a unit cost of approximately $580 per well for sampling. This amount is high in comparison with other sites, and may be a result of the remoteness of the site.

5.2.3 CHEMICAL COSTS

Total chemical costs are $71,000 per year and include sodium hypochlorite, anti-scale and defoaming agents, and either sulfuric acid or CO_2. Supplies total about $57,000 per year, and include approximately $9,000 for bag filters and air stripper blower intake filters; it is unclear what supplies account for the remaining $48,000 per year.

5.2.4 UTILITIES

Electrical power cost in the cost summary provided to the optimization review team for September 2012 to August 2013 was approximately $308,000 (used in Table 6), and for September 2011 to August 2012 was approximately $312,000. A summary of electricity use provided to the optimization review team indicated metered electrical use for the period September 2011 to August 2012 was approximately 4,500,000 kilowatt hours (kWh) and also indicated the average unit cost was approximately $0.057/kWh. Dividing the reported cost of $312,000 for that period by the metered use of 4,500,000 kWh would actually indicate a unit cost of $0.069/kWh, which is slightly higher than the unit cost included in the utility summary provided. The difference may be related to other electrical charges such as delivery or markup of utility charges by the contractor. The optimization review team notes that these are extremely high total energy costs for a groundwater remediation system. The site team noted during the optimization review site visit that approximately 75 percent of the electrical cost is for the C3 systems. Some of these utility costs are offset by the resale of the product recovered from the C3 systems (approximately $80,000 for the period September 2011 to August 2012, and approximately $55,000 for the period September 2012 to August 2013).

5.2.5 C3 SYSTEM

In addition to the high energy costs that result from the C3 system (detailed above), the lease and operation of the C3 system represent an extremely large cost of nearly $1.9 million per year. This amount is by far the highest component cost of the remedy. Use of an alternative approach to treat vapors therefore offers the greatest cost savings potential for this remedy.

5.3 APPROXIMATE ENVIRONMENTAL FOOTPRINT ASSOCIATED WITH REMEDY

The following subsections describe the environmental footprint of the site remedy, considering the five core elements of green remediation defined by the EPA (www.cluin.org/greenremediation).

5.3.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

The EPA Spreadsheets for Environmental Footprint Analysis (SEFA) were used to estimate the energy and air footprints. A summary of the SEFA inputs is presented in Appendix C, and the SEFA files are included as an electronic attachment.

XCel Energy is the electricity provider for the site, and based on a preliminary review of Xcel Energy's 2012 Annual Report, approximately 35 percent of the electricity is generated from coal, 29 percent from nuclear plants, 13 percent from natural gas, 12 percent from wind sources, 7 percent from hydroelectric plants, and 4 percent from other sources (solar, biomass, oil and waste). This mix for electricity generation was used in SEFA. For materials, the sulfuric acid used to this point in the remedy was utilized rather than the CO_2 that has recently replaced that material. The materials (sodium hypochlorite, sulfuric acid, antiscalent and defoamer) are not explicitly represented in SEFA as options, so user-defined generic emission footprint factors were assigned based on literature values for similar materials.

The results for key energy and air footprint metrics are summarized in Table 7.

Table 7: Summary of Energy and Air Annual Footprint Results (Annual)

Green and Sustainable Remediation Parameter	Approximate Annual Value
Greenhouse Gas Emissions (carbon dioxide equivalents [CO_{2e}]	2,710 tons
Total Nitrogen Oxides (NOx) + Sulfur Oxides (SOx) + Particulate Matter (PM) emissions	49,232 pounds
Total Hazardous Air Pollutant (HAP) Emissions	1,175 pounds
Total Energy Use	56,906 MMBtu
Voluntary Renewable Energy Use	None on-site

Notes: CO_2e = carbon dioxide equivalents of global warming potential
MMBtu = 1,000,000 Btu

Based on the assumptions made in SEFA, approximately 96 percent of the global warming potential (CO_2e) footprint is from electricity usage (electricity generation and related resource extraction and transmission). The next largest contributors are materials production at 1.4 percent, laboratory analysis items at 1.2 percent, and transportation of personnel and materials at 1 percent. Thus, electricity is the main driver of the global warming footprint.

Because the C3 system recovers product, the optimization review team did a simplified analysis to determine how much of the electricity use footprint is conceptually offset by productive use of the recycled material (which is assumed to be for energy production). It is estimated that the C3 system uses approximately 281,250 kWh per month, which is 75 percent of the total remedy electricity use of 4,500,000 kWh per year. The system recovers about 7,000 gallons of product/month. Using a 40 kWh per gallon for energy value (typical for diesel) if the product could be burned for energy, at 70 percent efficiency (typical maximum) at the site (no transportation energy, capital cost/energy use to provide generator not included), it would generate 196,000 kWh per month. Thus, this conceptually would offset 196,000 / 281,250 = 70 percent of the electricity use footprint for the C3 portion of the remedy. However, the remaining 30 percent of electricity use would still represent by far the highest contributor to the footprint for the site, and based on these estimates the energy required by the C3 units is 144 percent of the energy theoretically obtained from the recovered product. The high cost of operating the C3 units, in addition to the high footprints from the electricity usage, is perhaps an even greater consideration.

5.3.2 WATER RESOURCES

The Annual Report for September 2011-August 2012 states the following:

> "*Ground water contamination has been documented in the shallow and deep zones of the Ogallala aquifer, resulting in an impact of both private and public water supply wells. The contaminant plume is 1.2 mi long and extends about 0.7 mi beyond the edge of the eastern boundary of the former refinery. Supply wells in this area typically contain screen intervals that span the entire saturated thickness of the Ogallala aquifer. Potential human receptors include current and future onsite commercial/industrial worker and a potential future resident adult and child. Potential exposure routes from ground water include ingestion, dermal contact, and inhalation, primarily associated with exposure to the ground water plume.*"

The specific public water supply wells affected were not identified. The Annual Report for September 2011-August 2012 also discusses the following:

- EA evaluated the provision of treated groundwater for non-potable use to nearby businesses with water supply wells currently affected by the contaminant plume, which would allow for (1) the reduction in surface discharge and lower the demand on the injection wells; and (2) removal of the point-of-use filtration systems currently in place. The installation of treated water conveyance piping to these businesses is under consideration. These businesses include the Farmers Co-Op (estimated 650 linear feet [lf]) and T&B Services (estimated 700 lf), which currently have point-of-use filtration systems in place. Based on an initial evaluation, the provision of treated groundwater may require installation of an additional water storage tank to ensure an uninterrupted supply of water to each facility.

- Per EPA direction, EA intends to extend the City of Levelland water line to a new residence (estimated 100 linear feet, including a cased road bore) along Farm-to-Market 1490.

The Annual Report for September 2011-August 2012 also indicates that a private irrigation well north of the extraction well network, near the downgradient extent of the plume, has been pumping since at least 2010 and could have some influence on the direction of groundwater flow.

5.3.3 LAND AND ECOSYSTEMS

Operation of the remedy does not appear to have secondary effects on local land and ecosystems.

5.3.4 MATERIALS USAGE AND WASTE DISPOSAL

The primary chemicals and materials used are the anti-scale and filtration chemicals, bag filters, vapor GAC, and air stripper blower intake filters. Sludge disposal has only been one truck of wet sludge in 4 years. GAC change-outs have also been minimal, with only one change of 10,000 pounds in 4 years (the result of an upset in the C3 system).

5.4 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECOMMENDATIONS

This section provides several recommendations related to remedy effectiveness, cost control and technical improvement. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and QAPPs.

Cost estimates provided in this section have levels of certainty comparable to those done for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility studies ((-30 to +50 percent), and have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. A summary table of the recommendations with associated capital cost and changes in operating costs is included as Table 8.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 ADD SENTINEL MONITORING WELLS IF ACCESS ALLOWS

It does not appear that there are any sentinel monitoring wells, defined as clean wells located downgradient of the plume. The 1,2-DCA plume extends to the farthest monitoring well in the shallow/intermediate zone and the deep zone (MW-30I in the shallow/intermediate zone and EW-2 and EW-3 in the deep zone). The use of private well sampling to augment site monitoring wells generally suggests that high VOC concentrations have likely not spread far beyond the remedy extraction wells located farthest east. However, it is likely appropriate to add up to two pairs (intermediate and deep) of monitoring wells downgradient of the current monitoring and extraction well locations. The site team indicated that there are substantial access issues for addition of monitoring wells, so no specific locations are recommended herein. However, it is suggested that groundwater flow velocity be considered in selecting the locations. Assuming the plume moves at velocity on the order of 150 ft/yr, these wells would ideally be located on the order of 500 to 1,000 feet beyond the interpreted plume extent. That distance is close enough that it would allow plume migration, if it is occurring, to be detected within approximately 5 to 10 years. If those wells are already contaminated when they are drilled, further plume delineation may be merited. The optimization team assumes up to $100,000 may be needed to drill clusters of intermediate/deep wells a two locations, including planning, drilling, surveying and addressing access. The cost of sampling these new wells twice per year for VOCS, using PDBs, should be less than $1,000 per year when added to the other sampling already conducted.

6.1.2 FINALIZE INSTITUTIONAL CONTROLS (ICS)

During the optimization review site visit, it was stated that ICs still need to be finalized. This effort is especially important since there is the potential that the 1,2-DCA plume extent is not fully delineated in the downgradient direction (see Section 6.2.1) and groundwater impacts are located beneath current and potential future residents. A metes and bounds survey with a list of environmental conditions for each affected parcel is required for ICs that are enforceable by the state. The site team's recent experience is that the per parcel cost is between $4,000 and $8,000. The total number of parcels requiring ICs is not known by the optimization team. The property owner must sign the restrictive covenant (RC) for the IC to be an RC. If the property owner refuses to sign, the state will file a deed notice.

6.1.3 IMPLEMENT CHANGES TO EXTRACTION STRATEGY

As detailed in Section 5.1.1, the updated groundwater modeling recently performed by the site team illustrates that equal or better capture can likely be achieved while eliminating extraction at the on-site shallow wells that has been problematic as a result of persistent well fouling. The optimization team agrees that switching to an extraction approach such as Scenario 3 evaluated with the update model and described in Section 5.1.1 is preferred to the current extraction strategy. The optimization review team has not attempted to quantify the costs of drilling and connecting the new extraction wells. There will be savings in labor and project management that result from elimination of the problematic on-site extraction wells, and these savings are discussed in other recommendations below.

A network of key monitoring wells located downgradient of the target capture zone should be identified, and concentration trends at those wells should be regularly tracked, to confirm that capture is sufficient over time under the new extraction rates. One type of well would be "performance monitoring wells," which are currently contaminated by VOC concentrations above standards, and those wells should clean up over time if capture is sufficient. The other type of well would be the "sentinel wells" (see Section 6.1.1), which should initially have VOC concentrations below standards, and VOC concentrations should remain below standards if capture is sufficient. The costs for this are already included in current monitoring and reporting plus the costs estimated for recommendation 6.1.1.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 REPLACE/ELIMINATE THE C3 SYSTEMS

The five existing C3 systems are extremely expensive to lease and operate and should be replaced with alternative approaches and eliminated as soon as possible. The optimization review team recommends the following approach:

- The shallow SVE system is already being considered for shutdown based on the low mass relative to the deep SVE system. The site team has already suggested shutdown of the shallow SVE system (which will eliminate one of the C3 units) and the optimization team agrees with that suggestion.

- The site team has already suggested that air stripper off-gas can be treated with vapor GAC, eliminating the need for the Munters concentrator and one of the C3 units, and the optimization team agrees with that suggestion.

- Rather than using the remaining three C3 units for treatment of the deep SVE vapors, the optimization review team recommends that those C3 units be replaced with a regenerative thermal oxidizer, which can provide efficient performance at a wide range of influent concentrations. A system for 1,500 scfm at 15,000 ppmv total VOCs would cost approximately \$300,000 (see Anguil quote in Appendix B) and installation would likely be under \$150,000. The system costs would include less than \$500/month for electric, less than \$1,500/month for propane, and about \$3,000/month for maintenance and outside labor to operate (assumes conservatively a 1-day visit per month, and that the existing operator would handle daily checks and routine maintenance).

Removing the five C3 systems as suggested above would pay for itself in 3 months, and savings thereafter would be over \$150,000/month for the C3 lease and support and energy (savings of approximately \$1.8 million per year). The regenerative thermal oxidizer is preferred over other thermal oxidizer options because operating costs remain low as VOC mass recovery decreases over time.

The optimization review team also compared the benefits of this recommendation with regard to environmental footprints with the following simplified comparison:

- Alternative 1 – Five C3 units using 3,375,000 kWh per year (which is 75 percent of the total electricity use of 4,500,000 kWh per year estimated for the current remedy), plus 2,500 pounds per year of vapor carbon for off-gas from the C3 units.

- Alternative 2 – No shallow SVE, thermal oxidizer for the deep SVE system using 66,780 kWh per year of electricity and 24,623 hundred cubic feet (ccf) of natural gas. The natural gas value was used as a surrogate to represent both the fuel to be added to the thermal oxidizer (in this case, propane) as well as the combustion of the site-related VOCs, such that the total British thermal unit (Btu) of the thermal oxidizer (289,521 Btu per hour) is accounted for.

The SEFA results for Alternative 1 versus Alternative 2 include the following:

- The global warming potential footprint for this aspect of the remedy is reduced from 1,969 tons in Alternative 1 to 270 tons in Alternative 2 (86 percent reduction by eliminating the C3 units).

- The total energy use for this aspect of the remedy is reduced from 41,726 million British thermal units (MMBtu) in Alternative 1 to 3,639 MMBtus in Alternative 2 (91 percent reduction by eliminating the C3 units).

- The total nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM) emissions footprint for this aspect of the remedy is reduced from 35,965 pounds in Alternative 1 to 1,673 pounds in Alternative 2 (95 percent reduction by eliminating the C3 units).

No further offset for reuse of the recovered fuel in Alternative 1 is applied, since the thermal oxidizer in Alternative 2 is already fully accounting for the emissions that occur for the extra combustion associated with that alternative.

In summary, this recommendation provides extremely large reductions for both costs and environmental footprints.

6.2.2 REDUCE PLANT OPERATOR LEVEL OF EFFORT

The site team reports combined operating labor and management (including reporting) requirements of approximately 55 hours per week, plus addition support of 15 to 20 hours per month. A system resulting from the modifications suggested in recommendation 6.2.1 above should require less operator effort. The suggested system has an added thermal oxidizer component but elimination of on-site extraction well pumping, shallow SVE and time to coordinate operational changes created by C3 issues should result in a net reduction of operator time. Although not quantified in detail, assume savings of at least 20 percent of the operator costs listed in Table 6, or $57,200 per year, are possible.

6.2.3 REDUCE GROUNDWATER MONITORING

The site team is conducting a quantitative optimization evaluation of long-term monitoring including application of the Monitoring and Remediation Optimization System (MAROS) software. The optimization team recommends the following reductions in groundwater monitoring based on a qualitative review:

- Significant water quality changes over time would not be expected inside the target capture zone for groundwater. The optimization review team suggests that monitoring frequency be reduced to annual (from the current two to three times per year) for wells inside the target capture zone. The optimization team further suggests semi-annual frequency (twice per year) for "performance monitoring wells" and "sentinel wells" located downgradient of the target capture zone. This frequency applies only to monitoring wells and remedy extraction wells (including those that that are no longer being pumped) but not residences where sampling effort from taps is minimal and where residents may prefer more frequent sampling. Assuming recommendation 6.1.2 is implemented, the target capture zone would be based on extraction only as far east as the locations of EW-05 to EW-10.

- As discussed in Section 5.1.4, although some of the COCs for the site are metals, there does not appear to be a major technical need to sample for analysis of metals at individual monitoring wells on an annual basis. Sampling for analysis of metals could still be conducted regularly for operating extraction wells and residences, but perhaps only every 5 years at monitoring wells. This schedule would allow all VOC sampling at monitoring wells to be conducted with PDBs except for infrequent events where other sampling approaches could be employed.

Without a detailed inventory, it is assumed that the reduced sampling frequency suggested above for monitoring wells and extraction wells (and sampling most residences once per year as was done in 2012) would eliminate approximately half the samples relative to 2012 sampling described by Table 3 and Table 6, and therefore might save approximately half of the sampling costs listed in Table 6, or approximately $70,000 per year. Not analyzing for metals at monitoring wells would have no direct impact on costs under current use of the CLP laboratory, since the site does not pay for those costs from the CLP laboratory, but would result in minor laboratory cost savings to the state in the future. Using PDBs only for monitoring well sampling (since samples would not be analyzed for metals at those wells) would eliminate the use of low-flow sampling subcontract support, which would yield some savings, but the savings was not quantified by the optimization review team.

6.2.4 REDUCE PM/SUPPORT/REPORTING

Reporting for the site is very good but costs for project management/support and reporting are high, likely in part as a result of the complexities added by the significant well fouling issues and the need to coordinate with the contract and operation for the complex C3 systems. The optimization review team assumes that a simpler system resulting from eliminating the on-site extraction wells as well as the modifications suggested in recommendation 6.2.1 above to eliminate the C3 systems, plus the reduced groundwater monitoring frequency suggested in recommendation 6.2.3, should require less project management, support and reporting. Although not quantified in detail, it is estimated that savings of at least 20 percent of the Project Management/Tech Support/Reporting listed in Table 6, or $61,000 per year, are possible based on the professional judgment of the optimization review team.

6.2.5 REDUCE WELL REHABILITATION COSTS

Assuming on-site extraction wells are no longer used as per recommendation 6.1.2, well maintenance costs would be reduced substantially. Assuming that approximately 75 percent of the well rehabilitation costs currently pertain to the shallow on-site wells (the remaining maintenance costs are mostly related to injection wells), savings of 75 percent of the well rehabilitation costs listed in Table 6, or approximately $91,500 per year, are estimated. The optimization review team notes the site team has already suggested elimination of extraction at the on-site extraction wells, in large part to eliminate much of the well rehabilitation effort and cost.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 EVALUATE OPERATION WITH ONLY ONE AIR STRIPPER FOR MODIFIED SYSTEM

After the planned replacement extraction wells have been installed and are operating, the total flow rate of the extraction system should be assessed against the need to continue operation of both of the air strippers. With the current flow of less than 200 gpm and future flow likely to be less than 200 gpm, one stripper could be taken off-line. The site team may need to replace the stripper effluent pumps to allow the stripper to be taken off-line. The potential cost savings of operating only one air stripper can be compared against the replacement costs of the effluent pump necessary for operation of only one air stripper. Operating an extra 30-horsepower blower requires approximately $13,800/year in electric costs, so the cost of pump replacement would likely be paid for quickly and a change to one stripper would likely be cost-effective. However, a detailed quantification of up-front costs and annual savings has not been performed since the total future extraction rate is uncertain at this time.

6.3.2 ACCURATELY RECORD INJECTION RATES FOR EACH LOCATION

The modeling update included as Appendix A to the Annual Report for September 2011-August 2012 stated the following: "*The volume of water diverted to the impoundment was not metered, and meter records for the injection wells appeared to be in error. Consequently, the volume of water injected at wells versus the volume of water infiltrated at the impoundment is unknown*." During the optimization review site visit, it was stated the when the new injection wells were added, they shared panels on the SCADA with the adjacent injection wells in a manner that does not allow injection rates at individual wells to be recorded. Given that modeling is a useful tool for evaluating extraction and injection scenarios, and that injection rates can alter the capture zone of the extraction wells, it is recommended that tools and techniques be implemented to accurately monitor injection rate at each location. These rates should be summed and compared with the total discharge from the treatment system as a check on the accuracy of the measurements. Discrepancies of more than 5 percent in these totals should be resolved. An approximate effort of $15,000 is estimated to address this issue.

6.3.3 INCLUDE INJECTION WELL SCREEN LENGTHS IN WELL CONSTRUCTION TABLE

The optimization review team notes that well construction information (including screened intervals) is provided in the annual reports, but the construction information for the injection wells is not provided. It is recommended that well construction information for the injection wells be included. Costs to implement this recommendation are negligible.

6.3.4 PERFORM SIMULATIONS WITH NO RECHARGE OF TREATED WATER

The modeling indicates that a significant amount of treated water is recaptured, which increases the extraction rate required for capture. Although the model simulations account for the recapture of treated water, the modeling presented in the report does not illustrate the difference in capture that might result if treated was not recharged to groundwater. (In other words, the model has not been used to illustrate how much less extraction might be required to achieve similar capture if in absence of treated water being recharged.) It is suggested that model simulations be performed to illustrate and optimize capture in the absence of treated water being recharged. If the results show that the recharge of treated water is a significant detriment to capture, or is causing a large increase in the amount of extraction required for capture, then even greater effort might be merited for developing a re-use approach for the treated water. Evaluating and documenting these scenarios with the current model should require less than $5,000.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSEOUT

The groundwater remediation system is anticipated to continue operating under EPA supervision through September 2020, when EPA will transfer operation and maintenance of the system to the TCEQ to address any remaining contamination. The site team should make significant efforts to achieve consistent, cost-effective system operation because operation will continue for many years based on the site contaminant mass. The optimization review team does not believe that additional in situ technologies should be considered until cost-effective operation of the current remedy is achieved. Any in situ remedy would be extremely costly because of the large size of the contaminant plume and source area. It is unclear how effective an in situ remedy would be at reducing the time span for remediation.

6.5 RECOMMENDATIONS RELATED TO ENVIRONMENTAL FOOTPRINT REDUCTION

6.5.1 REPLACE/ELIMINATE THE C3 SYSTEMS

The most significant footprint reductions would be associated with reducing electricity use by replacing the C3 systems as described in recommendation 6.2.1. (Potential footprint reductions are also presented in Section 6.2.1.)

6.6 SUMMARY

Recommendations are provided in several categories including effectiveness, cost reduction, technical improvement, site closeout, and environmental footprint reduction. Table 8 summarizes estimated costs and savings associated with those recommendations. In particular, the recommendation to eliminate the C3 systems requires the greatest capital cost, but has a very short payback period and results in significant savings with respect to cost and environmental footprints.

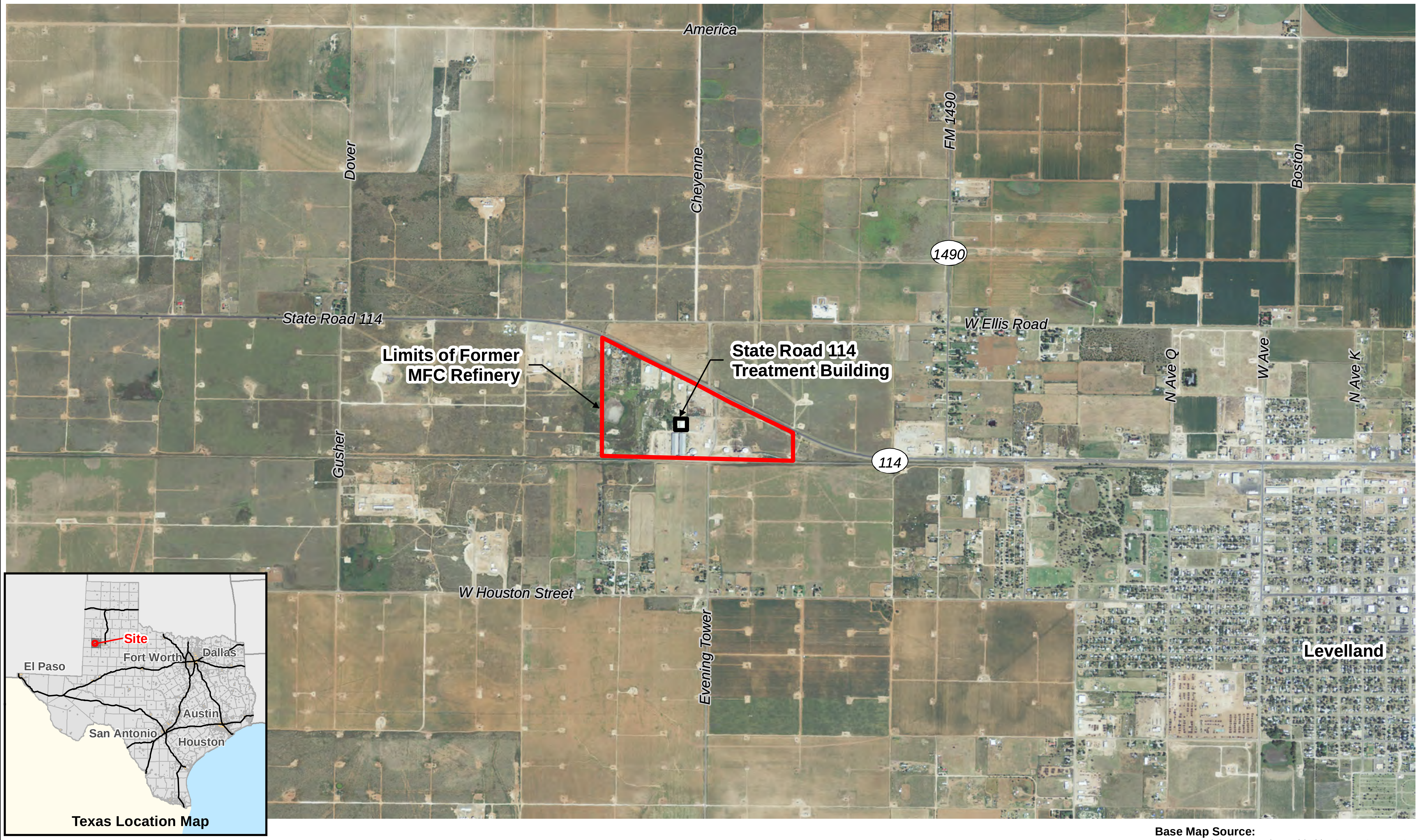
Table 8: Summary of Recommendations and Associated Costs

Recommendation	Reason	Capital Cost	Annual Cost	Notes
6.1.1 Add Sentinel Monitoring Wells if Access Allows	Effectiveness	$100,000	$1,000	May be limited by access
6.1.2 Finalize Institutional Controls (ICS)	Effectiveness	Not quantified (number of parcels uncertain)	Not quantified	$4,000 to $8,000 per parcel for surveys and related efforts required for state-enforceable ICs
6.1.3 Implement Changes to Extraction Strategy	Effectiveness	Costs to install and connect new extraction wells (not quantified)	Not quantified	Site team planning to add off-site pumping wells EW-5R to EW-7R (costs are significant but are not quantified herein)
6.2.1 Replace / Eliminate the C3 Systems	Cost Reduction	$450,000 ($300,000 capital + $150,000 install)	$ (1,800,000) (GEO contract+ electric- fuel recovery- thermal oxidizer operation- GAC)	Site team has started process
6.2.2 Reduce Plant Operator Level of Effort	Cost Reduction	$0	$ (57,200)	Caused by more simple system resulting from other recommendations
6.2.3 Reduce Groundwater Monitoring	Cost Reduction	$0	$ (70,000)	
6.2.4 Reduce PM/Support/ Reporting	Cost Reduction	$0	$ (61,000)	Caused by more simple system resulting from other recommendations
6.2.5 Reduce Well Rehabilitation Costs	Cost Reduction	$0	$ (91,500)	Caused by elimination of on-site remedy extraction
6.3.1 Operate with Only One Air Stripper (for modified system)	Technical Improvement	Not quantified	Not quantified	Larger discharge pumps Site team started process
6.3.2 Accurately Record Injection Rates for Each Location	Technical Improvement	$15,000	$0	
6.3.3 Include Injection Well Screen Lengths in Well Construction Table	Technical Improvement	negligible	$0	
6.3.4 Perform Simulations with no Recharge of Treated Water	Technical Improvement	$5,000	$0	
6.5.1 Replace / Eliminate the C3 Systems	Environmental Footprint Reduction	See 6.2.1	See 6.2.1	Same as 6.2.1
TOTAL		**$570,000 plus costs for installing and connecting new extraction wells and implementing ICs**	**More than $ (2,000,000)**	

( ) indicates a cost savings.

APPENDIX A

Select Figures from Site Documents



Base Map Source:
Aerial photograph provided by SDA-FSA-APFO
Aerial Photography Field Office. 2010

N

0 1000 2000 Feet

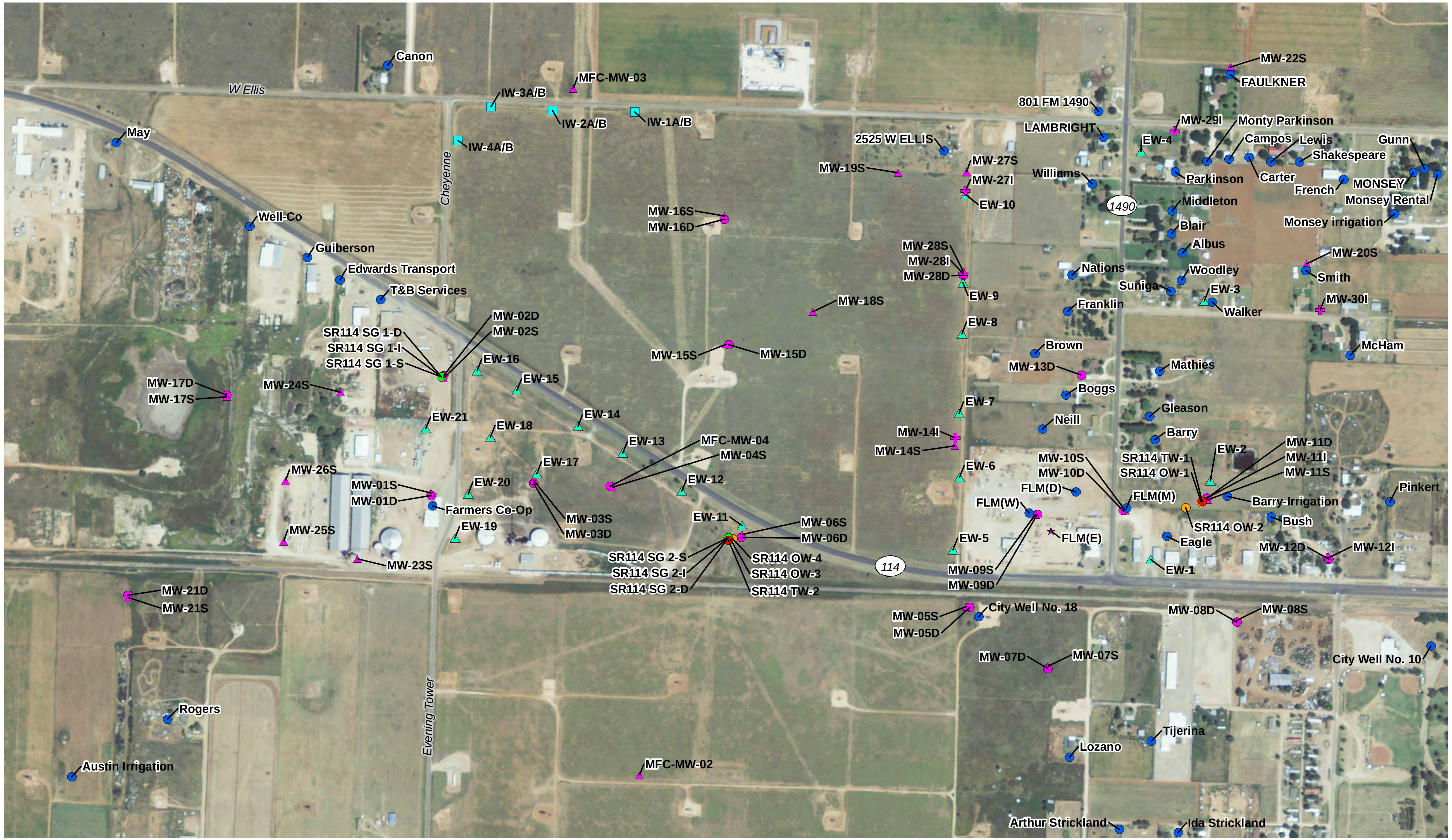
Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Location_maps\Site_location_map.mxd

Site Location Map

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY, INC.

FIGURE	1
PROJECT NO	1434273.B.08
DATE	9/25/2012
SCALE	1:24,000
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR



Base Map Source:
Aerial photograph provided by SDA-FSA-APFO
Aerial Photography Field Office. 2010

N

0 300 600 Feet

Explanation

- Monitoring well screened in the deep zone
- Monitoring well screened in the shallow zone
- Monitoring well screened in the intermediate zone
- Well screened in multiple zones
- Extraction well
- Injection well
- Supply well
- Observation well
- Soil gas
- Test well
- WMW-15A Well designation

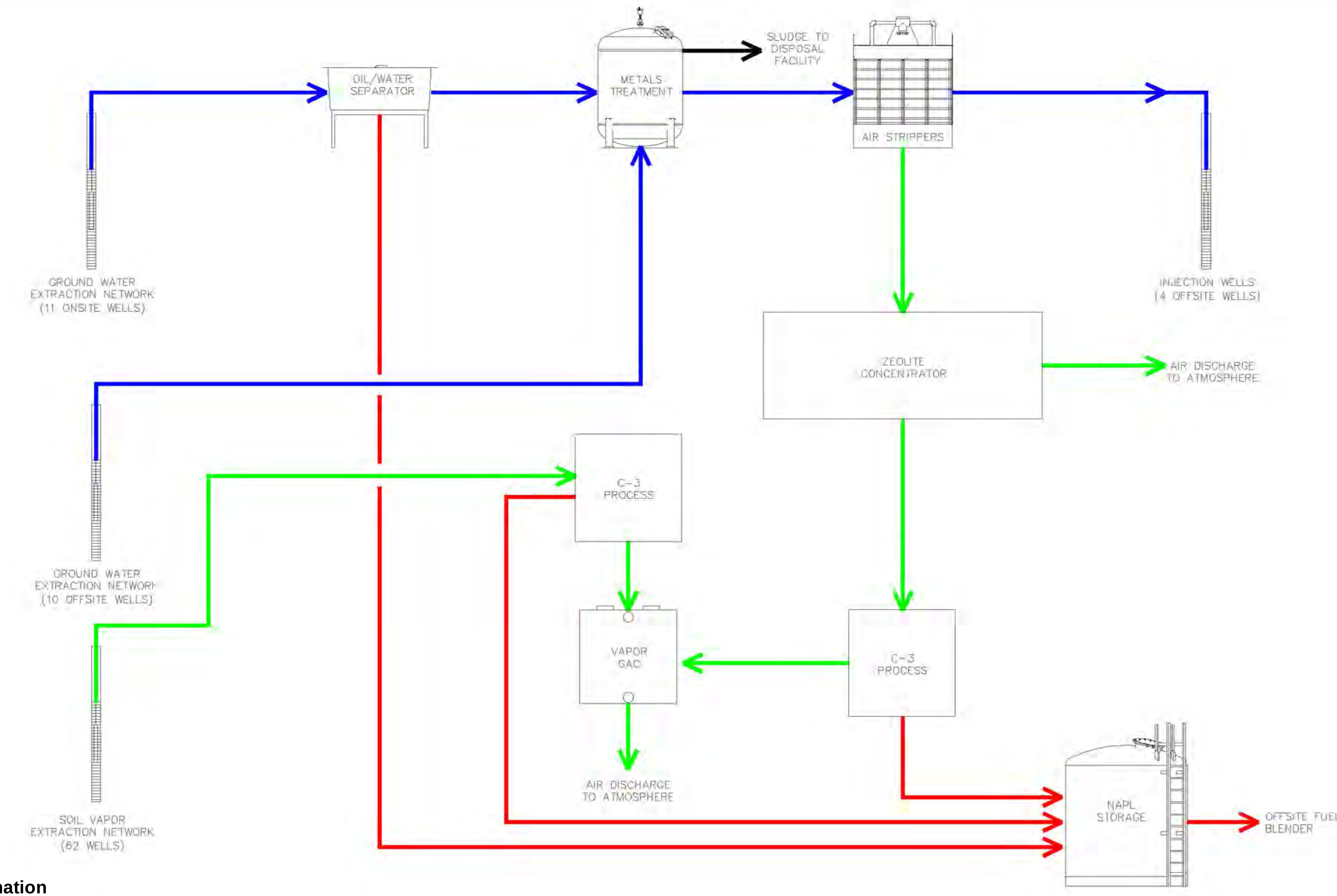
Well Location Map

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

FIGURE	2
PROJECT NO	1434273.B.08
DATE	02/20/2012
SCALE	1:7200
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Location_maps\Well_location_map_2011.mxd



Explanation

- Water
- Air/vapor
- LNAPL

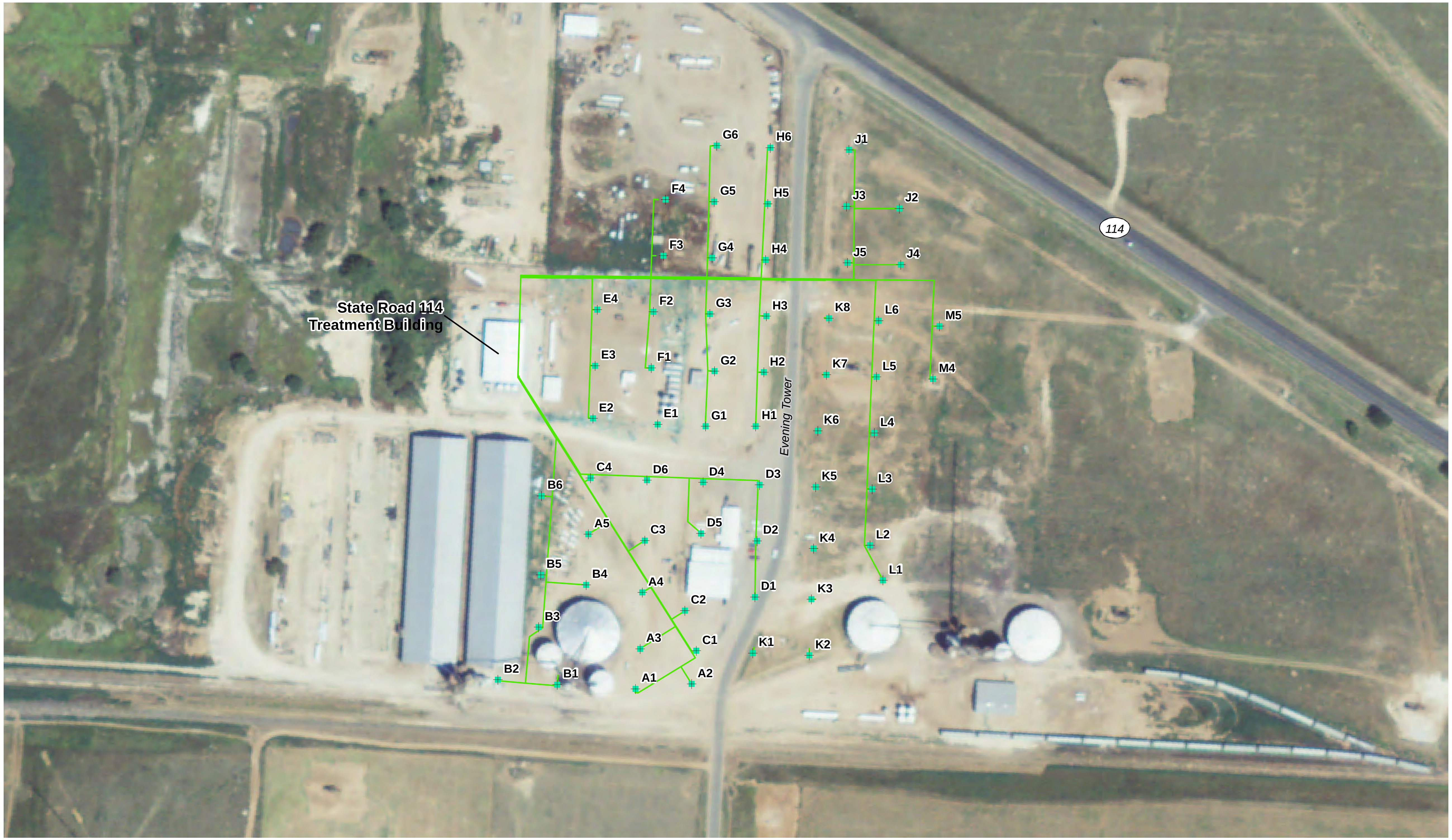
Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\process_flow_schematic.mxd

Process Flow Schematic

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY

FIGURE	PROJECT NO	DATE	SCALE	CHECKED BY	DRAWN BY	DESIGNED BY
3	1434273.B.08	01/26/2012	NONE	DWR	CRS	GH



Explanation

SVE well

SVE laterals/conveyance piping

F4 Well designation

N

0 100 200 Feet

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO
Aerial Photography Field Office. 2010

SVE System Layout

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

FIGURE	4
PROJECT NO	1434273.B.08
DATE	01/26/2012
SCALE	1:2400
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

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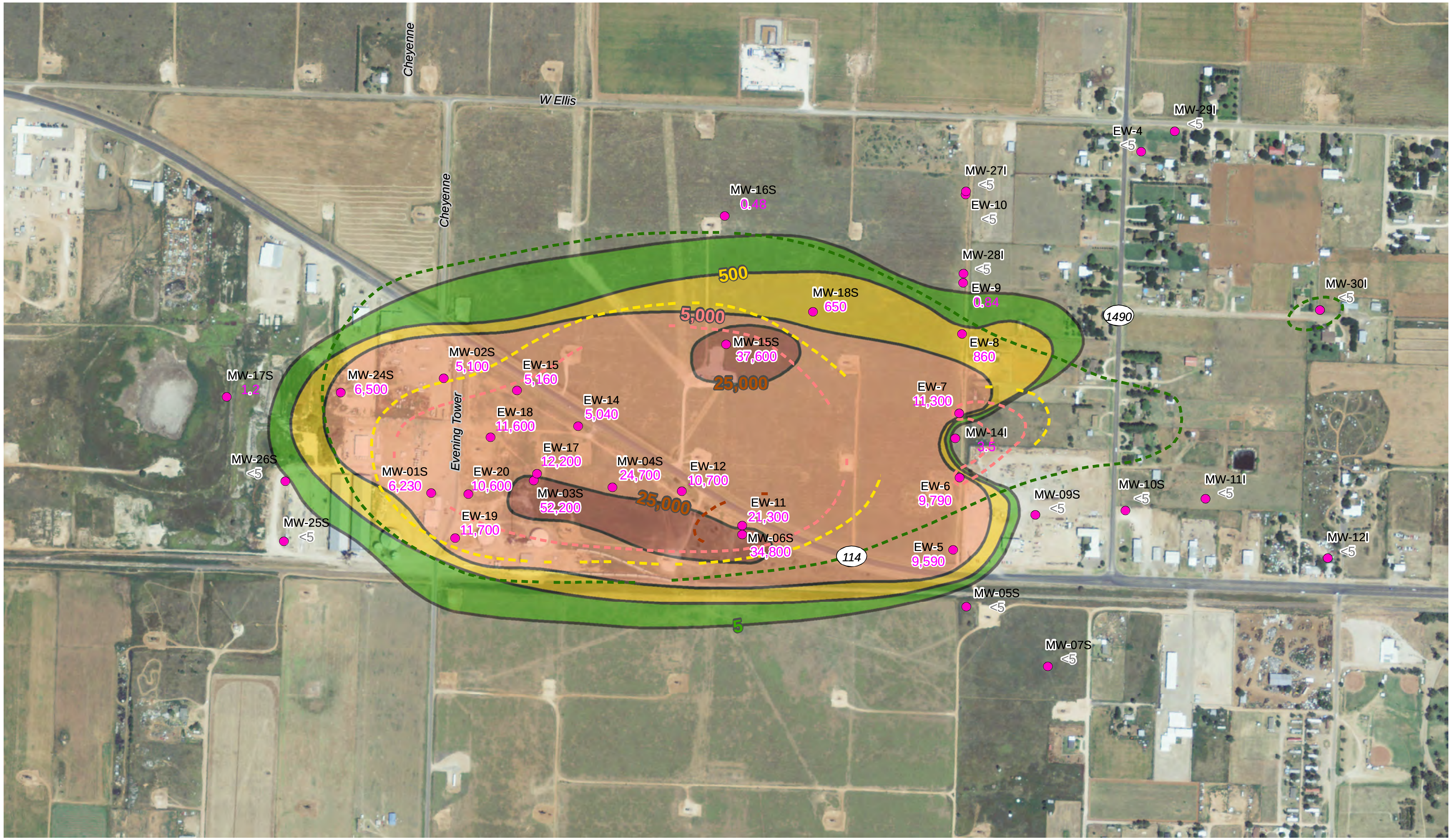
Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Location_maps\sve_well_location_map_2011.mxd



Explanation

MW-01S Sample location

6,230 Benzene concentration (µg/L)

<5 Benzene concentration below reporting limit

N

0 300 600 Feet

Estimated areal extent of benzene concentrations exceeding MCL of 5 µg/L

- 5 - 499
- 500 - 4,999
- 5,000 - 24,999
- >25,000
- 5 - 499 (August 2011)
- 500 - 4,999 (August 2011)
- 5,000 - 24,999 (August 2011)
- >25,000 (August 2011)

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO Aerial Photography Field Office. 2010

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Chemistry\benzene\2012_2011_benzene_shallow.mxd

Distribution of Benzene in the Shallow and Intermediate Zones August 2011 and August 2012

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

FIGURE	12
PROJECT NO	1434273.B.08
DATE	4/18/2013
SCALE	1:7200
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Chemistry\12dca\2012_2011_12dca_shallow.mxd

N

0 300 600 Feet

Explanation

MW-11I ● Sample location

59 1,2-DCA concentration (µg/L)

<5 1,2-DCA concentration below reporting limit

Estimated areal extent of 1,2-DCA concentrations exceeding MCL of 5 µg/L

5 - 49	5 - 49 (August 2011)
50 - 499	50 - 499 (August 2011)
>500	>500 (August 2011)

Notes:
1. 1,2-DCA = 1,2-Dichloroethane
2. * = 1,2-DCA plume at the MW-11 location presents results from the intermediate zone in 2012 and the shallow zone in 2011.

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO Aerial Photography Field Office. 2010

Distribution of 1,2-DCA in the Shallow and Intermediate Zones August 2011 and August 2012

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

FIGURE	13
PROJECT NO	1434273.B.08
DATE	5/7/2013
SCALE	1:7200
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

Explanation

MW-09D Sample location
14 1,2-DCA concentration (µg/L)
<5 1,2-DCA concentration below reporting limit

Estimated areal extent of 1,2-DCA concentrations exceeding MCL of 5 µg/L

- 5 - 49
- 50 - 499
- 5 - 49 (August 2011)
- 50 - 499 (August 2011)

N

0 300 600 Feet

Notes:
1,2-DCA = 1,2-Dichloroethane

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO Aerial Photography Field Office. 2010

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Chemistry\12dca\2012_2011_12dca_deep.mxd

Distribution of 1,2-DCA in the Deep Zone August 2011 and August 2012

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

FIGURE	14
PROJECT NO	1434273.B.08
DATE	4/18/2013
SCALE	1:7200
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

N

0 400 800 Feet

Explanation

MW-03S Sample location

-26.6 $-\delta^{13}c$ in 1,2-DCA (0/00 parts per thousand)

Estimated areal extent of 1,2-DCA concentrations exceeding MCL of 5 µg/L

- 5 - 49
- 50 - 499
- >500

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO
Aerial Photography Field Office. 2010

$-\delta^{13}c$ in 1,2-DCA Shallow and Intermediate Zones May 2012

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

FIGURE	15
PROJECT NO	1434273.B.08
DATE	4/30/2013
SCALE	1:9600
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Chemistry\12dca\2012_05_-δ13c in 1,2 DCA_shallow.mxd

Explanation

MW-28D Sample location

-18.8 $-\delta^{13}c$ in 1,2-DCA (0/00 parts per thousand)

Estimated areal extent of 1,2-DCA concentrations exceeding MCL of 5 µg/L

5 - 49

50 - 499

N

0 400 800 Feet

Base Map Source:
Aerial photograph provided by SDA-FSA-APFO
Aerial Photography Field Office. 2010

$-\delta^{13}c$ in 1,2-DCA
Deep Zone
May 2012

STATE ROAD 114
GROUND WATER PLUME
SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

FIGURE	16
PROJECT NO	1434273.B.08
DATE	4/30/2013
SCALE	1:9600
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	DWR

Path: M:\Projects\EPA_RAC\EPA6.05_SR_114\GIS\MXDs\Chemistry\12dca\2012_05_-δ13c in 1,2 DCA_deep.mxd

APPENDIX B

Informational Quote:

Anguil Thermal Oxidizer

ANGUIL For: Tetratech Proposal: AES-133256

MODEL 25 REGENERATIVE THERMAL OXIDIZER

Standard Base System

- Design flow – 2,500 SCFM
- 99% destruction efficiency
- 95% thermal energy efficiency
- 1550°F oxidation temperature design
- Skid mounted design
- Two-chamber carbon steel reactor
- Hot side bypass
- High temperature ceramic fiber insulation
- High temperature structured ceramic heat transfer media
- Two (2) pneumatic vertical poppet valves with compressed air accumulation tank
- Forced draft system fan and system motor (*TEFC, 460V/3ph/60Hz*)
- Variable frequency drive
- Burner (*natural gas or propane fired*) and fuel train (*FM design*)
- Flame arrestor
- Exhaust stack
- PLC based controls with touch screen display (HMI)
- NEMA 3R weatherproof control panel
- Digital chart recorder and data logger
- Remote communication via modem and Ethernet connectivity
- Factory quality run and test prior to shipment
- Start-up services, training of operators, operation & maintenance manuals

Shipment Terms

F.O.B. (Origin), Freight Prepaid & Add to the invoice

Budget Price
$290,000.00

*****Due to the rapidly changing market price of specialty alloys Global reserves the right to adjust the final price of the equipment accordingly to account for market price.***

ANGUIL

For: Tetratech

Proposal: AES-133256

432 gal/mo @ $3/gal

OPERATING COSTS – TECHNOLOGY COMPARISON

0.6 gallon propane/hr

1.80

$2.35/hr

Regnerative Thermal Oxidizer RTO

~75 lbs/hr avg

SELECT TECHNOLOGY									
Process Flow (SCFM)	Temperature (°F)	Dilution Flow (SCFM)	VOC Load (lb/hr)	Electrical Usage (kW)	Electrical Cost ($/hr)	Gas Usage (BTU/hr)	Gas Cost ($/hr)	Total Cost ($/hr)	Month Cost
1,500	120	1,000	91.00	7.73	$0.55	55,556	$0.39	$0.94	$676.00
1,500	120	0	55.00	2.31	$0.17	55,556	$0.39	$0.56	~~$676.00~~ 402
1,500	120	0	25.00	2.31	$0.17	55,556	$0.39	$0.56	$402.40
1,500	120	0	15.00	2.31	$0.17	55,556	$0.39	$0.56	$402.40
1,500	120	0	10.00	2.31	$0.17	72,353	$0.51	$0.68	$402.40
1,500	120	0	5.00	2.36	$0.17	180,937	$1.27	$1.44	$487.06
1,500	120	0	0.00	2.41	$0.17	289,521	$2.03	$2.20	$1,034.32

Catalytic Oxidizer 65% Heat Exchanger

SELECT TECHNOLOGY									
Process Flow (SCFM)	Temperature (°F)	Dilution Flow (SCFM)	VOC Load (lb/hr)	Electrical Usage (kW)	Electrical Cost ($/hr)	Gas Usage (BTU/hr)	Gas Cost ($/hr)	Total Cost ($/hr)	Monthy Cost
1,500	120	1,000	91.00	5.92	$0.42	55,556	$0.39	$0.81	$582.40
1,500	120	0	55.00	1.85	$0.13	55,556	$0.39	$0.52	$373.60
1,500	120	0	25.00	1.95	$0.14	210,190	$1.47	$1.61	$1,160.16
1,500	120	0	15.00	2.03	$0.15	330,482	$2.31	$2.46	$1,773.63
1,500	120	0	10.00	2.06	$0.15	388,503	$2.72	$2.87	$2,066.05
1,500	120	0	5.00	2.10	$0.15	445,173	$3.12	$3.27	$2,351.67
1,500	120	0	0.00	2.13	$0.15	500,539	$3.50	$3.65	$2,630.72

Thermal Recouperative Oxidizer 65% Heat Exchanger

SELECT TECHNOLOGY									
Process Flow (SCFM)	Temperature (°F)	Dilution Flow (SCFM)	VOC Load (lb/hr)	Electrical Usage (kW)	Electrical Cost ($/hr)	Gas Usage (BTU/hr)	Gas Cost ($/hr)	Total Cost ($/hr)	Month Cost
1,500	120	0	135.00	4.14	$0.29	55,556	$0.39	$0.68	$488.80
1,500	120	0	90.00	4.37	$0.31	446,836	$3.13	$3.44	$488.80
1,500	120	0	55.00	4.81	$0.34	1,212,052	$8.48	$8.82	$2,475.25
1,500	120	0	25.00	5.20	$0.37	1,867,951	$13.08	$13.45	$6,353.54
1,500	120	0	5.00	5.45	$0.39	2,305,218	$16.14	$16.53	$9,680.88
1,500	120	0	0.00	5.51	$0.39	2,414,534	$16.90	$17.29	$11,899.10

ANGUIL ENVIRONMENTAL SYSTEMS, INC. • www.anguil.com
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APPENDIX C

Input Summary for SEFA Footprint Analysis

Appendix C: Input Summary for SEFA Footprint Analysis

For quantitative evaluation of the environmental footprint, the U.S. EPA Spreadsheets for Environmental Footprint Analysis (SEFA) were used to organize this information and calculate the environmental footprint metrics.

Two sets of SEFA files were used to evaluate the remedy as a whole and the alternative suggested in the Optimization Review. The files are organized as follows:

- "TotalRemedy" SEFA files: Entire Remedy Evaluation
    - This set of SEFA files consists of one component that includes all contributors to the O&M footprint for the original remedy design, including:
        - Material Use
        - Transportation of Materials
        - Waste Transport and Disposal
        - Transport of Personnel
        - Electricity Use
        - Off-Site Laboratory Analysis
- "Recommendation" SEFA files: Evaluation of the C3 Systems and Suggested Alternative
    - This set of SEFA files consists of two components to evaluate the footprint of just the energy use and material use associated with the C3 systems and a Regenerative Thermal Oxidizer (an alternative to the C3 systems).
    - The "C3 System" component tab includes:
        - Electricity Use
        - Material Use
    - The "Alternative System" component tab includes:
        - Electricity Use
        - Natural Gas Use
        - Material Use

The Total Remedy SEFA files have been used to evaluate the total environmental footprint of annual O&M and calculate the footprint of each contributor (i.e. electricity use, transportation) as a percentage of the total footprint. The Recommendation SEFA files have been used to evaluate the potential reduction of environmental footprint that could be achieved by replacing the C3 units with a regenerative thermal oxidizer and replacing the zeolite wheel concentration with a Vapor GAC unit.

The follow tables detail the input to SEFA. These tables include a reference to where the information can be found in the Optimization Review Report and/or documents Tetra Tech (TT) reviewed and explain how the input values were derived and where they were inputted into the SEFA files.

<u>Total Remedy SEFA file input</u>

Table A: Material Use – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Treatment Chemical – Sodium Hypochlorite	• Optimization Review – Section 5.1.2 o "13 gallons per day (gpd) of 12.5% sodium hypochlorite" • A 12.5% solution of sodium hypochlorite has roughly the same density of water o Density of water = 8.35 lb/gal • 13 gpd x 8.35 lb/gal * 365 days = 39620.75 lb/year	*Material Use and Trans.* Selected: "Sodium Hypochlorite" *A user defined conversion factor (See note below)* Input: 39620 lbs. *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 67*
Treatment Chemical – Sulfuric Acid	• Optimization Review – Section 5.1.2 o "18 gpd of 93% sulfuric acid" • TT calculated 93% sulfuric acid has a density of 14.9 lb/gal o Density of sulfuric acid = 1.84 g/cm^3 o Density of water = 1 g/cm^3 o Density of 93% sulfuric acid = 1.84 x .93 + 1 x .07 = 1.78 g/cm^3 or 14.9 lb/gal • 18 gpd x 14.9 lb/gal * 365 days = 97893 lb/year	*Material Use and Trans.* Selected: "Sulfuric Acid" *A user defined conversion factor (See note below)* Input: 97890 lbs. *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 68*
Treatment Chemical – Antiscalent	• TT reviewed the document "Annual O&M Costs (September 2012 – August 2013)" from the Site that specified: o 2 x 55-gal drum every 60 days = 1.8 gpd • Antiscalent has a density of 1.3 g/cm^3 or 10.8 lb/gal o From Alfalaval – Alpacon Altreat 400 (scale inhibitor) • 1.8 gpd x 10.8 lb/gal * 365 days = 7095.6 lb/year	*Material Use and Trans.* Selected: "Anitscalent" *A user defined conversion factor (See note below)* Input: 7100 lbs. *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 69*
Treatment Chemical – Defoamer	• TT reviewed the document "Annual O&M Costs (September 2012 – August 2013)" from the Site that specified: o 2 x 55-gal drum every 75 days = 1.5 gpd • No literature value for density of defoamer could be found so TT assumed the density is roughly equal to water • 1.5 gpd x 8.35 lb/gal * 365 days = 4571.63 lb/year	*Material Use and Trans.* Selected: "Defoamer" *A user defined conversion factor (See note below)* Input: 4570 lbs. *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 70*

Treatment Material – Virgin GAC	• Optimization Review – Section 5.3.4 o "GAC change-outs have also been minimal, with only one change of 10,000 pounds in four years" • TT assumed GAC consumption is approximately 2,500 lb/year	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 2500 lbs. *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 71*

Note on User Defined Conversion Factors for Treatment Materials:
For all of the materials except Virgin GAC, a user defined conversion factor was used. The conversion factor used for these materials was taken from the Final ESTCP Report, *Quantifying Life-Cycle Environmental Footprints of Soil and Groundwater Remedies*, July 2013 (ESTCTP Project # ER-201127). All the materials used the Category 2 – Low Footprint conversion factors from Table 16: Chart of Suggested Footprint Factors for Generic Materials. The conversion factors were inputted into the "User Defined Factors" tab in SR114_TotalRemedy_energy.xlsx for each of the four materials as follows:

Metric	Conversion Factor per 1 lb. of Material	Units
Energy	0.0043	MMBtus/unit
CO2e	0.5	lbs/unit
NOx	0.001	lbs/unit
SOx	0.002	lbs/unit
PM	0.0004	lbs/unit

Note: A conversion factor for Air Toxics is not included in Table 16 from the ESTCP Report

Table B: Transportation of Materials – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Transportation of Treatment Materials – Sodium Hypochlorite and Sulfuric Acid	• TT reviewed the document "Annual O&M Costs (September 2012 – August 2013)" from the Site that specified: o Metals Filtration Chemicals are bought from Univar, Odessa, TX • TT assumed that the Sodium Hypochlorite and Sulfuric Acid are delivered together and are on a freight truck making other deliveries • Distance from the Site to Odessa, TX is approximately 140 miles	*Material Use and Trans.* Input for each material: 140 miles one-way Selected: Truck freight (gptm), Diesel 279.1 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 67 & 68*
Transportation of Treatment Materials – Antiscalent and Defoamer	• TT reviewed the document "Annual O&M Costs (September 2012 – August 2013)" from the Site that specified: o Antiscalent/Defoamer are bought from Analytix Technologies, Houston, TX • TT assumed that the antiscalent and defoamer are delivered together and are on a freight truck making other deliveries • Distance from the Site to Houston, TX is approximately 550 miles	*Material Use and Trans.* Input for each material: 550 miles one-way Selected: Truck freight (gptm), Diesel 93 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 69 & 70*
Transportation of Treatment Materials – Virgin GAC	• TT was unable to find source of GAC so the SEFA default value of 500 miles travel to site was used	*Material Use and Trans.* Input: No Input (Use Default) Selected: Truck freight (gptm), Diesel 18.1 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 71*

Table C: Waste Transportation/Disposal – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Transportation and Disposal of used GAC	• Optimization Review – Section 5.3.4 o "GAC change-outs have also been minimal, with only one change of 10,000 pounds in four years" • TT assumed GAC consumption is approximately 2,500 lb/year • TT assumed waste travels approximately 200 miles to non-hazardous waste landfill	*Waste Transport and Disposal* Selected: Non-hazardous waste landfill Input: 1.25 tons, 200 miles of transport Selected: Truck freight (gptm), Diesel 7.3 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 89*
Transportation and Disposal of Tank Sludge	• TT reviewed the document "Annual O&M Costs (September 2012 – August 2013)" from the Site that specified: o 90 bbls of Tank Sludge in 2010; up to 120 bbls scheduled for Oct/Nov 2013 • TT assumed Tank Sludge disposal is 100 bbls/year • Sewage Sludge has a density of 6.02 lb/gal o From Aqua-Calc.com • 1 bbl = 42 gals • 42 gals/bbl x 6.02 lb/gal x 100 bbls/yr = 25284 lbs of tank sludge disposal • TT assumed waste travels approximately 200 miles to non-hazardous waste landfill	*Waste Transport and Disposal* Selected: Non-hazardous waste landfill Input: 12.6 tons, 200 miles of transport Selected: Truck freight (gptm), Diesel 73.1 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 90*

Table D: Transportation of Personnel – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Permanent operator transportation during O&M period	• TT assumes 1 full time O&M personnel working 5 days a week, 52 weeks a year. • TT assumes operator commutes from Lubbock, TX to site, which is approximately 68 miles roundtrip, and drives a light duty truck.	*Labor, Mobilizations, Mileage, and Fuel* Input: 1 Full Time Operator Operators, 1 crew, 260 days, 8 hours per day, 260 trips, 68 miles roundtrip Selected: Light-Duty Truck, Gasoline 1040 Gallons of Fuel Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 16*

Table E: Electricity Use – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Annual Electricity Use for O&M	• Optimization Review – Section 5.2.4 o "Metered electrical use for the period September 2011 to August 2012 was approximately 4,500,000 kWh"	*On-Site Electricity Use* Input: 4500000 4500000 kWh, Energy Used *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 59*

Table F: Fuel Mix for Grid Electricity – Total Remedy and Recommendation

The grid electricity fuel mix for entry in the "Grid Electricity" is specified in Section 5.3.1 of the Optimization Review Report. This fuel mix is used in both the Total Remedy and Recommendation SEFA files.

Electricity Source	Fuel Mix %
Nonrenewable Resource	
Coal	35
Natural Gas	13
Oil	1
Nuclear	29
Nonrenewable Total	78
Renewable Resource	
Wind	12
Solar	2
Geothermal	0
Biomass	1
Hydro	7
Renewable Total	22

Table G: Off-Site Laboratory Analysis – Total Remedy

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Annual GW Analysis Sampling	• Based on Section 3.3.2 of the Optimization Review and TT professional judgment, groundwater analysis sampling consists of approximately 240 VOCs and 80 total metals samples a year • TT approximates the GW analysis sampling costs $40,000 a year	*Off-Site Laboratory Analysis* Input: GW analysis, 240 VOCs and 80 metals per year, 40000 Unit Cost, 1 Number of Samples *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 102*
Annual Process Sampling	• Based on Section 3.3.1 of the Optimization Review and TT professional judgment, process sampling consists of approximately 48 water samples and 96 air samples a year • TT approximates the process sampling costs $24,000 a year	*Off-Site Laboratory Analysis* Input: Process, 48 water and 96 air a year, 24000 Unit Cost, 1 Number of Samples *SR114_TotalRemedy_energy.xlsx → Total Remedy → Row 103*

<u>Recommendation SEFA file input – C3 System Components</u>

The C3 System tab of the Recommendation SEFA file has the same GAC material use as the Total Remedy SEFA file but only has 75% of the electricity use. This is because approximately 75% of the total electricity use is contributed to the C3 Systems and only that portion of the total electricity use could be affected by changing from the C3 systems to a regenerative thermal oxidation System.

Table H: Material Use – Recommendation – C3 System tab

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Treatment Material – Virgin GAC	• Optimization Review – Section 5.3.4 o "GAC change-outs have also been minimal, with only one change of 10,000 pounds in four years" • TT assumed GAC consumption is approximately 2,500 lb/year	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 2500 lbs. *SR114_Recommendation_energy.xlsx → C3 System → Row 67*

Table I: Electricity Use – Recommendation – C3 System tab

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Annual Electricity Use for C3 System	• Optimization Review – Section 5.3.1 o "The C3 system uses 281,250 kWh per month, which is 75% of the total remedy electricity use of 4,500,000 kWh per year." • 75% of 4,500,000 kWh = 3,375,000 kWh	*On-Site Electricity Use* Input: 3375000 3375000 kWh, Energy Used *SR114_Recommendation_energy.xlsx → C3 System → Row 59*

<u>Recommendation SEFA file input – Alternative System Components</u>

The Alternative System tab of the Recommendation SEFA file has revised electricity use and includes natural gas use. These inputs are based on Section 6.2.1 of the Optimization Review Report which states that the C3 systems could be replaced with a regenerative thermal oxidizer. In addition to replacing the C3 units, Section 5.1.6 of the Optimization Review Report states additional savings could be made by replacing the zeolite wheel concentrator with a vapor GAC unit. This increase to the amount of GAC used has also been documented below and is included in the Alternative System tab.

Table J: Material Use – Recommendation – Alternative System tab

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Treatment Material – Virgin GAC	• Optimization Review – Section 5.1.6 o The first suggestion states that the zeolite wheel concentrator could be replaced with Vapor GAC • TT assumed that the additional Vapor GAC unit would consume approximately 10,000 lbs of GAC a year	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 10000 lbs. *SR114_Recommendation_energy.xlsx → Alternative System → Row 67*

Table K: Electricity Use – Recommendation – Alternative System tab

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Annual Electricity Use for Regenerative Thermal Oxidizer	• Optimization Review – Section 6.2.1 o "Thermal oxidizer for the deep SVE system using 66,780 kWh per year of electricity"	*On-Site Electricity Use* Input: 66780 66780 kWh, Energy Used *SR114_Recommendation_energy.xlsx → Alternative System → Row 59*

Table L: Natural Gas Use – Recommendation – Alternative System tab

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SEFA
Annual Natural Gas Use for Regenerative Thermal Oxidizer	• Optimization Review – Section 6.2.1 o "thermal oxidizer for the deep SVE system using 24,623 hundred cubic feet (ccf) of natural gas" o Thermal oxidizer running at 289,521 BTU per hour "to represent both the fuel to be added to the thermal oxidizer (in this case propane) as well as the combustion of the site-related VOCs"	*On-Site Natural Gas Use* Input: Regenerative Thermox System, 289521 power rating, 100% efficiency, 8760 total hours 24623.34, Total ccf Used *SR114_Recommendation_energy.xlsx → Alternative System → Row 45*