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Optimization Review
Fairfield Coal Gasification Plant Superfund Site

Fairfield, Iowa

OPTIMIZATION REVIEW

FAIRFIELD COAL GASIFICATION PLANT SUPERFUND SITE
FAIRFIELD, IOWA

Report of the Optimization Review
Site Visit Conducted at the Fairfield Coal Gasification Plant Superfund Site on
February 14, 2012

Final Report
July 30, 2012

EXECUTIVE SUMMARY

Optimization Background

The U.S. Environmental Protection Agency's (USEPA) working definition of optimization as of December 2011 is as follows:

"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness and cost efficiency, and to facilitate progress toward completion of site work."

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 one 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 prior to implementation of the recommendation. Note that the recommendations are based on an independent review and represent the opinions of the review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the 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).

Site-Specific Background

The Fairfield Coal Gasification Plant (FCGP) also known as the Fairfield Former Manufactured Gas Plant (MGP) is located in the southwest 1/4 of the southeast 1/4, Section 26, Township 72 North, Range 10 West of Jefferson County, Iowa. The former FCGP address is 107 South Seventh Street in Fairfield, Jefferson County, Iowa. The former FCGP occupied 1.3 acres in area and is bordered by commercial and residential areas. The site is currently owned by Interstate Power and Light Company, an Alliant Energy subsidiary.

For the purpose of this report, the site is defined as the former FCGP and the parcel south of Washington Street that is currently occupied by the groundwater treatment plant and the former southern gas holder. This area includes approximately 3 acres and is bordered to the north by Burlington Street, to the east by residential property to the southwest and west by a salvage operation and to the south by residential property. Washington Avenue is orientated east to west and divides the site into two areas. Approximately two thirds of the site is located to the north of Washington Avenue and one third is located to the south.

Summary of Conceptual Site Model

The site geology consists of glacial deposits that generally have low hydraulic conductivity. Zones of higher conductivity (sand and gravel) are present at 35 to 55 below ground surface (bgs) but are not continuous and, therefore, poorly connected. Despite the low hydraulic conductivities, coal tar migrated from the former MGP structures to a maximum depth of 44 feet bgs near extraction well EX-4. Once the coal tar reached the lower cohesive unit it migrated through the discontinuous zones of higher conductivity in the direction of groundwater flow. Groundwater flows toward the southeast at 6 to 13 feet per year. Coal tar migrated horizontally over 200 feet to the southeast and was observed at 30 feet bgs in borings completed near the southern gas holder tank foundation. Dense non-aqueous phase liquid (DNAPL) remains measureable at times in extraction well EX-1 in this area. Coal tar was not encountered in the lower cohesive unit in this area. The lower cohesive unit may have limited the vertical migration of the coal tar. However, no monitoring wells are screened in the lower cohesive unit near EX-1; therefore, the vertical extent of groundwater impact is not defined in this area.

Removal of source structures and highly impacted soils during the 1993-1995 excavations has eliminated the primary source of coal tar at the site. This effort likely eliminated the largest driver for continued coal tar migration and has eliminated direct contact concerns from impacted surface materials.

Groundwater has been impacted by the coal tar and a dissolved groundwater plume exists at the site. However, the concentration of contaminants in the dissolved groundwater plume only exceed the remediation standards identified in the Record of Decision (ROD) in monitoring wells where coal tar was observed during the well installation. Evidence of bioremediation was documented in the 2004 Monitored Attenuation Report prepared by Black and Veatch. The groundwater monitoring data indicates that the plume is stable. It is possible that the rate of groundwater flow is in equilibrium with the rate of natural attenuation and results in a stable groundwater plume.

Summary of Findings

Based on a review of the information provided to the optimization review team, the site visit conducted on February 14, 2012, and interviews with persons knowledgeable about the site, the following main findings have been identified:

- Source structures and impacted soil removal may have limited the further migration of coal tar in the subsurface. Additional monitoring may be required to prove this finding.

- The dissolved phase groundwater plume appears to be stable, but additional monitoring is required to confirm plume stability.

- Given the nature of the site contaminant, the low permeability of site soils, and existing structures that can interfere with further source area remediation, the optimization review team believes that restoration of the aquifer in a timely manner is likely impractical and supports the establishment of Technical Impracticability Waivers for Areas 1, Area 2 and Area 3.

Summary of Recommendations

Recommendations are provided to improve remedy effectiveness, reduce cost, provide technical improvement, and assist with accelerating site closure. The recommendations in these areas are as follows:

Improving effectiveness – The current monitoring program suggests that the plume is stable, but there is no monitoring in the lower cohesive unit. The optimization review team suggests installing two deep monitoring wells to prove that the vertical migration of contamination is limited by the lower cohesive unit. The following wells are recommended: a well west of extraction well EX-4, and a well near MW-15. The wells should be doubled-cased with the outer casing extending past the known extent of contamination to about 55 feet bgs and the screen interval located between 65 and 70 feet bgs. Well construction would likely cost on the order of $33,000 – $50,000 for drilling, oversight, handling of investigation derived waste (IDW), surveying, and sampling for two events. Additional costs would be incurred for planning and reporting results. Water quality monitoring for two events will help determine if contamination is present at this depth, and water level measurements will help identify the general direction of groundwater flow.

Reducing cost – Given the stability of the observed dissolved plume and the DNAPL plume, and the limited mobility of coal tar, monitoring of DNAPL levels in the site wells can be reduced to once per year, in conjunction with the annual sampling. The optimization review team expects that this might reduce costs by approximately $5,000 per year.

Technical improvement – The optimization review team recommends adding an aerial photo to the existing figures to help orientate the reader to the site and providing trend charts for key monitoring wells instead of the data tables on the maps. The cost for implementing this recommendation is negligible.

Site closure – Given the site conditions, the optimization review team believes that it is impractical to achieve DNAPL remediation and aquifer restoration of the source area in a timely manner. Given the previous substantial source removal activities and the demonstration of plume stability for a 10-year period, the optimization review team believes that institutional controls (IC) and continued monitoring of plume stability is an appropriate remedial strategy for this site.

No opportunities were identified for meaningful reduction of the remedy’s environmental footprint.

NOTICE

Work described herein was performed by Tetra Tech GEO for the U.S. Environmental Protection Agency (USEPA). Work conducted by Tetra Tech GEO, including preparation of this report, was performed under Work Assignment 2-58 of USEPA 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 practices from remedial investigation to site completion implemented by the United States Environmental Protection Agency (USEPA) Office of Superfund Remediation and Technology Innovation (OSRTI). The project contacts are as follows:

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LIST OF ACRONYMS

µg/L	Micrograms Per Liter
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	Below Ground Surface
BETX	Benzene, Ethylbenzene, Toluene And Xylene
BMP	Best Management Practice
COC	Chemical of Concern
CSM	Conceptual Site Model
DNAPL	Dense Non Aqueous Phase Liquid
FCGP	Fairfield Coal Gasification Plant
FS	Feasibility Study
FYR	Five Year Review
gpm	Gallons Per Minute
IDNR	Iowa Department Of Natural Resources
IDW	Investigation Derived Waste
IC	Institutional Controls
IE	Iowa Electric Power and Light Company
IPL	Iowa Power and Light
LTM	Long-Term Monitoring
MGP	Manufactured Gas Plant
MNA	Monitored Natural Attenuation
msl	Mean Sea Level
NPL	National Priorities List
ORP	Oxidation-Reduction Potential
OSRTI	Office of Superfund Remediation and Technology Innovation
OU	Operable Unit
PAHs	Polynuclear Aromatic Hydrocarbons
P&T	Pump and Treat
PRP	Potential Responsible Party
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSE	Remedial System Evaluation
SVOCs	Semi-Volatile Organic Compound
TI	Technical Impracticability
USEPA	United States Environmental Protection Agency
VI	Vapor Intrusion
VOC	Volatile Organic Compound

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001, independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, U.S. Environmental Protection Agency (USEPA) 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 *OSWER Directive No. 9283.1-25, Action Plan for Groundwater Remedy Optimization*. Concurrently, USEPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). USEPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, and RSEs. USEPA's working definition of optimization as of December 2011 is as follows:

> *"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site completion."*

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 (e.g., focus on long-term monitoring [LTM] optimization or focus on one particular operable unit [OU]), but other site or remedy components 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, 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 reviews. The optimization review includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
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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 prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation and represent the opinions of the review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the 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 recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and USEPA OSRTI.

The Fairfield Former Manufactured Gas Plant (MGP) also known as the Fairfield Coal Gasification Plant Site (FCGP) is located at 107 South Seventh Street in Fairfield, Jefferson County, Iowa. The 1.3 acre site is bordered by commercial and residential areas. The site is bordered on the north by Burlington Street, on the east by residential property, on the south by an electrical substation and a salvage operation, and on the west by Seventh Street and residential property. The site was nominated for an optimization review by USEPA Region 7 given long-term interest by the Potential Responsible Party (PRP) in seeking a Technical Impracticability (TI) waiver.

1.2 TEAM COMPOSITION

The optimization review team consisted of the following individuals:

Name	Affiliation	Phone	Email
Tonya Howell	USEPA Region 7	913-551-7589	howell.tonya@epa.gov
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Jill Stevens	Interstate Power & Light (Alliant Energy)	608-458-0446	jillstevens@alliantenergy.com
Barbara Butler	Black & Veatch	913-458-6547	butlerba@bv.com
Kathy Yager	USEPA-HQ	617-918-8362	yager.kathleen@epa.gov

1.3 DOCUMENTS REVIEWED

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

- *Fairfield TI Evaluation Report* (Black & Veatch – August 2011)
- *2009 Groundwater Monitoring Report* (Black & Veatch – December 31, 2009)
- *Vapor Intrusion Evaluation Report* (Black & Veatch – July 2008)
- *Third Five Year Review* (USEPA, Region 7, Kansas City, KS – September 12, 2007)
- *2004 Monitored Natural Attenuation* (Black & Veatch – April 2005)
- *Second Annual MNA Report* (Black & Veatch Corp. – December 30, 2003)

- *Revised Approach to Groundwater Management* (Black & Veatch, Corp. – April 2001)
- *Operations and Maintenance Reports (Black & Veatch, Corp. – 1995, 1996, 1998, 1999, 2000, 2001)*
- *Additional Site Characterization Report* (Black & Veatch, LLP – June 1998)
- *Remedial Action Report for the Source Material and Contaminated Soils at the Fairfield Coal Gasification Site* (Bruce Morrison – August 1995)
- *Operations and Maintenance Manual Volume 1* (June 1992)
- *Phase II Remedial Action Air Monitoring Report Volume II* (Black & Veatch Waste Science, Inc. – August 1995)
- *Remedial Investigation/Feasibility Study Report Volume 1, Volume 2, Volume 3* (Black & Veatch Waste Science and Technology Corp. – June 1990)

1.4 QUALITY ASSURANCE

This optimization review utilizes existing environmental data to interpret the CSM, evaluate remedy performance, and make recommendations to improve the remedy. The quality of the existing data used during the review was evaluated by the optimization review team as appropriate. Data 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 made to improve data quality.

1.5 PERSONS CONTACTED

A stakeholders meeting was held on February 14, 2012, at the Fairfield Public Library in Fairfield, Iowa. The following persons were present for the stakeholders meeting:

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Tonya Howell	USEPA Region 7	howell.tonya@epa.gov
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Barbara Butler	Black & Veatch	butlerba@bv.com
Kathy Yager	USEPA-HQ	yager.kathleen@epa.gov

2.0 SITE BACKGROUND

2.1 LOCATION

The Fairfield Coal Gasification Plant (FCGP), also known as the Fairfield Former Manufactured Gas Plant (MGP), is located in the southwest 1/4 of the southeast 1/4, Section 26, Township 72 North, Range 10 West of Jefferson County, Iowa. The address of the former FCGP is 107 South Seventh Street in Fairfield, Jefferson County, Iowa. The former FCGP occupied 1.3 acres in area and is bordered by commercial and residential areas. The site is currently owned by Interstate Power and Light Company an Alliant Energy subsidiary.

For the purpose of this report, the site is defined as the former FCGP and the parcel south of Washington Avenue that is currently occupied by the groundwater treatment plant and the former southern gas holder. This area includes approximately 3 acres and is bordered to the north by Burlington Street, to the east by residential property, to the southwest and west by a salvage operation, and to the south by residential property. Washington Avenue is orientated east to west and divides the site into two areas. Approximately two thirds of the site is to the north of Washington Avenue and one third is to the south.

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND OPERATIONS

Coal gasification operations began at the FCGP site in 1878. The plant utilized a blue gas process until 1937 when the production was changed to a carburetted water gas process. Blue gas (sometimes called coal gas) was produced by reacting coal or coke with steam to yield a gas rich in hydrogen and carbon monoxide. The heating value of blue gas is enriched by adding petroleum oils. The blue gas is then thermally cracked to gaseous constituents known as the carburetion process. The resulting product was known as carburetted water gas or simply "water gas." Coal tar sludge, iron oxide wastes, and associated coal gasification wastes were generated at the plant during operations.

Most of the tar sludge containing polynuclear aromatic hydrocarbons (PAHs) was sold as a by-product for use as wood preservative, road treatment, and for coal tar refining. An undetermined amount of tar sludge was disposed in the gas holder pit, the 1927 tar separator and purifier pit, the relief gas holder, and in the nearby south drainage ditch. Elevated levels of benzene, ethylbenzene, toluene, and xylenes (BETXs) are also present in the tar sludge remaining on-site.

The site has been used for utilities since at least 1878. The site produced blue gas from 1878 to 1937. In 1937, the site switched to producing carbureted water gas. In 1950, the gas system in Fairfield was converted to natural gas. Operations at the MGP were terminated and the interior of the building was modified for use as an operations facility for Iowa Electric Power and Light Company (IE). In 1988, IE stopped using the site as a base for natural gas and electrical distribution systems maintenance operations. Currently, the site is used to stage electrical distribution supplies such as electrical cable. In addition, two electrical substations are located on the site and the groundwater treatment building is located on the portion of the site south of Washington Avenue.

2.2.2 Chronology of Enforcement and Remedial Activities

A 1986 study for IE discovered PAH compounds in soil and groundwater at the FCGP site. A 1987 study for the USEPA detected PAHs immediately adjacent to the FCGP site and PAHs, metals and cyanide on site. Based on these results, the site was proposed for the USEPA National Priorities List (NPL) in 1988. The site was listed on the NPL in August 1990. In 1989, IE and USEPA entered into an Administrative Order on Consent to construct and operate an interim groundwater treatment system and conduct a Remedial Investigation/Feasibility Study (RI/FS) for the FCGP site. In 1990, the RI/FS was completed and a ROD selecting the remedy was signed for the FCGP site. The following is a summary of the major remedial actions:

- An interim groundwater extraction and treatment system was constructed in late 1989 to extract water from highly contaminated areas and to dewater excavations associated with subsequent source material removals. The system operated until 1995.
- Removal actions were completed from June 1993 to July 1995 to remove source areas and to excavate contaminated soil to a depth of 6 feet below ground surface (bgs).
- In 1995, a permanent groundwater treatment system was constructed in a building on the south side of Washington Avenue. Groundwater extraction and treatment continued through July 2001, when the treatment system was shut down to evaluate alternate groundwater remedies. The system remains in place.
- In 1992 and 1993, an *in situ* bioremediation pilot study was conducted.
- Between 1993 and 2001, groundwater monitoring was conducted to evaluate the effectiveness of the treatment system.
- In 1997, additional site characterization activities were completed to further define the groundwater contaminant plume and to evaluate the effectiveness of the groundwater extraction system in capturing the plume.
- In 2001, a revised approach to groundwater management was implemented consisting of a monitored natural attenuation (MNA) demonstration. Groundwater extraction and treatment ceased in order to determine if MNA was occurring.
- Semi-annual groundwater monitoring as part of the MNA program was completed between 2001 and 2004.
- Since 2005, annual groundwater monitoring has been completed.
- Since mid-2007, quarterly monitoring of dense non-aqueous phase liquid (DNAPL) levels in selected wells has been completed.
- A vapor intrusion (VI) evaluation was conducted in 2007.

2.3 Potential Human and Ecological Receptors

Impacts at the site are limited to subsurface soil and groundwater. The exposure assumptions used to develop the Human Health Risk Assessment included both current exposures (off-site residents) and future exposures (off-site workers, on-site workers, and off-site residents). The following pathways were identified:

- Exposure of current residents to off-site contaminated groundwater through occasional ingestion of well water during outside activities, ingestion of garden produce watered with contaminated groundwater, and inhalation of contaminants volatilized during watering.
- Exposure of future workers on-site and off-site to contaminated soil through dermal contact and ingestion.

- Exposure of future residents to off-site contaminated groundwater used as a primary potable water source.

2.4 EXISTING DATA AND INFORMATION

The information provided in this section presents data available from existing site documents.

2.4.1 SOURCES OF CONTAMINATION

The contamination associated with the FGCP site is a result of the by-products generated from the production of coal gas. Compounds commonly found in coal tar include PAHs and BETX. While in operation, most of the coal tar sludge produced was sold as a by-product. An undetermined amount of coal tar sludge was disposed in the gas holder pit, the 1927 tar separator and purifier pit, and the relief gas holder. According to the Remedial Investigation (RI) completed in 1990, these areas are the three most probable sources of groundwater contamination at the FCGP site. In addition to these three source areas, other source areas (purifier pits, pipe chases, a second tar separator, and a tar well) were discovered during removal actions. All of these structures and associated contaminated soil were removed between 1993 and 1995.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

Site Geology
Jefferson County, Iowa is located in the Southern Iowa Drift Plain, which covers most of the southern half of Iowa. This landform consists of rolling hills of Wisconsin-age loess on Illinoian (or earlier) till. The local surface site geology is derived from Illinoian till and consists of four primary stratigraphic units as described in multiple site documents Black and Veatch:

- *Surface Fill* consists of a variety of material including silty clay, gravelly clay, silty sand, sand, gravelly sand, clayey gravel, silty gravel, gravel, and concrete and brick rubble. Thickness ranges from 0 to 20.3 feet. The fill is thickest in the areas of the relief gas holder pit, the former railroad right-of-way, and the former tar separator;
- *Shallow Cohesive Unit* consists of brown to gray silty clay with a trace of sand, gravel, cobbles, roots, root vesicles, and iron oxide nodules. Hairline fractures and iron-oxide staining are also present. Cohesive unit 1 is encountered at 1.5 to 14.5 feet bgs and ranges in thickness from 16 to 34 feet;
- *Interbedded Granular and Cohesive Unit* includes discontinuous sand and gravel beds within a silty clay. The silty clay is brown to gray in color, has a low plasticity, and contains minor sand and gravel. This unit is encountered at 25.5 to 35.5 feet bgs and ranges in thickness from 7 to 21 feet; and
- *Lower Cohesive Unit* of silty clay is encountered at 35 to 52 feet bgs and is 25 feet thick in the FI-3D boring that completely penetrated the unit, which overlies bedrock.

The bedrock beneath the lower cohesive unit is shale of the Pennsylvanian Age from the Lower Cherokee Group. The shale was encountered in boring FI-3D at 77 feet bgs and was described as dark-gray, thin-bedded, and slightly-weathered.

Site Hydrogeology
Groundwater is present as a localized perched system in the fill and as an unconfined system within the shallow cohesive, interbedded granular and cohesive, and deep cohesive units (collectively glacial drift). The localized perched water in the fill unit was removed and treated during soil excavations performed during the removal actions. Localized sand units in the interbedded granular and cohesive unit were determined to be the principal pathway for migration of contaminated groundwater and DNAPL. Falling head permeability, slug and aquifer pumping tests were performed to quantify the hydraulic conductivity of groundwater systems. Tables 1 and 2 summarize these results.

Table 1. Falling Head Permeability Test Summary

Geologic Unit	Test Location	Depth (feet bgs)	Test	Hydraulic Conductivity (cm/sec)
Shallow Cohesive Unit	Boring FI-6	8.5 – 11.0	Laboratory Falling Head Permeability Test	$1.7\text{x}10^{-8}$
Shallow Cohesive Unit	Boring FI-6	22.0 – 22.5	Laboratory Falling Head Permeability Test	$1.7\text{x}10^{-7}$
Interbedded Granular and Cohesive Unit	Boring FI-7	52.5 – 54.5	Laboratory Falling Head Permeability Test	$1.2\text{x}10^{-8}$
Deep Cohesive Unit	Boring FI-7	54.5 – 55.9	Laboratory Falling Head Permeability Test	$1.5\text{x}10^{-8}$

Table 2. Slug and Aquifer Pump Test Summary

Geologic Unit	Test Location	Depth (feet bgs)	Test	Hydraulic Conductivity (cm/sec)
Shallow Cohesive Unit	Monitoring Well FI-5	12.0 – 22.0	Monitoring Well Slug Test	$2.4\text{x}10^{-4}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-3	22.3 – 37.3	Monitoring Well Slug Test	$9.5\text{x}10^{-6}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-8	25.5 – 34.5	Monitoring Well Slug Test	$3.6\text{x}10^{-4}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-8	25.5 – 34.5	Extraction Well EX-1 Pump Test	$4.5\text{x}10^{-5}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-9	25.3 – 39.3	Extraction Well EX-1 Pump Test	$6.3\text{x}10^{-5}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-6	31.5 – 45.5	Monitoring Well Slug Test	$1.7\text{x}10^{-4}$
Shallow Cohesive Unit/Interbedded Granular and Cohesive Unit	Monitoring Well FI-7	34.0 – 48.0	Monitoring Well Slug Test	$6.2\text{x}10^{-5}$
Deep Cohesive Unit	Monitoring Well FI-3D	68.1 – 77.1	Monitoring Well Slug Test	$6.0\text{x}10^{-5}$

Water levels have been collected as part of routine groundwater sampling for more than 20 years. Generally, the depth to water varies from 5 to 20 feet bgs with the shallowest depths to water measured just south of the groundwater treatment building near monitoring wells MW-13 and MW-15, and the greatest depths to water measured along Washington Avenue in monitoring wells FI-3D, FI-4 and MW-16. Water levels indicate that the groundwater flow direction within the glacial drift is from the northwest to the southeast and exists at two general elevations. The August 11, 2011 water levels in the northeast portion of the site are approximately 762 feet above mean sea level (msl) and approximately 748 feet above msl to the southeast. These two areas are separated by a transition zone of approximately 250 to 500 feet indicating the hydraulic gradient ranges from 0.03 to 0.06. Sites with similarly significant hydraulic gradients typically indicate that the water bearing units have relatively low hydraulic conductivity. Groundwater velocity at the site is 0.02 to 0.04 feet per day or 6 to 13 feet per year (based on this gradient, the average hydraulic conductivity from the EX-1 aquifer pump test, and an effect porosity of 25 percent).

The results from the hydraulic testing and the water level measurements indicate the water bearing formation in the glacial drift does not represent a significant source of water and has a low enough hydraulic conductivity to be eligible for regulation by State of Iowa non-protected groundwater standards. The City of Fairfield obtains drinking water from the Cambrian-Ordovician bedrock aquifer that is separated from the glacial drift at the site by more than 400 feet of unconsolidated and consolidated deposits.

2.4.3 SOIL CONTAMINATION

In a 1986 study conducted for IE, PAH compounds were found on site in both the soil and groundwater. In a 1987 investigation by USEPA, elevated levels of PAHs were identified immediately adjacent to the old FCGP site, and concentrations of PAHs, metals, and low concentrations of cyanide were detected in soil samples collected in the drainage ditch south of the FCGP site. Removal actions were completed from June 1993 to July 1995 to excavate and remove source areas. Approximately 8,530 tons of material were excavated and used as a fuel substitute at a cement kiln (hazardous material) or thermally treated in a utility boiler (non-hazardous material).

Soil excavation outside of the source structures and north of Washington Avenue was generally limited to a depth of 6 feet bgs, based on the depth to groundwater. Soil below the relief gas holder, formerly located immediately north of Washington Avenue along the adjacent former 7th Street right-of-way, was excavated to a depth of 23 feet bgs. Contaminated soil was removed from the 38-foot diameter gas holder pit along Burlington Avenue in the northeast portion of the site to a depth of 10 feet bgs where clay was encountered. The gas holder base located south of Washington Avenue was not remediated. The gas holder base is an aboveground structure with a 2-foot thick foundation and remains in place. All visible MGP impacts in soil borings advanced in this area were observed at depths of 17 feet bgs or greater, with the majority of impacts present at depths below 27 feet bgs.

Elevated concentrations of PAHs and BETX are likely present in fractures and pore spaces of the shallow cohesive and the interbedded granular and cohesive units below the groundwater table and remain the primary source of contamination at the site. Residual soil contamination that may remain at the site is likely present in inaccessible locations below substations and existing utilities.

2.4.4 SOIL VAPOR OR INDOOR AIR CONTAMINATION

In 2008 a VI investigation was performed to determine if contaminated soil gas was migrating into on-site structures. Soil gas samples were collected from 10 soil probe locations near the groundwater treatment building. Four of these locations were advanced near existing monitoring wells that had elevated benzene concentrations in groundwater. None of the soil gas samples had detections of benzene above the screening level. Volatile organic compounds (VOCs) were detected in eight of the ten probes; however, the detected concentrations were below the USEPA screening levels for shallow soil gas.

Black and Veatch re-evaluated the data collected in 2008 based on updated USEPA VI guidance published in 2008, 2009, and 2010. Only one of the soil gas samples contained benzene at a concentration above the 2011 USEPA industrial air screening levels. This sample was collected near the relief gas holder and well EX-4 where an electrical substation has been constructed. Other VOCs (ethylbenzene, 1,3-dichlorobenzene) were detected in 8 of 10 probes. Black and Veatch indicated that all of the detections of other VOCs were below the USEPA standards by at least one order of magnitude. Based on the results of the investigation, VI was not considered a concern at the site.

2.4.5 GROUNDWATER CONTAMINATION

Wells EX-1, EX-4, and MW-15 consistently contain benzene and naphthalene at concentrations exceeding standards established in the ROD. The ROD standard for toluene has also been exceeded in extraction wells EX-1 and EX-4. Many PAHs have exceeded their respective ROD standards during at least one round of monitoring in both extraction wells. However, downgradient monitoring wells FI-4 and MW-14 have not exceeded a ROD standard in the previous seven sampling rounds (from February 2004 through August 2010). The other downgradient well, MW-16, had one exceedance during this same time period.

Despite evidence of residual DNAPL in the groundwater, the concentrations of PAHs and BETXs have remained low, if not non-detect, immediately downgradient of former site source areas. In downgradient wells MW-13, MW-14, and MW-16, no PAHs have exceeded the groundwater remediation levels specified in the ROD.

2.4.6 REMAINING DNAPL

DNAPL is present in clay fractures primarily in the upper cohesive unit (primarily north of Washington street) and in the discontinuous sand lenses of the interbedded unit from 25 to 45 feet bgs. DNAPL is also present south of Washington Avenue within the interbedded unit in the area of the groundwater treatment building and the gas holder base south of Washington Avenue. DNAPL has been measured in wells both north (FI-3 and EX-4) and south (EX-1) of Washington Avenue. These are the only wells in which DNAPL has been detected and quarterly measurement of the DNAPL levels has been performed since August 2007. The amounts detected have been highly variable and with the majority not measurable. When present, the DNAPL has generally been observed as intermittent staining along the measurement device. A sheen and strong tar odor have been observed on water removed from well MW-15 (located south of Washington Avenue). DNAPL appears in lower portions of the base of the interbedded unit near extraction wells EX-3 and EX-4. The most significant zone of subsurface DNAPL impact was observed at extraction well EX-4.

2.4.7 SURFACE WATER CONTAMINATION

No known surface water contamination exists at the site.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

This section presents information available from existing site documents. Interpretations included in this section are generally interpretations from the documents from which the information was obtained. The optimization review team's interpretation of this information and evaluation of remedy components are discussed in Sections 4.0 and 5.0.

3.1 REMEDY AND REMEDY COMPONENTS

The site remedy has consisted of several remedy components specified in the 1990 ROD and summarized in the Third Five-Year Review (FYR) and the 2011 TI Evaluation Report. Each of these remedy components is described in the following subsections.

3.1.1 GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

Construction of a groundwater extraction and treatment system was completed in December 1989. Originally designed as an interim treatment system, it was subsequently modified in 1993, and approved by USEPA as a permanent groundwater treatment system. Initially, extraction wells EX-1 and EX-2 were used to capture groundwater. Well EX-2 was abandoned during the source remedial action and replaced with well EX-4. Well EX-3 was installed to capture groundwater south of the Iowa Power and Light (IPL) property, but was abandoned in 1998 when additional investigation showed that the groundwater contaminant plume had not migrated past the property boundary.

The treatment system consists of a settling tank to remove DNAPL from the groundwater, bag filters and a modified clay media for filtration, and activated carbon adsorption. The clay media and activated carbon were used to treat benzene, PAHs, and other VOCs and semi-volatile organic compounds (SVOCs). The initial treatment system was designed to accommodate a flow rate of 20 gallons per minute (gpm). However, a subsequent pump test performed on well EX-1 during implementation of the system exhibited a maximum yield of 0.2 gpm. This yield is two orders of magnitude lower than what was calculated using the slug test data.

Groundwater extraction and treatment continued through July 2001 when the treatment system was shut down to evaluate alternate groundwater remedies. During 11 years of operation, the system treated over 675,000 gallons of groundwater. At the time of the system shut down, groundwater was being treated at a rate less than 0.2 gpm to prevent the wells from pumping dry. The system also recovered approximately 1,900 gallons of DNAPL from the interbedded granular and cohesive unit between August 1995 and April 2001. During the operation period, DNAPL was removed at an average rate of about 30 gallons per month. In 2000, an attempt to maximize the DNAPL extracted by lowering the pump in well EX-4 was not successful as the well contained an insufficient amount of tar.

3.1.2 REMOVAL OF SOURCE MATERIAL

The removal of coal tar source material and contaminated soil began in June 1993 and was completed in June 1995. Approximately 8,280 tons of contaminated soil and source material was excavated and transported off-site for incineration. The excavation removed contaminated soil from the relief gas holder pit, tar separator, and relief gas holder as well as contaminated soil beneath and around each of these former MGP structures. The excavation was conducted in three areas of the site, defined by the former MGP structures located in these areas (Figure 1) as described below:

- Area 1 – The eastern half of this area, located in the northern portion of the site and bordering Burlington Avenue, was excavated to the depth of groundwater during the remedial action, and included the gas holder pit (material removed to 10 feet bgs), the tar tank, the purifier pit, two tar separators, and a portion of the pipe chase.

- Area 2 – The central portion of this area, located in the central portion of the site, north of Washington Avenue, was excavated to the depth of groundwater during the remedial action, and included the relief gas holder (material removed to 23 feet bgs), a portion of the pipe chase, and the tar unloading pit.

- Area 3 – Located in the area of the site South of Washington Avenue, this area is comprised of the area around the gas holder base, which was the foundation for a historic aboveground structure. In addition, during the excavation activities, free phase liquids were removed from the excavation for on-site treatment.

3.1.3 IN SITU BIOREMEDIATION

A pilot-scale *in situ* bioremediation treatment system was designed and constructed in 1992 to evaluate the effectiveness of this technology for remediation at the site. Subsequent evaluations of the pilot-scale system concluded that *in situ* bioremediation was not effective due to the nature of hydrogeologic conditions at the site. Therefore, the pilot-scale *in situ* bioremediation system was terminated after 18 months, and the decision was made to cancel any future *in situ* bioremediation for the FCGP site.

3.1.4 LONG-TERM GROUNDWATER MONITORING

In 2001, a revised approach to groundwater management was implemented, consisting of a MNA demonstration. Groundwater extraction and treatment ceased in order to determine if MNA was occurring. Groundwater samples have been collected from monitoring wells FI-2S, FI-3, FI-3D, FI-4, FI-6, FI-10, FI-13, MW-13, MW-14, MW-15, and MW-16, and extraction wells EX-1 and EX-4. Semi-annual groundwater monitoring, performed as part of the MNA program, was completed between 2001 and 2004. Since 2005, annual monitoring of groundwater conditions has been performed. Since mid-2007, quarterly monitoring of DNAPL levels in selected wells has also been performed.

3.2 RAOS AND STANDARDS

The groundwater remediation levels established for all chemical of concerns (COCs) in groundwater are summarized in Table 3. In addition to benzene, the COCs include other VOCs (toluene, ethylbenzene, and total xylenes) and select PAHs.

Table 3. Potential ARARs and To-Be-Considered Criteria for Consideration as Groundwater Cleanup Standards

Chemical of Concern	ROD Remediation Level (µg/L)[1]	MCL (µg/L)[2]	IDNR Non-Protected Compliance Standard (µg/L)[3]
Benzene	1	5	100
Ethylbenzene	700	700	3,500
Toluene	1,000	1,000	5,000
Total Xylenes	10,000	10,000	50,000
Naphthalene	100	None	700
Benzo(a)pyrene	0.2	0.2	1
Benzo(a)anthracene	0.24	None	4.8
Benzo(b)fluoranthene	0.24	None	4.8
Benzo(k)fluoranthene	2.4	None	48
Chrysene	24	None	480
Dibenzo(a,h)anthracene	0.024	None	0.48
Indeno(1,2,3-cd)pyrene	0.24	None	4.8

Abbreviations and Footnotes:

ARARs = applicable or relevant and appropriate requirements
MCL = maximum contaminant level
IDNR = Iowa Department of Natural Resources
µg/L = micrograms per liter

(1) USEPA 1990.
(2) National Primary Drinking Water Regulations, 40 CFR Part 141.
(3) IDNR 2011.

3.3 PERFORMANCE MONITORING PROGRAMS

Performance monitoring programs were described in Section 3.1.4 as components of the remedy.

4.0 CONCEPTUAL SITE MODEL

This section discusses the optimization review team's interpretation of existing characterization and remedy operation data and site visit observations to explain how historic events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents. CSM elements discussed are based on data obtained from USEPA Region 7 and presented in the preceding sections of this report. This section is intended to include interpretation of the CSM only. It is not intended to provide findings related to remedy performance or recommendations for improvement. The findings and recommendations are provided in Sections 5.0 and 6.0, respectively.

4.1 CSM OVERVIEW

The site geology is typical of glacial till terrain that is present throughout the Midwest. As described in Section 2.4.2, silty clay is the dominate material at the site and has a relatively low hydraulic conductivity. Zones of higher conductivity (sand and gravel) are present at 35 to 55 bgs but are not continuous and, therefore, poorly connected. Despite the relatively low hydraulic conductivities, coal tar migrated from the former MGP structures to a maximum depth of 44 feet bgs near EX-4. Once the coal tar reached the lower cohesive unit it migrated through the discontinuous zones of relatively higher conductivity in the direction of groundwater flow. Groundwater flows toward the southeast at 6 to 13 feet per year. Coal tar migrated horizontally over 200 feet to the southeast and was observed at 30 feet bgs in borings completed near the southern gas holder tank foundation. DNAPL remains measureable at times in extraction well EX-1 in this area. Coal tar was not encountered in the lower cohesive unit in this area. The lower cohesive unit may have limited the vertical migration of the coal tar. No monitoring wells, however, are screened in the lower cohesive unit near EX-1; therefore, the vertical extent of groundwater impact is not defined in this area.

Removal of source structures and highly impacted soils during the 1993-1995 excavations has eliminated the primary source of coal tar at the site. This effort likely eliminated the largest driver for continued coal tar migration and has eliminated direct contact concerns from impacted surface materials.

Groundwater has been impacted by the coal tar and a dissolved groundwater plume exists at the site. However, the dissolved groundwater plume only exceeds ROD remediation standards in monitoring wells where coal tar was observed during the well installation. Evidence of natural attenuation was documented in the 2004 Monitored Attenuation Report prepared by Black and Veatch. The groundwater monitoring data suggests that the plume is stable, and several more years of monitoring would make the determination of plume stability more robust. It is possible that the rate of groundwater flow is in equilibrium with the rate of natural attenuation and results in a stable groundwater plume.

4.2 CSM DETAILS AND EXPLANATION

Additional information and analysis associated with the CSM are discussed in Section 5.0.

4.3 DATA GAPS

There are two primary data gaps at the site:

- The vertical groundwater impacts are not completely defined by monitoring well data.
- The last soil borings were completed in 1997. Insufficient information is available to determine if the DNAPL (coal tar) has stopped migrating with groundwater flow.

4.4 IMPLICATIONS FOR REMEDIAL STRATEGY

Given the CSM characteristics, Black and Veatch prepared a TI Evaluation Report that suggests that no additional remediation of the site is warranted. Black and Veatch divided the site into three areas (Figure 1) based on different conditions where cleanup is impracticable and prepared the following summaries for each area:

- TI Area 1-The eastern half of this area was excavated to the depth of groundwater during the remedial action, and included the gas holder pit (material removed to 10 feet bgs), the tar tank, the purifier pit, two tar separators, and a portion of the pipe chase This area currently contains a substation and a high pressure gas main extends north to south west of well MW-2S. Additional subsurface soil removal, therefore, cannot be performed in this area. Groundwater impacts in this area are minimal. With the exception of one detection of benzene in groundwater in 2008, contamination in well FI-2S is below the remediation standards.

- TI Area 2 -The central portion of this area was excavated to the depth of groundwater during the remedial action, and included the relief gas holder (material removed to 23 feet bgs), a portion of the pipe chase, and the tar unloading pit. This area also contains the substation and support components, as well as the high pressure gas main west of wells FI-3 and FI-3D. Therefore, as with Area 1, additional subsurface removal cannot be performed in this area. Contaminant concentrations in wells FI-3 and EX-4 exceed remediation standards. Well EX-4 has historically also contained DNAPL.

- TI Area 3 -This area is comprised of the gas holder base, which is the foundation for a historic aboveground structure. A substation is located over the eastern portion of the area. While excavation could be completed in portions of this area, impacts are generally below groundwater and deep subsurface sampling in this area shows that soil contamination concentrations are "below levels of concern." Groundwater from Wells MW-15 and EX-1, however, consistently contains chemicals at concentrations above the remediation standards. Groundwater from Well MW-13 intermittently contains benzene at concentrations above the remediation standard. Well EX-1 has also historically contained DNAPL.

The optimization review team generally agrees with these findings; however, additional monitoring data may be required to confirm that the coal tar is no longer migrating vertically and horizontally and that the dissolved plume is stable. Additional discussion is presented in Sections 5 and 6.

5.0 FINDINGS

The findings provided below are the interpretations of the optimization review team. They are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the USEPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.1 SOURCES

Much of the source material below and around the former MGP structures, as well as the structures themselves, has been removed at this site. However, DNAPL is still present in the subsurface and has been detected in extraction wells. As noted in the TI Evaluation, the residual contamination present below the groundwater table in the form of DNAPL will result in a continuous release of dissolved phase contaminants (PAHs and BETX) to the groundwater plume.

5.2 GROUNDWATER

5.2.1 PLUME DELINEATION

The plume is well-defined, and extends to the southern boundary of the IPL property. In addition, groundwater monitoring data collected over the last 10 years indicate that the plume appears to have remained stable. However, the August 25, 2011 groundwater analytical data from MW-13, located just off-site of the southern IPL boundary, indicated that higher concentrations of BETX and SVOCs were present and benzene was above remediation standards presented in the ROD.

5.2.2 Plume Capture

Extraction well EX-1 was designed to capture 20 gpm of groundwater. According to the TI Evaluation Report, a pump test completed after the well was installed showed that the maximum yield of the interbedded unit was only 0.2 gpm with 15 feet of drawdown. Field observations and the results of the pump test indicate that the sand lenses present in the interbedded unit are discontinuous across the site. Wells in this formation have low yields and a minimal radius of influence was observed from the pumped well during the pump test due to the relatively low permeability across the site. In addition, the residual coal tar present below the groundwater table may restrict groundwater flow through the formation and diminished extraction well performance and limited plume capture.

No decrease in the overall size of the groundwater contaminant plume was observed during the years the extraction and treatment system was in operation. Furthermore, groundwater contaminant plume conditions have not changed since the extraction and treatment system was shut down in 2001. Given a groundwater flow velocity of 6 to 13 feet per year, the dissolved plume should have migrated over 60 to 130 feet over the last 10 years. Monitoring well MW-13 is within 60 feet of MW-15 where significant impacts remain and yet very low levels of BETX and PAHs are present. However, the August 2011 analytical results indicate a very slight increase in BETX and PAHs in this well. Additional sampling will help determine if these increases are part of an increasing trend or random fluctuations.

The estimated groundwater flow velocity used in the above analysis would be lower if contaminant adsorption and retardation are considered, but the estimated groundwater flow velocity could be significantly higher if the effective porosity is lower than the assumed 0.25. Given the presence of low permeability material and the likelihood that groundwater preferentially flows through thin discontinuous sand or gravel lenses, the effective porosity is likely lower than 0.25. Absent additional information, it is reasonable to assume for calculation purposes that the retardation and a lower effective porosity would offset each other and that 6 to 13 feet per year is a reasonable estimate of the groundwater flow velocity. However, to be conservative, additional sampling is merited to confirm that contaminant concentrations are not increasing over time in MW-13 and that the plume is stable.

5.2.3 GROUNDWATER CONTAMINANT CONCENTRATIONS

The contaminant plume has not migrated any further south than the IPL property boundary on the south side of Washington Street. Groundwater monitoring data collected over the past 10 years indicate that BETX and PAH concentrations in groundwater continue to exceed the remediation standards identified in the ROD for wells where DNAPL is measurable. In addition, DNAPL was observed in the interbedded unit during well installation. In contrast, contaminant concentrations in downgradient wells, which are located between 100 and 200 feet from well EX-1, continue to remain predominantly below detection limits with intermittent low-level detections of benzene, toluene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, or phenanthrene (Figure 1). All of these detections are below the remediation standards identified in the ROD except for several benzene detections that were above the ROD remediation standards but below the MCLs. Groundwater contaminant concentrations in wells located within the plume and wells located immediately downgradient have remained stable since the extraction system was shut down, indicating that the plume is stable. Concentrations of BETX and PAH in groundwater samples collected from MW-13 increased slightly in the recent sampling event performed in August 2011. Additional monitoring is required to determine if this is a new trend that could be indicative of plume migration.

Groundwater samples collected from wells EX-1, EX-4 and MW-15 consistently contain benzene and naphthalene at concentrations exceeding the remediation standards identified in the ROD and the less stringent IDNR compliance standards for non-protected water. The IDNR compliance standard for toluene has also been exceeded in samples from extraction wells EX-1 and EX-4. Many PAHs have exceeded their respective IDNR compliance standards during at least one round of monitoring in both extraction wells. However, groundwater from downgradient monitoring wells FI-4 and MW-14 have not exceeded a ROD remediation standard or the IDNR compliance standard in the last seven sampling rounds performed between February 2004 and August 2010. The other downgradient well, MW-16 had only one exceedance in groundwater during this same time period.

DNAPL continues to be present in FI-3D, EX-1 and EX-4. The December 2011 DNAPL monitoring event indicated 0.17 to 0.08 feet of DNAPL was present in the wells. Despite evidence of residual DNAPL in the groundwater, the concentrations of PAHs and BETX have remained low, if not non-detect, immediately downgradient of former site source areas. In downgradient wells MW-13, MW-14, and MW-16, no PAHs have exceeded the groundwater remediation standards specified in the ROD. While benzene in wells MW-13 and MW-16 has intermittently exceeded the remediation standard in the ROD of 1 microgram per liter (μg/L), the concentrations have never exceeded the 5 μg/L MCL. Therefore, BETX and PAH groundwater contamination can be expected to exceed ROD remediation standards in the immediate vicinity of residual DNAPL, but this above-standard groundwater contamination does not extend more than 50 to 100 feet from the area where DNAPL has been detected, and the plume appears to be stable. The slight increase in BETX and PAHs at MW-13 in 2011 may warrant continued monitoring. In addition, wells FI-11 and FI-12 have not been sampled since 2001. It may be prudent to add these wells to the annual sampling program to confirm that the plume is stable.

5.2.4 NATURAL ATTENUATION

The groundwater plume data indicate that attenuation is occurring and that contaminant migration is retarded by the discontinuity of the sand lenses in the glacial till. Observed MNA trends include consistently elevated alkalinity, low oxidation-reduction potential (ORP), the presence of methane, and reduced nitrate, manganese, and iron. The MNA parameters indicate that contaminants are degrading as they are released into solution. No degradation products such as lighter PAHs have been detected in the downgradient wells, which may indicate that the degradation products are also attenuating before reaching the wells and or that flow is being retarded by the discontinuous sand lenses.

5.3 VI POTENTIAL AND AIR QUALITY

In 2008, the potential for contaminant migration from MGP-impacted groundwater as soil gas into overlying and nearby buildings was evaluated. Probes were advanced to collect soil gas samples to assess the level of benzene in the subsurface and to determine if contaminated gas was migrating to the on-site building. Soil gas probes were also advanced and sampled at the locations of several site wells to determine the concentration of benzene at depth in relation to the elevated concentrations of benzene in the groundwater at these wells.

Only one of the soil gas samples contained benzene above the USEPA industrial air screening level (USEPA 2011). This sample was collected near the relief gas holder and well EX-4 where the site has already been developed as a substation. Other miscellaneous VOCs (e.g., ethylbenzene, 1,3-dichlorobenzene) were detected in 8 of 10 probe samples. All concentrations were below their respective USEPA screening levels by at least an order of magnitude. Based on the results of this investigation, VI is not a concern at this site.

5.4 TREATMENT SYSTEM COMPONENT PERFORMANCE

Extraction well EX-1 was designed to capture 20 gpm of groundwater. According to the TI Evaluation Report, a pump test completed after the well was installed showed that the maximum yield of the interbedded unit was only 0.2 gpm with 15 feet of drawdown.

The extraction well pumps were periodically removed and cleaned. The DNAPL caused the bottom check valve in the pumps to seat improperly. This issue diminished over time. The extraction wells were never redeveloped or cleaned.

No issues with the treatment system components were reported.

5.5 REGULATORY COMPLIANCE

There are no current operating components of an existing remedy at the site and no permits or permit equivalencies in place. As such, there are no findings related to regulatory compliance with respect to remedy operation.

5.6 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

The treatment system has not been in operation since 2001. Therefore, the only current annual costs are those related to the annual groundwater sampling and the quarterly DNAPL monitoring. The costs for these activities for the past five years as provided by the PRP are as follows:

2007 – $47,000
2008 – $59,600
2009 – $35,800
2010 – $38,300
2011 – $51,100

5.7 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

The treatment system has not been in operation since 2001; therefore, no significant environmental footprint is currently associated with the remedy.

5.8 SAFETY RECORD

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

6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement, and site closure strategy. 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.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 EXPAND GROUNDWATER SAMPLING TO BETTER DEFINE THE PLUMES

The current monitoring program suggests that the plume is stable, but the monitoring in the lower cohesive unit is insufficient to confirm plume stability in that unit. The optimization review team suggests installing two deep monitoring wells to confirm whether the vertical migration of contamination is limited by the lower cohesive unit. The following wells are recommended: a well west of EX-4, and a well near MW-15. The wells should be doubled-cased with the outer casing extending past the known extent of contamination to about 55 feet bgs and the screen interval located between 65 and 70 feet bgs. Well construction would likely cost on the order of $33,000 – $50,000 for drilling, oversight, handling of IDW, surveying, and sampling for two events. Additional costs would be incurred for planning and reporting results. Water quality monitoring for two events will help determine if contamination is present at this depth, and water level measurements will help identify the general direction of groundwater flow.

The optimization review team also suggests that monitoring wells FI-11 and F-12 be sampled annually as part of the annual sampling program over the next 5 years to confirm that no downgradient migration has occurred. The documents provided indicate that these wells have not been sampled since 2001 and detectable concentrations of VOCs were last observed in 1998. However, groundwater flow velocity is relatively slow at the site and these wells may have been well beyond the limit of the plume 10 years ago. The cost for adding these two wells to the annual sampling program should be under $1,000 per year, including labor and analysis.

6.1.2 DNAPL PUMP INSTALLATION

Recovery of DNAPL from monitoring or extraction wells can be inefficient when the level of DNAPL observed in the well is less than 0.5 to 1 foot of discrete free product. However, should monitoring indicate an increase in DNAPL accumulation in the extraction or monitoring wells, it may be advisable to install pumps specifically designed by vendors for the recovery of DNAPL (e.g., those available from vendors such as Xitech or Blackhawk Technology Company). The pumps could be configured on timers to pump periodically to a container such as a 55 gallon drum, or be configured for operation during monitoring events. The optimization review team has not provided a cost for this item because it believes it is unlikely that this type of pump will be needed.

6.2 Recommendations to Reduce Costs

Annual costs for this site include only annual groundwater monitoring and quarterly DNAPL monitoring. Thus, opportunities for cost savings are limited. However, as discussed below, there is at least one opportunity to reduce annual costs.

6.2.1 Reduce DNAPL Monitoring Frequency

Given the stability of the observed dissolved plume and the DNAPL plume, and the limited mobility of coal tar, monitoring of DNAPL levels in the site wells can be reduced to once per year, in conjunction with the annual sampling. The optimization review team expects that this might reduce costs by approximately $5,000 per year.

6.3 Recommendations for Technical Improvement

A few recommendations are provided that could improve data management associated with the site and with assisting future evaluations.

6.3.1 Improve Monitoring Reports

The optimization team recommends adding an aerial photo to the existing figures to help orientate the reader to the site and providing trend charts for key monitoring wells instead of the data tables on the maps. The cost for implementing this recommendation is negligible.

6.4 Considerations for Gaining Site Close Out

Given the site conditions, the optimization review team believes that DNAPL remediation and aquifer restoration of the source area is impractical to achieve in a timely manner. Given the previous substantial source removal activities and the demonstration of plume stability of a 10-year period, the optimization review team believes that ICs and continued monitoring of plume stability is an appropriate remedial strategy for this site.

6.4.1 DNAPL Remedial Options

The groundwater contaminant plume conditions have not changed since the extraction and treatment system was shut down in 2001. The stability of the plume and the ineffectiveness of the system in reducing contaminant concentrations are in part related to the presence of DNAPL, in the form of residual coal tar, in the formation below the site. As noted in the TI Evaluation, the presence of DNAPL in the subsurface hinders the success of any extraction system or *in situ* treatment process. Complete DNAPL removal is limited by its physical properties and the discontinuous characteristics of the interbedded unit at the site. Unless the DNAPL is removed, a groundwater extraction remedy is unlikely to attain ROD remediation standards in a time frame that would be considered reasonable.

The amounts of DNAPL historically detected have been highly variable and generally not measurable. If present in a well, the DNAPL has generally been observed as intermittent staining along the measurement device. A sheen and strong tar odor have been observed on groundwater removed from well MW-15, located south of Washington Avenue. DNAPL appears in lower portions of the base of the interbedded unit near extraction wells EX-3 and EX-4. The maximum thickness of DNAPL impacts were observed during the installation of extraction well EX-4 when coal tar was observed in various intervals from 25 to 44.5 feet bgs.

The stability of the plume, as described by the lack of further migration to the south or overall plume expansion, may make further attempts to recover DNAPL of limited benefit as related to overall impacts to groundwater. Some options for removal of the DNAPL are presented and evaluated below.

- **Operation of the extraction and treatment system** – Despite the extraction wells and pumps not being designed to specifically remove DNAPL, 1,900 gallons of DNAPL were extracted between August 1995 and April 2001. This recovery was largely incidental to the operation of the system. Re-starting the system and reconfiguration of the extraction wells (for example, installation of pumps more appropriate for DNAPL recovery) will likely not be effective because the DNAPL is currently present not as a saturated zone or thickness but as blobs, lenses and stringers. The system will not recover discontinuous quantities of free product, which typically cannot be drawn into a well. The efficiency of a DNAPL extraction system decreases rapidly as the DNAPL saturated thickness decreases. Pneumatic fracturing of the subsurface could be used to increase the yield of the extraction wells; however, fracturing could present concerns for the existing infrastructure in the area. In addition, pneumatic fracturing might increase well yield, but would not meaningfully increase DNAPL recovery to the point where aquifer restoration would be achievable. Therefore, the optimization review team believes that this option would not provide a meaningful improvement for timely DNAPL remediation or aquifer restoration.

  Excavation – Excavation of the DNAPL-impacted soil at depth is possible using a variety of techniques. However, the presence of the sub-station, gas lines, as well as other utilities and roadways, will make it impractical to remove all of the residual DNAPL. Furthermore, the depth of the material (30 to 40 feet bgs), and its presence well below the water table, would make this option difficult to implement.

- ***In Situ* treatment options**

  - **Air sparging/soil vapor extraction** – These technologies are not effective with the semi- and non-volatile chemical constituents that comprise the majority of the coal tar mass. Furthermore, the DNAPL is present below the water table. Therefore, the optimization review team believes this option would not be beneficial.
  - **Water Flooding** – This technology introduces forced water into the area around the extraction wells to force recovery. However, it is aimed at removing pools of DNAPL but will not significantly reduce residual DNAPL in the form of stringers and blobs. Therefore, the optimization review team believes this option would not be beneficial.
  - **Chemical oxidation** – Oxidation of coal tar has been found to be largely ineffective, and has the potential to promote significant additional generation of vapor and heat, potentially resulting in a soil vapor exposure pathway where none previously existed. In addition, because of the impermeable nature of the subsurface material, effective delivery of the reagents would be difficult. Therefore, the optimization review team believes that this option would not provide a meaningful improvement for timely DNAPL remediation or aquifer restoration.
  - **Bioremediation** – This option would be limited to aqueous phase contamination at the interface of the free phase product and the surrounding water column and, therefore, may require a long period of time to reach site closure. Further, the toxicity of coal tar may significantly inhibit microbiological activity and limit the effectiveness. The relatively impermeable nature of the subsurface material would limit the delivery of bioremediation

nutrients. Therefore, the optimization review team believes that this option would not provide a meaningful improvement for timely DNAPL remediation or aquifer restoration.

  - **Thermal treatment** – This technology can be implemented by introducing heat to the subsurface in conjunction with soil vapor extraction, or simply to dissolve or mobilize the DNAPL for extraction via wells. Injection of high pressure steam may present physical hazards such as soil fracturing. The presence of the DNAPL below the water table would require large amounts of energy to sufficiently heat the DNAPL to mobilize it. Although heating would remove additional DNAPL mass, given the existing structures that would need to be avoided, it is unlikely that all DNAPL mass would be removed, and the optimization review team expects that there will be sufficient DNAPL remaining after remediation to prevent groundwater from meeting cleanup standards in a reasonable time frame. In addition, mobilization of DNAPL through heating without sufficient hydraulic controls could have the unintended consequence of allowing the DNAPL to further migrate from the site, expanding the plume extent. Therefore, the optimization review team believes that this option, despite the substantial level of effort and resources, would not result in complete DNAPL removal and restore the aquifer in a reasonable time frame.

- ***In situ* stabilization** – This option would not remove the DNAPL, but would eliminate it as a contributor to the dissolved plume. The presence of the sub-station, gas lines, and other utilities and roadways make this option impractical for addressing the DNAPL in all of the areas where it is expected to occur. Furthermore, the monitoring data indicates that the DNAPL and dissolved plume are currently stable, and stabilization would provide no additional benefit. Therefore, the optimization review team believes that this option would not be beneficial for DNAPL remediation.

- **Containment** – A cut off wall, in the form of sheet piling or a slurry wall, would isolate the area where DNAPL is present, and would prevent potential lateral movement of the residual DNAPL or dissolved plume migration. However, the presence of the sub-station, gas lines, and other utilities and roadways make this option difficult if not impractical to implement. The characteristics of the residual DNAPL make it unlikely that it would migrate. Furthermore, the monitoring data indicates that the DNAPL and dissolved plume are currently stable, and containment would provide no additional benefit. Therefore, optimization review team believes that this option would not be beneficial for DNAPL remediation.

Given the above options analysis and the apparent stability of the PAH and BETX plumes, the optimization review team does not believe that practical remedial options are available that would achieve DNAPL remediation and aquifer restoration in a meaningful time frame.

6.4.2 POTENTIAL PATH FORWARD

Although the plume appears to have been stable over the past 10 years, the optimization review team suggests conducting annual sampling for another 5 years to further evaluate plume stability. Given the relatively slow groundwater flow at the site and the general uncertainty in the groundwater flow velocity, an additional 5 years of annual sampling should help determine if contamination can migrate as far as MW-13 under non-pumping conditions. If the monitoring results in MW-13, other site wells, and the new wells suggest a stable plume, then the monitoring frequency could likely be reduced further, perhaps to coincide with each Five-Year Review. If monitoring results suggest the plume is migrating past MW-13 or one of the new deeper wells, the site team could install additional wells approximately 50 feet to 100 feet downgradient of MW-13 and monitor them for a number of years to determine if the plume stabilizes within that short distance. If the additional monitoring 50 feet to 100 feet downgradient of MW-13 suggests the plume continues to migrate, then some form of active remediation may be needed. Given the above concerns regarding effective source area remediation, an effective strategy may be to contain the plume hydraulically with groundwater extraction and treatment or with an *in situ* technology (for example, bioremediation).

The optimization review team agrees that no practical means exists to treat remaining impacts in the proposed TI Areas. However, if impacts are detected beyond the limit of the proposed TI Areas, additional treatment may be required to limit further migration. Treatment could include *in situ* methods (for example, oxygen or nutrient addition) to create a reactive zone at the downgradient boundary of the TI zone, hydraulic control through the use of recovery trenches, or off-site extraction wells. Recovered water could be treated at the existing treatment building.

6.5 RECOMMENDATIONS RELATED TO GREEN REMEDIATION

The current remedy has a very low environmental footprint. No green remediation recommendations are provided.

6.6 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The suggested order for implementing recommendations, along with estimated cost information, is provided in Table 4. The first step should be to conduct the expanded groundwater sampling event. Many of the additional evaluations and actions will depend on the results obtained from that event.

Table 4. Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
6.1.1 EXPAND GROUNDWATER SAMPLING TO BETTER DEFINE THE PLUMES	Effectiveness	$33,000 to $50,000	$1,000	$63,000 to $80,000	$53,000 to $70,000
6.1.2 DNAPL PUMP INSTALLATION	Effectiveness	No cost estimates provided			
6.2.1 REDUCE DNAPL MONITORING FREQUENCY	Cost Reduction	$0	($5,000)	($150,000)	($98,000)
6.3.1 IMPROVE MONITORING REPORTS	Technical Improvement	Negligible change in costs			
6.4.1 DNAPL REMEDIAL OPTIONS	Site Closure	No cost estimates provided			
6.4.2 POTENTIAL PATH FORWARD	Site Closure	No cost estimates provided			

** Assumes additional 30 years of system operation*
*** Assumes a discount rate of 3%*

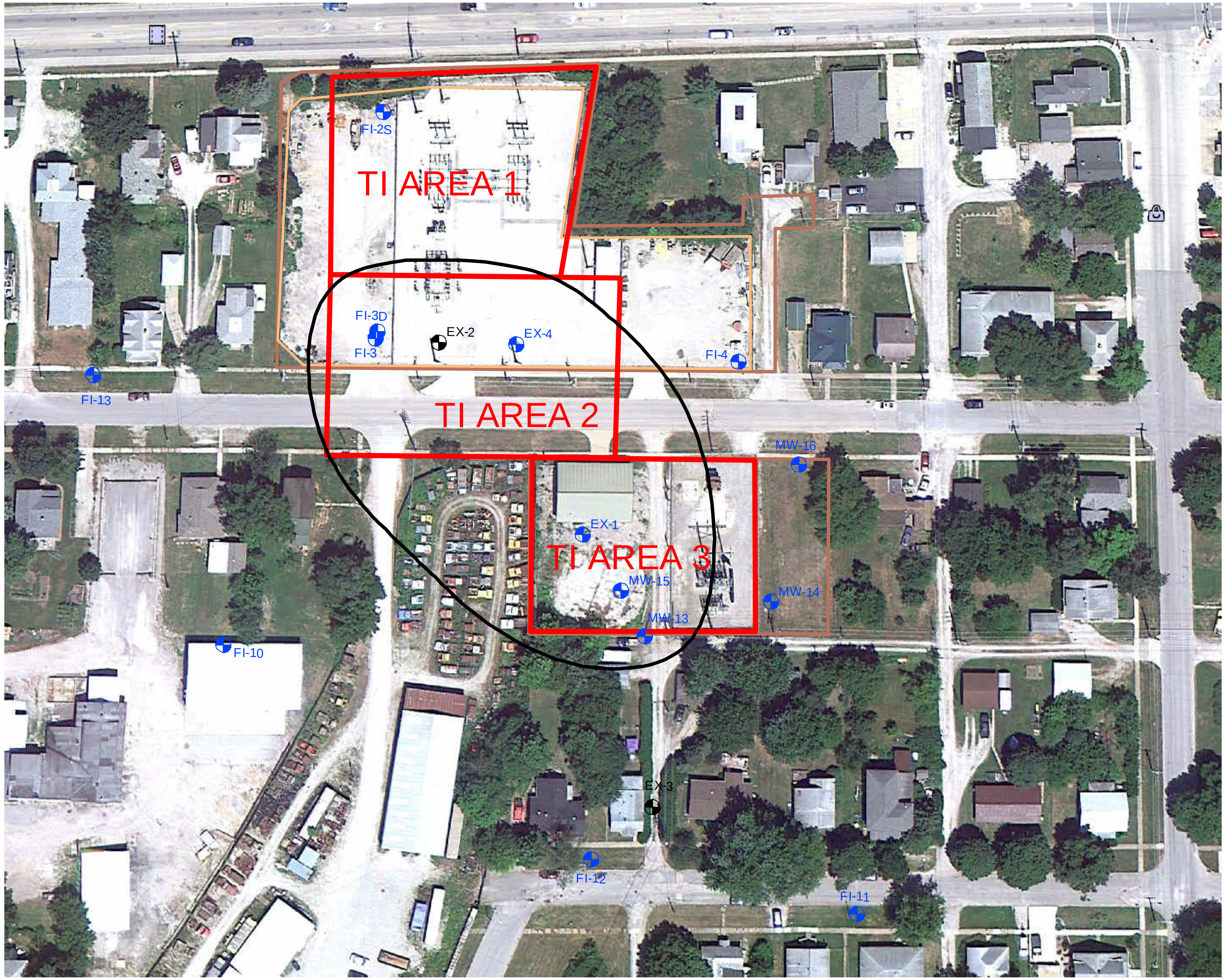
TABLE 6-1
Cost Summary Table

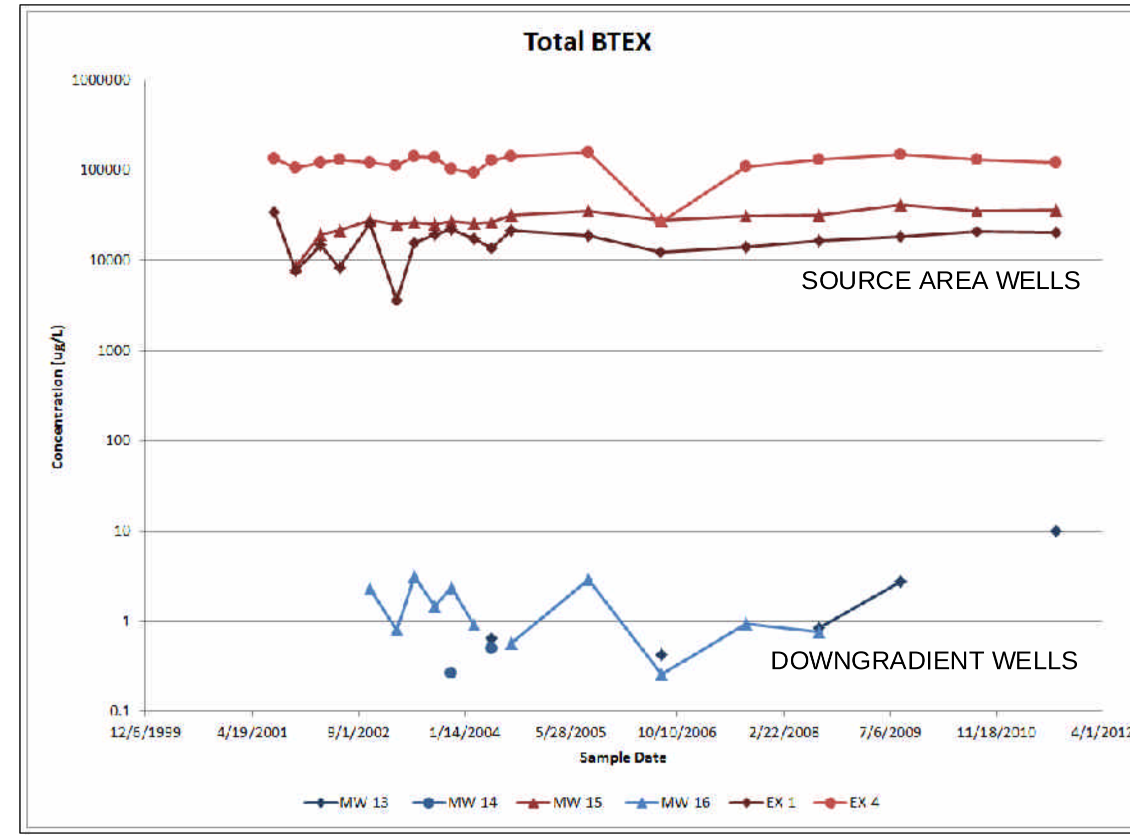
Table 6-1. Cost Summary Table

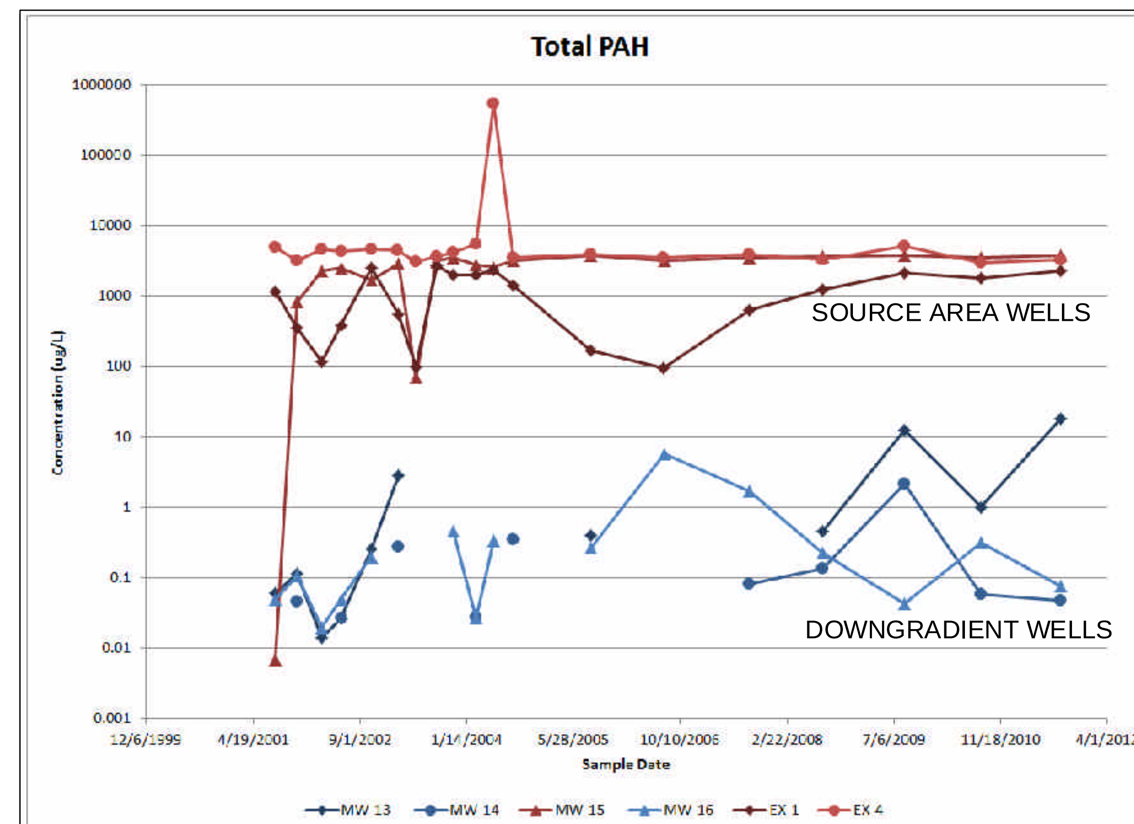
Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
6.1.1 EXPAND GROUNDWATER SAMPLING TO BETTER DEFINE THE PLUMES	Effectiveness	$50,000 to $75,000	$1,000	$80,000 to $105,000	$70,000 to $95,000
6.1.2 DNAPL PUMP INSTALLATION	Effectiveness	No cost estimates provided			
6.2.1 REDUCE DNAPL MONITORING FREQUENCY	Cost Reduction	$0	($5,000)	($150,000)	($98,000)
6.3.1 IMPROVE MONITORING REPORTS	Technical Improvement	Negligible change in costs			
6.4.1 DNAPL REMEDIAL OPTIONS	Site Closure	No cost estimates provided			
6.4.2 POTENTIAL PATH FORWARD	Site Closure	No cost estimates provided			

** Assumes additional 30 years of system operation*
*** Assumes a discount rate of 3%*

FIGURE 1
General Site Map







LEGEND

PROPERTY BOUNDARY
MGP SITE FENCE
TI WAIVER AREA
EXTENT OF BENZENE (>1 ug/L ON 8/25/11)

FI-12 WELL LOCATION

EX-3 ABANDONED WELL LOCATION

100' 50' 0 100' 200'

SCALE: 1" = 100'

N

TETRA TECH

CHECKED: MSK DATE: 5/10/2012

NOTE: AERIAL PHOTOGRAPHY JULY 2, 2011 FROM GOOGLE EARTH
ALL WELL LOCATIONS ARE APPROXIMATE BASED ON PREVIOUS MAPS

OPTIMIZATION REVIEW REPORT
FAIRFIELD COAL GASIFICATION PLANT SUPERFUND SITE
FAIRFIELD, IOWA

GENERAL SITE MAP

FIGURE 1

P:/Projects/EPA/Fairfield, Iowa/Figures 03/27/12 AGO 1

ATTACHMENT A
Photo Log

Photo Documentation Log

<table>
<tr><td>Photo: 1</td><td rowspan="4"></td></tr>
<tr><td>Direction: Northwest</td></tr>
<tr><td>Description:
Electrical substation to the North Northwest of the groundwater treatment plant. Also includes TI Areas 1 and 2.</td></tr>
<tr><td>Date: February 14, 2012</td></tr>
</table>

<table>
<tr><td>Photo: 2</td><td rowspan="4"></td></tr>
<tr><td>Direction: North</td></tr>
<tr><td>Description:
Fenced area, cable storage to the north of the groundwater treatment plant</td></tr>
<tr><td>Date: February 14, 2012</td></tr>
</table>

Photo Documentation Log

Photo: 3	
Direction: Southeast	
Description: View of the groundwater treatment plant from Washington Street	
Date: February 14, 2012	

Photo: 4	
Direction: Northwest	
Description: View of the groundwater treatment plant from Alley, includes gas holder base in foreground and includes Western portion of TI Area 3. EX-1 is located near the building along the southern berm.	
Date: February 14, 2012	

Photo Documentation Log

Photo: 5	
Direction: North	
Description: View of the groundwater treatment plant from Alley, includes gas holder base in foreground and includes Western portion of TI Area 3. EX-1 is located near the building along the southern berm.	
Date: February 14, 2012	

Photo: 6	
Direction: North	
Description: Western side of the groundwater treatment plant, EW-1 is near the building on the right side of the photo.	
Date: February 14, 2012	

Photo Documentation Log

Photo: 7	
Direction: NA	
Description: EX-1	
Date: February 14, 2012	

Photo: 8	
Direction: North	
Description: Electrical substation, TI Areas 1 and 2. Former Rail line ran through this area, currently serves as a utility corridor.	
Date: February 14, 2012	

Photo Documentation Log

Photo: 9

Direction: Northeast

Description:

EX-4 in the eastern central portion of TI Area 2.

Date: February 14, 2012

Photo: 10

Direction: Southeast

Description:

Adjacent property to the west is used as salvage yard for vintage Dodge power wagons, parts, service and storage.

Date: February 14, 2012

Photo Documentation Log

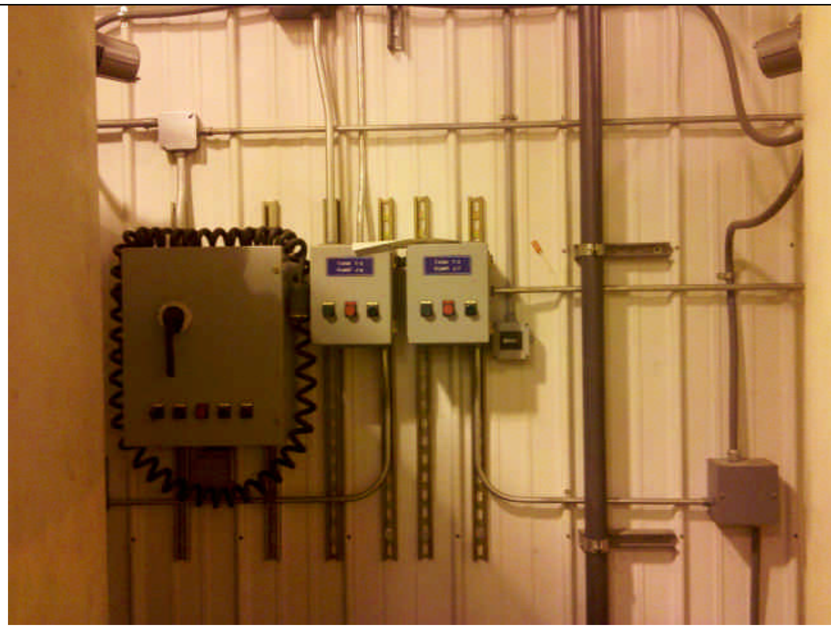
Photo: 11	
Direction: NA	
Description: Extraction well electric starters and general controls	
Date: February 14, 2012	

Photo: 12	
Direction: East	
Description: Typical piping	
Date: February 14, 2012	

Photo Documentation Log

Photo: 13

Direction: NA

Description:

Carbon vessels

Date: February 14, 2012

Photo: 14

Direction: East

Description:

Equalization tank used to collect DNAPL

Date: February 14, 2012

Photo Documentation Log

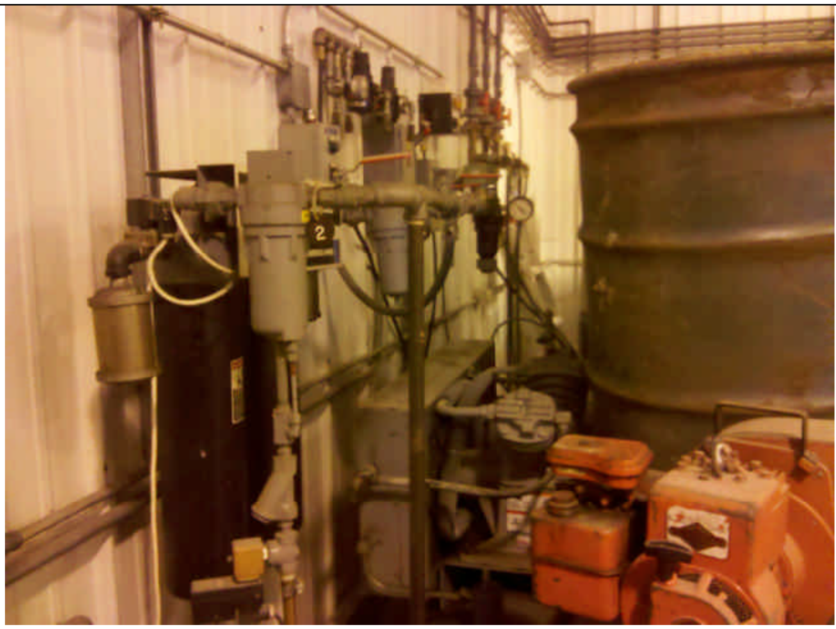
Photo: 15	
Direction: NA	
Description: System compressor and associated filter and controls	
Date: February 14, 2012	

Photo: 16	
Direction: East	
Description: Compressed air lines to extraction wells and return groundwater extraction lines from extraction wells.	
Date: February 14, 2012	

Photo Documentation Log

Photo: 17

Direction: NA

Description:

Main extraction well lines

Date: February 14, 2012

Photo: 18

Direction: East

Description:

Additional conveyance lines

Date: February 14, 2012

Photo Documentation Log

Photo: 19

Direction: NA

Description:

Main pre-carbon equalization tanks

Date: February 14, 2012

Photo: 20

Direction: East

Description:

Vapor phase carbon connected to pre-water treatment equalization tanks

Date: February 14, 2012

Photo Documentation Log

Photo: 21

Direction: NA

Description:

Equalization tanks with vapor phase carbon connected at the bottom of the photo.

Date: February 14, 2012

Photo: 22

Direction: East

Description:

Main storage and service area northwest corner of the building.

Date: February 14, 2012