UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6

RECORD OF DECISION
HUDSON REFINERY SUPERFUND SITE
OKD082471988
CUSHING, OKLAHOMA
November 2007

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LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-Containing Material
AOC	Area of Concern
API	American Petroleum Institute
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Aboveground Storage Tank
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
ESD	Explanation of Significant Difference
ft/day	feet per day
FR	Federal Register
FS	Feasibility Study
HEAST	Health Effects Assessment Summary Tables
HF	Hydrofluoric Acid
HI	Hazard Index
HQ	Hazard Quotient
HRS	Hazard Ranking System
IC	Institutional Control
IRIS	Integrated Risk Information System
LDR	Land Disposal Regulations
LNAPL	Light Non-Aqueous Phase Liquid
LTU	Land Treatment Unit
MCL	Maximum Contaminant Level
mg/kg	milligram/kilogram
mg/l	milligram/liter
µg/l	microgram/liter
MW	Monitoring Well
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFRAP	No Further Remedial Action Planned
NOAEL	No Observable Adverse Effects Level
NOWP	North Oily Water Pond
NPL	National Priorities List
NWI	National Wetland Inventory
O&M	Operation and Maintenance
ODEQ	Oklahoma Department of Environmental Quality
OPA	Oil Pollution Act
OSWMA	Oklahoma Solid Waste Management Act
OW	Oily Water

OWRB	Oklahoma Water Resources Board
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PM10	Small Particulate Matter
PRP	Potentially Responsible Party
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SF	Slope Factor
SH	State Highway
Site	Hudson Refinery Superfund Site
SLERA	Screening Level Ecological Risk Assessment
STSC	Superfund Technical Support Center
SVOC	Semivolatile Organic Compound
TAG	Technical Assistance Grant
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEL	Tetraethyl Lead
TSP	Total Suspended Particles
UCL	Upper Confidence Limit
USDOT	United States Department of Transportation
USFWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compound

PART I: THE DECLARATION

1.0 SITE NAME AND LOCATION

The Hudson Refinery Superfund Site is located in Cushing, Oklahoma, Payne County. The National Superfund Database Identification Number is OKD0082471988.

2.0 STATEMENT OF BASIS AND PURPOSE

This decision document presents the "Selected Remedy" for the Hudson Refinery Superfund Site (hereinafter "the Site," Figure 1 - Site Location Map) which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), 42 United States Code §9601 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, as amended.

The State of Oklahoma, acting through the Oklahoma Department of Environmental Quality (ODEQ), concurs with the selected remedy.

3.0 ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

4.0 DESCRIPTION OF THE SELECTED REMEDY

The overall cleanup strategy for this Site is to reduce the amount of contamination in soil, waste pond sediment, waste pond surface water and ground water to protect both human and ecological receptors. The selected remedy treats and/or removes the source materials constituting principal threats at the site. The Selected Remedy is estimated to cost $9,650,443. The components of this alternative are described in detail in Section 19.0 (Selected Remedy) of this ROD. Briefly, the major components of this alternative are:

- Institutional Controls – The process and tanks areas of the Site will be available for a reasonably anticipated reuse of commercial/industrial; therefore, Institutional Controls (ICs) will be required to aid in the management of waste left on-site for each of media listed below. ICs will include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, land use restrictions, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline. The ICs will be implemented and monitored by the ODEQ. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors until completion of Site cleanup. Current Site zoning is for industrial use.

- Other Media – Removal of Asbestos-Containing Material (ACM), Coke Tar, and Scrap Metal – ACM will be excavated, containerized, and transported to a regulated off-site disposal facility. Coke tar will be excavated, stabilized, and transported to a regulated off-site disposal facility. Material, including tanks and metal debris, that remains at the Site will be removed and salvaged. If any of the material is not salvageable, it will be disposed of at an authorized off-site disposal facility.
- Soil – Excavation and Off-site Disposal at Permitted Facility – Soil and waste will be excavated and transported to an off-site disposal facility. These areas include the North Refinery (North Tank Farm Area) and South Refinery (South-South Tank Farm Area, South Process Area, Northeast-South Tank Farm Area, North-South Tank Farm Area, and South Refinery Other Areas).
- Waste Pond Sediment – Excavation, Stabilization and Off-site Disposal at Permitted Facility – Contaminated sediment from waste ponds and sumps will be excavated, stabilized, and transported to an off-site disposal facility. These sediments will be excavated from the Aeration Pond 7 and Sumps, Wastewater Ponds 1 and 2, and the Coke Pond. The ponds will be backfilled, revegetated, and closed.
- Waste Pond Surface Water – On-site Treatment – Surface water from the ponds with contaminated sediment and water from ponds that are leveled to ensure proper site drainage will be treated on-site and discharged or transported off-site for disposal.
- Light Non-Aqueous Phase Liquid – Hydrocarbon Belt Skimmers – Light non-aqueous phase liquid (LNAPL) recovery skimmers and monitoring will be implemented where LNAPL has been observed. Recovered LNAPL will be contained in drums for off-site disposal or recycling.
- Ground Water – Ground Water Monitoring – A ground water monitoring plan will be developed during the remedial design and implemented to further delineate ground water contamination. The ground water analytical data collected will be evaluated to identify the potential for off-site migration to occur and to ensure that the areas with contamination are stable and/or decreasing.

5.0 STATUTORY DETERMINATIONS

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action (unless justified by a waiver), is cost effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The Selected Remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduce the toxicity, mobility, or volume of hazardous substances through treatment) for coke tar, sediment and surface water. The Selected Remedy does not satisfy the statutory preference for treatment as a principal element of the remedy for ACM, scrap metal, soil, LNAPL, and ground water for the following reasons. Scrap metal and soil do not contain hazardous levels of contaminants and treatment would be cost-prohibitive. The ACM is contained to a small and localized pile and treatment would be cost prohibitive. LNAPL has been found in one well and ground water sampling downgradient and laterally has shown that the LNAPL is localized to this one location. Ground water contamination has been found in discrete areas and has not migrated off-site. Treatment of the LNAPL and ground water would also be cost prohibitive. The Selected Remedy is expected to be most compatible with the long-range future land use described in the City of Cushing's letter of intent. (Appendix A)

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unrestricted use and unrestricted exposure, a statutory review will be conducted within five years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

6.0 DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision (Part 2). Additional information can be found in the Administrative Record file for this Site.

- Chemicals of concern and their respective concentrations (Section 14.1.1)
- Baseline risk represented by the chemicals of concern (Section 14.1.4)
- Cleanup levels established for chemicals of concern and the basis for these levels (Sections 15.1 and 19.4.3, Table 14)
- How source materials constituting principal threats are addressed (Section 18.0)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of ground water used in the Baseline Human Health Risk Assessment and ROD (Sections 13 and 19.4)
- Potential land and ground water use that will be available at the site as a result of the Selected Remedy (Sections 13 and 19.4)
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Sections 16.1 and 19.3; Tables 13, 13A-13H, and 16)
- Key factor(s) that led to selecting the remedy (i.e. describe how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Sections 14.3, 17.10, 19.1, and 20.0; Tables 12A-12H and 16)

7.0 AUTHORIZING SIGNATURE

This ROD documents the Selected Remedy for the Hudson Refinery Superfund Site. This remedy was selected by the Environmental Protection Agency (EPA) with the concurrence of the ODEQ. The Director of the Superfund Division (EPA, Region 6) has been delegated the authority to approve and sign this ROD.

U.S. Environmental Protection Agency (Region 6)

By:

Pamela Phillips, Acting — Nov. 23, 2007

Samuel Coleman, P.E., Director — Date
Superfund Division (6SF)

CONCURRENCE PAGE – RECORD OF DECISION
HUDSON REFINERY SUPERFUND SITE

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PART 2: THE DECISION SUMMARY

This Decision Summary provides a description of the site-specific factors and analyses that led to the selection of ICs, the remedies for “other media,” and soil, waste pond sediment, waste pond surface water, LNAPL, and ground water remedies for the Site. It includes background information about the Site, the nature and extent of contamination found at the Site, the assessment of human health and environmental risks posed by the contaminants at the Site, and the identification and evaluation of remedial action alternatives for the Site.

8.0 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The Site is located in the City of Cushing in Payne County, Oklahoma. (See Figure 1 – Site Location Map) The National Superfund Database Identification Number is OKD082471988. The ODEQ is the lead agency for conducting the Remedial Investigation/Feasibility Study (RI/FS). The EPA is the lead agency for the Site removal, current enforcement activities, and the ROD. The ODEQ is the support agency for the ROD. The potentially responsible parties (PRPs) identified for the Site did not participate in the RI/FS. Ongoing enforcement activities will continue and may result in an agreement for the cleanup of the Site. Otherwise public funds may be used to remediate the Site while enforcement efforts continue with respect to the recovery of costs expended by the government.

The approximately 200-acre Site is located on the west side of the City of Cushing, Oklahoma. The Site is bisected by State Highway (SH) 33 with approximately 165 acres north of SH 33 (North Refinery) and approximately 35 acres south of SH 33 (South Refinery).

The North Refinery is bounded by Depot Avenue to the east, the former Empire Refinery to the north, Kings Highway to the west, and SH 33 to the south. The South Refinery is bounded by Depot Avenue to the east, SH 33 to the north, Violet Avenue to the west, and Moses Street to the south. Residential neighborhoods are located to the east and west of the Site. There are commercial properties to the east and south of the Site. The Site is fenced; access to both the North and South Refinery is through locked gates.

The Site is an abandoned refinery that operated from 1922 until ceasing operation in 1982. Few structures currently remain on the site and much of the Site has been recently graded following the removal actions in 2002 and 2003. The North Refinery topography slopes to the southeast, and the South Refinery is relatively flat, but slopes slightly to the northeast. A Resource Conservation and Recovery Act (RCRA) Land Treatment Unit (LTU), a biotreatment LTU, unlined wastewater treatment impoundments, abandoned pipelines, and a few concrete-lined sumps remain on the Site. One active pipeline runs from east/west and bisects the North Refinery.

9.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section of the ROD provides the history of the Site and a brief discussion of the EPA's and the State's removal, remedial, and enforcement activities. The "Proposed Rule" proposing the Site to the National Priorities List (NPL) was published in the Federal Register (FR) on April 23, 1999 (64 FR 19968). The "Final Rule" adding the Site to the NPL was published in the FR on July 22, 1999 (64 FR 39878).

9.1 History of Site Activities

The now abandoned refinery operated from 1922 until 1982. Over sixty years of refinery operations have resulted in environmental contamination at the Site. The refinery produced liquid propane gas, gasoline, aviation fuel, diesel fuel, and fuel oils. These production activities generated wastes which resulted in the release of hazardous substances at the Site. The North Refinery consisted of a refinery process area, a hydrofluoric acid (HF) alkylation plant, a tetraethyl lead (TEL) building, associated aboveground storage tanks (ASTs), office, storage, and maintenance buildings, and treatment ponds. The South Refinery consisted of a refinery process area, a TEL building, laboratory buildings, ASTs, and an unlined coke pond. (See Figure 2 – Site Layout Map)

Refinery operations took place on the Site from the early 1900s through 1982 when the owners declared bankruptcy and abandoned the Site. Sanborn maps show that refinery operations may have started on the southern portion (south of SH 33) of the Site as early as 1917. Sanborn maps[1] from 1924 and 1931 show two small refineries, Inland Refinery Company and Cushing Refinery & Gasoline Company, on either side of the railroad track and south of SH 33. City of Cushing historical directories show various refineries operating on the site south of SH 33. These directories list – Gustafson & Spencer Refinery Company on the site in 1921, Cushing Refinery & Gasoline Company and Inland Refinery Company on the site in 1926, and Cushing Refinery & Gasoline Co. only on the site in 1938. Title records show the refinery changed ownership in 1943 when it was acquired by Midland Cooperative Wholesale (later Midland Cooperatives). The refinery changed ownership again in 1977 when it was acquired by Hudson Oil Refinery Company and operated by Hudson Refining Company.

The refinery expanded in size during its ownership by Midland Cooperatives. The refinery quadrupled in size in 1952 with the acquisition of property north of SH 33. Refinery records and aerial photographs outline construction of processing units on the southern edge of the portion of the site north of SH 33, including a fluids catalytic cracker plant with a polymerization unit, a platformer, an alkylation plant. Additionally, a delayed coking unit was built on the site south of SH 33. Aerial photographs show an increase, from the 1954 photograph to the 1969 photograph, in the number of refinery tanks with the addition of a concrete-lined aeration pond and six unlined wastewater treatment lagoons covering approximately 40 acres on the north portion of the Site. (See Photograph 1 – 1972 Aerial Photograph of the Refinery)

During Midland Cooperatives' ownership and operation of the refinery, Midland generated various hazardous substances and wastes, including slop oil emulsion solids, heat exchanger bundle cleaning sludge, Associated Petroleum Institute (API) separator sludge, leaded tank bottoms, process waste water, and waste hydrocarbon byproducts. Midland also operated numerous unlined waste ponds and pits, oil skimming ponds, an unlined coke pond, sumps, unlined settling ponds, cooling ponds, holding ponds and drainage ditches/berms for waste disposal. In addition, product and chemical spills and leaks occurred from tanks, ditches/berms, process units and waste areas.

Midland manufactured liquid propane gas, gasoline, diesel fuel, fuel oils and coke. Hudson Refinery continued manufacture of the same products. According to a March 1989 report titled "Comprehensive Ground-Water Monitoring Evaluation Report" by A.T. Kearney, Inc., "The

[1] Sanborn maps were originally created for assessing fire insurance liability in urban areas in the United States (U.S.). The maps include detailed information regarding town and building information in approximately 12,000 U.S. towns and cities from 1867 to 1970.

refinery was purchased from Midland Cooperative in 1977 and produced liquid propane gas, gasoline, diesel fuel, fuel oils and coke until operations were suspended in 1982."

During refinery operation by Hudson Refinery Company, the company applied in 1978 to the State of Oklahoma for a permit to place refining wastes on a 10.7-acre tract, the LTU, on the northwestern portion of the refinery. In 1980 upgrades to the LTU were enacted to increase the capacity of the retention pond and to more fully control LTU runoff and prevention of run-on to the LTU. The LTU was operated until refinery operations ceased. The LTU received the following RCRA hazardous wastes: K0048 (dissolved air flotation waste), K049 (slop oil emulsion solids), K050 (heat exchanger bundle cleaning sludge), K051 (API separator sludge), K052 (leaded tank bottoms), and K087 (decanter tank tar coking-sludge).

9.2 History of Federal and State Investigations and Removal/Remedial Actions

Refining operations ceased in 1982 and the Site was abandoned. Hudson Oil Company filed for bankruptcy in January 1984. On August 8, 1984, the Department of Justice filed a complaint on behalf of the EPA, alleging violations of RCRA statutory and regulatory requirements (E&E, 1999). A Final Consent Decree was filed in 1987, which required corrective actions including tank clean out, soil excavation, removal of sludges and soils from a pond located on the North Refinery, the North Oily Water Pond (NOWP), and biotreatment of contaminated soils, ground water remediation, and ground water monitoring at the LTU (ODEQ, 2003).

Since the early 1980s, areas of the Site have been sampled pursuant to the requirements of the Final Consent Decree or RCRA compliance monitoring. After Consent Decree funds allocated for the cleanup were depleted on November 30, 1993, Hudson filed a motion in the United States District Court of the Western District of Oklahoma (Court) to terminate the Final Consent Decree. The Court recognized that all of the requirements of the Final Consent Decree had not been met; however there were no financial resources remaining, so the Court moved to release Hudson from the obligations of the Final Consent Decree (E&E, 1999). An Order of Closure of the Final Consent Decree was issued in 1994 (ODEQ, 2003).

As part of the proposed relocation of SH 33 through the Hudson Refinery, an Initial Site Assessment was performed by the Oklahoma Department of Transportation (ODOT) to identify the potential of encountering hazardous wastes during highway construction. Eight soil boring samples were taken from zones reported as exhibiting strong petroleum odors found in 14 areas. During soil sampling, carbon disulfide, styrene, naphthalene, and 2-methylnaphthalene were detected and petroleum product was observed floating on ground water as it filled the boreholes. (ODOT, 1991).

In 1995, soils samples were collected for an EPA Site Inspection. These samples indicated inorganic constituents and organic polynuclear aromatic hydrocarbons (PAHs) at the Site. The Site Inspection Prioritization Report also documented that 28,000 pounds of chemicals, including HF, TEL, solid chlorine (hypochlorite), and ethylene dichloride, were stored in on-site buildings (ODEQ, 2003 and Shaw, 2004).

In November 1997, ODEQ requested EPA's assistance on the Site (ODEQ, 2003). Two joint inspections conducted by EPA and ODEQ in 1998 identified open, leaking tanks, stained soil, and debris, damaged and friable asbestos-containing material (ACM) hanging from the refinery vessels and pipes, overflowing ASTs and separators, and numerous deteriorated leaking drums and smaller containers of unknown materials. (See Photograph 2 – Abandoned Refinery Prior to Removal Actions)

In April 1998, Cushing Middle School students started a letter writing campaign to get public officials to investigate the abandoned refineries in the vicinity of Cushing. In September 1998, EPA contractors began emergency cleanup activities. Initial removal activities were focused on the South Refinery and included investigation of radiation sources, demolition of structurally unsafe buildings, removal of TEL, ACM abatement, and disposal of waste containing CERCLA hazardous substances. In addition, removal activities included excavation of oil-contaminated soils; removal of product from ASTs, separators, and sumps; construction of a bioremediation land-treatment unit; and biotreatment of Oil Pollution Act (OPA) wastes. Some removal activities occurred on the North Refinery and included the dismantling of HF alkylation unit which included approximately 5,600 gallons of product, removal of all catwalks from the towers that were left standing, and the removal of TEL ASTs.

Based on the investigation and analytical results from sampling that EPA performed as part of an Expanded Site Inspection in 1998, the Site was placed on the NPL on July 22, 1999.

On August 10, 1998, the Superfund Division Director, gave oral approval for the expenditure of up to $1 million to initiate an emergency removal action on the known existence of 23,000 square feet of loose and friable ACM on the South Refinery. On November 12, 1998, the Director orally approved an additional $750,000 to address the most immediate threats posed by the HF alkylation unit. On March 24, 1999, EPA signed a Removal Action Memorandum to perform the emergency cleanup activities on both the North and South Refineries. The Removal Action Memorandum documented EPA’s determination that the Site presented an imminent and substantial threat to public health and the environment.

On September 25, 2001, EPA signed a non-time critical Removal Action Memorandum to remove or eliminate principal threat wastes, thereby eliminating or reducing risks from potential exposure pathways from those wastes, at the site. From September 2002 through June 2003 EPA conducted a non-time-critical removal action. The areas addressed in this removal action were the: 1) superstructures, refinery process units containing potential hazardous chemicals and substances; and 2) miscellaneous items, including unlined collection basins, a sump, and structurally unsafe buildings. Existing refinery process equipment and structures were dismantled and removed from the site. Friable ACM was removed from process equipment and piping in coordination with decontamination and removal activities. Decontamination and removal of the process equipment required a three-step process that consisted of first draining or evacuating residual liquid contents, followed by disassembly and removal of the equipment, and finally a thorough cleaning of the equipment to remove residual sludge and solids. Few structures currently remain on the site.

Through a State Cooperative Agreement, ODEQ had the lead on conducting the RI/FS for the Site. From 2004 through 2007, ODEQ conducted an RI/FS. The RI identified the types, quantities, and locations of contaminants and the FS developed ways to address the Site contamination.

9.3 History of CERCLA Enforcement Activities

On January 18, 2001, a combination "special notice" and "demand" letter was sent to the PRPs for payment of the removal costs and the conduct of the RI/FS. The “special notice” and "demand" letter neither resulted in payment of past response costs nor the conduct of the RI/FS. As described in Section 9.2, ODEQ conducted the RI/FS.

On June 8, 2001, EPA filed a federal lien on the Site property. The lien notice was recorded on June 8, 2001, in Book 1340 of the Payne County records at pages 213-217. A full description of the property affected by the lien was included with the notice. The lien was amended on January 15, 2002, and recorded in Book 1340 of the Payne County records at pages 185-188. The owners of the property, at the time the amended lien was filed, received notice of the filing. This lien amount includes all response costs that the EPA has incurred and will incur in the future.

In February 2002, EPA issued "104(e) information request letters" to eight owners, operators, and generators associated with the Site. The EPA continues to follow its enforcement process, and will determine whether PRPs will either be pursued for the conduct of the selected remedial action or the recovery of public funds spent addressing the Site.

10.0 COMMUNITY PARTICIPATION

This section of the ROD describes the community involvement activities that have taken place at the Site. The ODEQ and EPA have been actively engaged in dialogue and collaboration with the affected community and have strived to advocate and strengthen early and meaningful community participation during the remedial activities at the Site. These community participation activities during the remedy selection process meet the public participation requirements in CERCLA and the NCP.

10.1 Community Involvement Plan

A Community Involvement Plan was prepared in December 2003. This plan describes the community involvement activities that the ODEQ and EPA have undertaken, and will continue to undertake, during the remedial activities planned for the Site.

10.2 Community Participation Activities

A Fact Sheet was distributed to the community in April 2004 to announce the beginning of the Fund-lead RI/FS. A kick off meeting was conducted in the City of Cushing at City Hall in May 2004. Fact Sheet updates were distributed to the community in November 2004, March 2005, and March 2006, providing an update on the status of the investigation. A public open house was held at the Cushing City Hall in March 2006 to present the results of the RI and Risk Assessment to the community.

The RI/FS and Proposed Plan for the Site were made available to the public in May 2007. These documents can be found in the Administrative Record for the Proposed Plan and the information repositories maintained with the ODEQ Central Records at the Oklahoma City Office, and at the Cushing Public Library. The notice of the availability of these documents was published in the Cushing Daily Citizen on May 17, 2007. A public comment period was held from May 29 to June 29, 2007, for the Proposed Plan. In addition, a public meeting was held on May 31, 2007, to present the Proposed Plan to the community. At this meeting, representatives from EPA and the ODEQ answered questions about the Site and the remedial alternatives outlined in the Proposed Plan. The EPA and ODEQ's response to the comments received during the public comment period for the Proposed Plan is included in the Responsiveness Summary (Part 3), which is part of this ROD.

10.3 Technical Assistance Grant

A Technical Assistance Grant (TAG) was awarded to a local citizens' group to secure the services of a technical advisor to increase citizen understanding of information that was developed about the Site. The TAG was awarded to the "Washington Heights Environmental Coalition" in September 2001, and closed out on July 31, 2004.

10.4 Superfund Redevelopment Initiative Grant

In September 2000, the City of Cushing was awarded a grant to conduct a Redevelopment Pilot Project at the Site. The city received $100,000 to conduct a plan for the redevelopment of the Site that best meets community needs and desires. The community has participated in meetings held by the city to discuss the reuse plans for the property. The City of Cushing sent a letter of intent for Site redevelopment on June 14, 2006, outlining the city's long-range plans. (Appendix A – City of Cushing Letter of Intent for Redevelopment) The city's plans include light industrial/commercial reuse for the South Refinery and a mixed reuse of light industrial/commercial and residential for the North Refinery (see Figure 3 – Cleanup Levels Map).

10.5 Local Site Repository

The purpose of the local Site Repository is to provide the public a location near their community to review and copy background and current information about the Site. The Site's repository is located near the Site at:

Cushing Public Library
215 North Steele
Cushing, Oklahoma 74023
Telephone Number: 918-225-4188

and at the ODEQ office at:

Oklahoma Department of Environmental Quality
707 N. Robinson, 6th Floor Central Records
Oklahoma City, Oklahoma 73102
Telephone Number: 405-702-6145

11.0 SCOPE AND ROLE OF OPERABLE UNITS AND RESPONSE ACTION

The NCP, 40 CFR §300.5, defines an operable unit as a discrete action that comprises an incremental step toward comprehensively addressing Site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the Site.

The EPA and ODEQ have chosen to use only one Operable Unit for this Site. The selected remedy addresses ICs, "other media," contaminated soil, waste pond sediment, waste pond surface water, LNAPL, and ground water. The removal and treatment methods vary depending on the media, and can be found in Section 19 of this ROD. This action will reduce the risks to human and ecological receptors.

This response action applies a comprehensive approach to all Site problems; therefore, only one operable unit is required to remediate the Site. The primary objectives of this action are to remediate the source of contamination at the Site, to reduce and minimize the downward migration of contaminants to the aquifer, and to minimize any potential future health and environmental impacts.

12.0 SITE CHARACTERISTICS

This section of the ROD provides a brief comprehensive overview of the Conceptual Site Model (CSM), a site overview, surface and subsurface features, sampling strategies used in the RI, known or suspected sources of contamination, types of contamination, location of contamination and known or potential routes of migration, and the geology and hydrology at the Site. Detailed information about the Site's characteristics can be found in the RI Report (Burns and McDonnell, 2006).

12.1 Conceptual Site Model

The CSM for the Site identifies the sources of contamination, release mechanisms, pathways for contaminant transport, the exposure route for contamination, and potential receptors. Figure 4 presents a representation of Site contaminant location and movement and potential routes of contaminant migration.

Human Health CSM
The CSM developed in the Baseline Human Health Risk Assessment (BHHRA) is presented in Figure 5. The human health CSM is based on the following exposure pathways: inhalation of outdoor air; ingestion of homegrown produce, ingestion of wild produce, of shallow soil; incidental ingestion and dermal contact with shallow soil. surface soil and subsurface soil; vapor intrusion from soil and ground water; incidental ingestion, dermal contact and inhalation of dust; outdoor vapor inhalation from soil; inhalation of household vapors; outdoor vapor inhalation from ground water; incidental ingestion and dermal contact with surface water; incidental ingestion and dermal contact with sediment; and ingestion of waste pond fish. Receptors evaluated include residents, trespassers, indoor workers, outdoor workers, construction/utility workers, and homeless shelter residents. The exposure pathways are discussed further in Section 14.1.

Ecological Heath CSM
The CSM developed in the Ecological Risk Assessment is presented in Figure 6. The ecological CSM is based on the following exposure pathways: respiration and leaf sorption from air; ingestion, dermal contact and root uptake from surface soils; ingestion, dermal contact, and root uptake from subsurface soil; ingestion, dermal contact, and root uptake from ground water; ingestion, dermal contact, root uptake, and leaf sorption from surface water; ingestion, dermal contact, and root uptake from sediment; and ingestion of waste pond fish. Receptors evaluated include terrestrial flora, wetland flora, aquatic flora, terrestrial fauna, wetland fauna, and aquatic fauna. The exposure pathways are discussed further in Section 14.2.

12.2 Site Overview

The Site is located on the west side of the City of Cushing, Oklahoma, and is the location of an abandoned refinery which has been inactive since 1982. The Site is bisected by SH 33, resulting in a North Refinery area, consisting of approximately 165 acres, and a South Refinery area, consisting of approximately 35 acres. A majority of the structures at the Site associated with the refinery operations (i.e., process equipment, fuel storage tanks, TEL tanks, office buildings, etc.) were removed during removal actions conducted by EPA from 1999 through 2003. Various surface water impoundments (two lined and 14 unlined) remain in the North Refinery area. Two unlined ponds as well as several abandoned buildings remain in the South Refinery area. Both the North and South Refinery areas are fenced with access provided through locked gates. One of the buildings, located in the southeastern portion of the South Refinery, is currently used as a homeless shelter. The homeless shelter is located on the exterior of the fence surrounding the South Refinery in an area where refinery activities did not occur. The City of Cushing has enacted an ordinance that prohibits access to the fenced areas of the Site access until cleanup has been completed.

The ASTs, fuel storage tanks, and TEL tanks in the North and South Refinery tank farm areas were contained with unlined berms. The berms around the tanks were designed to contain spills and overflow from the tanks and also for disposal of miscellaneous tank bottom waste.

12.3 Surface and Subsurface Features

Topography in the South Refinery is relatively flat, with a slight slope down to the northeast. More topographic relief is evident in the North Refinery, with an elevation gain of approximately 100 feet or more from the southeast to the northwest portions of the Site. There is an electrical vault located along the abandoned railroad track in the North Refinery. There are 16 ponds or impoundments located at the Site, 14 in the North Refinery and two in the South Refinery. All but two of the North Refinery ponds are unlined; the Aeration Pond is concrete-lined (See Photograph 3 – Aeration Pond) and Treatment Pond 8 has a geomembrane liner. Both of the South Refinery ponds are unlined. The pond surface water from both the North and South Refineries drain into Skull Creek on the east side of the North Refinery. There are no known areas of archaeological or historical features of importance at the Site. The subsurface aquifers beneath the Site are described in Section 12.9. The Site layout map is illustrated in Figure 2.

A series of three ponds (two are unlined), currently located on the eastern portion of the North Refinery, are located in the area of the NOWP. Based on aerial photography, the ponds were constructed prior to 1977 and were apparently used for storm and process water detention. The ponds were reconfigured prior to 1996, and the oily sludges and soils were reported to have been excavated. A fourth unlined pond appears to have been backfilled or capped and is referred to as the former NOWP (E&E, 1999). South Refinery surface drainage, with both contaminated and uncontaminated process wastewater and storm water, flowed to a concrete-lined American Petroleum Institute (API) separator in the northeast area of the South Refinery then through an unlined channel under SH 33. The flow continued and combined with contaminated and uncontaminated process wastewater and storm water from the North Refinery. The water flowed through an unlined channel to the NOWP area for routing through the wastewater treatment pond system.

The ponds in the NOWP area were constructed in 1972 and were apparently used for storm and process water detention. The ponds were reconfigured prior to 1996 into the current configuration. In 1987 the oily sludges and soils were excavated from the NOWP and Treatment Pond 8 areas by Hudson. Treatment Pond 8 was lined in the late 1990’s. The EPA received complaints that the lined Treatment Pond 8 was being used by trespassers for swimming; during the removal action in 2003 the pond liner was cut and the pond drained into Runoff Pond 9.

Two watersheds are defined on the Site. The first watershed results from refinery process and storm water runoff pumped from the former NOWP and into the aeration pond and wastewater treatment ponds. The second watershed defined on the Site is surface water runoff from the refinery that flowed into the east holding pond. The east holding pond was located where current

Treatment Pond 8 and Runoff Pond 9 are now located. The east holding pond then discharged by gravity to Skull Creek automatically when the water reached a certain level. When the north or south lift stations for pumping the refinery process wastewater to the oxidation ponds was overloaded or out of service the untreated process water would flow into the east holding pond. This resulted in the discharge of untreated process wastewater to Skull Creek. (Williams Brothers Waste Control, 1974)

Skull Creek is an intermittent stream for approximately 1.5 miles, at which point it joins two unnamed creeks upstream of the City of Cushing wastewater treatment plant. Vehicle salvage areas are interspersed in the residential/agricultural area through which Skull Creek flows. The former Empire Refinery is also located in the drainage area for this portion of Skull Creek.

Overland flow is generally from the upland area in the western portion of the Site to the topographically low areas to the east, ultimately draining into Skull Creek at the northeast portion of the Site. The Site is not situated within a flood plain according to the Federal Emergency Management Act Community Panel (E&E, 1999).

12.4 Sampling Strategy

The Phase 1 sampling activities were conducted at the Site from June to November 2004. Background samples were collected to establish a background comparison to on-site contamination concentrations. Phase I sampling included: collection of two background surface soil samples, four background subsurface soil samples, one background ground water sample, two background surface water samples, two background sediment samples, and one background air sample. Analytical samples were analyzed for volatile organic compounds (VOCs), semi-volatile compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals.

Direct-push equipment was used to collect surface and subsurface soil samples from on-site locations. A total of 518 soil samples were collected from 409 locations and field screened using a photoionization detector (PID). The purpose of the field screening was to optimize soil sample location design for the Site.

Surface soil samples were collected to determine the presence and extent of surficial contamination from the land surface to a depth of 0.5 feet below ground surface (bgs). Subsurface soil samples were collected to determine the presence and extent (horizontal and vertical) of contamination. Shallow subsurface soil samples were collected from approximately 0.5 to 2 feet bgs. The deep subsurface soil samples were collected from the interval below two feet bgs exhibiting the highest PID reading or from the total depth of the boring if PID readings were not detected (generally 9 to 15 feet bgs). During Phase 1 sampling, 89 surface soil samples and 84 subsurface soil samples were collected from on-site. The soil samples were analyzed for VOCs, SVOCs, PCBs, and metals. In order to delineate the approximate vertical extent of the contamination under the former TEL sump, six samples were collected for TEL analysis. Additionally, four soil samples were collected from the monitoring well (MW) MW-6 boring for geotechnical analysis.

During Phase 1, monitoring wells MW-1 through MW-7 were installed across the Site to evaluate the overall ground water conditions and to supplement existing Site wells. Monitoring well MW-9 was installed in the southeast corner of the Site to evaluate ground water conditions upgradient of the Site. Samples were collected from 19 monitoring wells [MW-1 through MW-7, MW-9, B-12, 105, 106-2, MW-1(LTU), MW-4 (LTU), OW-A (Oily Water), OW-B, OW-C, OW-2, OW-L, and OW-M]. Analytical samples were analyzed for VOCs, SVOCs, PCBs, metals, and water quality parameters. All existing and new wells were gauged for depth to water measurements and depth to LNAPL with an oil-water interface probe. Slug testing (slug-out method) was performed at monitoring wells OW-2, MW-6 and MW-7 to determine the hydraulic conductivity of the water-bearing media immediately surrounding the well. (Bouwer & Rice, 1976)

Surface water and sediment samples were collected in Phase 1 to evaluate the condition of surface water and sediment at both on-Site and off-Site locations. Twenty surface water samples from on-site surface water impoundments and Skull Creek and 22 sediment samples from on-site surface water impoundments and Skull Creek were collected. These samples were analyzed for VOCs, SVOCs, PCBs, metals and water quality parameters.

Four air samples were collected to evaluate the air quality in the proximity of human and ecological receptors. Sampling locations were chosen to provide a representative worst-case scenario using criteria such as a combination of winds and low precipitation, proximity to water source, access and/or land use to waste source and downwind areas. All samples were analyzed for VOCs, SVOCs, PCBs, metals, total suspended particulates (TSPs), and small particulate matter (PM10).

After review of the Phase I RI data, it was determined that additional sampling was necessary to further define the nature and extent of contamination and impacts to the Site. The following Phase II RI activities were completed between March and July 2005: 1) collection of four background surface soil samples; 2) collection of eight background subsurface soil samples; 3) collection of 81 soil screening samples from 28 locations on-site; 4) collection of 15 surface soil samples from on-site; 5) collection of 23 subsurface soil samples from on-site; 6) collection of one soil sample for geotechnical analysis; 7) collection of four sediment samples from on-site storm sewer manholes; 8) collection of one surface water and one sediment sample from LTU pond; 9) collection of surface water samples from on-site electrical vault; 10) collection of ground water samples from six monitoring wells on-site; and 11) performance of slug tests on two of the monitoring wells installed during the RI.

A pile of debris with possible ACM was noted north of the North Pig Station in the North Refinery during a Site visit by EPA and ODEQ on March 15, 2005. Additionally, a pipe with a black fibrous coating was observed in the South Refinery to the north of the Coke Pond. Three samples from the debris pile and one sample from the pipe with the black fibrous coating were collected on March 18, 2005, to determine if the material was ACM. ACM was confirmed in the pile on the North Refinery.

Ecological surveys were conducted at the Site during the week of August 16, 2004. Data recorded during the field investigation included commonly observed species, a description of the area ecology and habitat types, and evidence of stress or any abnormal conditions observed among local flora and fauna. These data were incorporated into the ecological risk assessment.

Fish sampling was conducted on August 9 and 10, 2005. This sampling was conducted to provide data for contaminant bioconcentration in fish tissue from species present in ponds at the Site. Ponds were selected for fish sampling based on the presence of a sustainable fish population and the contaminant concentrations detected in the surface water samples collected. Fish samples were obtained from Wastewater Pond 6 and the Firewater Pond. The Firewater Pond was selected as a reference sampling site since it was not used in the refinery processes and it is located upgradient from the rest of the refinery property. Five whole fish and five filet samples were collected from each of the ponds and submitted for laboratory analysis of metals. The data from the whole fish samples were used for ecological risk evaluation and the data from the filet samples were used for human health risk evaluation. (See Photograph 4 – Fish Sampling in Firewater Pond on North Refinery)

Residents near the site voiced concerns to the ODEQ and EPA that the Site contamination may have also contaminated their property. To address the residents' concerns and as public outreach, the ODEQ provided the TAG group with a fact sheet that described the residential yard sampling that the ODEQ would perform at the request of any landowners adjacent to the Site. The ODEQ and EPA performed soil sampling at ten residential properties near the site on July 19 & 20, 2004. Five-part soil sample composites were collected from the 0 to 6 inch interval from residential property. One composite sample was collected from the front yard and one composite sample was collected from the back yard of each residence. These residential soil samples were analyzed for VOCs, SVOCs, and metals. The results of the sampling indicated that the residential properties were not impacted with Site contamination.

12.5 Treatability Study

In November 2005 sediment samples were collected from the Aeration Pond 7 and associated sumps, Pond 1, Pond 2, and the Coke Pond for pH, moisture content, and bulk density; VOCs, SVOCs, eight RCRA metals; toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, and TCLP eight RCRA metals. Sediment samples were also collected for treatability testing and analysis.

The objective of the treatability study was to provide further evaluation of the chemical and physical characteristics of the pond sediments and to identify solidification/stabilization reagents which would improve the chemical and physical characteristics of the sediments. Initial testing was conducted to evaluate if any of the sediments exhibit hazardous characteristics and/or have concentrations of contaminants that could leach from the sediments at unacceptable levels (40 CFR §261.24). Initial testing was also conducted to evaluate the physical characteristics of the sediments and provide baselines for comparison of the solidification/stabilization results.

Solidification/stabilization treatment has historically been used to reduce leachable concentrations of contaminants of concern. While some reduction in total concentrations may be observed, the primary function of solidification/stabilization is to reduce the leachability of contaminants from the treated matrix and to improve physical characteristics for handling and final placement. Once the preliminary solidification/stabilization evaluation was completed and initial reagent and addition mixture rates were evaluated, chemical and physical verification testing was conducted.

The chemical leachability characteristics information was evaluated to provide information for disposal options and the physical characteristics, including material strengths and volumetric expansion rates, was to be used to evaluate material handling and final placement criteria.

The results of the TCLP analysis indicate that Waste Pond 2 has a TCLP chromium level higher than the maximum concentration of contaminants for the toxicity characteristic list at 40 CFR §261.24. The results of the Treatability Study indicate that stabilization would be successful in reducing the leachability of the chromium from the on-site waste pond sediment.

12.6 Known or Suspected Sources of Contamination

The RI confirmed that leakage and spills from refinery vessels, storage tanks, the dumping of contaminated material into on-site impoundments, and runoff has resulted in contaminated soil, surface water, sediment, and ground water. The primary contaminated areas include on-site impoundments, the North and South Refinery process areas, the North Refinery tank farm, and the South Refinery tank farms.

12.7 Types of Contamination and Affected Media

Operations at the Site have resulted in the discharge of contaminants to the on-site soil, on-site waste pond sediment, on-site pond surface water, and on-site ground water. The principal chemicals of concern (COC) for the soil pathway are benzo(a)pyrene, arsenic, and lead. The principal COCs for the waste pond sediment pathway are benzo(a)anthracene and benzo(a)pyrene. The principal COC for the waste pond surface water is benzo(a)pyrene. The principal COCs for the ground water pathway are benzene and thallium. The COCs for the Site are summarized in Tables 1A through 1D and discussed further in Section 14.

The COCs most frequently detected and at levels that could pose risk to human health were selected as the primary COCs to move forward in the Site investigation.

12.8 Locations of Contamination and Known or Potential Routes of Migration

Soil Contamination

Three COCs were identified in soil at the site. They included benzo(a)pyrene, arsenic and lead. RI sampling indicated that the areas of the Site that have soil contamination are the North Refinery Tank Farm, the South Process Area, the North-South Tank Farm, South-South Tank Farm, Northeast-South Tank Farm, and Other Areas in the South Refinery. The vertical extent of soil contamination varies across the site from 0.5 to two feet. The contamination in the soils represents a probable source of migration to ground water, surface water, and sediments.

Waste Pond Sediment Contamination

Two COCs were identified in on-site waste pond sediment. They include benzo(a)anthracene and benzo(a)pyrene. RI sampling indicated that the waste ponds that will require remediation are the Aeration Pond and its associated sumps, Wastewater Pond 1, Wastewater Pond 2, and the Coke Pond. The vertical extent of sediment contamination varies with each pond and is considered the depth of sediment in the bottom of each pond. The COCs in the contaminated sediments represent a probable source of contaminant migration to pond surface water, uncontaminated pond sediments, Skull Creek, and ground water. While chromium was not identified as a COC, the levels were such that TCLP chromium levels are higher than the maximum concentration of contaminants for the toxicity characteristic list at 40 CFR §261.24 and thus exhibit hazardous characteristics and/or represent a concentration of contamination that could leach from the sediments at unacceptable levels.

Sediment sampling was conducted in at the Coke Pond to determine the horizontal and vertical extent of coke tar material observed at the ground surface. (See Photograph 5 – Coke Pond on South Refinery) Based on visual observations, the coke tar material is limited to small areas on the ground surface, mainly to the west and north of the Coke Pond. The coke tar material is considered a probable source of contamination to the Coke Pond sediment. (See Photograph 6 – Coke Material from Coke Pond)

Waste Pond Surface Water Contamination

One COC, benzo(a)pyrene, was identified in water in one on-site waste pond. The RI surface water sampling indicated that the Coke Pond had an elevated surface water concentration for benzo(a)pyrene. All ponds that will be drained will require that the surface water be tested. The benzo(a)pyrene in the surface water of the Coke Pond represents a probable source of migration to soils and ground water.

Ground Water Contamination
Two COCs have been identified in the Site ground water, benzene and thallium. Benzene contamination was found in well OW-B and thallium contamination was found in wells MW-4 and OW-M. The COCs in ground water represent a probable source of migration to off site ground water.

LNAPL was found in well OW-D during the RI field activities. The well was gauged multiple times during the RI/FS and the thickness of the LNAPL was determined to be stable. LNAPL was not detected in wells recently installed downgradent of OW-D. It is estimated that 4,955 cubic feet of LNAPL may be on top of the water table in this area. The LNAPL represents a probable source of migration to non-contaminated ground water or surface water. Based on historical aerial photographs and previous site investigations, well OW-D is situated along the unlined channel flow path that carried mixed wastes (storm and process water) from the South Refinery to the NOWP area for detention and carried mixed wastes (storm and process water) from the North Refinery to the NOWP area for detention. The waste handling activities associated with the NOWP area represent the probable source for the LNAPL and the immediate ground water contamination.

Asbestos Contamination
ACM was discovered in one small disposal area on the North Refinery near well MW-6. The volume of material is approximately 10 cubic yards. The ACM could migrate through the air to other locations.

12.9 Site Ground Water

12.9.1 Geology

Payne County is directly underlain by bedrock of Upper Pennsylvanian and Lower Permian age. Because of the westerly dip of these rocks in Payne County, the older Pennsylvanian rocks are exposed at the surface in the eastern part of the county, while the younger Permian rocks are exposed in the western part. Quaternary (and recent) deposits of alluvium and stream terrace materials overlie the bedrock in many areas, with the thickest accumulations located along the Cimarron River and its larger tributaries (Shelton, et al., 1985).

The area is located in the unglaciated portion of the Osage Plains subdivision of the Central Lowlands physiographic province. Gently inclined sedimentary rock strata are generally characteristic of the Osage Plains (Resource Engineering, Inc. [REI], 1986).

The geologic strata underlying the site consist of Late Pennsylvanian shales with interbedded buried channel sandstones and some impure limestones (REI, 1986). The Vanoss, the upper aquifer, consists of thin limestones, variegated shale, red claystones, and lenticular sandstones and has a thickness of approximately 500 feet. The Vanoss lies conformably on the Ada Group and the Vamoosa Formation. The Ada Group is comprised of mostly orange-brown, fine-grained sandstone and red-brown to gray shale. Thin limestone beds are also present and the Lecompton Limestone exists at the base of this group. The Vamoosa Formation consists primarily of alternating thin to massive layers of fine to coarse-grained sandstone and sandy, silty shale. Some chert conglomerate may also be present in the middle and lower portions of the Vamoosa Formation. There are no solution cavities or evidence of karst terrain reported at this location. All of these geologic deposits dip approximately 40 feet per mile to the west-southwest (E&E, 1999).

A generalized stratigraphic column of the geology on the Site and vicinity is illustrated in Figure 7. Boring logs completed as part of the monitoring well installation and direct-push field activities indicated that bedrock was encountered at shallowest depths (five feet or less bgs) in the northeast portion of the North Refinery and seven feet bgs in the southeast portion of the South Refinery. The bedrock encountered consisted primarily of reddish-brown shale and sandstone with intermittent, thin limestone and siltstones.

12.9.2 Hydrology

Ground water occurs in all of the geologic units underlying the Site, including the unconsolidated soil, the Vanoss Group, and the Vamoosa-Ada Aquifer. The quality and quantity of the ground water in some of these units is very poor. The unconsolidated soil deposits consist of a thin veneer of soil and weathered bedrock. The occurrence of ground water in these deposits is variable depending on fluctuations in seasonal precipitation.

The Vanoss Group consists of thin limestones, variegated shale, red claystones, and lenticular sandstones and has a thickness of approximately 500 feet. Ground water in the shallow portions of the Vanoss generally has limited value as a drinking water source. Monitoring wells at the Site are generally screened in the upper to lower portions of the Vanoss. Depth to ground water measurements were obtained from the wells during Phase I and Phase II RI field activities. Water level measurements indicated depths to water in the South Refinery ranging from approximately 15 feet bgs in the eastern portion to approximately 40 feet bgs in the west. This is consistent with the surface relief in the South Refinery. Depth to water measurements in the North Refinery are much more pronounced, with the highest (approximately five feet bgs) occurring in the eastern portion and the deepest ground water (> 100 feet bgs) occurring in the topographically high areas in the western portion of the North Refinery. Based on the ground water elevation data collected during the Phase I and Phase II RI field activities, ground water flow at the Site is generally toward the north (see Figure 8).

The Vanoss lies conformably on the Ada Group and the Vamoosa Formation, which both serve as the aquifers in the Cushing well field area. The deeper sandstones of the Vamoosa-Ada aquifer are more prolific sources of ground water and are hydraulically isolated from shallow ground water by the mudstones of the Lower Vanoss. The City of Cushing has several municipal water-supply wells located on the east side of town in the Vamoosa-Ada Aquifer, ranging in depths from more than 300 feet to greater than 700 feet.

Geotechnical samples were collected during Phase I and Phase II RI field activities. During Phase I activities, one geotechnical sample was collected from a depth of 0.5 to 2.5 feet bgs from the MW-6 soil boring. The analytical results indicated that the average horizontal hydraulic conductivity for this sample was 3.4×10^{-8} centimeters per second (cm/sec). A second geotechnical sample was collected during Phase II from background boring, BG-520, from a depth of 0.5 to 2.5 feet bgs. The average hydraulic conductivity for this sample was 9.9×10^{-6} cm/sec.

The slug test data obtained from OW-2, MW-6, and MW-7 was analyzed to estimate the horizontal hydraulic conductivity of the underlying bedrock unit at the Site. Each of the monitoring wells is screened in the water-bearing sandstone unit underlying the Site. For each set of data, the Bouwer and Rice method was used to estimate hydraulic conductivity (Bouwer & Rice, 1976). Based on the data collected, the estimated hydraulic conductivity at OW-2, MW-6, and MW-7 is 6.9×10^{-4}, 1.0×10^{-4}, and 1.3×10^{-6} cm/sec, respectively.

13.0 CURRENT AND POTENTIAL FUTURE LAND AND WATER USES

This section discusses the current and reasonably anticipated future land uses and current and potential beneficial ground and surface water uses at the Site. This information forms the basis for reasonable exposure assessment assumptions and risk characterization conclusions presented in Section 14.

13.1 Current and Potential Future Land Uses

The Site is currently abandoned and is zoned for industrial use. Residential neighborhoods are located to the east and west of the Site. There are commercial properties to the east and south of the Site. The Site is fenced; access to both the North and South Refinery is through locked gates.

EPA policy directs that decision makers take into account "reasonably anticipated future land uses" when making remedial decisions. The scenarios used to evaluate risks to human health are based on anticipated future land uses in cooperation with the City of Cushing. The risk assessment scenarios evaluated the potential for residential, commercial, industrial, and recreational long-range uses anticipated by the City of Cushing. There are no current or short-range reuse plans for the Site. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. The ordinance provides an additional layer of protection until Site cleanup and future engineered controls are implemented on the Site. Currently the Site is zoned for industrial use.

The City of Cushing was awarded a Reuse Grant from EPA for the purpose of developing a future reuse plan for the Site. The community has participated in meetings held by the city to discuss the reuse plans for the property. The City of Cushing sent a letter of intent for site redevelopment on June 14, 2006, outlining the city's long-range plans. The city's plans include light industrial/commercial reuse for the South Refinery and a mixed reuse of light industrial/commercial and residential for the North Refinery (See Figure 3). ICs would be required to aid in the management of waste left on-site. ICs would include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, land use restrictions, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline.

13.2 Current and Potential Future Ground Water Uses

Monitoring wells at the Site are generally screened in the upper to lower portions of the Vanoss. Ground water in the shallow portions of the Vanoss generally has limited value as a drinking water source. This unit yields low quantities of poor quality, mineralized ground water. The poor water quality is the result regional elevated concentrations of chloride, nitrate, sulfate, and total dissolved solids (TDS). This coupled with poor yield reduces the viability of the Vanoss as a domestic water source. Based on current ground water monitoring data, the shallow ground water at the Site has naturally poor quality and would require extensive treatment for drinking water purposes. Because the Site is vacant, there are currently no ground water users water wells completed into the Vanoss underlying the Site. A survey of ground water use in the site vicinity indicated no municipal water supply wells or private wells completed into the Vanoss within one-half mile upgradient/downgradient of the Site. Residences within close proximity to the Site receive their water from the City of Cushing public water supply system.

The EPA ground water classification system consists of three general classes of ground water representing a hierarchy of ground water resource values to society. These classes are: Class I –

special ground water; Class II – ground water currently and potentially a source for drinking water; and Class III – ground water not a source of drinking water. Class II ground water is divided into two subclasses: current sources of drinking water and potential sources of drinking water. The EPA ground water classification system describes a potential source of drinking water as one which is capable of yielding 150 gallons/day and with a TDS concentration of less than 10,000 milligrams per liter (mg/l). (EPA, 1986b) Oklahoma Water Development Board rules define Class III ground water (Limited Use Ground water) as ground waters which have poor quality due to natural conditions, which could require extensive treatment for use as a source of drinking water, and which have a mean concentration of TDS greater than or equal to 3,000 milligrams per liter (mg/l) but less than 5,000 mg/l. (Oklahoma Administrative Code (OAC) 785:45-7-3)

While some of the Site wells have TDS levels greater then 3000 mg/l (based on conversion from specific conductance data), these levels are discontinuous across the Site. Based on current ground water monitoring data, the shallow ground water at the Site generally has the characteristics of a Class II ground water resource, since most Site wells produce water with a concentration less than 3,000 mg/L TDS and several wells on Site are capable of producing more than 150 gallons/day. The shallow ground water at the Site, however, is not expected to be utilized as a drinking water source in the future and the appropriate ICs will be implemented. The contaminated ground water will not exert a long-term detrimental impact on available water supplies or other environmental resources. The contaminated ground water in the northeast and southeast portions of the Site is localized and, based on current ground water data, extends over a small area wholly contained within Site boundaries.

While the shallow portions of the Vanoss are not anticipated to be used as a water supply, there are no current prohibitions for its use. ICs would be required to aid in the management of waste left on-site in ground water. ICs would include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline.

13.3 Current and Potential Future Surface Water Uses

Multiple surface water impoundments are present at the Site. The North Refinery has more topographic relief with a slope to the southeast. Surface water drainage at the Site is to the north and east and ultimately discharges into Skull Creek. Some of these surface water impoundments received refinery process water for holding or treatment. There are no anticipated future uses for the water in the wastewater holding or treatment impoundments/ponds.

Records indicate that one pond on the North Refinery in the southwestern corner, the “Firewater Pond,” was used to store water for fire-fighting needs. It was not used for holding refinery process water; runoff from refinery process areas flowed to the east and away from this pond. This pond has been used for recreational fishing. Sampling results indicate that this pond has no levels of contamination that would make it unfit for recreational fishing.

14.0 SUMMARY OF SITE RISKS

This section of the ROD provides a summary of the Site's human health and environmental risks. A BHHRA for the Site was completed in 2006, which estimated the probability and magnitude of potential adverse human health and environmental effects from exposure to contaminants associated with the Site assuming no remedial action was taken. A Screening Level Ecological Risk Assessment (SLERA) for the Site was completed in 2006. Both the BHHRA and the SLERA are included in the RI Report (Burns and McDonnell, 2006).

14.1 Summary of Baseline Human Health Risk Assessment

The BHHRA estimates what human health risks the Site poses if no action were taken. It provides the basis for taking action at this Site and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The BHHRA evaluates the baseline potential risk that might be experienced by human receptors coming into contact with contaminated air, soil, sediment, surface water, ground water, and fish tissue. This section of the ROD summarizes the results of the BHHRA. This BHHRA followed a four step process:

a. Hazard identification (Identification of COCs),
b. Exposure assessment,
c. Toxicity assessment, and
d. Risk characterization.

The EPA used an exposure point concentration (EPC) for each COC and the reasonable maximum exposure (RME) scenario to estimate risk. The EPC was the lesser of the maximum detected concentration and the 95% upper confidence limit (UCL) of the arithmetic mean concentration of the COCs in soil or ground water. 95% UCL is a statistically-derived value based on sample data within an exposure area. The maximum detected concentration was used for the EPC for sediment, surface water, air, fish tissue, and ground water data. The RME scenario is the maximum exposure that is reasonably expected to occur at the Site and is based on "upper bound" and "central tendency" estimates.

Due to the relatively diffuse distribution of contaminants in the North and South Refineries, the risk assessment is not organized around the individual functional areas of the Site that formed the basis of the field investigation. Rather, the Site has been subdivided into the North and South Refineries for risk evaluation.

A separate risk assessment was not conducted for the ACM and coke tar as these are considered source materials and defined as principal threat wastes. The ACM and coke tar will be addressed during the RA to remove the principal threat wastes.

14.1.1 Identification of Chemicals of Concern

Tables 1A through 1D (Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations) present the COCs and EPCs for each of the COCs detected in soil, waste pond sediments, waste pond surface water, and ground water. The EPC is the contaminant concentration used to estimate the exposure and risk or hazard from each COC. These COCs, the contaminants driving the need for remedial action, were identified from the data collected during the RI for Phase I sampling in 2004 and Phase II supplemental sampling in 2005. Sampling data were reviewed as described in *RAGS Part D* and based on the Data Validation and Usability requirements outlined in the Site's RI/FS Quality Assurance Project Plan (Burns and McDonnell 2004c).

Table 1A presents the concentrations of COCs that pose potential threats to human health in the surface soil, the shallow soil, and subsurface soil for both the North and South Refineries. Tables 1B, 1C, and 1D present the concentrations of COCs that pose potential threats to human health in the sediments, surface water, and the ground water. The tables also identify the concentration ranges for the COCs, the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the Site), and how the EPC was derived.

As shown in Tables 1A through 1D, arsenic and lead are the most frequently detected COCs in Site soils. Arsenic was the most frequently detected COC in North Refinery soils and both lead and arsenic are the most frequently detected COCs in South Refinery soils. As shown in Table 1B, benzo(a)pyrene and benzo(a)anthracene are the most frequently detected COCs in sediments in Waste Ponds 1 and 2 on the North Refinery and the Coke Pond on the South Refinery. The North Refinery waste pond surface water samples do not contain COCs that would pose a human health threat; however, the sediment in some of the ponds contains COCs that would pose a threat. Benzo(a)pyrene is the most frequently detected COCs in the waste pond surface water in the Coke Pond on the South Refinery. As shown in Table 1D, benzene and thallium are the most frequently detected COCs in Site ground water. Due to the limited amount of data for waste pond sediment and waste pond surface water, the maximum concentration was used as the default exposure point concentration. The COCs most frequently detected and at levels that could pose risk to human health were selected as the primary COCs to move forward in the BHHRA.

14.1.2 Exposure Assessment

Exposure refers to the potential contact of an individual (the receptor) with a contaminant. The exposure assessment evaluates the magnitude, frequency, duration, and route of potential exposure. This section describes which populations may be exposed, the exposure pathways, and the level of exposure to the contaminants present. A complete discussion of all the scenarios and exposure pathways is presented in the BHHRA.

The objective of the exposure assessment is to evaluate potential current and future human exposures to COCs in all media of concern – air, soil, sediment, surface water, ground water, and fish tissue. The current and potential future human receptors were determined by the Site's configuration, land and water use, and activity patterns. Receptors were identified for both current and potential future Site conditions.

A complete discussion of all the scenarios and exposure pathways is presented in Section 6 of the Site RI Report (Burns & McDonnell, 2006), summarized in the following discussion, and depicted in the Site CSM for human health included as Figure 5. As depicted in the CSM, the following pathways for current and future receptors were considered complete:

- **Inhalation of dust and/or volatile emissions in air -** North and South Refineries - trespasser/recreationist and outdoor commercial/industrial worker
- **Ingestion and/or direct contact with Site soils**
    - Surface soil (0 - 6 inches bgs (or 0 - 0.5 feet bgs)) - North and South Refineries - outdoor commercial/industrial worker
    - Shallow soil (0 - 2 feet bgs - North Refinery - resident; South Refinery - homeless shelter resident; North and South Refineries - trespasser/recreationist, and outdoor commercial/industrial worker;
    - Soil (0 feet to total sampling depth) - North and South Refineries - construction utility worker
- **Ingestion of homegrown produce grown in Site soils -** North Refinery - residents
- **Ingestion of wild produce grown in Site soils -** North and South Refineries - trespasser/recreationist
- **Vapor intrusion from Site soils -** North Refinery – residents

- **Inhalation and outdoor vapor inhalation of Site soils -** North and South Refineries - outdoor commercial/industrial worker
- **Vapor intrusion from Site ground water -** North Refinery - residents; South Refinery - homeless shelter resident; North and South Refineries - indoor commercial/industrial worker
- **Ingestion of ground water -** North Refinery – residents
- **Dermal contact with ground water -** North Refinery - residents and construction utility worker
- **Inhalation of household vapors from ground water** - North Refinery - residents
- **Outdoor vapor inhalation from ground water**- North Refinery - construction utility worker
- **Incidental ingestion and/or direct contact with waste pond surface water -** North Refinery - residents and construction utility worker; North and South Refineries - trespasser/recreationist and outdoor commercial/industrial worker
- **Incidental ingestion and/or direct contact with waste pond sediment -** North Refinery - residents; North and South Refineries - trespasser/recreationist, outdoor commercial/industrial worker and construction utility worker
- **Ingestion of waste pond fish -** North Refinery - residents and trespasser/recreationist

Exposure route, receptor, receptor-specific assumptions, exposure point, exposure parameters values (duration, frequency, etc.) are presented in Tables 2A through 2F (Values Used Risk Assessment). These exposure routes were evaluated to determine Site risk to contamination.

As discussed in Section 13, the city's plans include light industrial/commercial reuse for the South Refinery and a mixed reuse of light industrial/commercial and residential for the North Refinery. The areas indicated by the city with a planned residential reuse are areas that had no refinery operations or require no cleanup. The city was still evaluating reuse of the entire portion of the North Refinery as residential during the performance of the BHHRA; therefore a residential exposure scenario was evaluated for the North Refinery process areas, tank areas, etc. The soil results from these areas were compared to residential risk-based cleanup numbers and no exceedances were found. The calculated risk based cleanup numbers for residential soil are benzene 0.12 milligram per kilogram (mg/kg), xylenes (total) 90.1 mg/kg, benzo(a)anthracene 0.62 mg/kg, benzo(a)pyrene 0.062 mg/kg, dibenzo(a,h)anthracene 0.062 mg/kg, arsenic 19.1 mg/kg, and the polychlorinated biphenyl (PCB), Arcoclor-1254 0.22 mg/kg. Additionally, residences within close proximity to the Site receive their water from the City of Cushing public water supply system. It is anticipated that any long-range future Site residents would also received water from the city.

14.1.3 Toxicity Assessment

Toxicity assessment is accomplished in two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining whether exposure to a chemical is associated with a particular adverse health effect and involves characterizing the nature and strength of the evidence of causation. The dose-response assessment is the process of predicting a relationship between the dose received and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity values are derived that can be used to estimate the potential for adverse effects as a function of potential human exposure to the chemical.

Tables 3A and 3B show the cancer and the non-cancer toxicity data, respectively, for the COCs that are the major risk contributors at the Site. For complete information on the toxicity of the COCs, see the BHHRA.

The carcinogenic oral/dermal and inhalation slope factors for the COCs are presented in Table 3A. Based on data from EPA's Integrated Risk Information System (IRIS) and other published data, the COCs have the following carcinogen classifications for the ingestion, dermal, and inhalation routes of exposure:

- Two of the COCs are human carcinogens (EPA weight of evidence A).
- Two of the COCs are probable human carcinogens (EPA weight of evidence B2).

One COC has toxicity data which describe its potential for adverse non-carcinogenic health effects. The chronic toxicity data available for this COC have been used to develop oral, dermal, and inhalation reference doses (RfDs). The RfD is a level that an individual may be exposed to that is not expected to cause any harmful effect. The oral, dermal, and inhalation RfDs are presented in Table 3B.

Lead does not have a nationally approved RfD, slope factor, or other accepted toxicological factor which can be used to assess risk; therefore, standard risk assessment methods cannot be used to evaluate the health risks associated with lead contamination. Elevated lead levels were isolated to a discrete area of the South Refinery where the anticipated reuse was commercial/industrial. The ODEQ "Soil Clean Up for Lead in Nonresidential Soil" using the EPA Adult Lead Methodology was used to determine the appropriate leads levels for a commercial/industrial scenario.

The following sources are used in the BHHRA to determine toxicity values:

IRIS: Integrated Risk Information System, (USEPA 2005)
PAH: Slope factor for benzo(a)pyrene adjusted as recommended in Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons (USEPA, 1993)
Region 6: USEPA Region 6 Human Health Medium Specific Screening Levels (USEPA, 2004)
ODEQ: "Soil Clean Up for Lead in Nonresidential Soil" memo (ODEQ, 2006)

14.1.4 Risk Characterization

The risk characterization section of the ROD summarizes and combines output from the exposure and toxicity assessments to characterize baseline risk at the Site. Baseline risks are those risks and hazards that the Site poses if no action were taken. For the North Refinery, Tables 4A through 4C present the carcinogenic risk characterization for trespassers (recreationists), indoor (commercial/industrial) workers, and outdoor (commercial/industrial) workers, respectively. For the South Refinery, Tables 4D through 4G present the carcinogenic risk characterization for trespassers (recreationists), indoor (commercial/industrial) workers, outdoor (commercial/industrial) workers, and construction (utility) workers, respectively. Noncarcenogenic risk characterization for the construction (utility) worker is presented in Table 5.

Carcinogens

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated using the following equation:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where:

Risk = a unitless probability (e.g., 2×10^{-5}) of an individual's developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)

SF = slope factor, expressed as (mg/kg-day)-1.

An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an “excess lifetime cancer risk” because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual’s developing cancer from all other causes has been estimated to be as high as one in three. EPA’s generally acceptable risk range for site-related exposures is $1x10^{-4}$ to $1x10^{-6}$.

Noncarcinogens

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a RfD derived for a similar exposure period. A RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). A HQ less than 1 indicates that a receptor’s dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. A HI less than 1 indicates that, based on the sum of all HQ’s from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. A HI greater than 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where:
CDI = Chronic daily intake
RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Lead

For lead, hazards and risks cannot be developed using the procedures for other COCs because toxicity factors are not available. As stated in Section 14.1.3, the ODEQ “Soil Clean Up for Lead in Nonresidential Soil” was used to determine the appropriate leads levels for a commercial/industrial scenario.

Lead does not have a nationally approved RfD, slope factor, or other accepted toxicological factor which can be used to assess risk; therefore, standard risk assessment methods cannot be used to evaluate the health risks associated with lead contamination. Elevated lead levels were isolated to a discrete area of the South Refinery where the anticipated reuse was commercial/industrial. This approach uses the EPA Adult Lead Methodology to determine appropriate levels for a commercial/industrial scenario.

14.1.4.1 Risk Estimations – North Refinery

For the North Refinery, Tables 4A through 4C present the carcinogenic risk characterization for trespassers (recreationists), and outdoor (commercial/industrial) workers, respectively. Non-carcinogenic risk was not a factor for the North Refinery. The BHHRA calculated carcinogenic risk greater than upper risk range for the following site-related exposures:

- Current Trespasser (recreationist) – Waste Pond Sediments from Waste Ponds 1 and 2
- Future Outdoor (commercial/industrial) worker – Shallow Soil and Waste Pond Sediments from Waste Ponds 1 and 2

Current trespassers have a total carcinogenic risk from primarily from dermal exposure to benzo(a)pyrene and benzo(a) anthracene in waste pond sediments from Waste Ponds 1 and 2 of 4 x 10^{-4}. Future outdoor (commercial/industrial) workers have an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene in shallow soil of 2 x 10^{-5} and an increased carcinogenic risk from primarily dermal exposure to benzo(a)pyrene in waste pond sediments from Waste Ponds 1 and 2 of 2 x 10^{-4}.

14.1.4.2 Risk Estimations – South Refinery

For the South Refinery, Tables 4D through 4G present the carcinogenic risk characterization for trespassers (recreationists), indoor (commercial/industrial) workers, and outdoor (commercial/industrial) workers, respectively. Noncarcenogenic risk characterization for the construction (utility) worker is presented in Table 5. The BHHRA calculated carcinogenic risk greater than upper risk range for the following site-related exposures:

- Current Trespasser (recreationist) – Shallow Soil, Coke Pond, Surface Water, and Coke Pond Sediments
- Future Indoor (commercial/industrial) worker – Surface Soil
- Future Outdoor (commercial/industrial) worker – Shallow Soil, Coke Pond, Surface Water, and Coke Pond Sediments

The BHHRA calculated non-carcinogenic HI risk greater than one for the following site-related exposure:

- Construction (utility) worker – Soil

Current trespassers have an increased carcinogenic risk from both ingestion and dermal exposure to arsenic in shallow soil of 3 x 10^{-5}, an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene in coke pond surface water of 4 x 10^{-4}, and an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene in coke pond sediments of 5 x 10^{-4}. Future indoor (commercial/industrial) workers have an increased carcinogenic risk from ingestion exposure to benzo(a)pyrene and arsenic in shallow soil of 8 x 10^{-5}. Future outdoor (commercial/industrial) workers have an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene and arsenic in shallow soil of 1 x 10^{-4}, an increased carcinogenic risk dermal exposure to benzo(a)pyrene in coke pond surface water of 1 x 10^{-4}, and an increased carcinogenic risk from dermal exposure to benzo(a)pyrene and benzo(a)anthracene in coke pond sediments of 1 x 10^{-3}.

Future construction (utility) workers have an increased non-carcinogenic risk from both ingestion and dermal exposure to arsenic in surface soil with a HI of 3.

Residents at the homeless shelter were not shown to be experiencing risk. The average homeless shelter resident was determined to be an adult spending 12 hours per day at the shelter with a stay of one year or less. This area was evaluated as a residential area using factors that included a one-year residential time frame.

The Remedial Action basis addressing both human health and ecological risk is outlined in Section 14.3.

14.1.5 Uncertainty Analysis

Some level of uncertainty is introduced into the risk characterization process every time an assumption is made. In regulatory risk assessment, the methodology dictates that assumptions err on the side of overestimating potential exposure and risk. The effect of using numerous assumptions that each overestimated potential exposure provides a conservative estimate of potential risk.

14.1.5.1 COC Identification Uncertainty

Various types of data qualifiers are attached to analytical data by either the laboratory conducting the analyses or by the person performing data validation. A common data qualifier in data packages is the "J" qualifier. Data qualified with a "J" are estimated concentrations reported below the minimum confident sample quantitation limit, also known as the practical quantitation limit, or are estimated because quality assurance parameters were out of range. In this BHHRA, all data qualified with a "J" were used the same way as positive data that did not have the qualifier. The use of J-qualified data as the reported concentration is believed to result in a potential overestimation of the actual concentration and thus, the actual cancer risks and noncancer hazards or overall BHHRA results.

Only limited sampling was done in certain areas of the site. There were limited samples for pond surface water, pond sediment, fish tissue, and in Skull Creek. Due to the limited amount of data for pond sediment and pond surface water the maximum concentration was used as the default exposure point assessment. Limited amounts of data may result in either an over- or underestimation of risk

14.1.5.2 Exposure Assessment Uncertainty

The results of the RI investigation indicated the presence of VOCs, SVOCs, PCBs, and metals in soil samples from the North Refinery. Maximum concentrations of different constituents were generally not found together at the North Refinery. Because of this dispersion of high concentrations, no apparent “hot spots” were found during data evaluation. Therefore, although samples were taken in historically separate functional areas of the Site, the data were relatively homogeneous and were evaluated for the North Refinery as a whole. The South Refinery exhibited similar homogeneous conditions and was evaluated similarly to the North Refinery

As discussed, the maximum detected concentrations of individual constituents at the Site were typically not co-located. Since it is impossible for a single receptor to spend all of his/her time in multiple locations, the maximum detected concentration evaluation is likely overly conservative. To account for the fact that the contaminant distribution at the Site makes it impossible for a single receptor to be simultaneously exposed to maximum detected concentration of every COPC in soil, a second set of risk calculations was completed using 95 percent UCL as the exposure concentrations for soil. Additionally, the 95 percent UCL evaluation allows for consideration of highly elevated reporting limits that occurred as a result of sample dilution. When samples require high levels of dilution for analysis of PAHs, it can generally be deduced that the sample likely contained weathered petroleum, and therefore also likely contained PAHs at levels below the elevated reporting limits. The calculation of UCLs includes non-detect results at one-half the reporting limit, and thus addresses the probable presence of PAHs at levels below the reporting limits. Limited amounts of data and use of the maximum concentration for waste pond sediment and waste pond surface water may result in either an over- or underestimation of risk.

The analytical methods for some constituents are not sensitive enough to provide detection limits below the applicable human health and/or ecological screening levels. If these chemicals are present at levels below the detection limit but above the screening level, it is possible that exposure to them could lead to unacceptable health risks. However, the inclusion of undetected compounds in a risk assessment provides results that are difficult to use in the remedial decision-making process and likely results in an overestimate of risk. Therefore, with the exception of the fish tissue data, chemicals that were not detected in any samples from a given area and medium, including those with detection limits exceeding risk-based screening levels, were not retained in the risk assessment. If the undetected chemicals are present at concentrations below the reporting limit, excluding them from the risk assessment could result in an underestimation of risk. Not all chemicals that were retained in the evaluation of fish tissue are present or were determined to be COCs in Site media, including them in the risk assessment likely results in an overestimation of risk.

Chemicals that weren’t detected, but had reporting limits that one-half the reporting limit exceeded the screening level, were also retained as contaminants of potential concern. Uncertainty arises from the treatment of non-detected concentrations in the risk assessment. One-half of the reporting limit was used as a proxy concentration for non-detect samples. The actual concentration of the contaminant could be anywhere between zero and the reporting limit. This may result in either an over- or underestimation of risk.

14.1.5.3 Toxicity Assessment Uncertainty

For some chemical substances there is little or no toxicity information available and for many chemicals, what is available is typically from animal studies. The relative strength of the available toxicological information generates some uncertainty in the evaluation of possible adverse health effects and the exposure level at which they may occur. To provide for a margin of error, EPA applies conservative adjustments to the toxicity values.

To quantify risk from chemicals that do not have toxicity numbers posted in IRIS or Health Effects Assessment Summary Tables (HEAST), provisional numbers generated by Superfund Technical Support Center (STSC) are used when available. These provisional numbers typically have not been subjected to the rigorous review process undergone by values in IRIS. Uncertainty is generated by the use of provisional numbers. However, this uncertainty is less than that generated by ignoring or qualitatively assessing risks.

Numerical toxicity values for dermal exposures have not been developed by EPA. To quantitatively assess risk from dermal exposure, EPA guidance recommends adjusting oral RfDs and slope factors, usually presented as administered instead of absorbed doses, by chemical-specific gastrointestinal absorption factors to account for the differing dose calculation. Because of potential differences in patterns of distribution, metabolism, and excretion between oral and dermal routes of exposure, use of adjusted oral toxicity values may over- or under-estimate risk, depending on the chemical.

Toxicity assessment uncertainty may results in result in either an over- or underestimation of risk.

14.1.5.4 Risk Characterization Uncertainty

Aeration Pond 7 and associated sumps and Wastewater Ponds 1, 2, 3, 4, 5, 6, and 6a are all interconnected. Water flows from the aeration pond sumps, into Aeration Pond 7, and then flowing successively through the wastewater ponds. Aeration Pond 7 and the associated sumps will be remediated as a source control measure; therefore, they were removed from the risk assessment. Samples from Wastewater Pond 1 and Wastewater Pond 2 had analytical results that were distinctly different from the remaining ponds in the group; therefore, these two ponds were evaluated separately and individually. Given the similarity in detected constituents and concentrations, the remaining wastewater ponds were grouped together and evaluated as a single unit. Additionally, the LTU Pond is located immediately adjacent to the wastewater ponds, and the samples from the LTU Pond showed similar constituents and concentrations as were identified in Wastewater Ponds 3-6A. Therefore, the LTU Pond was included in the same group with Wastewater Ponds 3-6a. Ponds 8, 8a, and Runoff Pond 9 are interconnected and most ponds located immediately adjacent to each other; therefore, these three ponds were evaluated as a single unit. The Firewater Pond and Skull Creek are not connected to the other pond surface water bodies, nor are they located in close proximity to any of the other ponds, and were, therefore, evaluated individually. Similarly, the electrical vault located in the North Refinery was evaluated as an individual unit. Evaluation of the ponds or the electrical vault separately or as a group may either result in an over- or underestimation of risk.

As noted in Section 14.1.3, residents could be exposed to contaminated soil, pond sediment, pond surface water, and ground water. The property indicated by the city with a planned residential reuse are areas that showed no unacceptable risk, had no refinery operations, and/or require no cleanup. ICs would be required to aid in the management of waste left on-site for the areas with a planned commercial/industrial reuse. ICs would include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, land use restrictions, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline.

14.2 Summary of Screening Level Ecological Risk Assessment

The SLERA (Burns and McDonnell, 2006) estimates what ecological risks the Site poses if no action were taken. It provides the basis for taking action at this Site and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The SLERA evaluates the potential risk that might be experienced by ecological receptors coming into contact with contaminated air, soil, sediment, surface water, ground water, and fish tissue. This section of the ROD summarizes the results of the SLERA. This SLERA followed a four step process:

a. Ecological Site characterization
b. Hazard identification (Identification of contaminants of potential concern (COPCs)),
c. Exposure assessment, and
d. Ecological Risk characterization

A SLERA was performed for the Site for evaluation of ecological risk. A SLERA provides a general indication of the *potential* for ecological risk. Cleanup programs generally use the Baseline Ecological Risk Assessments (BERA) to further identify and characterize the COPCs identified in the SLERA, the potential threat to the environment, evaluate the ecological impacts of alternative remediation strategies, and establish cleanup levels in the selected remedy that will protect those natural resources at risk. (USEPA 1994b) While a SLERA was performed for the Site, some components that would normally be part of BERA were included as components of the SLERA: fish tissue concentration studies, field studies, and bench top food chain modeling

14.2.1 Ecological Site Characterization

The ecological Site characterization is a description of the local ecology of the potentially impacted areas and ecological receptors. The first step in the ecological Site characterization is to characterize the environmental conditions at the Site. A background search of references, including the Payne County Soil Surveys (USDA, 1987), topographical maps, National Wetland Inventory (NWI) maps, and various other sources, was conducted to provide preliminary information on the Site's ecological communities. Field investigations were conducted to confirm the preliminary information obtained in developing the ecological characterization. Data recorded during the field investigation included commonly observed species, a description of the area ecology and habitat types present, and evidence of stress or any abnormal conditions observed among local flora and fauna. The potential presence of sensitive receptors in the area, including threatened or endangered species, wetlands, streams, lakes, etc., were identified by reconnaissance conducted by biologists (including U.S. Fish and Wildlife Service (USFWS) biologists) familiar with regional flora and fauna.

The majority of the Site has been previously disturbed. Minimal habitat for wildlife species is present in the vicinity of the former north and south production areas and tank farms of the Site. Only common species that are tolerant of human disturbances are likely to occur in this area. According to the USFWS, Oklahoma Department of Wildlife Conservation, and the Oklahoma Biological Survey, four protected species are known or are likely to occur in Payne County. These species include the Arkansas River shiner, interior least tern, piping plover, and whooping crane; however, none of the protected species known to occur in Payne County are likely to occur at the Site because these species inhabit large rivers and streams, such as the Cimarron River.

14.2.1.1 North Refinery

The North Refinery was once occupied by refinery equipment. With the exception of the wastewater treatment ponds, all of the former north production area's facilities and ASTs have been removed. The North Refinery also contains two former LTUs that were part of a previous cleanup effort. The LTUs occupy approximately 15 acres of the North Refinery Site and have been planted with a mix of grass species. Eastern red cedar and common weedy species have been slowly invading the LTUs.

The north production area currently consists primarily of previously disturbed areas that have been planted with grasses and are being invaded by common weed and shrub species. This mixed grass vegetative community provides open grazing opportunities for the white-tailed deer observed at the Site, as well as cover for many small mammal species, such as shrews, mice, voles, and cottontail rabbits. The north half of the North Refinery also includes some wooded and shrubby areas between the wastewater treatment ponds, along the west edge of the North Refinery, and in the northeast and northwest corners of the property. These areas provide cover for many of the common mammal and bird species observed or that are likely to occur on the North Refinery.

No streams or drainage ways are present on the North Refinery. Skull Creek is adjacent to the northeast corner of the North Refinery. This creek originated on the Site when the refinery was in operation. It was dry during the field investigations that occurred in August 2004. A total of 14 ponds are present on the north half of the North Refinery. All of these ponds are man-made and have a narrow fringe of emergent wetland vegetation, consisting mostly of cattails and black willow, along their banks. Fish and/or painted turtles were observed in Runoff Pond 9 and some of the wastewater treatment ponds (Wastewater Ponds 4 through 6). Several of the wastewater ponds (e.g. Wastewater Ponds 2 through 5) have partly silted in and become over grown with cattails. The overflow from two ponds, Wastewater Pond 6 and Runoff Pond 9, flows into Skull Creek.

14.2.1.2 South Refinery

Much of the South Refinery was once occupied by refinery equipment, ASTs, and buildings associated with the former south production area and tank farms. Most of the South Refinery's facilities have been removed; however, several abandoned buildings and concrete foundations still remain. The South Refinery currently consists of previously disturbed areas that have been planted with grasses but, over time, have reverted to a mixed grassy and weedy vegetative community. Several patches of dense shrubs and trees occur along the fence lines, the abandoned railroad corridor, and between the abandoned buildings and remaining foundations. Texas horned lizards, a category II state species of concern, were observed at two separate locations in the South Refinery in the former South Process Area and the former East-South Tank Farm. Two ponds, the South Runoff Pond and the Coke Pond, are the only water features on the South Refinery. Neither pond appeared to contain fish or turtles. Both of these ponds are man-made, had a narrow fringe of emergent wetland vegetation (e.g. sedges, rushes, and common cattails), and are not associated with any streams or drainages.

Stained soils devoid of vegetation were observed in the vicinity of former NE-S Tank Farm, south of the South Runoff Pond. Additionally, an oily sheen was observed on the surface water of the Coke Pond. The remainder of the South Refinery consisted of visibly disturbed areas with debris and gravel scattered in the vicinity of the former buildings and facilities that made up the South Refinery.

14.2.2 Identification of Chemicals of Potential Concern

Tables 6A through 6O (Summary of Ecological Chemicals of Concern) present the chemicals of potential ecological concern (COPCs) for earthworms, plants, aquatic plants, benthic invertebrates, aquatic invertebrates, and fish. Tables 7A and 7B present the COPCs for the representative wildlife species: cottontail rabbit, white-tailed deer, short-tailed shrew, white-footed mouse, meadow vole, and American robin. Tables 8A through 8F present the COPCs for aquatic birds: great blue heron, belted kingfisher, and mallard duck. Only those contaminants that were determined to be COPCs are included in the tables. The evaluation of receptor exposure is more fully discussed in Section 14.2.3. Additional information on the ecological COPCs can be found in the RI. (Burns and McDonnell, 2006)

The first step in determining a COPC is to review the analytical data collected for soil, sediments, surface water samples, and fish tissue samples and determine the potential exposure pathways for various species of wildlife, plant, and aquatic organisms. In surface water, sediments, soils, and fish tissue, organic compounds and metals were considered as preliminary COPCs if they were detected, exceeded ecological screening levels, or had no available screening level.

COPCs include those Site-related chemicals that have the potential to impact ecological receptors. For this risk assessment, the COPCs were identified primarily through a comparison to ecological-based screening levels (Burns and McDonnell, 2006).

Constituents with detections greater than screening levels were retained. Detections of constituents without screening levels were also retained. Constituents that were classified as non-detects were not retained. All PAHs detected in the North and South Refineries were retained if any one detected PAH exceeded a screening level. Similarly, bioaccumulative compounds such as PCBs, mercury, and arsenic were retained even if they did not exceed screening levels. Major nutrients such as calcium, magnesium, potassium, and sodium were not retained as COPCs.

14.2.2.1 North Refinery

The following chemicals were selected as COPCs for soils in the North Refinery:

- VOCs: acetone, benzene, cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohexane, xylenes (total)
- SVOCs: acenaphthene, anthracene, benzo(a)anthracene, , benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene bis(2-ethylhexyl)phthalate, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, , 2-methylnaphthalene, naphthalene, phenanthrene, pyrene
- PCBs: Aroclor 1254, Aroclor 1260
- Metals: aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc

While not all of the COPCs for soils were found in the pond surface water and pond sediments, there were no contaminants found in these media that were not also identified in soils. The primary group of COPCs for the pond surface water was metals. Wastewater Pond 1 and 2 sediments had VOCs, SVOCs and metals. The primary group of COPCs for sediments in Wastewater Ponds 3-6A, the LTU Pond, the Firewater Pond, and Skull Creek sediments was metals. The primary groups of COPCs in sediments for Ponds 8, 8a, and Runoff Pond 9 were VOCs and metals.

Fish samples were collected from the Firewater Pond and Waste Pond 6. Metals, including cobalt, were identified as the COPCs.

14.2.2.2 South Refinery

The following chemicals were selected as COPCs for soils in the South Refinery:

- VOCs: benzene, cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohexane, xylenes (total)
- SVOCs: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, , 2-methylnaphthalene, naphthalene, , phenanthrene, pyrene
- PCBs: Aroclor 1242, Aroclor 1254
- Metals: aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc

While not all of the COPCs selected for soils were found in the pond surface water and pond sediments, there was one contaminant found in these media that was not also identified in soils. The Coke Pond had SVOCs and metals. The primary group of COPCs for the South Runoff Pond surface water and sediment was metals. The Coke Pond sediments had VOCs (also including toluene), SVOCs and metals.

14.2.3 Exposure Assessment

For this ecological evaluation, potential ecological receptors (terrestrial and aquatic wildlife, terrestrial and aquatic plants, and soil and benthic organisms) were selected based on species observed while conducting the field investigation, habitats available at the Site, and best professional judgment of what species are likely present in the area. A complete discussion of all the scenarios and exposure pathways is presented in Section 7 of the Site RI Report (Burns and McDonnell, 2006), summarized in the following discussion, and depicted in the CSM for ecological health included as Figure 6.

Surface soil, surface water, sediment, subsurface soil, ground water, and fish tissue were sampled at the Site. These potentially impacted media may provide a contact point for ecological receptors. Surface soils, subsurface soils, surface water, were evaluated as potential exposure media for terrestrial receptors. Surface water, pond sediments, and fish tissue were evaluated as potential exposure media for aquatic species. Ground water was not analyzed in this ecological evaluation because it was assumed that, due to the depth, the wildlife and plants at the Site would not come in contact with the ground water. Additionally, there is no current evidence that contaminated ground water discharges to surface water. Fish tissue field studies were the only field studies performed; no additional field studies or ecological effects studies were conducted.

The primary completed exposure pathways (i.e., pathways for those contaminants that can reach ecological receptors) for the contaminated media and the potentially exposed ecological receptors include direct and accidental ingestion of contaminants through feeding. Soil invertebrates, burrowing animals, insectivorous animals, and herbivores may be exposed to contaminants in the soils due to ingesting soils, whether intentionally or accidentally. Aquatic species may be exposed to contaminants in the surface water and sediments by ingesting contaminants in the water and sediments, whether intentionally or accidentally. Plants and soil invertebrates may accumulate soil contaminants and subsequently be consumed by insectivorous, herbivorous, and omnivorous species. Predatory animals may consume smaller animals that have consumed contaminated soils or plants and other smaller animals that have accumulated contaminants. Lastly, waste pond surface water may also be a potential source of contamination. Potential Site contaminants may be ingested by animals while drinking water from the various ponds at the Site. Similarly, aquatic plants, fish, and aquatic and benthic invertebrates, may accumulate surface water and pond sediment contaminants and subsequently be consumed by herbivorous, insectivorous, and piscivorous birds. Table 9 depicts the ecological pathways of concern and further discussion is provided below.

14.2.3.1 Terrestrial Species

VOCs, SVOCs, PCBs, and metals were detected in soil from the North and South Refineries. There were no apparent hot spots found during the data evaluation. Maximum concentrations of the VOCs, SVOCs, PCBs, and metals were spread across the areas sampled in the North and South Refineries. As in the BHHRA, the data were relatively homogeneous for the North and South Refineries and were evaluated for the respective refinery portions as a whole.

The maximum detected concentration for each COPC in soil, regardless of depth, was used in this evaluation. This is the most conservative approach because it assumes that the highest concentration for each COPC will be encountered.

Potential risk to ecological receptors from soil contaminants was assessed using analytical data for samples collected from surface soil and subsurface soils. The area of the former north and south production areas and tank farms, which contain a mix of grasses and weeds, contains cover and grazing opportunities for small and larger animal species. Soil organisms, including microorganisms and earthworms, may be directly exposed to impacted soil. Plants may be exposed by the uptake of nutrients through root systems.

Terrestrial receptors could be exposed to soils as they graze and burrow in the former north and south production areas and tank farms. The soil exposure pathway was assumed to be limited to only those chemicals detected in surface and subsurface soils within the vicinity of the former north and south production areas and tank farms, and receptor species were assumed to spend all of their time and feed within these areas.

Representative species that were selected for evaluation of completed soil exposure pathways in the North and South Refineries include the short-tailed shrew, white-footed mouse, meadow vole, eastern cottontail rabbit, red fox, white-tailed deer, and American robin. All of these species could potentially accidentally or intentionally ingest Site soils. Based on feeding patterns, it was assumed that the red-tailed hawk does not accidentally or intentionally ingest soils.

14.2.3.2 Aquatic Species

Aquatic wildlife species observed at the Site include painted turtles, frogs, and toads. Other species not observed but likely to be within the area and potentially exposed to the exposure pathways for aquatic species include aquatic and benthic invertebrates, fish, ducks, belted kingfishers, and great blue herons. These species are likely to be exposed to contaminants within the waste pond surface water, waste pond sediments, and by consuming fish, aquatic vegetation, and aquatic and benthic invertebrates that have accumulated contaminants. The fish, frogs, and aquatic and benthic invertebrates likely inhabit only one pond at the Site for their entire lives. Great blue herons, ducks, belted kingfishers and various shore birds likely inhabit the narrow riparian areas around the ponds in the north and south halves of the Site and visit many other ponds off the Site.

All the ponds in the North and South Refineries are manmade and most were created to treat the wastewater from refinery processes. Skull Creek is an intermittent stream that did not contain any water at the time of the field surveys. All the terrestrial wildlife receptor species, short-tailed shrew, white-footed mouse, meadow vole, eastern cottontail rabbit, red fox, white-tailed deer, American robin, and red-tailed hawk, are assumed to be ingesting water from the ponds on Site. Maximum concentrations detected in the ponds in the North Refinery and South Refinery were used for evaluating the risk to terrestrial wildlife. This method of evaluating surface water exposure by representative terrestrial wildlife species is conservative in that it assumes the receptor is spending all of its time within the vicinity and/or is habitually drinking from the pond containing the highest detected concentration of each COPC.

Representative aquatic species that were selected for evaluation of completed pond sediment exposure pathways in the North and South Refineries include aquatic invertebrates, aquatic plants, fish, mallard duck, great blue heron, and belted kingfisher. Potential risk to ecological receptors from surface water contaminants was assessed using analytical data for samples collected from the North and South Refinery ponds as well as Skull Creek. All the aquatic receptor species are assumed to be ingesting constituents detected in the water from the ponds on Site.

No aquatic reptile or amphibian species were selected as representative species because of the lack of toxicological benchmarks in the available literature; however, the mallard duck was selected to be a surrogate for the painted turtles observed in the North Refinery.

Fish collection field studies were performed for the ponds on the North Refinery. Fish from the Firewater Pond and fish from Pond 6 were collected and evaluated for COPCs. Fish were not observed or collected in any of the ponds in the South Refinery. The maximum detected COPC from the whole fish samples was used in this ecological evaluation. The great blue heron and the belted kingfisher inhabiting the North Refinery are potential ecological receptors that could consume fish that have accumulated potential Site constituents.

14.2.3.3 Bioaccumulation

The potential for COPCs to be transferred from soil to plants, soil to soil invertebrates (earthworm), sediments to benthic invertebrates, and surface water to fish, aquatic plants, and aquatic invertebrates by uptake was evaluated. It was assumed that the terrestrial insectivorous, herbivorous, and omnivorous species were consuming vegetation and earthworms that have been exposed and accumulated COPCs by root uptake (plants) or by direct ingestion of soils (earthworms). Similarly, the terrestrial carnivores (red fox and red-tailed hawk) were assumed to consume the small mammals (shrew, white-footed mouse, vole, and cottontail rabbit) that inhabit the Site. These small mammals are consuming soils, surface water, soil organisms (earthworms), and vegetation that may contain concentrations of COPCs.

It was also assumed that the omnivorous mallard duck was consuming aquatic vegetation, aquatic invertebrates, and benthic invertebrates that have been exposed and accumulated COPCs by absorption (aquatic plants) or by direct ingestion of surface water (aquatic invertebrates) and sediments (benthic invertebrates). Similarly, the carnivorous great blue heron and belted kingfisher were assumed to consume the fish that inhabit the ponds at the Site. The fish are assumed to be consuming sediments, surface water, and aquatic and benthic invertebrates that may contain concentrations of COPCs.

14.2.4 Ecological Risk Characterization

Risk characterization assesses the likelihood of adverse ecological effects associated with exposure to Site contamination. The risk characterization combines the quantitative evaluation with the qualitative assessment to conclude if significant risk to ecological receptors exists (USEPA, 1997c). All the areas of the North and South Refineries were evaluated both qualitatively and quantitatively to assess risk to ecological receptors. The entire Site was evaluated for the presence of completed ecological exposure pathways. During the ecological risk characterization it was noted that the primary areas where ecological risk was indicated were co-located with areas where human health risk was also identified.

The areas determined to have completed exposure pathways for Site-related contaminants were the area in the vicinity of the former tank farms and North and South Production Areas. Based upon observed Site conditions in the vicinity of these areas, it was concluded that flora and fauna could be exposed to Site-related constituents through uptake, direct contact and/or ingestion of soil, pond sediments, surface water, and fish. Similarly, it was concluded that area fauna could be exposed to Site-related constituents through the bioaccumulation of Site related constituents in benthic invertebrates, aquatic and terrestrial invertebrates, aquatic and terrestrial plants, small mammal prey, and fish.

After ecological receptors were identified, receptors with available toxicity data or benchmarks were selected. A benchmark represents the highest concentration of a COPC where long term exposure results in no observed effects. Benchmarks have been established for many individual COPCs in a variety of environmental media (soil, water, sediment) and for ingestion by some receptors. In many cases benchmarks are not available and alternative methods are used to access toxicity. For each contaminant where media specific benchmarks were available, a ratio of the estimated environmental concentration to media specific benchmarks was used to generate a value called a hazard quotient (HQ). For some receptors, a ratio of the estimated dose received from ingestion (mg COPC/ kg body weight per day) was compared to benchmark values to generate HQ values for specific receptors. The sum of HQ values for all COPC's present in a particular environmental media, or for a specific receptor is called the HI value.

Chemical concentrations that exceeded benchmarks were detected in soils, sediments, and surface water. Although, no visible adverse ecological effects to terrestrial and aquatic receptors were observed during field investigations conducted by biologists, the quantitative assessment, discussed below, indicates that the plant and wildlife communities within the Site may be experiencing some adverse affects due to the detected contaminants.

14.2.4.1 North Refinery

The highest exposure on the North Refinery was from soils and sediments from Waste Pond 2. The following ecological receptors had HI values calculated as greater than 1. The hazard was from metals; toxicity data were not available for VOCs and SVOCs COPCs.

- Soil Invertebrates
- Terrestrial Plants
- Terrestrial Species – short-tailed shrew, white-footed mouse, meadow vole, cottontail rabbit, red fox, white-tailed deer, and American robin
- Aquatic Species – mallard duck and great blue heron
- Benthic Invertebrates
- Aquatic Invertebrates
- Aquatic Plants
- Fish

Analysis of soils and water from the North Refinery indicate that soil contaminants, especially metals, show the greatest potential for risk to terrestrial plant and wildlife species. The other soil contaminants that significantly contributed to environmental risk were xylenes, bis(2-ethylhexyl)phthalate, and the PCB, Aroclor 1254. The detected concentrations of chemicals are greatest in Wastewater Pond 2 in the North which likely results in greater risk for wildlife that spend all or a part of their lives in this pond.

14.2.4.2 South Refinery

The highest exposure on the South Refinery was from soils. The following ecological receptors had HI values calculated as greater than 1. The hazard was from metals; toxicity data were not available for VOCs and SVOCs COPCs.

- Soil Invertebrates
- Terrestrial Plants
- Terrestrial Species – short-tailed shrew, white-footed mouse, meadow vole, cottontail rabbit, red fox, white-tailed deer, and American robin
- Aquatic Species – mallard duck, great blue heron, and belted kingfisher
- Benthic Invertebrates
- Aquatic Invertebrates
- Aquatic Plants
- Fish

Generally, detected concentrations of chemicals in soil are greater in the South Refinery than in the North Refinery, which likely results in greater risk for terrestrial wildlife that spend all or a part of their lives in the South Refinery. Analysis of soils and water from the South Refinery indicates that soil contaminants, especially metals, show the greatest potential for risk to terrestrial plant and wildlife species. The other soil contaminants that significantly contributed to environmental risk were xylenes, bis(2-ethylhexyl)phthalate, and the PCB Aroclor 1254. The detected concentrations of chemicals are greatest in the Coke Pond in the South Refinery, which likely results in greater risk for wildlife that spend all or a part of their lives in this pond.

14.2.4.3 Skull Creek

The following ecological receptors had HI values calculated as greater than 1. The hazard was from metals; toxicity data were not available for VOCs and SVOCs COPCs.

- Aquatic Species – mallard duck, great blue heron, and belted kingfisher
- Benthic Invertebrates
- Aquatic Invertebrates
- Aquatic Plants
- Fish

Estimates may over predict the amount of risk resulting from Skull Creek, which is an intermittent stream and was dry at the time of the Site visit.

14.2.5 Uncertainty Analysis

When evaluating the ecological risks, several inherent uncertainties exist. These uncertainties pertain to all aspects of the risk analysis. In order to evaluate the potential ecological risk, several assumptions must be made. Uncertainties associated with this ecological evaluation are presented in the following assumptions.

- The samples collected adequately cover all areas of concern and accurately represent what is occurring at the Site.
- All ecological receptors, including plants and wildlife, are identified.
- All chemicals are identified.
- Reported chemical concentrations are accurate.
- Chemicals identified do not interact in a synergistic manner.
- Relevant exposure pathways have been identified.
- Species exposure values under laboratory conditions are applicable to natural conditions.
- Wildlife exposure values are applicable to species of similar size and life history.
- Ingestion rates for representative species are accurate.
- The sizes of home ranges for representative species are comparable to what occurs in the field.
- Uptake modeling is representative of actual events that occur in the field.
- The facility is used by certain wildlife species for at least some portion of their lives and that use is a reflection of the percentage of the species range composed by the area.
- The facility is used by certain migratory species for at least some portion of their lives.
- Percentage of soil, sediment, water, and food ingested by ecological receptors is related to the percentage of time receptors spend within the Site.

The benchmark screening method uses conservative assumptions that represent a worst case scenario in relation to the amount of contamination that receptors are exposed to. This method overstates risk, and increases uncertainty because its intended use is to develop a list of effected areas and potential COPCs for further examination in the BERA. The results of a SLERA are typically used to design more precise studies that utilize realistic values for the amount of exposure that a receptor has. Because the results of the SLERA indicated that the areas with potentially unacceptable risk were largely co-located with areas that had unacceptable risk to human health, and because the intended future use of the site will eliminate much of the habitat used by ecological receptors, the decision was made to accept a higher level of uncertainty in the ecological risk assessment.

Skull Creek was dry at the time of the ecological evaluation. This creek originates at the eastern edge of the North Refinery. It travels beneath Depot Street and into a residential/agricultural area. Vehicle salvage areas are interspersed in the residential area. The creek travels through a concrete/stone-lined channel as it travels through the residential/agricultural areas; ecological habitat is limited. The origin (refinery related or attributable to off-site sources) of the metals contamination in Skull Creek is uncertain.

The Remedial Action basis addressing both ecological risk and human health risk management is outlined in the following section, Section 14.3.

14.3 Basis for Remedial Action

The response action selected in this ROD is necessary to protect the public health or welfare and the environment from actual or threatened releases of hazardous substances into the environment. The response action is warranted because:

- Unacceptable carcinogenic risks exist on the North Refinery for current trespassers, future indoor commercial/industrial workers and future commercial/industrial outdoor workers. Current trespassers/recreationists have a total carcinogenic risk from primarily dermal exposure to benzo(a)pyrene and benzo(a)anthracene in sediments from Waste Ponds 1 and 2 of 4×10^{-4}. Future outdoor commercial/industrial workers have an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene in shallow soil of 2×10^{-5} and an increased carcinogenic risk from primarily dermal exposure to benzo(a)pyrene in sediments from Waste Ponds 1 and 2 of 2×10^{-4}.
- Unacceptable carcinogenic risks exist on the South Refinery for current trespassers, future indoor commercial/industrial workers, and future commercial/industrial outdoor workers. Current trespassers have an increased carcinogenic risk from both ingestion and dermal exposure to arsenic in shallow soil of 3×10^{-5}, an increased carcinogenic risk from ingestion and dermal exposure to benzo(a)pyrene in Coke Pond surface water of 4×10^{-4}, and an increased carcinogenic risk from ingestion and dermal exposure to benzo(a)pyrene in coke pond sediments of 5×10^{-4}. Future indoor commercial/industrial workers have an increased carcinogenic risk from ingestion exposure to benzo(a)pyrene and arsenic in shallow soil of 8×10^{-5}. Future outdoor commercial/industrial workers have an increased carcinogenic risk from both ingestion and dermal exposure to benzo(a)pyrene and arsenic in shallow soil of 1×10^{-4}, an increased carcinogenic risk dermal exposure to benzo(a)pyrene in coke pond surface water of 1×10^{-4}, and an increased carcinogenic risk from dermal exposure to benzo(a)pyrene and benzo(a)anthracene in Coke Pond sediments of 1×10^{-3}.
- Unacceptable non-carcinogenic risks exist on the South Refinery for future construction/utility workers. Future construction/utility workers have an increased non-carcinogenic risk from both ingestion and dermal exposure to arsenic in soil with a HI of 3.
- Unacceptable elevated lead levels were isolated in a discrete area of the South Refinery where the anticipated reuse was commercial/industrial. These levels are above the ODEQ

"Soil Clean Up for Lead in Nonresidential Soil" memo management approach which uses the EPA Adult Lead Methodology.

- LNAPL found on the ground water will continue to act as a source of contamination. Additionally, the LNAPL has the potential to migrate off-site.
- The concentrations of benzene in the shallow ground water at well OW-B and thallium in wells MW-4 and OW-M exceed the National Primary Drinking Water maximum contaminate levels (MCLs) (40 CFR Part 141) for the respective contaminants. While use of the shallow ground water is not anticipated, the pathway should be addressed to ensure that ground water contamination does not migrate beyond Site boundaries and to ensure that the areas with contamination are stable and/or decreasing. Thallium contamination will be investigated further during the remedial design as described in Section 24.1.

Cleanup goals for the South Refinery and the north process area and north tank farm areas of the North Refinery are commercial/industrial. Based on the City of Cushing's reasonably anticipated reuse of commercial/industrial, EPA determined that cleanup of the site set to an excess cancer risk of 1×10^{-5} is appropriate for the areas requiring cleanup. This level is intermediate within the EPA generally acceptable risk range of for site-related exposures of 1×10^{-4} to 1×10^{-6} and consistent with EPA guidance. The decision to clean up these areas for commercial/industrial levels was made in cooperation with the City of Cushing and the city's long-range plans for the site and for that area of the city. ODEQ supports this decision.

The ecological risk assessment identified the potential for unacceptable risk to ecological receptors on the Site. These areas of the Site where unacceptable risk was identified are co-located in the areas where unacceptable risk is identified for human receptors. Ecological habitat on-site will be limited and disturbed following cleanup of waste ponds and Site soils. The Site is currently zoned for commercial/industrial use and the city's long-range plans for site redevelopment continue with a commercial/industrial scenario. It is anticipated that ecological habitat will continue to be limited after redevelopment. Cleanup to address human health risks will likely be protective of potential ecological receptors (terrestrial and aquatic wildlife, terrestrial and aquatic plants, and soil and benthic organisms) in the limited areas of ecological habitat that remain at the Site.

Remedial action for Skull Creek is not planned. Skull Creek exists primarily off of the Site and the creek's ecological habitat is limited and the creek was primarily dry at the time of sampling. Metals that were detected in Skull Creek sediment and surface water were less than or equivalent to background sediment and surface water samples. Additionally, no human health risk was identified.

15.0 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) consist of medium-specific or location-specific goals for protecting human health and the environment. This section presents the RAOs for soil, waste pond sediment, waste pond surface water, ground water and LNAPLs, and other media at the Site. It outlines the risks identified in Section 14 and provides the basis for evaluating the cleanup options presented in Section 16. The RAOs also serve to facilitate the five-year review determination of protectiveness of human health and the environment.

15.1 Remedial Action Objectives for the Site

RAOs were developed in the FS for the Site by medium. Areas of Concern (AOCs) were then developed for each media.

Soil - AOCs for soil are shown on Figure 9.

- Prevent exposure to current and future human receptors and ecological receptors through direct contact with, inhalation, or ingestion of contaminated soil that exceeds a Hazard Index greater than 1 or in excess of 10^{-5} excess cancer risk.

Waste Pond Sediment - AOCs for sediment are shown on Figure 10.

- Prevent exposure to current and future human receptors and ecological receptors through direct contact with and ingestion of contaminated waste pond sediment that exceeds a Hazard Index greater than 1 or in excess of 10^{-5} cancer risk.

Waste Pond Surface Water - AOCs for surface water are also shown on Figure 10.

- Prevent exposure to current and future human receptors and ecological receptors through direct contact with and ingestion of contaminated waste pond surface water that exceeds a Hazard Index greater than 1 or in excess of 10^{-5} cancer risk.

Ground Water and LNAPL - AOCs for ground water and LNAPL are shown on Figure 11.

- Restore ground water to drinking water quality by attaining the National Primary Drinking Water MCLs for ground water COCs.
- Prevent LNAPL from moving off-site and/or discharging into surface water bodies.
- Reduce or eliminate the potential for ground water to be impacted by contamination located in the subsurface by removing LNAPL from the ground water until the performance standard (a threshold thickness of 0.1 foot of LNAPL, measured using an interface probe in monitoring or extraction wells) is attained. (USEPA, 1986b)

Other Media - AOCs for other media are also shown on Figure 10.

- Prevent unacceptable exposure risks to current and future human populations from the inhalation or ingestion of ACM or associated contaminated materials.
- Eliminate and prevent further degradation of the surrounding environment as a result of exposure to coke tar and coke tar contaminated soil.
- Eliminate and prevent human health, environmental and public safety hazards presented by aeration pond 7, associated sumps, the electrical vault, and scrap metal.

The cleanup levels for the Site are:

ACM

ACM cleanup will be compliant with NESHAP standards considered at 40 CFR Part 61 Subpart M.

Soil Cleanup Levels

The cleanup levels for a commercial/industrial cleanup of soil are: benzo(a)pyrene - 4.22 milligram/ kilogram (mg/kg), arsenic - 31.8 mg/kg, and lead - 1000 mg/kg.

Waste Pond Sediment Cleanup Levels

The cleanup levels for a commercial/industrial cleanup of waste pond sediment are: benzo(a)anthracene 42.2 mg/kg and benzo(a)pyrene - 4.22 mg/kg.

Waste Pond Surface Water Cleanup Levels

The cleanup level for a commercial/industrial cleanup of waste pond surface water is: benzo(a)pyrene - 6.0 microgram/liter (µg/l). Additional cleanup levels may be necessary for discharge or off-site treatment.

Ground Water

The cleanup levels for ground water are: benzene - 5.0 µg/l and thallium - 2.0 µg/l.

The cleanup level for LNAPL is a threshold thickness of 0.1 foot or less of LNAPL, measured using an interface probe in monitoring or extraction wells. (EPA, 1996b)

Cleanup levels are described in further detail in Section 19.4.3

15.2 Basis and Rationale for Remedial Action Objectives

The basis for the commercial/industrial RAOs for the contaminated Site media is the anticipated long-range future land use for the portions of the Site that had refinery operations and refinery-related contamination above risk levels. Areas that had no refinery operations or require no cleanup are the areas targeted by the city for residential reuse. The soil results from these areas were compared to calculated residential risk-based cleanup numbers and no exceedences were found.

Waste pond surface water must also be removed to be able to remediate the sediment and removal will prevent trespasser exposure to waste pond surface water.

The purpose of the extraction of LNAPL is to keep it from continuing to act as a source of contamination for soil and ground water. Due to the nature of the extraction methods for LNAPL plumes, it is more appropriate to establish a performance standard for LNAPL extraction than it is to select a remediation goal based on concentrations of COCs. Therefore, this ROD requires LNAPL to be extracted until a maximum of one-tenth of a foot (0.1 foot) of LNAPL remains in the monitoring well(s) completed in the LNAPL contamination. The LNAPL thickness will be measured using an interface probe. Once the LNAPL thickness in the monitoring well(s) has stabilized at 0.1 foot or less the LNAPL removal may stop. Monitoring must be conducted to determine if the LNAPL contamination has stabilized. This standard is based on EPA guidance and common engineering practice during hydrocarbon recovery operations at underground storage tank locations (USEPA, 1996).

The basis for the RAOs for the ground water is to ensure that current and future receptors are not exposed to contaminated ground water, to ensure that contaminated ground water does not move off-site, and that contaminant levels are stable and/or decreasing.

15.3 Risks Addressed by the Remedial Action Objectives

The risks addressed by remediation of soil include:

- Elimination of risk from incidental ingestion to indoor commercial/industrial worker exposed to surface soil;
- Elimination of risk from incidental ingestion and dermal contact to trespassers/recreationists, indoor commercial/industrial workers and outdoor commercial/industrial workers exposed to shallow soil; and
- Elimination of risk from incidental ingestion and dermal contact to construction/utility workers exposed to the complete soil column.

The risk to residents from incidental ingestion and dermal contact from soil was determined not to be a completed pathway after review of the City of Cushing’s letter of intent for long-range reuse.

The risks addressed by remediation of waste pond sediments, coke tar and coke tar contaminated soils include:

- Elimination of risk from incidental ingestion and dermal contact to trespassers/recreationists, and outdoor commercial/industrial workers exposed to waste pond sediments; and

- Both contaminated waste pond sediments and coke tar are considered principal threat wastes. Waste pond sediments are considered principal threat waste as source material and a significant risk based on the presence of hazardous levels of metals. Coke tar is considered principal threat waste as source material.

The risk to residents from incidental ingestion and dermal contact with sediment was determined to not be a completed pathway after receipt of the City of Cushing's letter of intent for long-range reuse.

The risks addressed by remediation of surface water include:

- Elimination of risk from incidental ingestion and dermal contact to trespassers/recreationists, and outdoor commercial/industrial workers exposed to surface water.

The risks addressed by remediation of LNAPL and ground water include:

- Elimination of risk dermal contact and incidental ingestion to trespassers/recreationists, outdoor commercial/industrial workers, and construction/utility workers exposed to LNAPL or ground water;
- Elimination of risk from outdoor vapor inhalation to construction/utility workers exposed to LNAPL or ground water;
- Elimination of risk from ingestion of ground water; and
- Elimination from LNAPL continuing to contaminate ground water.

The risk to residents from incidental ingestion and dermal contact with ground water was determined to not be a completed pathway after review of the City of Cushing's letter of intent for long-range reuse.

The risks addressed by remediation of other media include:

- Elimination of inhalation risks from exposure to ACM; and
- Elimination of public safety hazards from aeration pond 7, associated sumps, the electrical vault, and scrap metal.

16.0 DESCRIPTION OF ALTERNATIVES

Many technologies were considered to clean up the Site. Twelve alternatives were developed for detailed evaluation. Appropriate technologies were identified and screened for applicability to site conditions. The potential technologies were then assembled into alternatives for each media. Potential remedial alternatives of the Site were identified, screened, and evaluated. The range of alternatives developed included no action, institutional controls, containment, treatment, and disposal. The alternatives for each media were evaluated and the selected remedy is discussed in Section 19. (Burns & McDonnell, 2007)

16.1 Description of Remedy Components

In addition to a site-wide "no action" alternative, three alternatives were evaluated for soil, two alternatives were evaluated for waste pond sediment, two alternatives were evaluated for waste pond surface water, two alternatives were evaluated for LNAPL, and four alternatives were evaluated for ground water. The description of remedy components are organized by media starting with a "common elements" discussion. There is only one alternative for "other media" components. These wastes were determined to have only one viable option in the FS. Table 10 provides a summary of remedial alternatives.

16.1.1 Other Media

Institutional Controls

ICs will be required to aid in the management of the wastes left on-site. ICs would include deed notices placed on land parcels that are contained in the Site. ICs would notify current and potential future deed holders of the presence of wastes left on-site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, land use restrictions, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. ICs are components of the alternatives described for each medium. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. Currently the Site is zoned for industrial use. The costs for ICs are included with each of the alternatives being evaluated

Asbestos-Containing Material

Estimated Capital Cost - $13,440
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $16,523
Discount Rate - 7%
Estimated Construction Timeframe - 3 months
Estimated Time to Achieve RAOs - 3 months
Approximately 10 cubic yards of ACM would be excavated, containerized, and transported to a regulated off-site disposal facility. The ACM is considered principal threat waste as source material. Because the contaminants will be removed and disposed of off-site, this remedy does not meet the EPA's preference for treatment of principal threat wastes. ACM cleanup will be compliant with standards considered at 40 CFR Part 61 Subpart M.

Coke Tar

Estimated Capital Cost - $619,984
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $646,551
Discount Rate - 7%
Estimated Construction Timeframe - 3 months
Estimated Time to Achieve RAOs - 3 months
Approximately 6,000 cubic yards of coke tar would be excavated, stabilized, and transported to a regulated off-site disposal facility. Once the coke tar is removed, these areas would be subject to the soil/sediment RAOs and cleanup levels. The area of coke tar removal would require EPA to conduct a five-year review of the remedy because the area would be cleaned up for a commercial/industrial reuse. The coke tar materials are considered principal threat wastes as source material. Because the waste will be stabilized, this alternative meets the EPA's preference for treatment of principal threat wastes.

Scrap Metal

Estimated Capital Cost - $16,500
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $19,583
Discount Rate - 7%
Estimated Construction Timeframe - 1 month
Estimated Time to Achieve RAOs - 1 month

Material, including tanks and metal debris, that remains at the Site would be removed and salvaged. If any of the material is not salvageable, it would be disposed of at an authorized off-site disposal facility.

16.1.2 Alternative 1 for all Media – No Action

Estimated Capital Cost - $0
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $345,819
Discount Rate - 7%
Estimated Construction Timeframe - None
Regulations governing the Superfund program generally require that the “no action” alternative be evaluated to establish a baseline for comparison. Under this alternative, EPA would take no action at the Site to prevent exposure to the soil, sediment, ground water, other Site contamination, and movement of LNAPL in the ground water. Principal threat wastes will continue to remain at the Site and no attempts will be made to restore ground water or to prevent contaminated ground water migration from the Site. This alternative will not comply with the Applicable or Relevant and Appropriate Requirements (ARARs) for the Site. The magnitude of risks at the Site is likely to remain the same since contaminated media that pose a risk to human health will remain on the Site. By leaving the waste on-site, the EPA will be required to conduct five-year reviews. Costs associated with this “no action” alternative include conducting five-year reviews. Conducting remedy reviews is assumed to include monitoring of all media and wastes remaining on the Site.

16.1.3 Soil, North Refinery and South Refinery

Alternative 2 – Clay Cap
Estimated Capital Cost - $1,417,292
Estimated Annual O&M Cost - $47,056 (Years 2 – 10; with closure post year 10)
Estimated Present Worth Cost - $1,795,403
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
Under this alternative, approximately 32,000 cubic yards of soil would be capped in place on the North and South Refineries. This alternative includes capping contaminated soil in place with a vegetated soil cap to prevent direct contact with soil that has concentrations above the cleanup levels.

Fencing would be maintained around the Site to separate it from the highway and adjacent properties. Annual ground water monitoring would be conducted to detect movement of contaminants leaching from the capped area. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs, and to verify the cap retains its integrity. Signs would be posted at the property boundary to provide notification of the capped areas, the presence of contaminants, and to warn against intrusive activities. In the event that contaminated soils are capped in place, this remedy would be compliant with the Oklahoma Solid Waste Management Act (OSWMA) (OAC 252:515). If soils were determined to be characteristically hazardous, this alternative would be compliant with closure and post-closure standards at 40 CFR Part 264 subpart G.

ICs would be required to aid in the management of the contamination capped on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the capped areas. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would identify the reason for the notice, the affected property, the remedy, and engineering controls. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities (i.e., digging) that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the soil cap, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ.

Because waste will be left in place with this alternative, EPA will be required to conduct five-year reviews to evaluate remedy effectiveness. This alternative will achieve applicable RAOs and meet the cleanup levels by preventing exposure through engineering controls, institutional controls, and monitoring for off-site migration.

The Site would be available for limited reuse due to the capped areas. This alternative will not be compatible with the long range future land use described in the City of Cushing's letter of intent. While the capping will eliminate exposure pathways, it will reduce the amount of Site property available for appropriate reuse.

Alternative 3 – Excavation and On-site Disposal Cell
Estimated Capital Cost - $2,640,330
Estimated Annual O&M Cost - $14,269 (Years 2 – 10; with closure post year 10)
Estimated Present Worth Cost - $2,788,163
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
Under this alternative, approximately 32,000 cubic yards of soil would be excavated and placed in an on-site disposal cell. The excavated areas would be graded for drainage and backfilled with clean soil. The cell would be capped with a minimum 2-foot vegetated soil cap to prevent direct contact with soil that has concentrations above the cleanup levels and to prevent contact with storm water. The cover would be designed for adequate drainage and controls would be put in place to minimize erosion. The most appropriate location of the cell would be determined during design.

Fencing would be maintained around the cell to separate it from the highway, adjacent properties and cleaned portions of the Site. Annual (per cost estimate) ground water monitoring would be conducted to determine if the contents of the cell are impacting ground water beneath the cell. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs, and to verify the cap retains its integrity. Signs would be posted at the property boundary to provide notification of the capped areas, the presence of contaminants, and to warn against intrusive activities. In the event that contaminated soils are capped within a disposal cell, this remedy would be compliant with the OSWMA (OAC 252:515). If soils were determined to be characteristically hazardous, this alternative would be compliant with closure and post-closure standards at 40 CFR Part 264, Subpart G.

ICs would be required to aid in the management of the contamination in the on-site cell and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the on-site cell. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would identify the reason for the notice, the affected property, the remedy, and engineering controls. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities (i.e., digging) that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the on-site cell, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ.

Because waste will be left in place with this alternative, EPA will be required to conduct five-year reviews to evaluate remedy effectiveness. This alternative will achieve applicable RAOs and meet the cleanup levels by preventing exposure through engineering controls, institutional controls, and monitoring for off-site migration.

While waste consolidation allows more of the Site to be available for reuse, this alternative may not be compatible with the long range future land use described in the City of Cushing's letter of intent. The on-site disposal will eliminate exposure pathways; however, it will reduce the amount of Site property available for appropriate reuse.

Alternative 4 – Excavation and Off-site Disposal at Permitted Facility
Estimated Capital Cost - $3,532,830
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $3,571,397
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
For this alternative, approximately 32,000 cubic yards of soil in the South and North Refineries would be excavated and transported to an appropriate off-site permitted landfill. The contaminated soil would be excavated and loaded onto trucks and transported to an off-site permitted waste landfill for disposal. Confirmation sampling would occur during remedial activities to verify the classification of the waste for disposal. The excavated areas would be backfilled with clean soil, graded for adequate drainage, and re-vegetated.

ICs would be required to aid in the management of waste left on-site and to ensure the protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders placed on land parcels that are contained in the Site. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and land use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. This alternative will achieve applicable RAOs and meet the cleanup levels by permanently removing contaminated material from the Site and reducing risk by minimizing contact with hazardous substances, pollutants, or contaminants. As cleanup levels are for protection under a commercial/industrial scenario, five-year reviews of the remedy will be required.

This alternative would be compliant with the OSWMA (OAC 252:515). If soils were determined to be characteristically hazardous, this alternative would be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils. Soils trucked to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

16.1.4 Waste Pond Sediment - Aeration Pond 7 and Sumps, Wastewater Ponds 1 and 2, and Coke Pond

These alternatives address remediation of waste pond sediments that exceed remediation goals. Waste pond surface water would be removed and treated by the alternatives as described in Section 16.1.5.

Alternative 2 – Excavation, Stabilization and On-site Disposal Cell
Estimated Capital Cost - $3,719,610
Estimated Annual O&M Cost - $14,269 (Years 2 – 10; with closure post year 10)
Estimated Present Worth Cost - $3,867,444
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
Under this Alternative, approximately 21,000 cubic yards of waste pond sediment, would be dewatered, stabilized, excavated, and placed in an on-site disposal cell. TCLP analysis indicated that TCLP chromium levels are higher than the maximum concentration of contaminants for the toxicity characteristic list at 40 CFR §261.24 and thus exhibit hazardous characteristics and/or have concentrations of contaminants that could leach from the sediments at unacceptable levels. The results of the 2006 Treatability Study indicate that stabilization would be successful in reducing the leachability of the chromium from the waste pond sediment. The ponds would be drained, with measures taken to retain pond sediments within the pond. The sediment from the ponds would be dewatered as necessary, stabilized, and excavated for loading and transport to an on-site disposal cell. The excavated areas would be graded for drainage and backfilled with clean soil. The cell would be capped with a minimum 2-foot vegetated soil cap to prevent direct contact with soil that has concentrations above the cleanup levels and to prevent contact with storm water. The cover would be designed for adequate drainage and controls would be put in place to minimize erosion. The most appropriate location of the cell would be determined during design.

These waste pond sediments are considered principal threat wastes as source material. Because the waste will be stabilized, this alternative meets the EPA’s preference for treatment of principal threat wastes.

The Aeration Pond, waste ponds 1 through 6a and ponds, 8a, and 9 on the North Refinery are interconnected as part of the refinery’s wastewater management system and directly affect Site drainage. The ponds not requiring remediation would be drained, berms leveled, and graded to ensure that rainwater runoff is allowed to drain properly from the Site and to eliminate the potential for flooding in the adjacent commercial/residential areas.

Fencing would be maintained around the cell to separate it from the highway, adjacent properties and cleaned portions of the Site. Annual ground water monitoring would be conducted to determine if the contents of the cell are impacting ground water beneath the cell. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs, and to verify the cap retains its integrity. Signs would be posted at the property boundary to provide notification of the capped areas, the presence of contaminants, and to warn against intrusive activities. In the event that contaminated sediments are capped in place, this remedy would be compliant with the OSWMA (OAC 252:515). If soils were determined to be characteristically hazardous, this alternative would be compliant with closure and post-closure standards at 40 CFR Part 264 Subpart G.

ICs would be required to aid in the management of the contamination in the on-site cell and to ensure protectiveness of the remedy. ICs would include a deed notice to notify current and potential future deed holders of the presence of contaminants and of the on-site cell. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would identify the reason for the notice, the affected property, the remedy, and engineering controls. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities (i.e., digging) that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the on-site cell, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ.

Because waste will be left in place with this alternative, EPA will be required to conduct five-year reviews to evaluate remedy effectiveness. This alternative will achieve applicable RAOs and meet the cleanup levels by preventing exposure through engineering controls, institutional controls, and monitoring for off-site migration.

While waste consolidation allows much of the Site to be available for reuse, this alternative may not be compatible with the long range future land use described in the City of Cushing's letter of intent. The on-site disposal will eliminate exposure pathways; however, a disposal cell will reduce the amount of Site property available for appropriate reuse.

Alternative 3 – Excavation, Stabilization and Off-site Disposal at Permitted Facility
Estimated Capital Cost - $4,581,330
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $4,619,897
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
Under this alternative, approximately 21,000 cubic yards of waste pond sediment would be dewatered, stabilized, as needed, excavated, and transported to a permitted off-site disposal facility. As stated in alternative 2 above, TCLP analysis indicated that TCLP chromium levels are higher than the maximum concentration of contaminants for the toxicity characteristic list at 40 CFR §261.24 and thus exhibit hazardous characteristics and/or have concentrations of contaminants that could leach from the sediments at unacceptable levels. The results of the 2006 Treatability Study indicate that stabilization would be successful in reducing the leachability of the chromium from the waste pond sediment. The ponds would be drained, with measures taken to retain pond sediments within the pond. The sediment from the ponds would be dewatered as necessary, stabilized, and excavated for loading and transport to an appropriate off-site permitted landfill. The excavated areas would be backfilled with clean soil, graded for adequate drainage, and re-vegetated.

These waste pond sediments are considered principal threat wastes as source material. Because the waste will be stabilized, this alternative meets the EPA's preference for treatment of principal threat wastes.

The Aeration Pond, waste ponds 1 through 6a and ponds, 8a, and 9 on the North Refinery are interconnected as part of the refinery's wastewater management system and directly affect Site drainage. The ponds not requiring remediation would be drained, berms leveled, and graded to ensure that rainwater runoff is allowed to drain properly from the Site and to eliminate the potential for flooding in the adjacent commercial/residential areas.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders placed on land parcels that are contained in the Site. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and land use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. This alternative will achieve applicable RAOs and meet the cleanup levels by permanently removing contaminated material from the Site and reducing risk by minimizing contact with hazardous substances, pollutants, or contaminants. As cleanup levels are for protection under a commercial/industrial scenario, five-year reviews of the remedy will be required.

This alternative would be compliant with the OSWMA (OAC 252:515). If sediments were determined to be characteristically hazardous, this alternative would be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils. Sediments trucked to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

16.1.5 Waste Pond Surface Water - Aeration Pond 7 and Sumps, Wastewater Ponds 1 and 2, and Coke Pond

Surface water volume varies significantly with rainfall additions to and evaporation from the waste ponds. For the cost estimate purposes it was assumed that 7.5 million gallons would need to be treated.

Alternative 2 – On-site Treatment
Estimated Capital Cost - $345,120
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $352,403
Discount Rate - 7%
Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year

This alternative would consist of the collection and treatment of contaminated surface water from the aeration pond, wastewater ponds 1 and 2, and the coke pond at an on-site water treatment facility. Non-contaminated surface water from the waste ponds that will be graded to ensure proper Site drainage will be treated, as necessary. On-site treatment would involve the design and construction of a water treatment facility to treat contaminant concentrations and/or remove metals and organics from the surface water. Applicable and appropriate surface water discharge requirements would need to be met for this alternative. The treated water would be discharged to either Skull Creek or transported off-site for disposal. This alternative will achieve applicable RAOs, meet cleanup levels and any necessary discharge treatment levels.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

Alternative 3 – Off-site Treatment at Regulated Facility
Estimated Capital Cost - $2,179,500
Estimated Annual O&M Cost - $0
Estimated Present Worth Cost - $2,186,783
Discount Rate - 7%

Estimated Construction Timeframe - 1 year
Estimated Time to Achieve RAOs - 1 year
This alternative would consist of the collection and treatment of contaminated surface water from the aeration pond, wastewater ponds 1 and 2, and the coke pond at an off-site water treatment facility. Also non-contaminated surface water from the ponds not requiring remediation would be treated at the off-site treatment facility. The surface water may need to be treated to meet the requirements of the facility receiving the water. This alternative will achieve applicable RAOs, meet cleanup levels, and any necessary levels necessary for off-site disposal. Surface water transport to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

16.1.6 Light Non-Aqueous Phase Liquid

The estimated volume of LNAPL found on the site is 4,955 cubic feet and is currently located in one well on-site.

Alternative 2 – Hydrocarbon Belt Skimmers
Estimated Capital Cost - $37,200
Estimated Annual O&M Cost - $10,800 (Years 1 – 5)
Estimated Present Worth Cost - $124,260
Discount Rate - 7%
Estimated Construction Timeframe - 3 months
Estimated Time to Achieve RAOs - 5 years
For this alternative, hydrocarbon belt skimmers would be installed to remove LNAPL in wells where LNAPL was observed. LNAPL is considered principal threat waste as a continuing source of ground water contamination. Hydrocarbon belt skimmer technology is based on the properties of certain types of media to attract hydrocarbon and repel water. The hydrocarbon belt skimmer or hydroskimmer involves circulation of an endless hydrocarbon resistant belt from the surface, down a well or sump and through the hydrocarbon/water interface. A drive/recovery unit at the wellhead is used to circulate the belt and remove the recovered hydrocarbon. The recovered hydrocarbon would be placed into a drum or tank for storage then disposed or recycled off-site. Operation of the system would be required for the five years it is estimated that the system would run to achieve RAOs.

Fencing would be maintained around the LNAPL treatment system. Signs would be posted to provide notification of the presence of contaminants, and to warn against entry into the fenced area. Annual inspections will occur to evaluate the condition of the hydrocarbon belt skimmers and associated equipment. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs. Ground water monitoring would be conducted to ensure that the LNAPL is not migrating downgradient or laterally. After LNAPL removal has been completed, continued ground water monitoring will be performed as part of the Ground Water Remedy. This will also include surveying the LNAPL well(s) for the presence of LNAPL with an oil-water interface probe during each ground water sampling event for 2 years after completion of LNAPL removal.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the hydrocarbon belt skimmer system at the property. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of hydrocarbon belt skimmer and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. As a continuing source of ground water contamination, LNAPL removal would be considered part of ground water restoration to achieve applicable RAOs and cleanup levels.

This alternative would permanently remove LNAPL from the Site and is an acceptable practice that reduces the risk posed by hazardous substances by minimizing contact with the public and environment. Because the contaminants will be contained and disposed of off-site, this remedy does not meet the EPA's preference for treatment of principal threat waste.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

Alternative 3 – Collection Trenches with Hydrocarbon Belt Skimmers, and Ex-Situ Treatment *Estimated Capital Cost* - $219,840
Estimated Annual O&M Cost - $10,800 (Years 1 – 5)
Estimated Present Worth Cost - $279,993
Discount Rate - 7%
Estimated Construction Timeframe - 6 months
Estimated Time to Achieve RAOs - 6 months
For this alternative, collection trenches would be installed down gradient of the LNAPL plume to remove LNAPL. As stated in alternative 2 above, LNAPL is considered principal threat waste as a continuing source of ground water contamination. Hydroskimmers would be installed in sumps along a trench. The sumps could also be used to draw down ground water to better allow free product to flow into the trenches. Ground water withdrawn from the trenches would be treated prior to discharge. Treatment would include an oil/water separator (to remove the LNAPL), pH adjustment, precipitation and flocculation (to remove metals), and air stripping (to remove VOCs from the ground water). The recovered hydrocarbon/contamination would be placed into a drum or tank for storage then disposed or recycled off-site.

Fencing would be maintained around the LNAPL treatment system. Signs would be posted to provide notification of the presence of contaminants, and to warn against entry into the fenced area. Annual inspections will occur to evaluate the condition of the collection trenches and hydrocarbon belt skimmers and associated equipment while system is operational. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs. Ground water monitoring would be conducted to ensure that the LNAPL is not migrating downgradient or laterally. After LNAPL removal has been completed continued ground water monitoring will be performed as part of the Ground Water Remedy. This will also include surveying the LNAPL well(s) for the presence of LNAPL with an oil-water interface probe during each ground water sampling event for 2 years after completion of LNAPL removal.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the collection trenches and hydrocarbon belt skimmer system at the property. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of collection trenches and hydrocarbon belt skimmer system and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. As a continuing source of ground water contamination, LNAPL removal would be considered part of ground water restoration to achieve applicable RAOs and cleanup levels.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse. This alternative would permanently remove LNAPL from the Site and is an acceptable practice that reduces the risk posed by hazardous substances by minimizing contact with the public and environment. Only the contaminated ground water will be treated. Because the LNAPL will be contained and disposed of off-site, this remedy does not meet the EPA's preference for treatment of principal threat waste.

16.1.7 Ground Water, Site Wide

Alternative 2 – Ground Water Monitoring
Estimated Capital Cost - $80,880
Estimated Annual O&M Cost - $29,520 (Years 3 – 10; O&M costs will be reevaluated after 10 years if contamination above cleanup levels remains)
Estimated Present Worth Cost - $335,829
Discount Rate - 7%
Estimated Construction Timeframe - 2 years
Estimated Time to Achieve RAOs - 30 years
Under this alternative, a ground water restoration monitoring program would be developed during the remedial design to monitor ground water until cleanup levels are achieved. Data will be collected from selected monitoring wells to provide additional contamination delineation information. While data indicate that no off-site migration of contaminated ground water has occurred, the data would be used to continue to evaluate the potential of future off-site migration and to ensure that the areas with contamination are stable and/or decreasing. This alternative will only be considered if the source (LNAPL) of ground water contamination is removed. After LNAPL removal has been completed, the ground water in the area where LNAPL was located would be monitored as part of the Ground Water Remedy.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the ground water monitoring wells installed at the property and identifying the area where the ground water monitoring wells are located. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the ground water monitoring wells and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. This alternative will achieve applicable RAOs and cleanup levels.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

Alternative 3 – Monitored Natural Attenuation
Estimated Capital Cost - $64,440
Estimated Annual O&M Cost - $108,000 (Years 4 – 10; O&M costs will be reevaluated after 10 years if contamination above cleanup levels remains)
Estimated Present Worth Cost - $870,599
Discount Rate - 7%
Estimated Construction Timeframe - 3 years
Estimated Time to Achieve RAOs - 30 years
This alternative consists of reduction in ground water contaminant levels and restoration through natural attenuation processes until cleanup levels are achieved. Literature indicates that benzene will naturally degrade over time through biodegradation. Thallium cannot be destroyed through biodegradation, but the transport can be affected by abiotic and biotic processes that impact the ground water chemistry and the form of the metal. Because no site-specific data are available to show that subsurface conditions are favorable for natural attenuation processes to reduce contaminant mass or concentration, treatability studies would need to be conducted. The treatability studies would include monitoring to ensure that conditions are favorable for natural attenuation, contaminant levels are decreasing, the contaminant plume is stable and/or decreasing in size. After LNAPL removal has been completed, the ground water in the area where LNAPL was located would be monitored as part of the Ground Water Remedy.

Monitored natural attenuation could only be considered if aggressive removal of the source (LNAPL) of the ground water contamination is completed. Institutional controls (i.e., ground water use restrictions, deed notices, etc.) will be required to ensure the protectiveness of the remedy. Post-closure ground water monitoring would be conducted to detect movement of contaminants. Because waste will be left on-site with this alternative, the EPA will also be required to conduct five-year reviews. This alternative will achieve applicable RAOs and meet the cleanup levels.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the monitored natural attenuation wells installed at the property and identifying the area where the monitoring wells are located. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the monitored natural attenuation wells and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. This alternative will achieve applicable RAOs and cleanup levels.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

Alternative 4 – Phytoremediation with Natural Attenuation
Estimated Capital Cost - $113,500
Estimated Annual O&M Cost - $20,000 (Years 4 – 10; O&M costs will be reevaluated after 10 years if contamination above cleanup levels remains)
Estimated Present Worth Cost - $301,584
Discount Rate - 7%
Estimated Construction Timeframe - 3 years
Estimated Time to Achieve RAOs - 30 years
For this alternative, vegetation would be planted to restore ground water until cleanup levels are achieved. Plants, including trees and grasses, remove ground water and degrade subsurface contamination as part of their natural growth. Trees and grasses would be planted and nutrients added to achieve the best balance for plant and microbial growth. Natural attenuation process would also contribute to the reduction of contaminant concentrations. Trees and grasses will be planted and nutrients such as nitrogen, phosphorous, and potassium added, as necessary. Nutrients that are used to amend soil conditions to enhance phytoremediation will likely boost the effectiveness of the biological component of the natural attenuation processes. Ground water would be monitored to evaluate the potential of future off-site migration and to ensure that the areas with contamination are stable and/or decreasing. After LNAPL removal has been completed, the ground water in the area where LNAPL was located would be monitored as part of the Ground Water Remedy.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the phytoremediation system installed at the property and identifying the area where the phytoremediation system is located. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the phytoremediation system and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. This alternative will achieve applicable RAOs and cleanup levels.

This alternative may be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse. The areas where the trees and grasses have been planted would not be available for all commercial/industrial reuses.

Alternative 5 – Pump and Treat Hydraulic Containment, Ex-Situ Treatment
Estimated Capital Cost - $1,011,980
Estimated Annual O&M Cost - $190,119 (Years 3 – 10; O&M costs will be reevaluated after 10 years if contamination above cleanup levels remains)
Estimated Present Worth Cost - $2,394,909
Discount Rate - 7%

Estimated Construction Timeframe - 2 years
Estimated Time to Achieve RAOs - 30 years
This alternative would consist of an active on-site remediation system to restore ground water and remove contamination above the cleanup levels. Removal wells would hydraulically contain and extract contaminated ground water. The installation of remedial wells would prevent exposure to contaminants and prevent contaminant migration. This alternative would be combined with ex-situ treatment (e.g. air stripping, precipitation, or flocculation) and institutional controls to contain and treat ground water impacts at the Site. The extracted ground water would then be treated and discharged to Skull Creek or to an off-site facility. After LNAPL removal has been completed, the ground water in the area where LNAPL was located would be monitored as part of the Ground Water Remedy.

Fencing would be maintained around the pump and treat hydraulic containment system. Signs would be posted to provide notification of the presence of contaminants, and to warn against entry into the fenced area. Annual inspections will occur to evaluate the condition of the pump and treat hydraulic containment system and associated equipment during system operation. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs during system operation.

ICs would be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs would include deed notices to notify current and potential future deed holders of the presence of contaminants and of the collection pump and treat hydraulic containment system at the property. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of pump and treat hydraulic containment system and associated equipment, and other engineering controls in place at the Site. The deed notices would be filed by the ODEQ should the property owner decline. The ICs would be implemented and monitored by the ODEQ. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. This alternative will achieve applicable RAOs and cleanup levels.

This alternative may be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

16.2 Common Elements and Distinguishing Features

This section describes common elements and distinguishing features of the alternatives described for each medium. Common elements and distinguishing features unique to each alternative include key ARARs, long-term reliability of the remedy, quantities of untreated wastes. Tables 12A through 12H as outlined in Section 17 also provides an in depth comparative analysis of each alternative.

Five-Year Reviews will be required for all alternatives, including the "no action "alternative. Reviews will be required because the area requiring cleanup will be remediated for commercial/industrial reuse, and not available for unrestricted reuse. Since no cleanup would be completed under the "no action "alternative, all waste would be left in place and unrestricted reuse would be prohibited.

ICs are a component common to all alternatives except the no action alternative. These controls will be required to aid in the management of the wastes left on-site and to ensure that only appropriate reuse options are implemented. ICs would include deed notices placed on land parcels that are contained in the Site. ICs would notify current and potential future deed holders of the presence of wastes left on-site. The deed notices would identify the reason for the notice, the affected property, the remedy, engineering controls, and land and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline.

16.2.1 Applicable or Relevant and Appropriate Requirements

Alternative 1, the No Action Alternative will not comply with the ARARs for the Site. All of the other alternatives would meet their respective ARARs from Federal and State law.

16.2.2 Long-Term Reliability

The magnitude of risks at the Site for alternative 1 is likely to remain the same since ACM, coke tar, contaminated soils, contaminated waste pond sediment, LNAPL and ground water contamination will remain on the Site at levels that pose a risk to human health. The stabilization process for waste pond sediment alternative 2 (stabilization and on-site disposal cell) and alternative 3 (stabilization and off-site disposal) and the coke tar will effectively reduce the mobility of the contaminants and also reduce risks associated with exposure. The stabilized sediments for waste pond sediment alternative 3 (stabilization and off-site disposal), soil alternative 4 (off-site disposal), the ACM and stabilized coke tar will be transported off-site to appropriate waste disposal facilities and effectively reduce the risk of exposure to future human receptors on the Site.

Construction of a clay cap for soil (alternative 2) and on-site consolidation and containment of contaminated soils (alternative 3) and sediment (alternative 2) will mitigate the potential exposure to future human receptors. Contaminated soils that will remain on-site for soil alternative 2 are covered with an engineered cap; consequently, this alternative provides long-term protection of future Site users. Removal of LNAPL and continued ground water monitoring will assess the long-term effectiveness of all ground water alternatives.

16.2.3 Quantities of Untreated Waste

Alternative 1 does not include a treatment component and approximately 32,000 cubic yards of contaminated soil, 21,000 cubic yards of contaminated waste pond sediment, 4,955 cubic feet of LNAPL, 10 cubic yards of ACM, and 6,000 cubic yards of coke tar will remain on the Site.

All other alternatives will treat, contain, or remove Site waste to allow for commercial/industrial reuse scenario. For soil alternatives 2 and 3 construction of a clay cap and on-site consolidation and containment of contaminated soil, 32,000 cubic yards of contaminated soil would be managed on-site. 21,000 cubic yards of waste pond sediment would be managed on-site with waste pond sediment alternative 2.

16.2.4 Presumptive Remedies

There are no presumptive remedies applicable to Alternative 1. The stabilization process for the waste pond sediments will significantly reduce the toxicity and mobility of the contaminants by chemically binding and stabilizing them. This generally follows EPA Directive: *Presumptive Remedy for Metals-in-Soil Sites* EPA 540-F-98-054, OSWER-9355.0-72FS, PB99-963301, September 1999.

16.2.5 Media-Specific Common Elements and Distinguishing Features

The discount rate for all remedies except for the "No Action" alternative is 7%. The estimated capital cost, annual O&M cost, total present worth cost, estimated construction timeframe and estimated time to achieve RAOs are listed in Section 16.1 with the description of each remedial alternative. For cost and alternative evaluation purposes, O&M activities were estimated for a 10 year period for the soil and waste pond sediment alternatives where waste would be managed on-site.

Other Media
ACM, coke tar, and scrap metal were determined to have only one viable option in the FS. These wastes will be removed from the Site and transported for disposal at authorized facilities. The estimated time for design and construction and for meeting RAOs is three months or less. A distinguishing feature for remediation of coke tar is that it will be stabilized prior to off-site disposal.

Soil and Waste Pond Sediment
The primary common element for all of the soil alternatives and the waste pond sediment alternatives is an expected time frame to achieved RAOs of one year. Common elements for soil alternatives 2 (capping) and 3 (on-site disposal cell) and waste pond sediment alternative 2 (stabilization and on-site disposal cell) include treating or maintaining waste on-site. Soil alternative 3 (on-site disposal cell) and 4 (off-site disposal) and the waste pond sediment alternatives include the common element of excavation. Soil alternative 4 and waste pond sediment alternative 3 (stabilization and off-site disposal) include the common element of off-site disposal. The primary differences between the soil alternatives and the waste pond sediment alternatives are on-site treatment/management versus off-site disposal and costs.

Waste Pond Surface Water
The waste pond surface water alternatives include the common elements of treatment and time frame to achieve RAOs of one year. The primary differences between the alternatives are on-site treatment/management versus off-site treatment and costs.

LNAPL
The LNAPL alternatives include the common element of LNAPL removal. The primary differences between the alternatives are ex-situ treatment, time frame to achieve RAOs and costs.

Ground Water, Site Wide
The primary common element for all of the ground water alternatives is a monitoring component and expected time frame to achieved RAOs of 30 years. The primary differences between the ground water alternatives are treatment methods for alternative 4 (phytoremediation) and 5 (pump and treat) and the costs of all the alternatives.

16.3 Expected Outcomes of Each Alternative

The "no action" alternative would leave the site as presenting the same risks as are currently present. It would not allow the Site to be available for a reasonably anticipated reuse. Contamination migration would be expected to continue.

Other Media – ICs, Removal of ACM, Coke Tar, and Scrap Metal
ICs will be required to aid in the management of the wastes left on-site. ICs would include deed notices placed on land parcels that are contained in the Site. ICs would notify current and potential future deed holders of the presence of wastes left on-site. The deed notices would

identify the reason for the notice, the affected property, the remedy, engineering controls, and land and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices would be filed by the ODEQ should the property owner decline. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. ACM, coke tar, and scrap metal – These wastes will be removed from the Site and transported for disposal at authorized facilities. The estimated time for design and construction and for meeting RAOs is three months or less.

Soil and Waste Pond Sediment
All of the soil alternatives and the waste pond sediment alternatives are expected to meet applicable RAOs and cleanup levels within a time frame of one year. Soil alternatives 2 (capping) and 3 (on-site disposal cell) and waste pond sediment alternative 2 (stabilization and on-site disposal cell) may not be compatible with the long range future land use described in the City of Cushing's letter of intent. While the capping and on-site disposal cell methods will eliminate exposure pathways, it will reduce the amount of Site property available for appropriate reuse. Soil alternative 4 (off-site disposal) and waste pond sediment alternative 3 (stabilization and off-site disposal) would permanently remove contaminated material from the Site and would reduce risk by minimizing contact with hazardous substances by minimizing contact with the public and environment. It is also expected that these alternatives will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

Waste Pond Surface Water
The waste pond sediment alternatives would permanently remove contaminated material from the Site and would reduce risk to human health and the environment by minimizing contact with hazardous substances, pollutants, or contaminants. It is also expected that these alternatives will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

LNAPL
The LNAPL alternatives would permanently remove contaminated material from the Site and would reduce risk to human health and the environment by minimizing contact with hazardous substances, pollutants, or contaminants. It is also expected that these alternatives will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse after LNAPL removal.

Ground Water, Site Wide
All ground water alternatives may be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse. All alternatives also required ground water monitoring and installation/maintenance of monitoring wells and/or pump and treat wells. Buffer areas would need to be maintained for the monitoring and/or pump and treat wells and those areas would not be available for all commercial/industrial reuses. The areas where the trees and grasses have been planted for alternative 4 (phytoremediation) would not be available for all commercial/industrial reuses.

17.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The EPA uses nine NCP criteria to evaluate remedial alternatives for the cleanup of a release or Site. These nine criteria are categorized into three groups: threshold, balancing, and modifying. The threshold criteria must be met in order for an alternative to be eligible for selection. The threshold criteria are overall protection of human health and the environment and compliance with ARARs. The balancing criteria are used to weigh major tradeoffs among alternatives. The five balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; short-term effectiveness; implementability; and cost. The modifying criteria are state acceptance and community acceptance. Table 11 (Evaluation Criteria for CERCLA Remedial Alternatives) briefly describes the nine evaluation criteria specified in the NCP §300.430(f)(5)(i).

In addition to a site-wide "no action" alternative, three alternatives were evaluated for soil, two alternatives were evaluated for waste pond sediment, two alternatives were evaluated for waste pond surface water, two alternatives were evaluated for LNAPL, and four alternatives were evaluated for ground water in the FS (Burns & McDonnell, 2007). Tables 12A through 12H - Comparison of Remedial Alternatives summarizes, per media, how these alternatives comply with the nine criteria. Following is a comparative analysis of the remedial alternatives.

17.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment. This is a threshold criterion.

All of the alternatives except Alternative 1, the "no action" alternative, would provide adequate protection of human health and the environment by eliminating, reducing, or controlling risk through treatment, containment, engineering controls, and/or institutional controls.

ACM, coke tar, and scrap metal would provide adequate protection from exposure. Wastes would be removed from the Site and transported for disposal at authorized facilities. The coke tar element would provide additional protection from possible exposure with the stabilization of contaminants prior to disposal. ICs would aid in the management of the wastes left on-site and ensure the protectiveness of the remedy. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. The city ordinance currently provides protection of human health.

Soil alternatives 2 (capping) and 3 (on-site disposal cell) and waste pond sediment alternative 2 (on-site disposal) would provide adequate protection from exposure due to direct contact or ingestion. Perpetual cap maintenance would be required to ensure total protectiveness. A breach in the cap or disturbance of the disposal cell would potentially expose individuals to existing levels of contamination. Both waste pond sediment alternatives would provide additional protection from possible exposure through the stabilization of sediment contaminants. Soil alternative 4 (off-site disposal) and waste pond sediment alternative 3 (off-site disposal) would provide the greatest on-site protection since wastes/treated wastes would be disposed off-site.

Both of the waste pond surface water alternatives would provide adequate protection from exposure due to contact or ingestion through treatment. Both LNAPL removal alternatives and the ground water alternatives would provide adequate protection from exposure. Ground water alternative 2 (monitoring) and 3 (monitored natural attenuation) provides protection from exposure through monitoring the stability and decrease of ground water contamination. Ground water alternative 4 (phytoremediation) and 5 (pump and treat) provide additional protection from possible exposure through more active remediation of ground water contaminants.

17.2 Compliance with ARARs

Section 121(d) of CERCLA and the NCP §300.430(f)(l)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA §121(d)(4). This is a threshold criterion.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site.

Alternative 1 does not comply with ARARs. Because the “no action” alternative is not protective of human health and the environment and does not comply with ARARs, it was eliminated from consideration under the remaining seven criteria. Because Alternative 1 does not comply with either of the threshold criteria, it cannot be selected as a remedy.

All of the remaining alternatives will comply with all ARARs through the use of standard engineering and waste management techniques as well as through the implementation of a Site-specific Health and Safety Plan. All alternatives would meet their respective ARARs from Federal and State laws.

All alternatives would need to meet substantive requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) and the Oklahoma Air Pollution Control Act relevant to particulate matter and air pollutants. ACM cleanup would need to be compliant with NESHAPs for ACM found at 40 CFR Part 61 Subpart M.

Alternatives that require transportation of contamination and wastes to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations. Facilities accepting these wastes would have to be certified to accept the respective wastes. Land disposal restrictions (LDRs) would not apply to off-site disposal alternatives of non-hazardous wastes. The alternatives that include on-site containment or treatment of non-hazardous wastes are not required to meet LDR standards or minimum technology requirements because contamination is nonhazardous and would either remain in place or would be consolidated on-site.

Soil and waste pond sediment alternatives that transport waste off-site for disposal would be compliant with the OSWMA (OAC 252:515). If soils or sediments were determined to be characteristically hazardous, these alternatives would be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils/sediments. In the event that contaminated soils and waste pond sediments are managed on-site, these remedies would be compliant with the OSWMA. If soils and sediments were determined to be characteristically hazardous, these alternatives would be compliant with closure and post-closure standards at 40 CFR Part 264 Subpart G.

The waste pond sediments that are considered hazardous waste are subject to the RCRA LDRs if the waste is excavated and removed from the area of contamination or disposed of on-site. All remedies involving such activities will comply with the LDR (63 FR 28555; May 26, 1998) and will meet 90% removal efficiency or ten times the universal treatment standard (40 CFR §268.48) for that contaminant in the material prior to land disposal in a RCRA-compliant landfill.

In addition, all activity will be in compliance with OSHA requirements. Appropriate Clean Water Act (CWA) requirements would need to be followed during treatment and discharge of waste pond surface water or treated ground water. Permits would be required for off-site discharge. Because the ground water meets the characteristics of a potential drinking water supply the MCL drinking water standards are considered relevant and appropriate.

17.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

All of the alternatives (except No Action) would be effective and permanent in the long-term as long as O&M and institutional and engineering controls are enforced. Reviews at least every five years, as required, would be necessary to evaluate the effectiveness of any of these alternatives because hazardous substances, pollutants, or contaminants would remain on-site above levels that allow for unlimited use and unrestricted exposure.

Other Media – ICs, Removal of ACM, Coke Tar, and Scrap Metal

ICs would aid in the management of the wastes left on-site and ensure the long-term protectiveness of the remedy. Removal of “Other Media” would prevent direct contact exposure, contaminant migration, and reduce the inherent hazards posed by the contaminants at the Site. As RAOs for coke tar removal are for protection under a commercial/industrial scenario, monitoring of institutional controls and five-year reviews of the remedy will be required for soils/sediments in the area of coke tar removal.

Soil

Alternative 2 (capping) and alternative 3 (on-site disposal cell) would prevent direct contact exposure and contaminant migration; however, monitoring and cap/disposal cell maintenance would be necessary to ensure the long-term effectiveness and permanence of these alternatives. Alternative 4 (off-site disposal) would be the most effective and permanent in the long-term as the potential for exposure is completely eliminated through removal of contamination from the Site. As cleanup levels are for protection under a commercial/industrial scenario, monitoring of institutional controls and five-year reviews of the remedy will be required.

Waste Pond Sediment

Alternative 2 (stabilization and on-site disposal cell) would prevent direct contact exposure and contaminant migration; however, monitoring disposal cell maintenance would be necessary to ensure the long-term effectiveness and permanence of this alternative. Alternative 3 (stabilization and off-site disposal) would be the most effective and permanent in the long-term as the potential for exposure is completely eliminated through removal of contamination from the Site. As cleanup levels are for protection under a commercial/industrial scenario, monitoring of institutional controls and five-year reviews of the remedy will be required.

Waste Pond Surface Water
All surface water alternatives would be effective in the long term by reducing contaminant concentrations.

LNAPL
The LNAPL removal alternatives would be effective in the long term by reducing LNAPL contaminant concentrations on ground water. As RAOs are for protection under a commercial/industrial scenario, monitoring of institutional controls and five-year reviews of the remedy will be required.

Ground Water, Site -Wide
The estimated time to achieve RAOs and cleanup levels is 30 years for all ground water alternatives. Alternative 2 (monitoring) would prevent direct contact exposure and migration; however, to ensure the long-term effectiveness and permanence of this alternative, continued monitoring would be necessary until cleanup levels are achieved. Alternatives 3 (monitored natural attenuation), 4 (phytoremediation), and 5 (pump and treat) would be effective in the long term by reducing contaminant concentrations in ground water. The adequacy and reliability of the pump and treatment technologies (Alternative 5) have been well proven for the COCs. Natural attenuation and phytoremediation (Alternatives 3 and 4) have some uncertainty associated with remediation methods and the time required to reach the final cleanup levels. While current data indicate that ground water contamination is stable or decreasing, alternative remedial measures may need to be considered if off-site migration of contamination is determined to be occurring.

17.4 Reduction in Toxicity, Mobility, and Volume
Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Other Media – ICs, Removal of ACM, Coke Tar, and Scrap Metal
While ICs would aid in the management of the wastes left on-site and ensure the protectiveness of the remedy, they do not reduce the toxicity and volume of the contaminants. Removal of “Other Media” does not reduce the toxicity and volume of the contaminants; however, the volume of contaminated material on-site will be transferred to an off-site disposal facility. Removal of ACM and scrap metal the does not achieve reduction of toxicity, mobility, and volume through treatment. Stabilization and removal of coke tar reduces toxicity and mobility of contamination through treatment; however some increase in the volume of material may occur during the stabilization process due to the addition of stabilization reagents.

Soil
None of the alternatives achieve reduction of toxicity, mobility, and volume through treatment. Alternative 2 (capping) and Alternative 3 (on-site disposal cell) provide reduction of the mobility of the contaminants through the use of a physical barrier to prevent contact of the contaminants with the environment. Alternative 4 (off-site disposal) does not reduce the toxicity and volume of the contaminants; however, the volume of contaminated material on-site will be transferred to an off-site disposal facility.

Waste Pond Sediment
All sediment alternatives reduce toxicity and mobility of contamination through treatment; however some increase in the volume of material may occur during the stabilization process due to the addition of stabilization reagents.

Waste Pond Surface Water
All surface water alternatives reduce toxicity, mobility and volume of contamination through treatment.

LNAPL
Alternative 2 (hydrocarbon belt skimmer) does not achieve reduction of toxicity, mobility, and volume through treatment; however, the volume of contaminated material on-site will be transferred to an off-site facility. Alternative 3 (collection trench with hydrocarbon belt skimmer, ex-situ treatment) treats the ground water that is removed along with the LNAPL.

Ground Water, Site-Wide
Alternative 2 (monitoring) does not achieve reduction of toxicity, mobility, and volume through treatment. Alternative 3 (monitored natural attenuation) will identify a reduction in toxicity, mobility, and volume but is not considered a treatment technology. Alternatives 4 (phytoremediation) and 5 (pump and treat) reduce toxicity, mobility and volume of contamination through treatment.

17.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. All of the alternatives are effective in the short-term, but vary in the amount of time to reach RAOs and prevent potential exposure.

Other Media – ICs, Removal of ACM, Coke Tar, and Scrap Metal
ICs would aid in the management of the wastes left on-site and ensure the short-term protectiveness of the remedy. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. The city ordinance provides short-term protectiveness. Additionally, current Site zoning is for industrial use.

Removal of ACM and coke tar involves handling of contaminated material and thus presents a potential for short-term exposure. Removal of ACM, coke tar, and scrap metal pose potential risks to construction workers and nearby residents during excavation/removal and handling of contaminated material primarily associated with equipment movement and exposure to contaminated dust. Control of dust and runoff will limit the amount of materials that may migrate to a potential receptor, and workers would be required to wear the appropriate level of protection to avoid exposure during excavation and treatment activities. Removal of ACM and coke tar may also pose additional short term risks to the nearby residents and on-site workers due to the increased handling required.

Soil
Alternative 2 (capping) does not present a short term threat except to the extent that the area presents direct contact or migration potential during the time it takes to fully implement the remedy. Alternatives 3 (on-site disposal cell) and 4 (off-site disposal) involve excavation of

contaminated soils and thus present a potential for short-term exposure. Alternatives 3 and 4 pose potential risks to construction workers and nearby residents during excavation and handling of contaminated material primarily associated with equipment movement and exposure to contaminated dust. Control of dust and runoff will limit the amount of materials that may migrate to a potential receptor, and workers would be required to wear the appropriate level of protection to avoid exposure during excavation and treatment activities. Alternative 4 may present a higher short-term risk to the nearby residents because of the potential for exposure to the contaminated soils by trucking the material to an off-site facility.

Waste Pond Sediment
All sediment alternatives involve excavation of contaminated soils and thus present a potential for short-term exposure. All alternatives pose potential risks to construction workers and nearby residents during excavation and handling of contaminated material primarily associated with equipment movement and exposure to contaminated dust. Control of dust and runoff will limit the amount of materials that may migrate to a potential receptor, and workers would be required to wear the appropriate level of protection to avoid exposure during excavation and treatment activities. The alternatives may also pose additional short term risks to the nearby residents and on-site workers due to the increased handling required for application of the reagent and potential emissions from the on-site stabilization. Alternative 3 (stabilization and off-site disposal) may present a higher short-term risk to the nearby residents because of the potential for exposure to the contaminated sediment by trucking the material to an off-site facility.

Waste Pond Surface Water
Precautions will be taken to eliminate any risk to the public from surface water collection. Short-term risk to workers associated with normal construction hazards and potential contact with contaminated water will be eliminated through appropriate controls and adherence to proper health and safety protocols. Alternative 3 (off-site treatment) may present a higher short term risk to the nearby residents because of the potential for exposure to the surface water by trucking the material to an off-site facility.

LNAPL
Precautions will be taken during construction of the extraction wells and trenches under alternatives 2 (hydrocarbon belt skimmer) and 3 (collection trench with hydrocarbon belt skimmer, ex-situ treatment) to eliminate any risk to the public from excavation. Short-term risk to workers associated with normal construction hazards and potential contact with contaminated water will be eliminated through appropriate controls and adherence to proper health and safety protocols. There may also be risk from inhalation of VOC vapors during LNAPL removal, the worker risks would need to be eliminated through appropriate controls and adherence to proper health and safety protocols. Alternative 3 may present increased risk to workers due to additional time needed for trench construction. These alternatives may present a higher short-term risk to the nearby residents because of the potential for exposure to the extracted LNAPL by trucking the material to an off-site facility.

Ground Water, Site-Wide
Alternatives 2 (monitoring) and 3 (monitored natural attenuation) have no risks associated with implementation and require little or no implementation time. Precautions taken during tree planting under alternative 4 (phytoremediation) and during construction of the extraction wells under alternative 5 (pump and treat) will eliminate any risk to the public from excavation. Short-term risk to workers associated with normal construction hazards, monitoring well installation, and potential contact with contaminated water will be eliminated through appropriate controls and adherence to proper health and safety protocols.

17.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

For all alternatives, administrative coordination, labor, equipment, materials, and outside services will be required. These alternatives utilize conventional material and equipment which are widely used and accepted in the construction industry. Difficulties may be encountered for soil alternative 3 (on site disposal cell) and sediment alternative 2 (stabilization and on-site disposal cell) during construction of the on-site disposal cell depending on the conditions of the subsurface soil. Ground water alternative 5 (pump and treat) presents implementability issues due to the potential low yield of the aquifer. ICs, such as deed notices, will be placed on the land parcels that are contained in the Site boundary by the ODEQ under Oklahoma statute 27A O.S. §2-7-123.

17.7 Cost

Soil
The estimated present worth cost for alternative 2 (capping) is less than alternative 3 (on site disposal cell). Alternative 4 (off-site disposal) is the most costly; however, this alternative requires no O&M costs.

Waste Pond Sediment
The estimated present worth cost for alternative 2 (stabilization and on-site disposal cell) is less than alternative 3 (stabilization and off-site disposal). While alternative 3 is the most costly, this alternative requires no O&M costs.

Waste Pond Surface Water
The estimated present worth cost for alternative 2 (on-site treatment) is less than alternative 3 (off-site treatment).

LNAPL
The estimated present worth cost for alternative 2 (hydrocarbon belt skimmer) is less than alternative 3 (collection trench with hydrocarbon belt skimmer, ex-situ treatment).

Ground Water, Site-Wide
The estimated present worth cost for alternative 2 (monitoring) is less than alternative 3 (monitored natural attenuation). Alternative 4 (phytoremediation) is less than alternative 2, and alternative 5 (pump and treat) is the most costly.

17.8 State Acceptance

The State of Oklahoma, represented by the ODEQ, agrees with the EPA's decision to implement Soil Alternative 4 (off-site disposal), Waste Pond Sediment Alternative 3 (stabilization and off-site disposal), Waste Pond Surface Water Alternative 2 (on-site treatment), LNAPL Alternative 2 (hydrocarbon belt skimmer), and Ground Water, Site-Wide Alternative 2 (containment monitoring). The ODEQ acknowledged its support for this decision by letter to the EPA dated October 24, 2007, (Appendix B). The ODEQ conducted the RI/FS and the Proposed Plan with technical support from EPA. ODEQ provided technical support for this ROD.

17.9 Community Acceptance

The ODEQ and EPA jointly conducted a public meeting on May 31, 2007, to present the Proposed Plan to the public. The ODEQ and EPA presented the following as the preferred alternatives per medium for the Site: ICs and Other Media; Soil – Excavation and Off-site Disposal at Permitted Facility (Alternative 4); Waste Pond Sediment – Excavation, Stabilization and Off-site Disposal at Permitted Facility (Alternative 3); Waste Pond Surface Water – On-site Treatment (Alternative 2); LNAPL – Hydrocarbon Belt Skimmers (Alternative 2); and Ground Water, Site-Wide – Ground Water Monitoring (Alternative 2).

Based on comments received during the public meeting and those received during the 30-day public comment period, the community accepts the alternatives presented in the Proposed Plan.

17.10 Summary of Comparative Analysis of Alternatives

In addition to a site-wide "no action" alternative, three alternatives were evaluated for soil, two alternatives were evaluated for waste pond sediment, two alternatives were evaluated for waste pond surface water, two alternatives were evaluated for LNAPL, and four alternatives were evaluated for ground water and were taken through the FS (Burns & McDonnell, 2007). Alternative 1, the "no action" alternative," was evaluated as required by the NCP and was eliminated from further consideration as a viable remedial alternative. All other alternatives meet the RAOs identified for the Site and comply with all ARARs. Additionally, these remedies also will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

Soil alternative 3 (off-site disposal) and waste pond sediment alternative 3 (stabilization and off-site disposal), two of the remedies selected per media as presented in this ROD, meet all of the statutory criteria for a remedial action and are accepted by the public. These alternatives, although the most expensive of the other soil and waste pond sediment alternatives, are the most protective because no soil or waste pond sediments wastes will remain on the Site above a level which would allow for commercial/industrial reuse. These remedies will also be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

The remedies selected in this ROD for waste pond surface water alternative 2 (on-site treatment), LNAPL alternative 2 (hydrocarbon belt skimmer), and ground water - site-wide alternative 2 (monitoring), all meet the statutory criteria for a remedial action and are accepted by the public. Also, these selected remedies are the least expensive of the alternatives evaluated.

18.0 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP §300.430(a)(l)(iii)(A)). Identifying principal threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied.

The principal threat wastes for the Site consist of waste pond sediment, coke tar, LNAPL, and ACM. These are considered "principal threat wastes" because the contaminants of concern are found at concentrations that may pose a significant risk or are considered to be source material. The waste pond sediments are considered principal threat waste because they are considered to be a source material and a significant risk based on the presence of hazardous levels of metals. The coke tar, LNAPL and ACM are also considered principal threat wastes because they are considered to be source material. The proposed remedial action would address the principal threat waste at the Site.

Through the use of treatment as a principal element for remediation of waste pond sediment and coke tar, the response action will satisfy the preference for treatment and reduce the mobility of the hazardous source material that constitutes the principal threat wastes at the Site.

LNAPL alternative 2 (hydrocarbon belt skimmer), ground water alternative 2 (containment monitoring) and ACM removal do not achieve reduction of toxicity, mobility, and volume through treatment; however, the volume of contaminated material on-site will be transferred to an off-site facility and will eliminate exposure risk on Site.

19.0 SELECTED REMEDY

The Preferred Alternatives for cleaning up the Hudson Refinery Site are: ICs and Other Media; Soil – Excavation and Off-site Disposal at Permitted Facility (Alternative 4); Waste Pond Sediment – Excavation, Stabilization and Off-site Disposal at Permitted Facility (Alternative 3); Waste Pond Surface Water – On-site Treatment (Alternative 2); Light Non-Aqueous Phase Liquid – Hydrocarbon Belt Skimmers (Alternative 2); and Ground Water – Ground Water Monitoring (Alternative 2).

19.1 Summary of the Rationale for the Selected Remedy

The selected remedial alternatives are protective of human health and environment and comply with ARARs. ICs are a component common to all of the selected alternatives. These controls will be required to aid in the management of the wastes left on-site and to ensure that only appropriate reuse options are implemented.

O&M activities and five year reviews will be required since hazardous substances, pollutants, or contaminants would remain on-site above levels that would allow for unlimited use and unrestricted exposure. The alternatives selected provide the best balance of tradeoffs between alternatives with respect to the balancing and modifying criteria. Based on public comments received during the public meeting held to present the Proposed Plan and comments received during the public comment period, the public voiced no defining preference for any particular set of alternatives. The selected remedy is the preference of the City of Cushing since it allows for more of the Site to be available for appropriate reuse.

Soil alternative 3 (off-site disposal) and waste pond sediment alternative 3 (stabilization and off-site disposal), two of the remedies selected per media as presented in this ROD, meet all of the statutory criteria for remedial action and are accepted by the public. These alternatives, although the most expensive of the other soil and waste pond sediment alternatives, are the most protective because no soil or waste pond sediments wastes will remain on the Site above a level which would allow for commercial/industrial reuse. These remedies are compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

The remedies selected in this ROD for waste pond surface water alternative 2 (on-site treatment), LNAPL alternative 2 (hydrocarbon belt skimmer), and ground water - site-wide alternative 2 (monitoring), all meet the statutory criteria for a remedial action and are accepted by the public.

Also, these selected remedies are the least expensive of the alternatives evaluated. LNAPL contamination is limited and has been identified in only one well. LNAPL removal through the use of hydrocarbon belt skimmer technology is the most cost effective means of remediation within a reasonable time frame. Ground water contamination is discontinuous and in isolated areas on the Site; monitoring is also the most cost effective remedial alternative. Since the estimated time to achieve RAOs and cleanup levels was 30 years for all ground water alternatives, selection of the least costly alternative did not extend the time for remediation. Additionally, these remedies also may be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

19.2 Description of the Selected Remedy

Following is a description of each component of the Selected Remedy. Although the EPA does not expect significant changes to this remedy, it may change "somewhat" as a result of the remedial design and construction processes. Any changes to the remedy described in this ROD would be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences, or a ROD Amendment, as appropriate and consistent with the applicable regulations.

19.2.1 Other Media – ICs, Removal of ACM, Coke Tar, and Scrap Metal

ICs

ICs will be required to aid in the management of the wastes left on-site. ICs will include deed notices placed on land parcels that are contained in the Site. ICs will notify current and potential future deed holders of the presence of wastes left on-site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and land and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline. ICs are components of the alternatives described for each medium. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. Currently the Site is zoned for industrial use.

ACM

ACM was identified in a pile located near MW-6 in the North Refinery during the RI field activities. Approximately 10 cubic yards of ACM will be excavated, containerized, and transported to a regulated off-site disposal facility. Air monitoring will be conducted to ensure public health protection and confirmation sampling will be conducted to ensure RAOs and cleanup levels are met. ACM cleanup will be compliant with standards considered at 40 CFR Part 61 Subpart M.

Coke Tar

Coke tar material was identified in several locations of the South Refinery, mainly to the west and north of the Coke Pond. Based on visual observations, the material was limited to small areas on the ground surface and did not extend into the subsurface. Because of the viscous nature of the coke tar, this material will most likely need to be stabilized prior to off-site disposal. Approximately 6,000 cubic yards of coke tar will be excavated, stabilized, and transported to a regulated off-site disposal facility. The base of the excavation will be sampled to confirm the contaminated zone is below the soil cleanup criteria, the excavations will be backfilled with clean fill, and the surface of the soil seeded to establish a vegetative cover.

Scrap Metal
Although most tanks from the former refinery were removed from the Site, some metal debris hazards remains in various areas of the Site. This metal debris presents a public safety hazard and site management hazard. Material including tanks and metal debris that remains at the Site will be removed and salvaged. If any of the material is not salvageable, it will be disposed of at an authorized off-site disposal facility.

19.2.2 Soil - Alternative 4, Excavation and Off-site Disposal at Permitted Facility

The selected alternative for soil in the North Refinery (North Tank Farm Area) and South Refinery (South-South Tank Farm Area, South Process Area, Northeast-South Tank Farm Area, North-South Tank Farm Area, and Other Areas in the South Refinery) is excavation and transport of soil and waste to an off-site disposal facility. Alternative 4 meets the RAOs and is selected over other alternatives because it is easily implemented and expected to achieve substantial and long-term risk reduction through off-site disposal.

Approximately 32,000 cubic yards, of soil in the South and North Refineries will be excavated and transported to an appropriate off-site permitted landfill. The contaminated soil would be excavated and loaded onto trucks and transported to an off-site permitted waste landfill for disposal. Confirmation sampling would occur during remedial activities to verify the classification of the waste for disposal. The excavated areas would be backfilled with clean soil, graded for adequate drainage, and re-vegetated.

Soils with contamination levels greater than the remediation goals will be excavated and transported to a staging area. The base of the excavation will be sampled to confirm the contaminated zone is below the soil cleanup criteria, the excavations will be backfilled with clean fill and the surface of the soil seeded to establish a vegetative cover. The areas with surface soil contamination shall be excavated to a minimum depth of one-half foot. The base of the excavation shall be sampled and tested to confirm that benzo(a)pyrene, arsenic, and lead have been removed to meet the soil cleanup levels. If cleanup levels have not been met, additional soil shall be excavated until the surface soil cleanup levels have been met to a maximum of two feet or to the extent of visual contamination. The excavated areas will be backfilled with clean soil, graded for adequate drainage, and re-vegetated.

Confirmation sampling will occur during remedial activities to verify the classification of the waste for disposal. This alternative will be compliant with the OSWMA (OAC 252:515). If soils were determined to be characteristically hazardous, this alternative will be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils. Soils transport to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations.

ICs will be required to aid in the management of waste left on-site and to ensure the protectiveness of the remedy. ICs will include deed notices to notify current and potential future deed holders placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and land use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline. This alternative will achieve applicable RAOs and meet the cleanup levels by permanently removing contaminated material from the Site and reducing risk by minimizing contact with hazardous substances, pollutants, or contaminants. As cleanup levels are for protection under a commercial/industrial scenario, five-year reviews of the remedy will be required.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

19.2.3 Waste Pond Sediment – Alternative 3, Excavation, Stabilization and Off-site Disposal at Permitted Facility

Stabilization and transport to an off-site disposal facility are recommended for contaminated pond and sump sediments. These sediments will be excavated from the Aeration Pond 7 and Sumps, Wastewater Ponds 1 and 2, and Coke Pond. Alternative 3 meets the RAOs and is selected over other alternatives because it is easily implemented and expected to achieve substantial and long-term risk reduction through treatment and off-site disposal.

Under this alternative, approximately 21,000 cubic yards of waste pond sediment, will be dewatered, stabilized, as needed, excavated, and transported to a permitted off-site disposal facility. TCLP analysis indicated that TCLP chromium levels are higher than the maximum concentration of contaminants for the toxicity characteristic list at 40 CFR §261.24 and thus exhibit hazardous characteristics and/or have concentrations of contaminants that could leach from the sediments at unacceptable levels. The results of the 2006 Treatability Study indicate that stabilization would be successful in reducing the leachability of the chromium from the waste pond sediment. The ponds will be drained, with measures taken to retain pond sediments within the pond. The sediment from the ponds will be dewatered as necessary, stabilized, and excavated for loading and transport to an appropriate off-site permitted landfill. The excavated areas will be backfilled with clean soil, graded for adequate drainage, and revegaeated. These waste pond sediments are considered principal threat wastes as source material. Because the waste will be stabilized, this alternative meets the EPA's preference for treatment of principal threat wastes.

Waste pond sediment will be sampled and analyzed under the TCLP procedure to determine if it is a RCRA characteristic hazardous waste. Stabilization or other appropriate treatment may allow it to be treated as a non-hazardous waste. Stabilization treatability studies were performed during the FS for waste pond sediment evaluation. If treatment is necessary, treatment is usually done by mixing reagents into the waste pond sediments using a backhoe, auger, or rotary tilling device. The treatability studies determined that the addition of pozzolanic agents consisting of 15% Type I Portland Cement is the most effective mixture for the waste pond sediments. The exact mixture required can be refined in the future remedial design or action process.

The Aeration Pond, Wastewater Ponds 1 through 6a, Treatment Pond 8, Pond 8a, and Runoff Pond 9 on the North Refinery are interconnected as part of the refinery's wastewater management and directly affect Site drainage. Wastewater Ponds 3 through 6a, Treatment Pond 8, Pond 8a, and Runoff Pond 9 do not have sediment or surface water contamination above risk levels. These ponds not requiring remediation will be drained, berms leveled, and graded to ensure that rainwater runoff is allowed to drain properly from the Site and to eliminate the potential for flooding in the adjacent commercial/residential areas.

ICs will be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs will include deed notices to notify current and potential future deed holders placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and land use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline. This alternative will achieve applicable RAOs and meet the cleanup levels by permanently removing contaminated material from the Site and reducing risk by minimizing contact with hazardous substances, pollutants, or contaminants. As cleanup levels are for protection under a commercial/industrial scenario, five-year reviews of the remedy will be required.

This alternative will be compliant with the OSWMA (OAC 252:515). If sediments were determined to be characteristically hazardous, this alternative will be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils. Sediments trucked to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse.

19.2.4 Waste Pond Surface Water – Alternative 2, On-site Treatment

Contaminated surface water from the aeration pond, wastewater ponds 1 and 2, and the coke pond will be collected and treated at an on-site water treatment facility. Non-contaminated surface water from the ponds that will be graded to ensure proper Site drainage will be treated, as necessary (described in Section 19.2.3). Alternative 2 meets the RAOs and is selected over other alternatives because it is easily implemented, expected to achieve substantial and long-term risk reduction through on-site treatment and discharge. Surface water volume varies significantly with rainfall additions to and evaporation from the waste ponds. For the estimate purposes it was assumed that 7.5 million gallons will need to be treated.

The waste pond surface water will be pumped or drained from the waste ponds. On-site treatment will involve the design and construction of a water treatment facility. Treatment will be able to adsorb the contaminant concentrations or remove metals and organics from the surface water. Applicable and appropriate surface water discharge requirements will need to be met for this alternative. The treated water will be discharged to either Skull Creek or transported off-site for disposal.

19.2.5 LNAPL – Alternative 2, Hydrocarbon Belt Skimmers

Hydrocarbon belt skimmers will be installed in the well(s) where LNAPL has been observed. Hydrocarbon belt skimmer technology is based on the properties of certain types of thermoplastics to attract hydrocarbon and repel water. The hydrocarbon belt skimmer or hydroskimmer involves circulation of an endless hydrocarbon resistant thermoplastic belt from the surface, down a well or sump and through the hydrocarbon/water interface. A drive/recovery unit at the wellhead is used to circulate the belt and remove the recovered hydrocarbon. The recovered hydrocarbon will be placed into a drum or tank for storage then disposed or recycled off-site. Operation of the system will be required for the five years it is estimated that the system would run to achieve RAOs.

Fencing would be maintained around the LNAPL treatment system. Signs would be posted to provide notification of the presence of contaminants, and to warn against entry into the fenced area. Annual inspections will occur to evaluate the condition of the hydrocarbon belt skimmers and associated equipment. Annual Site inspections would be conducted to evaluate the condition of the ICs, fencing and signs. Ground water monitoring would be conducted to ensure that the LNAPL is not migrating downgradient or laterally. After LNAPL removal has been completed, continued ground water monitoring will be performed as part of the Ground Water Remedy. This will also include surveying the LNAPL well(s) for the presence of LNAPL with an oil-water interface probe during each ground water sampling event for 2 years after completion of LNAPL removal.

ICs will be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs will include deed notices to notify current and potential future deed holders of the presence of contaminants and of the hydrocarbon belt skimmer system at the property. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of hydrocarbon belt skimmer and associated equipment, and other engineering controls in place at the Site. The deed notices will be filed by the ODEQ should the property owner decline. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. As a continuing source of ground water contamination, LNAPL removal would be considered part of ground water restoration to achieve applicable RAOs and cleanup levels.

This alternative will permanently remove LNAPL from the Site and is an acceptable practice that reduces the risk posed by hazardous substances by minimizing contact with the public and environment. Because the contaminants will be contained and disposed of off-site, this remedy does not meet the EPA’s preference for treatment of principal threat wastes.

This alternative will be compatible with the long-range future land use described in the City of Cushing’s letter of intent, by allowing most of the Site property to be available for appropriate reuse.

19.2.6 Ground Water – Alternative 2, Ground Water Monitoring

Under this alternative, a ground water restoration monitoring program would be developed during the remedial design to monitor ground water until cleanup levels are achieved. Data will be collected from selected monitoring wells to provide additional contamination delineation information. While data indicate that no off-site migration of contaminated ground water has occurred, the data would be used to continue to evaluate the potential of future off-site migration and to ensure that the areas with contamination are stable and/or decreasing. After LNAPL removal has been completed, the ground water in the area where LNAPL was located would be monitored as part of the Ground Water Remedy.

Additional investigation will be conducted during the remedial design to more precisely determine background thallium levels in the shallow ground water of the Vanoss for the City of Cushing and Payne County and to determine if the thallium levels measured at the Site are consistent with city and regional background levels. (See Section 24.1 for further discussion)

ICs will be required to aid in the management of waste left on-site and to ensure protectiveness of the remedy. ICs will include deed notices to notify current and potential future deed holders of the presence of contaminants and of the ground water monitoring wells installed at the property and identifying the area where the ground water monitoring wells are located. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notice will also include land use restrictions on the property and prohibit any intrusive activities that could compromise the integrity, damage, alter, destroy or interfere with the effectiveness of the ground water monitoring wells and associated equipment, and other engineering controls in place at the

Site. The deed notices will be filed by the ODEQ should the property owner decline. Because waste is expected to remain on-site, EPA will be required to conduct five-year reviews. This alternative will achieve applicable RAOs and cleanup levels.

This alternative will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

19.3 Summary of the Estimated Remedy Costs

The estimated costs for the selected remedy are presented in nine tables. Table 13 is a cost estimate summary table for all of the media-specific selected remedies. The estimated total cost to implement and construct the media-specific selected remedies presented in this ROD is $9,650,443. Tables 13A through 13H present the subtotal capital and O&M costs associated with different media components of the selected remedial alternative, the subtotal discounted costs, and the total present worth costs for implementation of the media-specific remedial alternative.

The cost summary tables are based on the best available information regarding the anticipated scope of the remedial action. Changes in the cost elements are likely to occur as a result of the new information and data collected during the remedial design phase. Major changes may be documented in the form of a memorandum to the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment. The projected cost is based on an order-of-magnitude engineering cost estimate that is expected to be within +50 or -30 percent of the actual project cost.

19.4 Expected Outcomes of the Selected Remedy

Following are the expected outcomes of the Selected Remedial Alternatives in terms of resulting land and ground water uses, the cleanup levels and the risk reduction achieved as a result of the response action, and the anticipated community impacts.

19.4.1 Available Uses of Land

Because hazardous substances, pollutants, or contaminants will remain on-site above levels that allow for unlimited use and unrestricted exposure ICs will be required to aid in the management of the wastes left on-site. ICs will include deed notices placed on land parcels that are contained in the Site. ICs will notify current and potential future deed holders of the presence of wastes left on-site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline.

The city's plans include light industrial/commercial reuse for the South Refinery and a mixed reuse of light industrial/commercial and residential for the North Refinery (See Figure 3). The expected outcome of the Selected Remedial Alternatives will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse.

19.4.2 Available Uses of Ground Water

LNAPL

The LNAPL alternative (hydrocarbon belt skimmer) will permanently remove contaminated material from the Site and will reduce risk by removing hazardous substances, pollutants, or contaminants.

Ground Water, Site Wide
The ground water alternative (ground water monitoring) will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing most of the Site property to be available for appropriate reuse. This alternative requires ground water monitoring and installation/maintenance of monitoring wells. Use of ground water will be restricted through ground water use restriction ICs.

Based on current ground water monitoring data, the shallow ground water at the Site generally has the characteristics of a Class II ground water resource, since most Site wells produce water with a concentration less than 3,000 mg/L TDS and several wells on Site are capable of producing more than 150 gallons/day. The shallow ground water at the Site, however, is not expected to be utilized as a drinking water source in the future and the appropriate ICs will be implemented. The contaminated ground water will not exert a long-term detrimental impact on available water supplies or other environmental resources. The contaminated ground water in the northeast and southeast portions of the Site is localized and, based on current ground water data, extends over a small area wholly contained within Site boundaries. The EPA believes that monitoring and ICs can be effectively implemented at the Site until cleanup levels are reached.

19.4.3 Final Cleanup Levels

Table 14 provides the cleanup levels for ACM, soil, waste pond sediment, waste pond surface water, and LNAPL/ground water.

ACM
ACM cleanup will be compliant with NESHAP standards considered at 40 CFR Part 61 Subpart M. Under the NESHAP, ACM is material containing >1% asbestos as analyzed by polarized light microscopy (PLM). The ACM cleanup will be met when the remaining soil/substrate contains less than 1% asbestos.

Soil Cleanup Levels
The cleanup levels for a commercial/industrial cleanup of soil are: benzo(a)pyrene - 4.22 mg/kg, arsenic - 31.8 mg/kg, and lead - 1000 mg/kg. Cleanup to these levels achieves a 1.0×10^{-5} cancer risk level; the probability of 1 individual in 100,000 developing cancer due to exposure to the individual contaminant. These cleanup levels address risks for trespassers, indoor (commercial/industrial) workers, outdoor (commercial/industrial) workers, and construction (utility) workers.

Waste Pond Sediment Cleanup Levels
The cleanup levels for a commercial/industrial cleanup of waste pond sediment are: benzo(a)anthracene 42.2 mg/kg and benzo(a)pyrene - 4.22 mg/kg. Cleanup to these levels achieves a 1.0×10^{-5} cancer risk level. These cleanup levels address risks for trespassers, indoor (commercial/industrial) workers, outdoor (commercial/industrial) workers, and construction (utility) workers.

Waste Pond Surface Water Cleanup Levels
The cleanup level for a commercial/industrial cleanup of waste pond surface water is: benzo(a)pyrene - 6.0 µg/l. Cleanup to this level achieves a 1.0×10^{-5} cancer risk level. This cleanup level will provide protection to outdoor (commercial/industrial) workers from ingestion and dermal exposure. The water may need to meet discharge limits if discharged to Skull Creek or treatment requirements if disposed off-site.

Ground Water
The cleanup levels for ground water are: benzene - 5.0 µg/l and thallium – 2.0 µg/l. The EPA believes that monitoring and ICs can be effectively implemented at the Site. Ground water use will be restricted and monitoring will ensure that the cleanup levels are achieved.

The cleanup level for LNAPL is a threshold thickness of 0.1 foot or less of LNAPL, measured using an interface probe in monitoring or extraction wells. (EPA, 1996b)

Ecological Risk
The ecological risk assessment did not identify specific cleanup levels for the soil, waste pond sediment, and waste pond surface water because these concentrations were not calculated. While the ecological risk assessment identified the potential for unacceptable risk to ecological receptors on the Site, these areas of the Site where unacceptable risk was identified are co-located in the areas where unacceptable risk is identified for human receptors. Ecological habitat on-site will be limited and disturbed following cleanup of waste ponds and Site soils. The Site is currently zoned for commercial/industrial use and the city's long-range plans for site redevelopment continue with a commercial/industrial scenario. It is anticipated that ecological habitat will continue to be limited after redevelopment. Cleanup to address human health risks will likely be protective of potential ecological receptors (terrestrial and aquatic wildlife, terrestrial and aquatic plants, and soil and benthic organisms) in the limited areas of ecological habitat that remains at the Site.

Remedial action for Skull Creek is not planned. Skull Creek exists primarily off of the Site and the creek's ecological habitat is limited and the creek was primarily dry at the time of sampling. Metals that were detected in Skull Creek sediment and surface water were less than or equivalent to background sediment and surface water samples. Additionally, no human health risk was identified.

19.4.4 Anticipated Community Revitalization Impacts

EPA policy directs that decision makers take into account "reasonably anticipated future land uses" when making remedial decisions. The scenarios used to evaluate risks to human health are based on anticipated future land uses in cooperation with the City of Cushing. The risk assessment scenarios evaluated the potential for residential, commercial, industrial, and recreational long-range uses anticipated by the city. There are no current or short-range reuse plans for the Site. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. Currently the Site is zoned for industrial use.

The city's plans include light industrial/commercial reuse for the South Refinery and a mixed reuse of light industrial/commercial and residential for the North Refinery (See Figure 3). These media-specific remedial alternatives will be compatible with the long-range future land use described in the City of Cushing's letter of intent, by allowing more of the Site property to be available for appropriate reuse. ICs will be required to aid in the management of waste left on-site. ICs will include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, land use restrictions, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline.

Based on the estimated construction timeframe, commercial/industrial reuse will be available within a year of the start of the cleanup. A residential scenario may be an appropriate reuse for the areas on the North Refinery where no refinery operations took place and a complete exposure pathway is not present.

20.0 STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP §300.430(f)(5)(ii), the EPA must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

20.1 Protection of Human Health and the Environment

ICs would aid in the management of the wastes left on-site and ensure the protectiveness of the remedy. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. ACM, coke tar, and scrap metal removal would provide adequate protection from exposure. Wastes will be removed from the Site and transported for disposal at authorized facilities. The coke tar element will provide additional protection from possible exposure with the stabilization of contaminants prior to disposal.

Excavation and off-site disposal of soil and excavation, stabilization of waste pond sediment will provide the protection of human health and the environment and will reduce the cancer risk level to below the acceptable risk level of 1×10^{-5} since wastes/treated wastes would be disposed off-site.

Water pond surface water removal will provide adequate protection from exposure due to contact or ingestion. LNAPL removal and ground water monitoring will provide adequate protection from exposure. Ground water contamination is discontinuous and in isolated areas on the Site; monitoring is the most cost effective remedial alternative. Since the estimated time to achieve RAOs and cleanup levels was 30 years for all ground water alternatives, selection of the least costly alternative did not extend the time for remediation.

There are no short-term threats associated with the media-specific selected remedies that cannot be controlled. In addition, no adverse cross-media impacts are expected from the Selected Remedy.

20.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and the NCP §300.430(f)(l)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA §121(d)(4).

All of the selected remedial alternatives will comply with all ARARs through the use of standard engineering and waste management techniques as well as through the implementation of a Site-specific Health and Safety Plan. The selected remedial alternatives will meet their respective ARARs from Federal and State laws.

All selected remedial alternatives will meet substantive requirements of the NESHAPS and the Oklahoma Air Pollution Control Act relevant to particulate matter and air pollutants. ACM cleanup will be compliant with NESHAPs for ACM founds at 40 CFR Part 61 Subpart M.

Selected remedial alternatives that require transportation of contamination and wastes to an off-site disposal facility will have to be conducted pursuant to Federal and State transportation and disposal regulations. Facilities accepting these wastes would have to be certified to accept the respective wastes. Land disposal restrictions (LDRs) would not apply to off-site disposal alternatives of non-hazardous wastes.

Selected remedial alternatives that transport waste off-site for disposal will be compliant with the OSWMA (OAC 252:515). If soils or sediments were determined to be characteristically hazardous, these alternatives would be compliant with disposal standards considered at 40 CFR Part 263 and at 264 Subpart E for non-hazardous soils/sediments.

The waste pond sediments that are considered hazardous waste are subject to the RCRA land disposal restrictions (LDR) if the waste is excavated and removed from the area of contamination or disposed of on-site. All remedies involving such activities will comply with the LDR (63 FR 28555; May 26, 1998) and will meet 90% removal efficiency or ten times the universal treatment standard (40 CFR §268.48) for that contaminant in the material prior to land disposal in a RCRA-compliant landfill.

In addition, all activity will be in compliance with OSHA requirements. Appropriate Clean Water Act (CWA) requirements will need to be followed during treatment and discharge of waste pond surface water or treated ground water. Permits may be required for the discharge.

Ground water will be in compliance with ARARs. Because the ground water meets the characteristics of a potential drinking water supply the MCL drinking water standards are considered relevant and appropriate.

A summary of ARARs and "to be considereds" criteria for the selected remedy are presented in Table 15.

20.3 Cost-Effectiveness

The Selected Remedy is cost-effective because the remedy's costs are proportional to its overall effectiveness (see 40 CFR §300.430(f)(l)(ii)(D)). This determination was made by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., that are protective of human health and the environment and comply with all Federal and any more stringent State ARARs, or as appropriate, waive ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). The overall effectiveness of each alternative was then compared to each alternative's costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence represents a reasonable value for the money to be spent.

Off-site disposal is initially more expensive than on-site disposal alternatives; however, the remedy meets the threshold criteria of protection of human health and the environment and compliance with ARARs. Cost is a balancing criterion that must be weighed against other criteria such as implementability; as well as effectiveness and permanence. Modifying criteria including community and state acceptance must also be considered.

Disposal in a permitted off-site facility ensures long term effectiveness and regulatory compliance. Groundwater monitoring and other post closure requirements at permitted disposal facilities ensure the engineering controls remain in place. On-site disposal would require long term operations and maintenance. Also, on-site disposal takes away from the portion of the land that the city can productively re-use. The city's plans for the property were based on off-site disposal. Long term plans for the property and effectiveness are criteria that need to be considered as well as cost.

The selected remedy maximizes the land available for the redevelopment of the site, while the other alternatives do not. This has higher value because of redevelopment potential and because of the city's long-range redevelopment plans.

The estimated present worth cost of the soil and waste pond sediment selected remedies is higher in costs than the other alternatives evaluated in the FS. These remedies, however, offer a much higher degree of protectiveness and overall effectiveness than any of the other alternatives because they offer removal/treatment and removal of wastes versus no action, on-site containment of wastes (capping) or on-site consolidation and management of a waste disposal cell. The benefits of the Selected Remedy compared to the other alternatives are much higher than the increase in costs because more of the Site can be redeveloped. Additionally, the Selected Remedy is the remedy preferred by the City of Cushing.

Table 16 presents a matrix of cost and effectiveness.

20.4 Utilization of Permanent Solutions to the Maximum Extent Practicable

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, the EPA has determined that the media-specific selected remedies provide the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and considering State and community acceptance. The selected remedies for ACM, coke tar, and scrap metal remove these wastes from the Site for off-site disposal. The selected remedy for soil excavates and removes the contaminated soil from the Site. The selected remedy for waste pond sediment stabilizes, excavates and removes the contaminated sediments constituting principal threat from the Site.

Pumping, treatment and discharge of waste pond surface water and removal of LNAPL utilize permanent solutions. Monitoring of ground water will prevent direct contact exposure and contaminant migration; however, continued monitoring will be necessary until cleanup levels are achieved to ensure the long-term effectiveness and permanence of this alternative.

20.5 Preference for Treatment as a Principal Element

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Off-site disposal of soil, ACM, scrap metal, LNAPL, and ground water monitoring does not constitute treatment; however, soil, scrap metal, and ground water are not principal threat waste.

Stabilization, excavation, and off-site disposal of waste pond sediments and coke tar do meet the preference for treatment. Additionally, waste pond sediments and coke tar are principal threat wastes. These wastes are considered “principal threat wastes” because the contaminants of concern are found at concentrations that may pose a significant risk or are considered to be source material. The waste pond sediments are considered principal threat waste because they are considered to be a source material and a significant risk based on the presence of hazardous levels of metals. The coke tar is also considered principal threat waste because it is considered to be source material.

By treating the contaminated waste pond sediments and coke tar by stabilization techniques, these media-specific selected remedies address principal threats posed by the Site through the use of treatment technologies. By utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

20.6 Five-Year Review Requirements

Section 121(c) of CERCLA and the NCP §300.430(f)(5)(iii)(C) provide the statutory and legal bases for conducting five-year reviews. Because this remedy will result in hazardous substances remaining on-site in the ground water and in the soils above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of the remedial action to ensure that the remedy is, or will continue to be, protective of human health and the environment.

21.0 DOCUMENTATION OF SIGNIFICANT CHANGES FROM PREFERRED ALTERNATIVE OF PROPOSED PLAN

The Proposed Plan was released for public comment in May 2007. The Preferred Alternatives for cleaning up the Hudson Refinery Site are: ICs and Other Media; Soil – Excavation and Off-site Disposal at Permitted Facility (Alternative 4); Waste Pond Sediment – Excavation, Stabilization and Off-site Disposal at Permitted Facility (Alternative 3); Waste Pond Surface Water – On-site Treatment (Alternative 2); Light Non-Aqueous Phase Liquid – Hydrocarbon Belt Skimmers (Alternative 2); and Ground Water – Ground Water Monitoring (Alternative 2).

The public comment period for the Proposed Plan was held from May 29, 2007, to June 29, 2007. A public meeting was held on May 31, 2007, to present the preferred media-specific alternatives in the Proposed Plan. Based on the comments received at the public meeting and during the comment period, the public and the City of Cushing agree with the preferred media-specific alternatives. The EPA believes that monitoring and ICs can be effectively implemented at the Site. Ground water use will be restricted and monitoring will ensure that the cleanup levels are achieved.

The objective for ground water remediation has been changed from containment to restoration. Ground water contamination is discontinuous and in isolated areas on the Site; monitoring is the most cost effective remedial alternative. Since the estimated time to achieve RAOs and cleanup levels was 30 years for all ground water alternatives, selection of the least costly alternative did not extend the time for remediation.

Two inconsistencies from the proposed plan were discovered during the draft of the ROD. The Proposed Plan outlined three COCs for waste pond sediment – benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene. Benzo(b)fluoranthene has been removed as a COC for waste pond sediment, leaving benzo(a)anthracene and benzo(a)pyrene as COCs.

Benzo(b)fluoranthene exceeded residential risk levels but not the selected commercial/industrial cleanup levels to achieves a 1.0 x 10^{-5} cancer risk level. Additionally, the cost estimations for the selected LNAPL remedial alternative were recalculated and corrected in this ROD. The estimated capital cost was changed from $82,200 to $91,200 and the estimated present worth cost was changed from $133,993 to $124,260. This changed is also reflected in the recalculation of the total clean cost for the Site as described below.

After a re-evaluation of the FS Report, it was determined that a re-calculation of soil volume for cleanup was needed. Recalculations of soil volume requiring cleanup were performed for both the North and South Refineries and discussed, as follows:

Benzene, listed as a COC in the Proposed Plan, has been removed in this ROD. The excess cancer risk calculated for benzene is 1 x 10^{-5} for future indoor workers for the vapor intrusion pathway on the North Refinery. This level meets the EPA cleanup decision point for acceptable carcinogenic risk for industrial/commercial reuse of 1 x 10^{-5} for the Site (as described in Section 14.3). Benzene did not have an elevated risk for any other pathways or receptors; therefore, benzene does not demonstrate a risk above the acceptable risk level. The portion of soil calculated for the benzene risk pathway has been removed from the final cleanup volume. The volume of soil requiring cleanup on the North Refinery has been reduced from an estimation of 34,300 cubic yards to an estimation of 16,500 cubic yards.

The original calculations in the FS included cleanup for soil on the South Refinery at depths from 2 to 6 feet bgs. These calculations were based on contamination estimations from elevated laboratory analytical levels for the COC, benzo(a)pyrene, in total depth soil from the North-South Tank Farm Area. Recalculation of soil volume requiring cleanup on the South Refinery eliminates this portion of soil at depth. The volume of soil requiring cleanup on the South Refinery has been reduced from an estimation of 25,500 cubic yards to an estimation of 15,200 cubic yards.

The estimated volume of soil to be cleaned-up has been corrected from an estimation of 60,000 to 32,000 cubic yards. This recalculation in soil volume requiring cleanup reduces the cost for soil from $5,996,297 to $3,535,397 and the total cleanup cost for the Site from $12,111,343 to $9,650,443. The soil volume changes continue to meet the long-range plans for the City of Cushing. ODEQ supports these changes.

22.0 STATE ROLE

The ODEQ, on behalf of the State of Oklahoma, has reviewed the various alternatives as outlined in the ROD and has indicated its support for the Selected Remedy. The State conducted the RI/FS, BHHRA, and SLERA (Burns and McDonnell, 2006), and has determined that the Selected Remedy is in compliance with ARARs and State environmental and facility siting laws and regulations.

Through a State Cooperative Agreement, ODEQ had the lead on conducting the RI/FS for the Site. From 2004 through 2007, ODEQ conducted an RI/FS and developed the Proposed Plan with technical support from EPA. ODEQ provided technical support for this ROD. The State of Oklahoma concurs with the Selected Remedy for the Site (Appendix B – ODEQ Concurrence with the Selected Remedy).

PART 3: RESPONSIVENESS SUMMARY

23.0 RESPONSIVENESS SUMMARY

The Responsiveness Summary provides information about the views of the public and the support agency regarding both the remedial alternatives and general concerns about the Site submitted during the public comment period.

The public comment period for the Proposed Plan was held from May 29, 2007, to June 29, 2007. A public meeting was held on May 31, 2007, to present the preferred media-specific alternatives in the Proposed Plan. Based on the comments received at the public meeting and during the comment period, the public and the City of Cushing agree with the preferred media-specific alternatives. During the public meeting ODEQ and EPA answered questions from the public. The questions and answers discussed during this meeting can be found in the meeting transcript as part of the Administrative Record. Formal answers to the questions raised during the public meeting are addressed below.

During the public comment period, one letter and one e-mail were received. EPA's responses to the verbal and written comments are as follows.

1) Written comments submitted during the public comment period and received by EPA on June 29, 2007, from Mr. Rick Reiley:

a. On the ground water issue, is 30 years to achieve RAOs a reasonable time frame? How does this compare to similar sites?
b. What responsibilities do the current property owners have to the EPA, ODEQ, and the public? Will they bear any costs or accept any liability for remediation?
c. What legal mechanism, aside from zoning, ordinances, and condemnation proceedings, is available to the city in guiding future development of the Site?
d. Would Brownfields redevelopment funding be available? Tax credits for redevelopment?
e. How soon can remediation begin?

EPA Response:

a. The 30-year time frame for ground water to achieve RAOs is typical of remediation at former refinery sites. The Fourth Street Abandoned Refinery Superfund Site and Double Eagle Refinery Superfund Site, both in Oklahoma City, Oklahoma have expected ground water remediation time frames of 25 years, with a 25 to 40-year variation. Due to the low levels of ground water contamination more aggressive and costly cleanup alternatives were not estimated to achieve RAOs in a more rapid time frame. The EPA guidance document – "Groundwater Cleanup: Overview of Operating Experience at 28 Sites," EPA 542-R-99-006, September 1999 (http://clu-in.org/download/remed/ovopex.pdf), provides a good comparison of ground water cleanup at sites across the United States. The selected remedy for removal of LNAPL, a probable source of ground water contamination, is estimated to be completed in five years or less.
b. Current and former property owners may be responsible for Site cleanup and liable for costs incurred in responding to conditions at the Site. EPA is in the process of identifying PRPs and investigating the viability of any such parties. In the future, PRPs may be asked to perform response actions at the Site and may be found liable for response costs incurred by EPA. Additionally, CERCLA authorizes EPA to place liens on property to address response costs in certain circumstances. A lien was place on the property in June

2001 and amended in January 2002. Determinations of responsibility and potential payment of remediation costs will be determined during the Remedial Design/Remedial Action (RD/RA) Negotiation phase.

c. EPA places a high priority on land revitalization as an integral part of its waste management and cleanup programs. The Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.7-04, May 1995, Land-Use in the CERCLA Remedy Selection Process affirms the importance of future land use assumptions when making remedy selection decisions at Superfund sites. Reasonably anticipated future use of the land at NPL sites is an important consideration in determining the appropriate extent of remediation. The City of Cushing was awarded a Reuse Grant from EPA to develop a future reuse plan for the Hudson Refinery Site. The city sent a letter of intent for site redevelopment on June 14, 2006, outlining the city's long-range plans. Mechanisms used by the city to guide future development of the Site are decisions that must be made by the city. ICs will be required to aid in the management of waste left on-site. ICs will include deed notices placed on land parcels that are contained in the Site. The deed notices will identify the reason for the notice, the affected property, the remedy, engineering controls, and ground water use restrictions prohibiting use of the shallow ground water. An easement may also be granted by the landowners to ODEQ for continued remedial response. The deed notices will be filed by the ODEQ should the property owner decline. The city currently has an ordinance in place that prohibits Site access with the exception of EPA, ODEQ, and federal/state remediation contractors. Currently the Site is zoned for industrial use.

d. Section 101(39)(B)(ii) of CERCLA excludes NPL sites as Brownfield Sites. The Brownfields Tax Incentive was originally signed into law in 1997 and extended through December 31, 2007. The Brownfields Tax Incentive encourages the cleanup and reuse of brownfields. Under this law, environmental cleanup costs are fully deductible in the year incurred, rather than capitalized and spread over time. These tax incentives apply only to Brownfields cleanup. Since federal Superfund or PRP money would be used to clean up the Site, Brownfields tax incentives would not be applicable.

e. Site cleanup occurs in two stages – RD and RA. During RD the remedial actions specified in the ROD are designed; during the RA the remedial action specified in the ROD are implemented. Currently, the estimated schedule for initiation of RD/RA is 2009 to 2010; however, this is just a planning estimation, the start of RD/RA may occur later or earlier. EPA initially attempts to reach an agreement with the PRPs to finance or implement a remedy. If an agreement cannot be reached, then the government will utilize federal Superfund money (90%) and state money (10%) to remediate the site. The government may then seek to recover costs from the responsible parties. These negotiations may add to the time frame before the RD can be initiated. Sites using federal Superfund money are prioritized for cleanup; however, priorities may change causing a site to be remediated either sooner or later.

2) Written comments submitted during the public comment period and received electronically by EPA on May 31, 2007, from Mr. Sam Harris. These comments were also raised by Mr. Harris at the public meeting:

a. At the North West corner of the property, (i.e., on the west side of the hill west of the top bio pond) is a small spring or shelf outlet that discharges to the west, and then northwest across the private property on the west side of Kings Highway. This water outlet is about 100 foot south of the northwest corner of the property and back east inside of the property about 50 to 60 foot. Have samples been taken for contaminants along this natural flow line route?

b. Have samples been taken across this private property flow line route?

EPA Response:

a. Ground water samples were taken during RI on the North Refinery in the north-western area. While no unacceptable levels of contamination were identified in the monitoring wells; the location of a spring in this area had not been identified at the time of sampling. Additional sampling may be necessary during the RD.
b. Should unacceptable levels of contamination be identified during the additional RD investigation, sampling along the flow path may also be necessary.

3) Verbal comments raised by Mr. Glenn McCauley at the public meeting:

a. The commenter had questions about Site cleanup funding. Does the Site have money for remediation?
b. The commenter expressed concern that there has been a lot of rain this year and the grass at the Site is getting tall. Will mowing be conducted at the Site?

EPA Response:

a. The Site is on the NPL. Cleanup will either be paid by a PRP(s) or through federal Superfund money. EPA initially attempts to reach an agreement with the PRPs to finance or implement a remedy. If an agreement cannot be reached, then the government will utilize federal Superfund money (90%) and state money (10%) to remediate the site. The government may then seek to recover costs from the responsible parties. If the Site is remediated through federal Superfund money then it will be prioritized based on risk and scheduled for funding and remediation.
b. The ODEQ replied during the meeting that discussions about mowing were on-going with the City of Cushing. Mowing will be a part of Site maintenance during Site remediation of soil, wastewater pond sediment, LNAPL, ground water, and other media. After this remediation is completed the site would be safe for an intended reuse of commercial/industrial and general mowing could occur with no special safety concerns.

4) Verbal comments raised by Mr. Jim Mullins at the public meeting:

a. The commenter expressed concern over the tall grass at the Site, varmints, and mosquitoes. He also wanted to know if mowing be conducted at the Site? Mr. Mullins noted that the scrap metal creates difficulties for the mowers.

EPA Response:

a. See Response (b) for commenter 3.

5) Verbal comments raised by Mr. Mike McDonald at the public meeting:

a. The commenter asked when Site remediation would begin.

EPA Response:

a. See Response (e) for commenter 1.

6) Verbal comments raised by Mr. Troy Leitschuh at the public meeting:

a. The commenter asked if the Hudson Refinery company was still in existence. Is there a predecessor that would probably act as PRP in this case?

EPA Response:

a. The Hudson Refinery Company declared bankruptcy in 1984. EPA participated in the Hudson bankruptcy and received funding to partially remediate the Site. Those funds were used for corrective actions at the Site including tank clean out, soil excavation, removal of sludges and soils from the NOWP, and biotreatment of contaminated soils, ground water remediation, and ground water monitoring at the LTU. Those funds are completely used and Hudson Refinery is no longer considered a viable PRP. Other responsible parties are being investigated. Two special notice letters were issued at the completion of the removal actions. One was to Quantum Realty, the other was to Land O' Lakes. The EPA will continue to engage in enforcement activities, and determine whether PRPs will either be pursued for the conduct of the remedial action or the recovery of public funds expended at the Site.

24.0 TECHNICAL AND LEGAL ISSUES

24.1 Technical Issues

The EPA has included the following components in the selected remedy:

- Thallium was found in two wells, OW-M and MW-4, at 8.6 µg/l and 4.4 µg/l, respectively. Both results were qualified with a "J," as estimated concentrations reported below the minimum confident sample quantitation limit, also known as the practical quantitation limit. These results were above the MCL of 2.0 µg/l. Background samples were collected for all media, including ground water. The thallium background result was determined to be less then 25 µg/l or less than the practical quantitation limit. Additional investigation will be conducted during the RD to more precisely determine background thallium levels in the shallow ground water of the Vanoss for the City of Cushing and Payne County and to determine if the thallium levels measured at the Site are consistent with city and regional background levels.
- An issue was raised during the Proposed Plan comment period as described in Section 23. At the North West corner of the property, (i.e., on the west side of the hill west of the top bio pond) is a small spring or shelf outlet that discharges to the west, and then northwest across the private property on the west side of Kings Highway. This water outlet is about 100 foot south of the northwest corner of the property and back east inside of the property about 50 to 60 foot. Ground water samples were taken during RI on the North Refinery in the north-western area. While no unacceptable levels of contamination were identified in monitoring wells in the north-western portion of the property; the location of a spring in this area had not been identified at the time of sampling. Additional sampling may be necessary during the RD. If unacceptable levels of contamination are identified during the additional RD investigation, sampling along the flow path may also be necessary.

24.2 Legal Issues

There are no outstanding legal issues.

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Photographs

Photograph 1 – 1972 Aerial Photograph of the Refinery

Photograph 2 – Abandoned Refinery Prior to Removal Actions

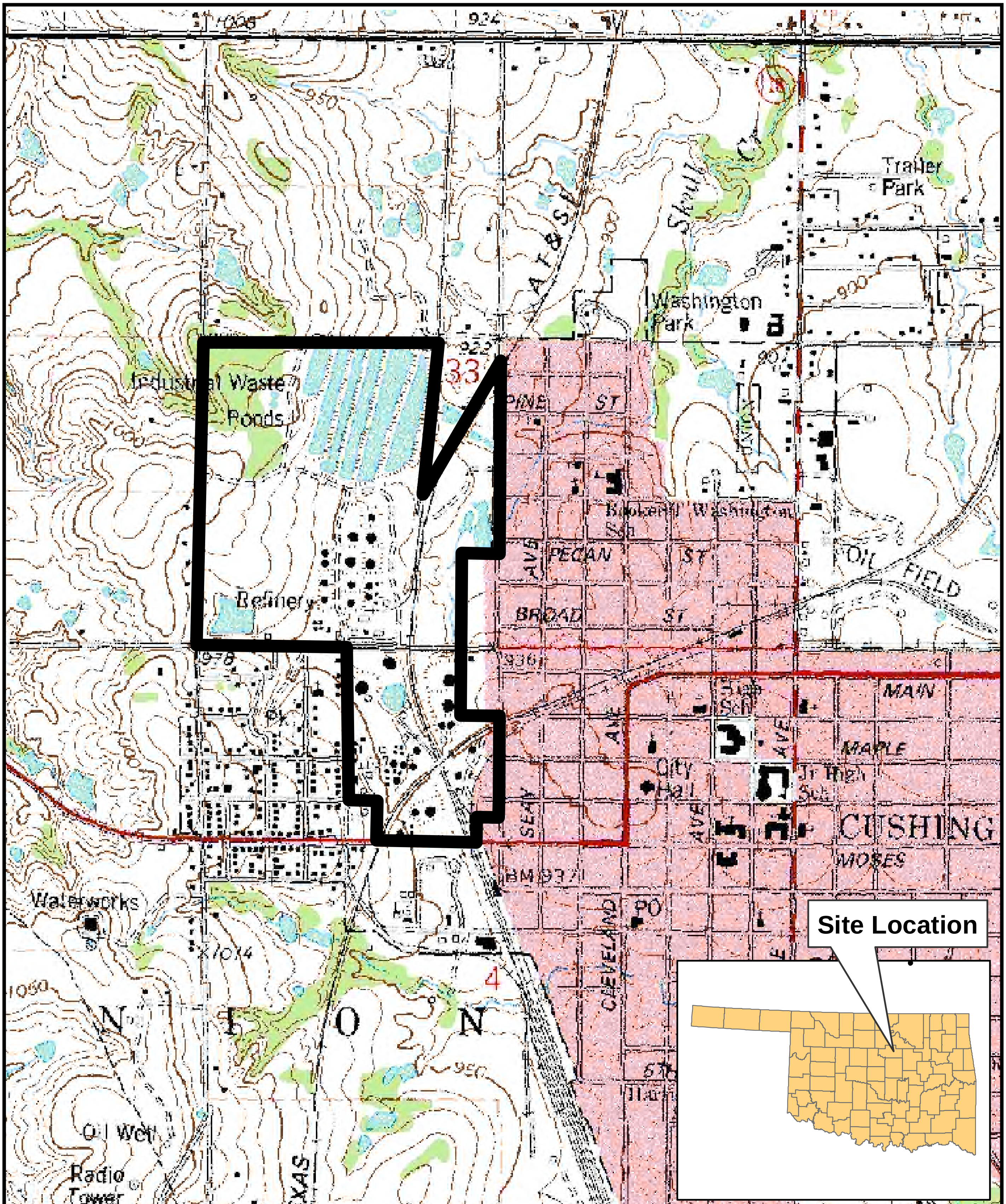
Photograph 3 – Aeration Pond

Photograph 4 – Fish Sampling in Firewater Pond on North Refinery

Photograph 5 – Coke Pond on South Refinery

Photograph 6 – Coke Material from Coke Pond

Figures



LEGEND

Site Boundary

N

0 500 1,000 2,000 Feet

Figure 1

SITE LOCATION MAP

HUDSON OIL REFINERY
SUPERFUND SITE
CUSHING, OK

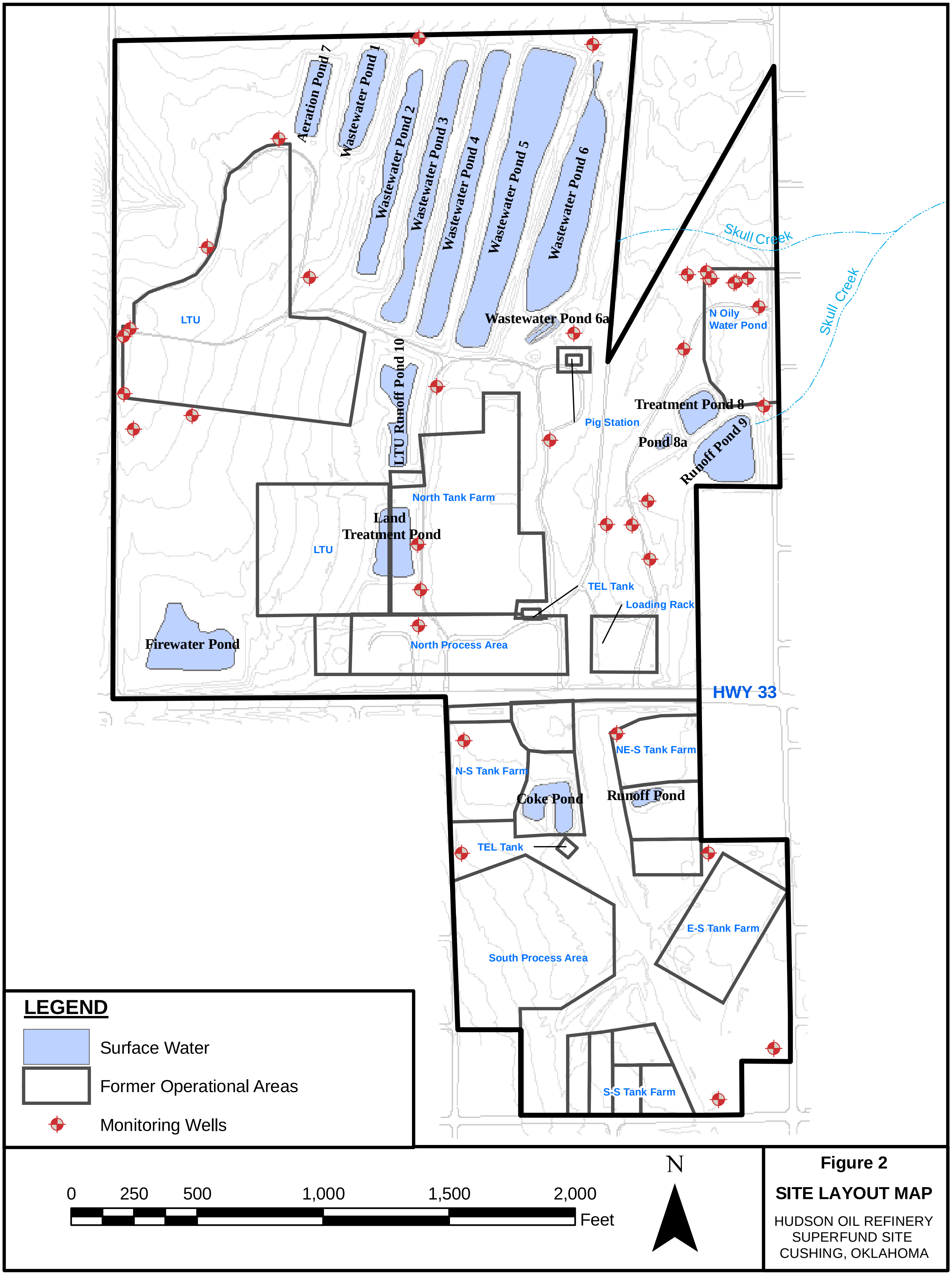


Figure 2

SITE LAYOUT MAP

HUDSON OIL REFINERY
SUPERFUND SITE
CUSHING, OKLAHOMA

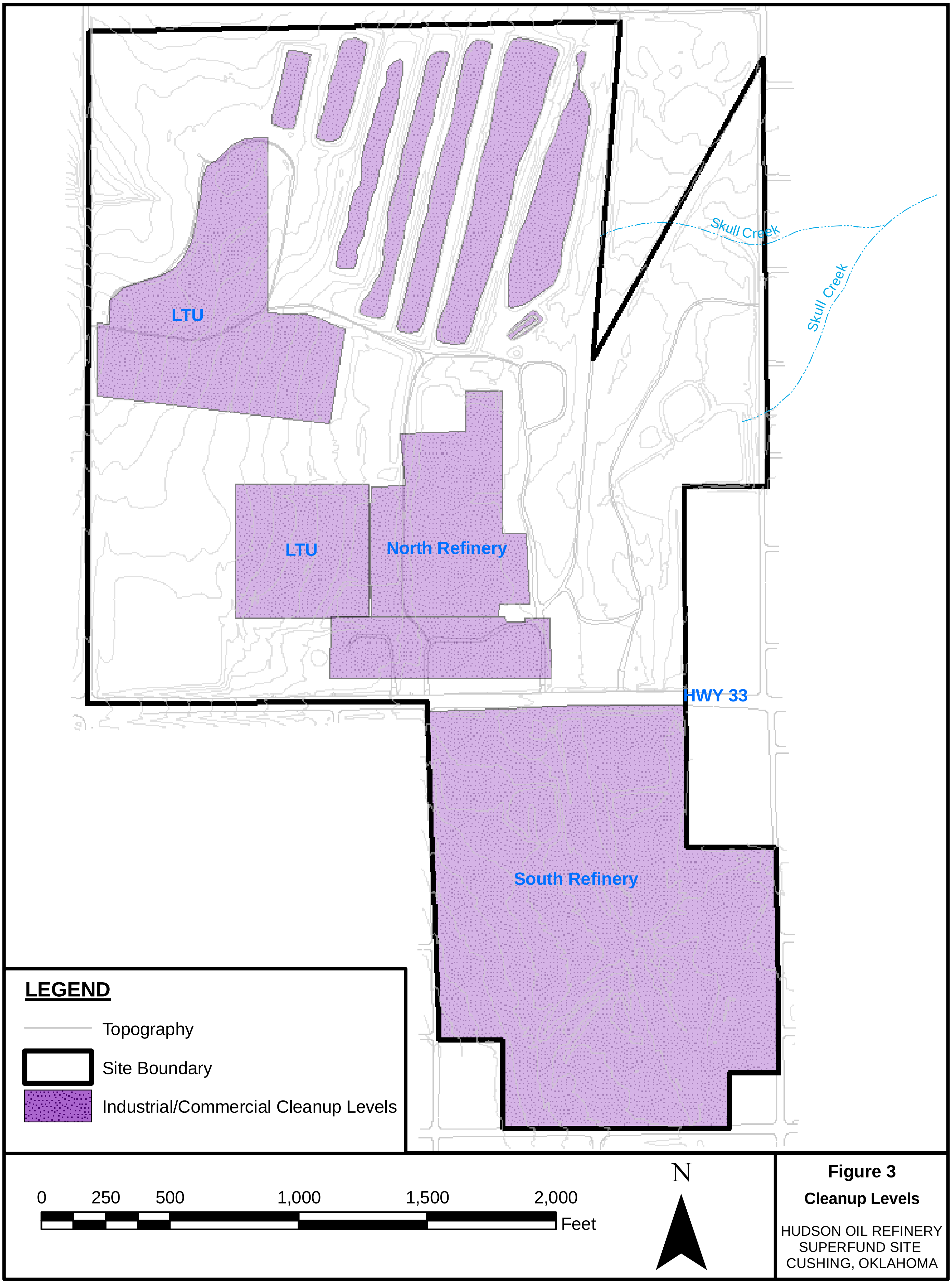


Figure 3

Cleanup Levels

HUDSON OIL REFINERY
SUPERFUND SITE
CUSHING, OKLAHOMA

Figure 4 - Contaminant Location and Movement

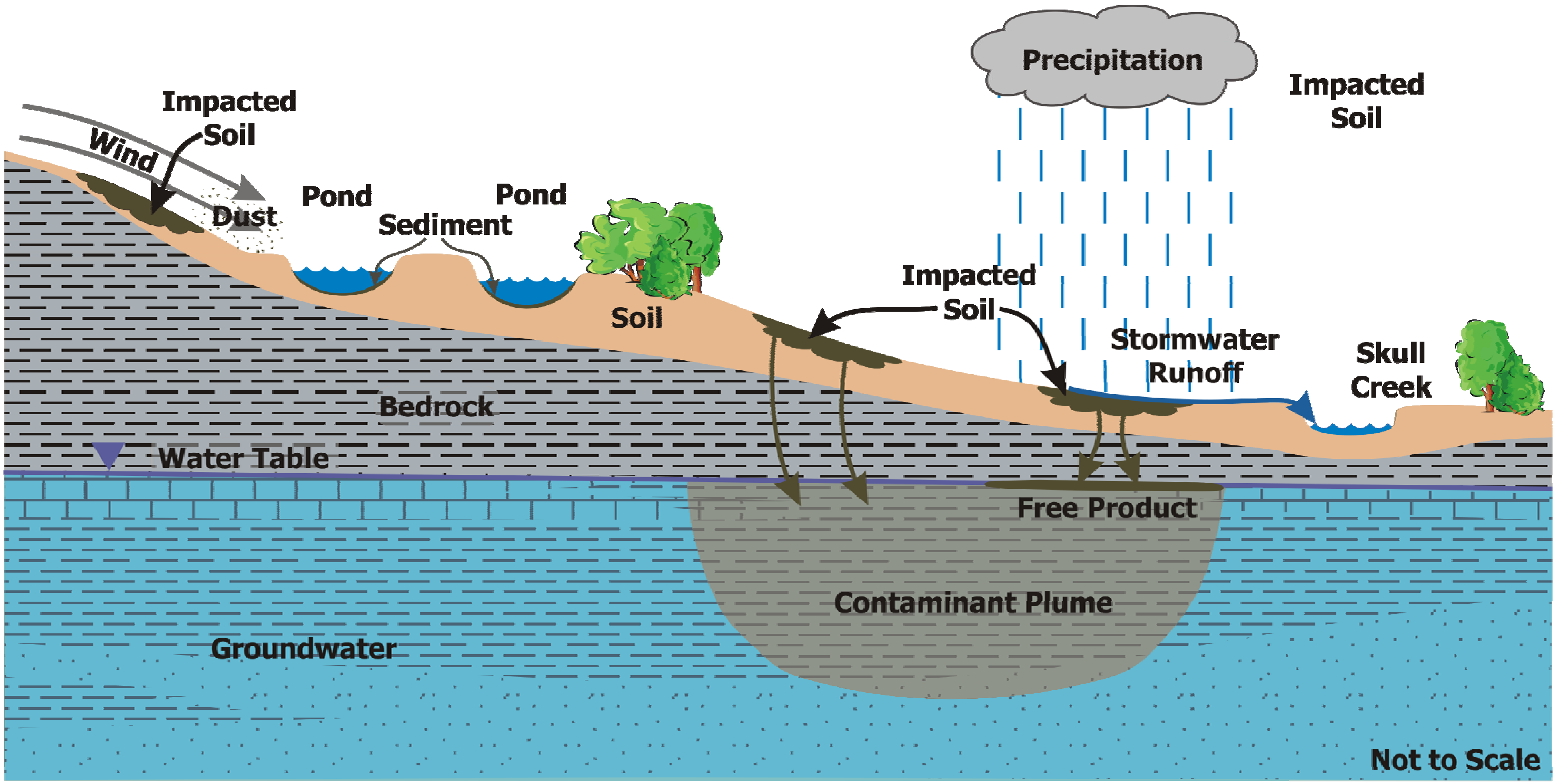


Figure 5: Conceptual Site Model for Human Health

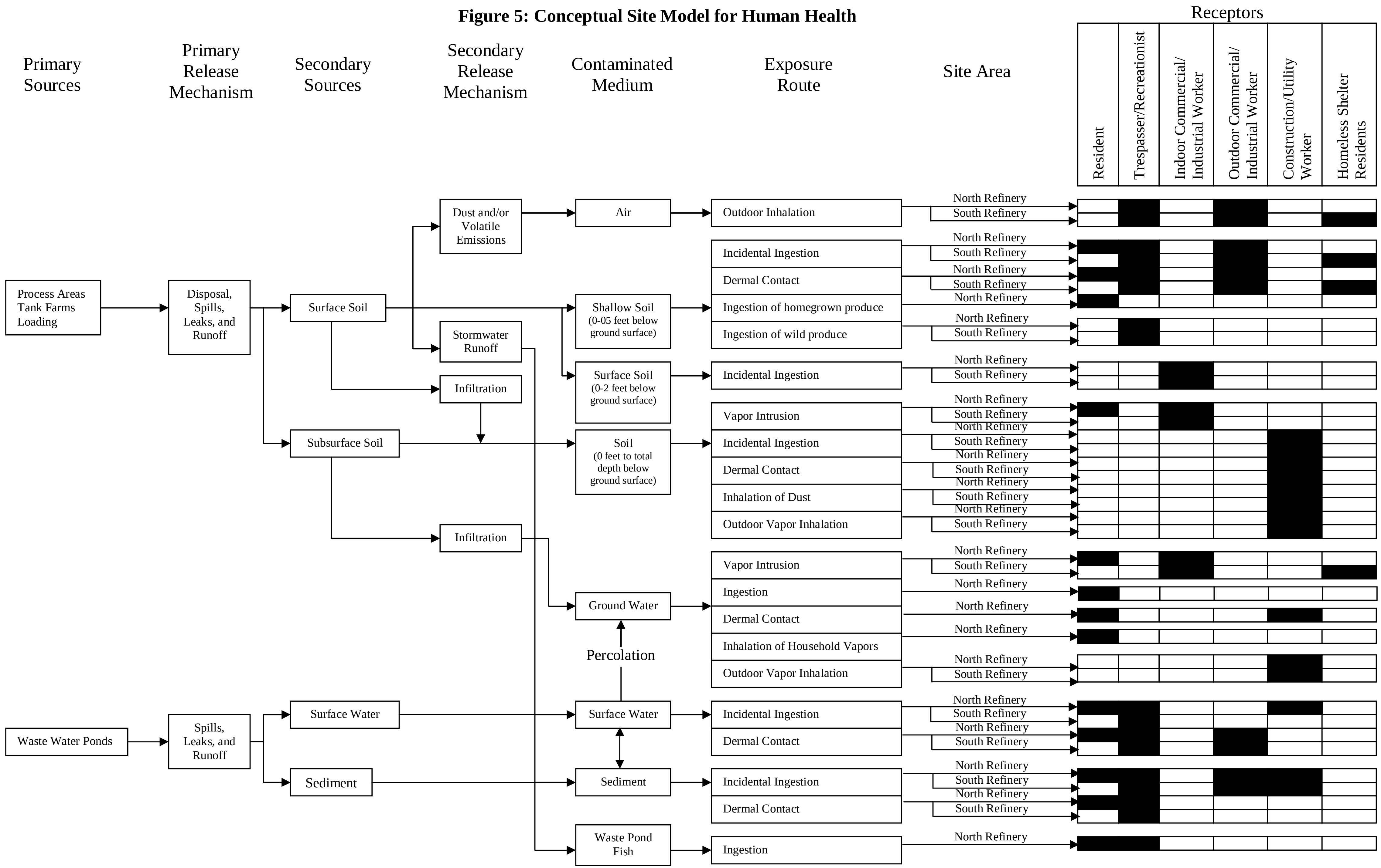
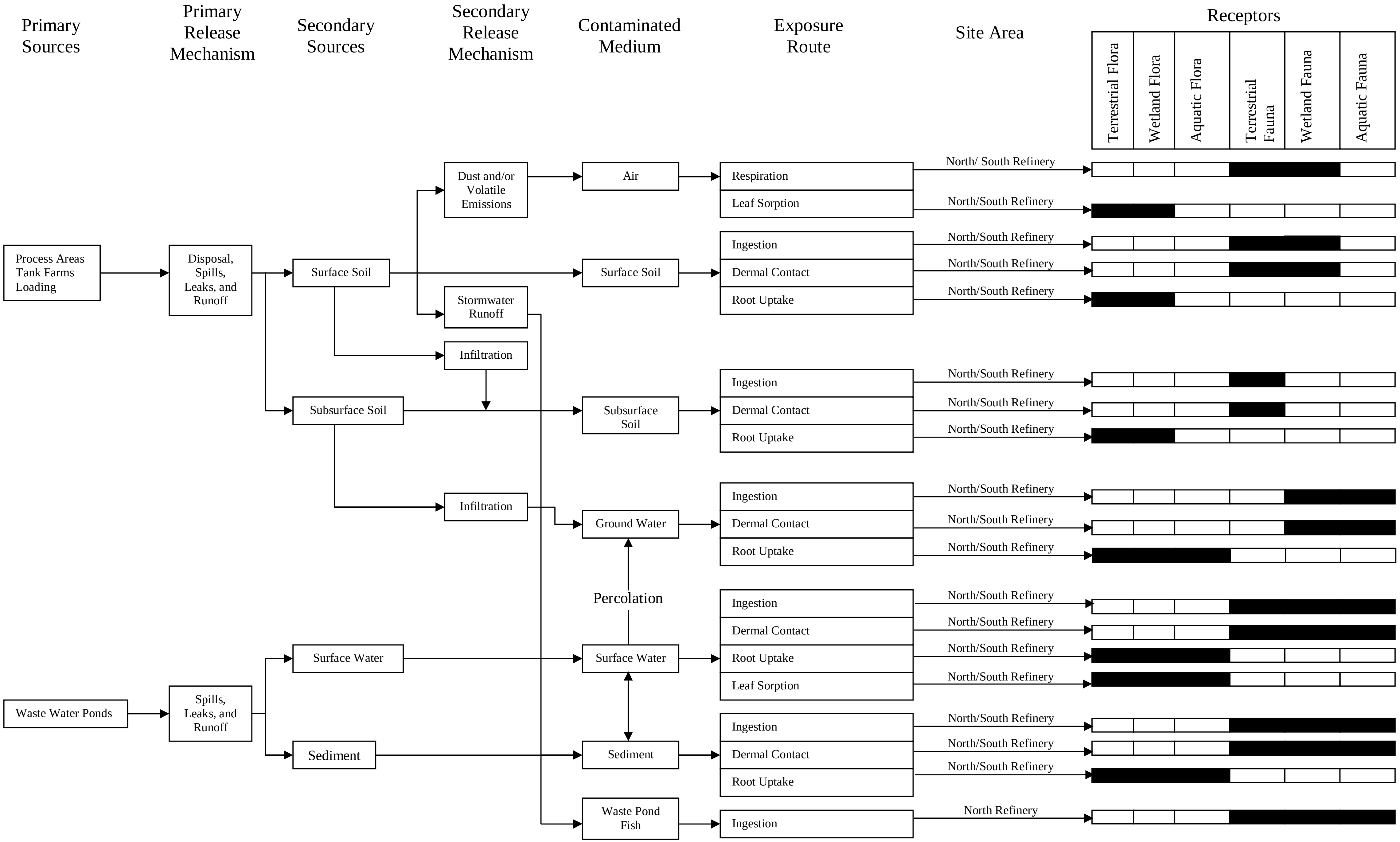


Figure 6: Conceptual Site Model for Ecological Health



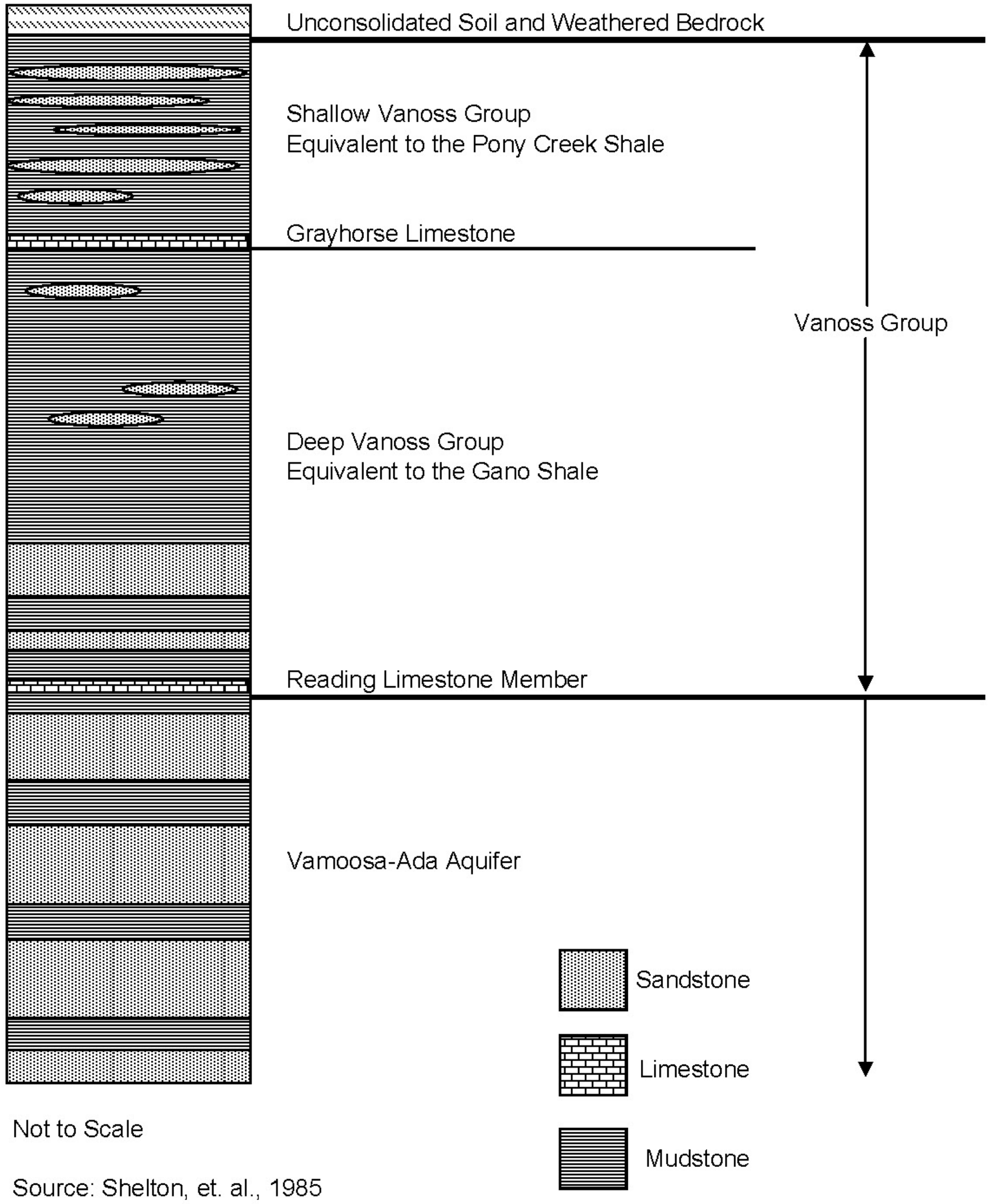


FIGURE 7: GENERALIZED STRATIGRAPHIC COLUMN

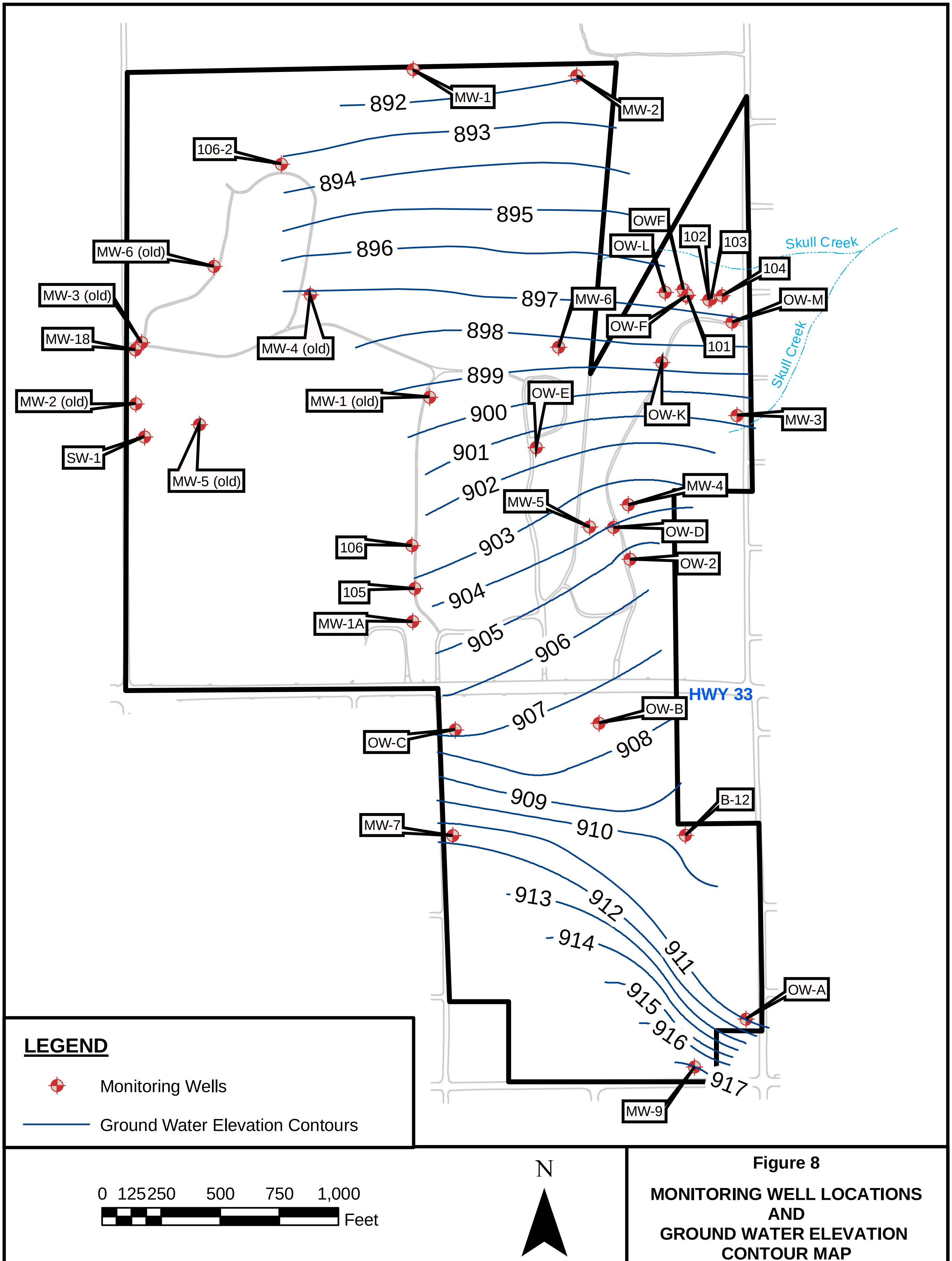


Figure 8

MONITORING WELL LOCATIONS AND GROUND WATER ELEVATION CONTOUR MAP

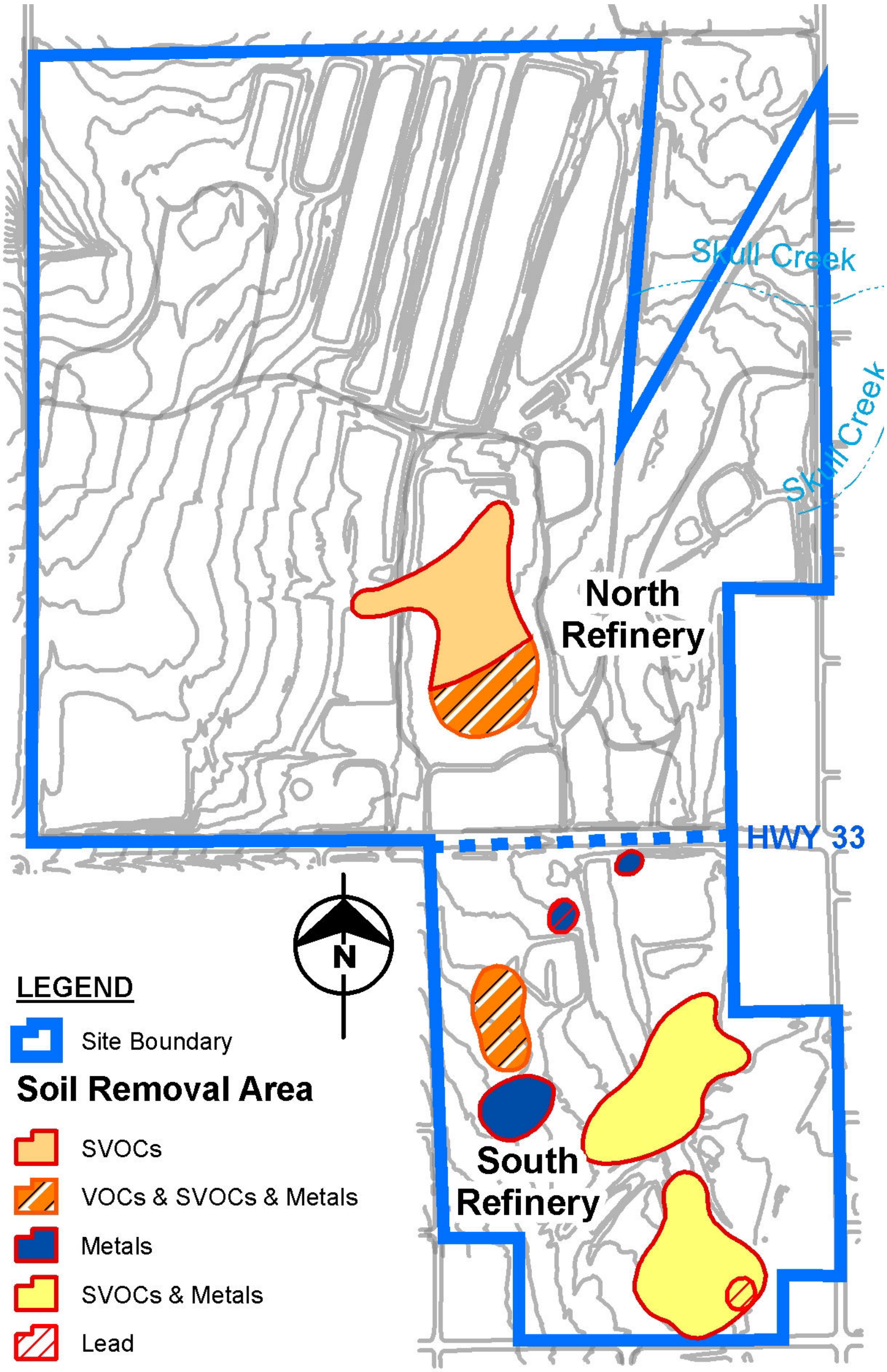


FIGURE 9: SOIL AREA OF CONCERN

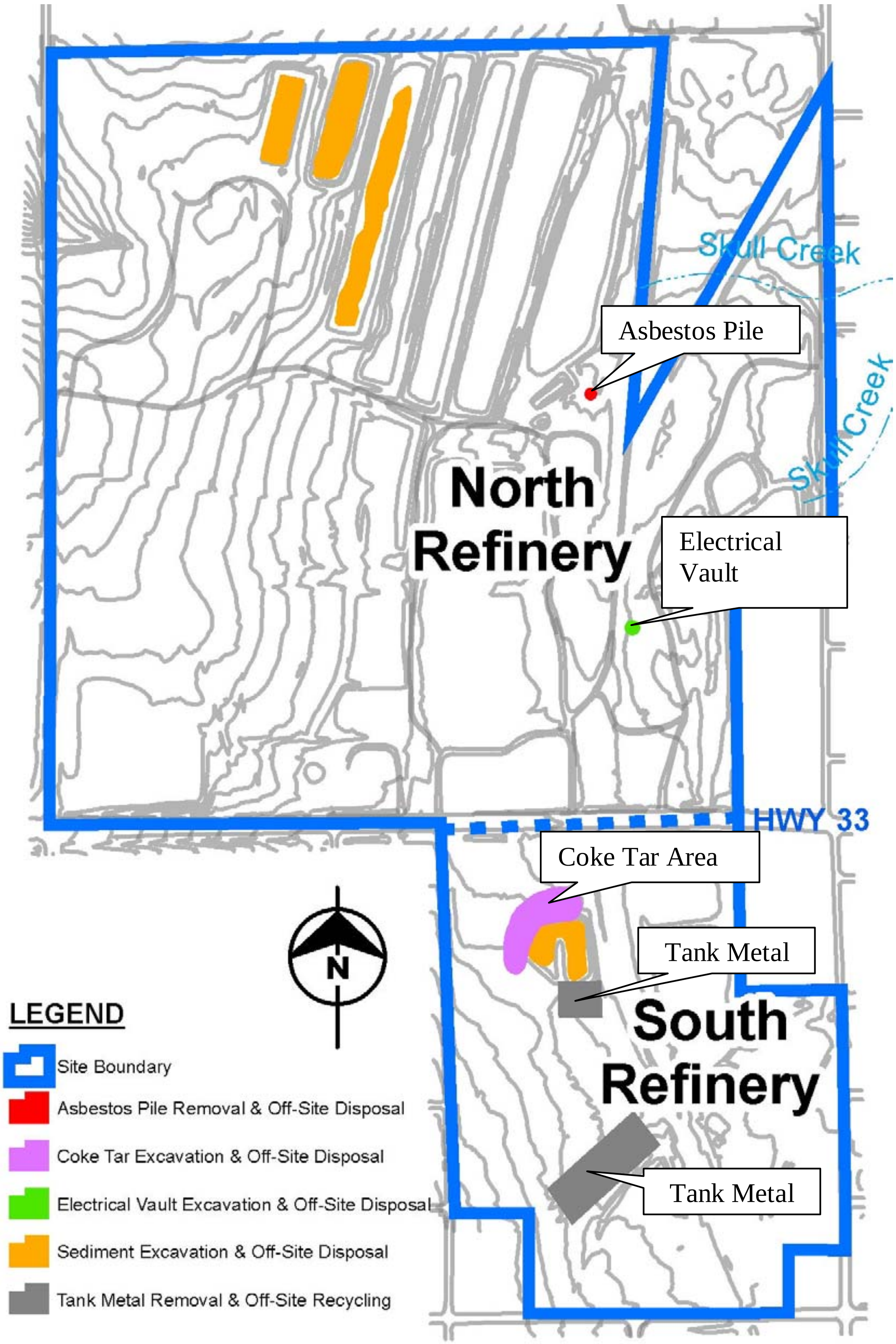


FIGURE 10: WASTE POND SEDIMENT AND SURFACE WATER AND OTHER MEDIA AREAS OF CONCERN

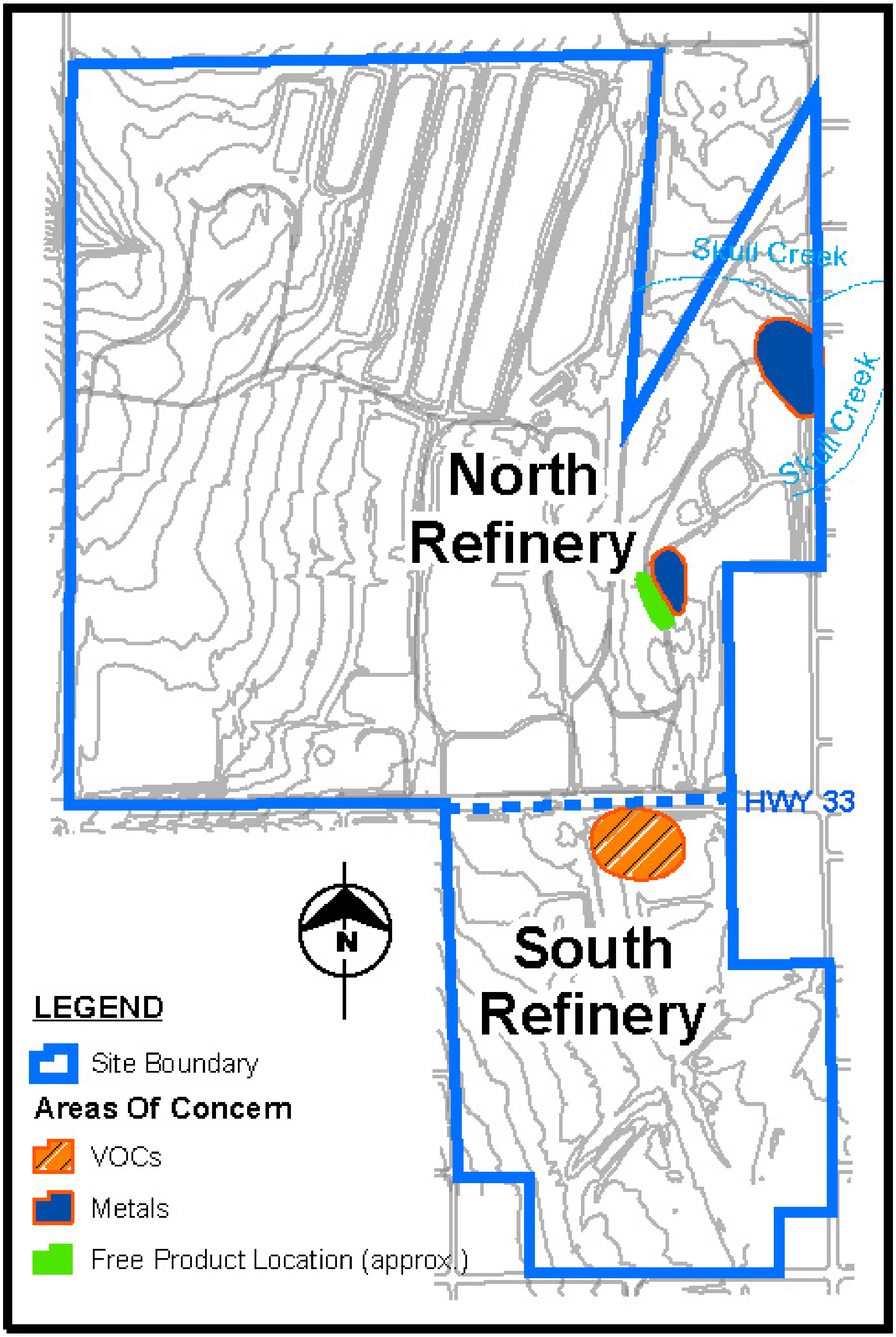


FIGURE 11: LIGHT NON-AQUEOUS PHASE LIQUID AND GROUND WATER AREAS OF CONCERN

Tables

Table 1A: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Shallow Soil North Refinery	Benzo(a) pyrene	0.071	9.2	ppm	8/50	9.2	ppm	Max
Surface Soil South Refinery	Arsenic	2.2	272	ppm	46/71	272	ppm	Max
	Lead	3.7	3460	ppm	67/71	3460	ppm	Max
Shallow Soil South Refinery	Benzo(a) pyrene	0.058	8.8	ppm	6/74	8.8	ppm	Max
	Arsenic	2.2	272	ppm	70/112	272	ppm	Max
	Lead	3.7	3460	ppm	112/112	3460	ppm	Max
Soil South Refinery	Lead	3.7	3460	ppm	130/144	3460	ppm	Max

Key:
ppm: Parts per million
Max: Maximum Concentration
Min: Minimum Concentration
Surface Soil = 0 to 0.5 feet below ground surface
Shallow Soil = 0 to 2.5 feet below ground surface
Soil = 0 to total depth below ground surface

Table 1B: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Waste Pond 1 Sediment	Benzo(a) anthracene	150	150	ppm	1/1	150	ppm	Max
	Benzo(a) pyrene	170	170	ppm	1/1	170	ppm	Max
Waste Pond 2 Sediment	Benzo(a) pyrene	140	140	ppm	1/1	140	ppm	Max
Coke Pond Sediment	Benzo(a) anthracene	200	200	ppm	1/1	200	ppm	Max
	Benzo(a) pyrene	990	990	ppm	1/1	990	ppm	Max

Key:
ppm: Parts per million
Max: Maximum Concentration
Min: Minimum Concentration
Surface Soil = 0 to 0.5 feet below ground surface
Shallow Soil = 0 to 2.5 feet below ground surface
Soil = 0 to total depth below ground surface

Table 1C: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations								
Scenario Timeframe: Current Medium: Surface Water Exposure Medium: Surface Water								
Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Coke Pond Surface Water	Benzo(a) pyrene	0.001	0.009	ppm	2/19	0.009	ppm	Max
Key: ppm: Parts per million Max: Maximum Concentration Min: Minimum Concentration								

Table 1D: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations								
Scenario Timeframe: Current Medium: Surface Ground Water Exposure Medium: Ground Water								
Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Ground Water	Benzene	0.007	0.007	ppm	2/19	0.009	ppm	Max
Ground Water	Thallium	0.0044	0.0088	ppm	2/19	0.0088	ppm	Max
Key: ppm: Parts per million Max: Maximum Concentration Min: Minimum Concentration								

Table 2A: Values Used in Risk Assessment

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Soil

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Ingestion/ Trespasser	Youth	Direct Contact – Soil	CS	Chemical concentration in soil	MAX	mg/kg	Intake (mg/kg/day) = CS x IR x CF x FI x EF x ED / (BW x AT)
			IR	Ingestion rate	100	mg-soil/day	
			CF	Conversion factor	10^{-6}	kg/mg	
			FI	Fraction ingested	1.0	unitless	
			EF	Exposure frequency	72	days/year	
			ED	Exposure duration	6	years	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	
Dermal/ Trespasser	Youth	Direct Contact – Soil	CS	Chemical concentration in soil	MAX	mg/kg	Adsorbed Dose (mg/kg/day) = CS x CF x SA x AF x ABS x EF x ED / (BW x AT)
			CF	Conversion factor	10^{-6}	kg/mg	
			SA	Skin surface area	7085	cm^2/day	
			AF	Soil to skin adherence factor	0.2	mg/cm^2	
			ABS	Absorption factor	0.13	unitless	
			EF	Exposure frequency	72	days/year	
			ED	Exposure duration	6	years	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	

Table 2B: Values Used in Risk Assessment

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Ingestion/ Trespasser	Youth	Direct Contact– Sediment	CS	Chemical concentration	MAX	mg/kg	Intake (mg/kg/day) = CS x IR x CF x FI x EF x ED / (BW x AT)
			IR	Ingestion rate	100	mg-soil/day	
			CF	Conversion factor	10^{-6}	kg/mg	
			FI	Fraction ingested	1.0	unitless	
			EF	Exposure frequency	72	days/year	
			ED	Exposure duration	6	years	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	
Dermal/ Trespasser	Youth	Direct Contact – Sediment	CS	Chemical concentration	MAX	mg/kg	Adsorbed Dose (mg/kg/day) = CS x CF x SA x AF x ABS x EF x ED / (BW x AT)
			CF	Conversion factor	10^{-6}	kg/mg	
			SA	Skin surface area	7085	cm^2/day	
			AF	Soil to skin adherence factor	3.3	mg/cm^2	
			ABS	Absorption factor	0.13	unitless	
			EF	Exposure frequency	72	days/year	
			ED	Exposure duration	6	years	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	

Table 2C: Values Used in Risk Assessment

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Ingestion/ Trespasser	Youth	Direct Contact–Surface Water	CW	Chemical concentration	MAX	mg/L	Intake (mg/kg/day) = CW x CR x ET x EF x ED / (BW x AT)
			CR	Contact Rate	0.05	L/hour	
			ET	Exposure time	4	hours/event	
			EF	Exposure frequency	72	events/year	
			ED	Exposure duration	6	years	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	
Dermal/ Trespasser	Youth	Direct Contact – Surface Water	CW	Chemcial concentration	MAX	Mg/L	Adsorbed Dose (mg/kg/day) = CW x SA x Kp x ET x EF x ED x CF / (BW x AT)
			SA	Skin surface area available for contact	13200	cm^2/day	
			Kp	Chemical-specific dermal permeability constant	See table 6-59 in RI report	cm/hr	
			ET	Exposure time	4	hours/event	
			EF	Exposure frequency	72	days/year	
			ED	Exposure duration	6	years	
			CF	Volumetric conversion factor for water	0.001	L/cm^3	
			BW	Body weight	45.5	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	

Table 2D: Values Used in Risk Assessment

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Ingestion/ Indoor Worker	Adult	Direct Contact – Soil	CS	Chemical concentration in soil	MAX	mg/kg	Intake (mg/kg/day) = CS x IR x CF x FI x EF x ED / (BW x AT)
			IR	Ingestion rate	50	mg-soil/day	
			CF	Conversion factor	10^{-6}	kg/mg	
			FI	Fraction ingested	1.0	unitless	
			EF	Exposure frequency	250	days/year	
			ED	Exposure duration	25	years	
			BW	Body weight	70	kg	
			AT-NC	Averaging time–noncancer effects	9125	days	
			AT-C	Averaging time-cancer effects	25550	days	
Ingestion/ Outdoor Worker	Adult	Direct Contact – Soil	CS	Chemical concentration in soil	MAX	mg/kg	Intake (mg/kg/day) = CS x IR x CF x FI x EF x ED / (BW x AT)
			IR	Ingestion rate	100	mg-soil/day	
			CF	Conversion factor	10^{-6}	kg/mg	
			FI	Fraction ingested	1.0	unitless	
			EF	Exposure frequency	125	days/year	
			ED	Exposure duration	25	years	
			BW	Body weight	70	kg	
			AT-NC	Averaging time–noncancer effects	9125	days	
			AT-C	Averaging time-cancer effects	25550	days	
Dermal/ Outdoor Worker	Adult	Direct Contact – Soil	CS	Chemical concentration in soil	MAX	mg/kg	Adsorbed Dose (mg/kg/day) = CS x CF x SA x AF x ABS x EF x ED / (BW x AT)
			CF	Conversion factor	10^{-6}	kg/mg	
			SA	Skin surface area	3300	cm^2/day	
			AF	Soil to skin adherence factor	0.2	mg/cm^2	
			ABS	Absorption factor	0.13	unitless	
			EF	Exposure frequency	125	days/year	
			ED	Exposure duration	25	years	
			BW	Body weight	70	kg	
			AT-NC	Averaging time–noncancer effects	9125	days	
			AT-C	Averaging time-cancer effects	25550	days	
Ingestion/ Construction	Adult	Direct Contact –	CS	Chemical concentration in soil	MAX	mg/kg	Intake (mg/kg/day) = CS x IR x CF x FI x EF x ED / (BW x AT)
			IR	Ingestion rate	300	mg-soil/day	

Worker		Soil	CF FI EF ED BW AT-NC AT-C	Conversion factor Fraction ingested Exposure frequency Exposure duration Body weight Averaging time–noncancer effects Averaging time-cancer effects	10^{-6} 1.0 130 1 70 180 25550	kg/mg unitless days/year years kg days days	
Dermal/ Construciton Worker	Adult	Direct Contact – Soil	CS CF SA AF ABS EF ED BW AT-NC AT-C	Chemical concentration in soil Conversion factor Skin surface area Soil to skin adherence factor Absorption factor Exposure frequency Exposure duration Body weight Averaging time–noncancer effects Averaging time-cancer effects	MAX 10^{-6} 3300 0.3 0.13 130 1 70 180 25550	mg/kg kg/mg cm²/day mg/cm² unitless days/year years kg days days	Adsorbed Dose (mg/kg/day) = CS x CF x SA x AF x ABS x EF x ED / (BW x AT)

Table 2E: Values Used in Risk Assessment

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Dermal/ Outdoor Worker	Adult	Direct Contact – Sediment	CS CF SA AF ABS EF ED BW AT-NC AT-C	Chemical concentration Conversion factor Skin surface area Soil to skin adherence factor Absorption factor Exposure frequency Exposure duration Body weight Averaging time–noncancer effects Averaging time-cancer effects	MAX 10^{-6} 3300 0.9 0.13 26 25 70 9125 25550	mg/kg kg/mg cm²/day mg/cm² unitless days/year years kg days days	Adsorbed Dose (mg/kg/day) = CS x CF x SA x AF x ABS x EF x ED / (BW x AT)

Table 2F: Values Used in Risk Assessment

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Route/ Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Equation
Dermal/ Outdoor Worker	Adult	Direct Contact – Surface Water	CW	Chemcial concentration	MAX	mg/L	Adsorbed Dose (mg/kg/day) = CW x SA x Kp x ET x EF x ED x CF / (BW x AT)
			SA	Skin surface area available for contact	3300	cm^2/day	
			Kp	Chemical-specific dermal permeability constant	See table 6-59 in RI report	cm/hr	
			ET	Exposure time	2.5	hours/event	
			EF	Exposure frequency	26	days/year	
			ED	Exposure duration	25	years	
			CF	Volumetric conversion factor for water	0.001	L/cm^3	
			BW	Body weight	70	kg	
			AT-NC	Averaging time–noncancer effects	2190	days	
			AT-C	Averaging time-cancer effects	25550	days	

Table 3A: Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal						
Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Cancer Guideline Description	Source	Date
Benzo(a) anthracene	$7.3x10^{-1}$	$7.3x10^{-1}$	1/(mg/kg/day)	B2	PAH	2005
Benzo(a) pyrene	7.3	7.3	1/(mg/kg/day)	B2	IRIS	2005
Arsenic	1.5	1.5	1/(mg/kg/day)	A	IRIS	2005

Pathway: Inhalation							
Chemical of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight Evidence/Cancer Guideline Description	Source	Date
Benzo(a) anthracene			$3.1x10^{-1}$	1/(mg/kg/day)	B2	Region 6	2004
Benzo(a) pyrene			3.1	1/(mg/kg/day)	B2	Region 6	2004
Arsenic			$1.5x10^{1}$	1/(mg/kg/day)	A	IRIS	2005

Key
Blanks indicate no information is available
IRIS: Integrated Risk Information System, USEPA
PAH: Slope factor for benzo(a)pyrene adjusted as recommended in Provisional Guidance for Quantitative Risk Assessment of polycyclic Aromatic Hydrocarbons (USEPA, 1993).
Region 6: USEPA Region 6 Human Health Medium Specific Screening Levels (USEPA, 2004)

A: Human carcinogen
B2: probable human carcinogen – Indicates sufficient evidence in annals and inadequate or no evidence in humans

Table 3B: Non-Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal									
Chemical of Concern	Chronic/ Subchronic	Oral RfD Values	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combinded Uncertainty / Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ
Arsenic	Chronic	$3x10^{-4}$	mg/kg/day	$3x10^{-4}$	mg/kg/day	Integument		IRIS	2005

Key
Blanks indicate no information is available
IRIS: Integrated Risk Information System, USEPA

Table 4A: Risk Characterization Summary – Carcinogens

Scenario Timeframe: Current
Receptor Population: Trespasser, North Refinery
Receptor Age: Youth
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes
Sediment	Waste Pond Sediments	Sediment in Waste Pond 1	Benzo(a) pyrene	$8x10^{-6}$	N/A	$2x10^{-4}$	$2x10^{-4}$
			Benzo(a) anthracene	$7x10^{-7}$	N/A	$2x10^{-5}$	$2x10^{-5}$
		Sediment in Waste Pond 2	Benzo(a) pyrene	$6x10^{-6}$	N/A	$2x10^{-4}$	$2x10^{-4}$
						Sediment risk total=	$4x10^{-4}$
						Total Risk=	$4x10^{-4}$

Key
N/A: Route of exposure is not applicable to this medium

Table 4B: Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Outdoor Worker, North Refinery
Receptor Age: Adult
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes
Soil	Shallow Soil	Shallow Soil, North Refinery	Benzo(a) pyrene	$1x10^{-5}$	N/A	$1x10^{-5}$	$2x10^{-5}$
						Soil risk total=	$2x10^{-5}$
Sediment	Waste Pond Sediments	Sediment in Waste Pond 1	Benzo(a) pyrene	N/A	N/A	$1x10^{-4}$	$1x10^{-4}$
		Sediment in Waste Pond 2	Benzo(a) pyrene	N/A	N/A	$1x10^{-4}$	$1x10^{-4}$
						Sediment risk total=	$2x10^{-4}$
						Total Risk=	$2x10^{-4}$

Key
N/A: Route of exposure is not applicable to this medium
Shallow Soil = 0 to 2.5 feet below ground surface

Table 4C: Risk Characterization Summary – Carcinogens

Scenario Timeframe: Current
Receptor Population: Trespasser, South Refinery
Receptor Age: Youth
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes
Soil	Shallow Soil	Shallow Soil, South Refinery	Arsenic	$2x10^{-5}$	N/A	$6x10^{-6}$	$3x10^{-5}$
						Soil risk total=	$3x10^{-5}$
Surface Water	Waste Pond Surface Water	Surface Water in Coke Pond	Benzo(a) pyrene	$2x10^{-6}$	N/A	$4x10^{-4}$	$4x10^{-4}$
						Surface Water risk total=	$4x10^{-4}$
Sediment	Waste Pond Sediments	Sediment in Coke Pond	Benzo(a) pyrene	$1x10^{-4}$	N/A	$2x10^{-5}$	$1x10^{-4}$
						Sediment risk total=	$1x10^{-4}$
						Total Risk=	$5x10^{-4}$

Key
N/A: Route of exposure is not applicable to this medium
Shallow Soil = 0 to 2.5 feet below ground surface

Table 4D: Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Indoor Worker, South Refinery
Receptor Age: Adult
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes
Soil	Surface Soil	Surface Soil, South Refinery	Arsenic	$7x10^{-5}$	N/A	N/A	$7x10^{-5}$
						Soil risk total=	$7x10^{-5}$
						Total Risk=	$7x10^{-5}$

Key
N/A: Route of exposure is not applicable to this medium
Surface Soil = 0 to 0.5 feet below ground surface

Table 4E: Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Outdoor Worker, South Refinery
Receptor Age: Adult
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes
Soil	Shallow Soil	Shallow Soil, South Refinery	Benzo(a) pyrene	$1x10^{-5}$	N/A	$1x10^{-5}$	$2x10^{-5}$
			Arsenic	$7x10^{-5}$	N/A	$1x10^{-5}$	$8x10^{-5}$
						Soil risk total=	$1x10^{-4}$
Surface Water	Waste Pond Surface Water	Surface Water in Coke Pond	Benzo(a) pyrene	N/A	N/A	$1x10^{-4}$	$1x10^{-4}$
						Surface Water risk total=	$1x10^{-4}$
Sediment	Waste Pond Sediments	Sediment in Coke Pond	Benzo(a) anthracene	N/A	N/A	$2x10^{-5}$	$2x10^{-5}$
			Benzo(a) pyrene	N/A	N/A	$1x10^{-3}$	$1x10^{-3}$
						Sediment risk total=	$1x10^{-3}$
						Total Risk=	$1x10^{-3}$

Key
N/A: Route of exposure is not applicable to this medium
Shallow Soil = 0 to 2.5 feet below ground surface

Table 5: Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Construction Work , South Refinery
Receptor Age: Adult
Evaluation Type: Maximum Detected Concentration

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes
Soil	Soil	Soil	Arsenic	Integument	3	N/A	$3x10^{-1}$	3
							Soil risk total=	3
							Total Risk=	3

Key
N/A: Route of exposure is not applicable to this medium
Soil = 0 to total depth below ground surface

Table 6A: Selection of Ecological Chemicals of Concern					
Exposure Medium: Soil Wildlife Species: Earthworms Site Area: North Refinery					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Benchmark (ppm)	Screening Benchmark Value Source	Hazard Quotient	COPC?
Barium	533	330	USEPA Eco-SSLs	1.62	Yes
Chromium	139	0.4	Efroymson et al, 1997	$3.48x10^2$	Yes
Copper	166	50	Efroymson et al, 1997	3.32	Yes
Mercury	4.3	0.1	Efroymson et al, 1997	$4.3x10^1$	Yes
Nickel	348	200	Efroymson et al, 1997	1.74	Yes
Zinc	2730	200	Efroymson et al, 1997	$1.37x10^1$	Yes
Key ppm: milligrams per kilogram Hazard Quotient= maximum concentration/screening benchmark					

Table 6B: Selection of Ecological Chemicals of Concern					
Exposure Medium: Soil Wildlife Species: Earthworms Site Area: South Refinery					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Benchmark (ppm)	Screening Benchmark Value Source	Hazard Quotient	COPC?
Arsenic	272	60	Efroymson et al, 1997	4.53	Yes
Barium	5640	330	USEPA Eco-SSLs	$1.71x10^1$	Yes
Chromium	179	0.4	Efroymson et al, 1997	$4.48x10^2$	Yes
Copper	609	50	Efroymson et al, 1997	$1.22x10^1$	Yes
Lead	3460	1700	USEPA Eco-SSLs	2.04	Yes
Mercury	5.27	0.1	Efroymson et al, 1997	$5.27x10^1$	Yes
Nickel	281	200	Efroymson et al, 1997	1.41	Yes
Zinc	11044	200	Efroymson et al, 1997	$5.52x10^1$	Yes
Key ppm: milligrams per kilogram Hazard Quotient= maximum concentration/screening benchmark					

Table 6C: Selection of Ecological Chemicals of Concern					
Exposure Medium: Soil Wildlife Species: Plants Site Area: North Refinery					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Benchmark (ppm)	Screening Benchmark Value Source	Hazard Quotient	COPC?
Aluminum	59300	50	Efroymson et al, 1997	$1.19x10^3$	Yes
Antimony	16.9	5	Efroymson et al, 1997	3.38	Yes
Arsenic	25.7	10	Efroymson et al, 1997	2.57	Yes
Barium	533	500	Efroymson et al, 1997	1.07	Yes
Chromium	139	1	Efroymson et al, 1997	$1.39x10^2$	Yes
Copper	166	100	Efroymson et al, 1997	1.66	Yes
Lead	370	50	Efroymson et al, 1997	7.4	Yes
Manganese	3880	500	Efroymson et al, 1997	7.76	Yes
Mercury	4.3	0.3	Efroymson et al, 1997	$1.43x10^1$	Yes
Nickel	348	30	Efroymson et al, 1997	$1.16x10^1$	Yes
Selenium	1.1	1	Efroymson et al, 1997	1.10	Yes
Thallium	6	1	Efroymson et al, 1997	6.0	Yes
Vanadium	92	2	Efroymson et al, 1997	$4.60x10^1$	Yes
Zinc	2730	50	Efroymson et al, 1997	$5.46x10^1$	Yes
Key ppm: milligrams per kilogram Hazard Quotient= maximum concentration/screening benchmark					

Table 6D: Selection of Ecological Chemicals of Concern					
Exposure Medium: Soil Wildlife Species: Plants Site Area: South Refinery					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Benchmark (ppm)	Screening Benchmark Value Source	Hazard Quotient	COPC?
Aluminum	52500	50	Efroymson et al, 1997	$1.05x10^3$	Yes
Antimony	49.2	5	Efroymson et al, 1997	9.84	Yes
Arsenic	272	10	Efroymson et al, 1997	$2.72x10^1$	Yes
Barium	5640	500	Efroymson et al, 1997	$1.13x10^1$	Yes
Chromium	179	1	Efroymson et al, 1997	$1.79x10^2$	Yes

Copper	609	100	Efroymson et al, 1997	6.09	Yes
Lead	3460	50	Efroymson et al, 1997	$6.92x10^{1}$	Yes
Manganese	3480	500	Efroymson et al, 1997	6.96	Yes
Mercury	5.27	0.3	Efroymson et al, 1997	$1.76x10^{1}$	Yes
Nickel	281	30	Efroymson et al, 1997	9.37	Yes
Selenium	1.2	1	Efroymson et al, 1997	1.2	Yes
Silver	21.7	2	Efoymson et al, 1997	$1.09x10^{1}$	Yes
Thallium	13.7	1	Efroymson et al, 1997	$1.37x10^{1}$	Yes
Vanadium	95.1	2	Efroymson et al, 1997	$4.76x10^{1}$	Yes
Zinc	11044	50	Efroymson et al, 1997	$2.21x10^{2}$	Yes

Key
ppm: milligrams per kilogram
Hazard Quotient= maximum concentration/screening benchmark

Table 6E: Selection of Ecological Chemicals of Concern

Exposure Medium: Sediment
Wildlife Species: Benthic Invertebrates
Site Area: North Refinery Waste Pond 1

Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Mercury	$3.36x10^{-1}$	$1.3x10^{-1}$	Jones et al., 1997	2.58	Yes
Chromium	$9.87x10^{2}$	$5.23x10^{1}$	Jones et al., 1997	$1.89x10^{1}$	Yes
Copper	$6.71x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	3.59	Yes
Lead	$5.03x10^{1}$	$3.02x10^{1}$	Jones et al., 1997	1.67	Yes
Nickel	$3.69x10^{1}$	$1.59x10^{1}$	Jones et al., 1997	2.23	Yes
Zinc	$3.36x10^{2}$	$1.24x10^{2}$	Jones et al., 1997	2.71	Yes

Exposure Medium: Sediment
Wildlife Species: Benthic Invertebrates
Site Area: North Refinery Waste Pond 2

Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Mercury	$6.04x10^{-1}$	$1.30x10^{-1}$	Jones et al., 1997	4.65	Yes
Chromium	$2.49x10^{3}$	$5.23x10^{1}$	Jones et al., 1997	$4.76x10^{1}$	Yes
Copper	$6.52x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	3.49	Yes
Lead	$4.35x10^{1}$	$3.02x10^{1}$	Jones et al., 1997	1.44	Yes
Nickel	$2.42x10^{1}$	$1.59x10^{1}$	Jones et al.,	1.52	Yes

			1997		
Zinc	$5.72x10^{2}$	$1.24x10^{2}$	Jones et al., 1997	4.61	Yes
Exposure Medium: Sediment Wildlife Species: Benthic Invertebrates Site Area: North Refinery Waste Ponds 3-6A and LTU Pond					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Chromium	$3.59x10^{2}$	$5.23x10^{1}$	Jones et al., 1997	6.86	Yes
Copper	$5.69x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	3.04	Yes
Lead	$5.50x10^{1}$	$3.02x10^{1}$	Jones et al., 1997	1.82	Yes
Nickel	$1.80x10^{1}$	$1.59x10^{1}$	Jones et al., 1997	1.13	Yes
Exposure Medium: Sediment Wildlife Species: Benthic Invertebrates Site Area: North Refinery Waste Ponds 8 and 8a and Runoff Pond 9					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Mercury	$3.37x10^{-1}$	$1.30x10^{-1}$	Jones et al., 1997	2.59	Yes
Chromium	$8.08x10^{1}$	$5.23x10^{1}$	Jones et al., 1997	1.54	Yes
Copper	$4.71x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	2.52	Yes
Lead	$1.04x10^{2}$	$3.02x10^{1}$	Jones et al., 1997	3.44	Yes
Nickel	$1.73x10^{1}$	$1.59x10^{1}$	Jones et al., 1997	1.09	Yes
Zinc	$2.79x10^{2}$	$1.24x10^{2}$	Jones et al., 1997	2.25	Yes
Exposure Medium: Sediment Wildlife Species: Benthic Invertebrates Site Area: North Refinery Firewater Pond					
Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Copper	$3.95x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	2.11	Yes
Key ppm: milligrams per kilogram Hazard Quotient= maximum concentration/screening value					

Table 6F: Selection of Ecological Chemicals of Concern

Exposure Medium: Sediment
Wildlife Species: Benthic Invertebrates
Site Area: Skull Creek

Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Copper	$2.45x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	1.31	Yes
Lead	$8.60x10^{1}$	$3.02x10^{1}$	Jones et al., 1997	2.85	Yes
Nickel	$1.70x10^{1}$	$1.59x10^{1}$	Jones et al., 1997	1.07	Yes

Key
ppm: milligrams per kilogram
Hazard Quotient= maximum concentration/screening value

Table 6G: Selection of Ecological Chemicals of Concern

Exposure Medium: Sediment
Wildlife Species: Benthic Invertebrates
Site Area: South Refinery Coke Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Xylenes (Total)	$1.20x10^{3}$	$2.50x10^{1}$	Jones et al., 1997	$4.80x10^{1}$	Yes
Benzo(A)Pyrene	$9.90x10^{2}$	$3.30x10^{2}$	Jones et al., 1997	3.00	Yes
Chromium	$2.29x10^{2}$	$5.23x10^{1}$	Jones et al., 1997	4.38	Yes
Nickel	$1.11x10^{2}$	$1.59x10^{1}$	Jones et al., 1997	6.98	Yes

Exposure Medium: Sediment
Wildlife Species: Benthic Invertebrates
Site Area: South Refinery Runoff Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Screening Values (ppm)	Screening Value Source	Hazard Quotient	COPC?
Mercury	$1.99x10^{-1}$	$1.30x10^{-1}$	Jones et al., 1997	1.53	Yes
Chromium	$6.23x10^{1}$	$5.23x10^{1}$	Jones et al., 1997	1.19	Yes
Copper	$2.84x10^{1}$	$1.87x10^{1}$	Jones et al., 1997	1.52	Yes
Lead	$5.54x10^{1}$	$3.02x10^{1}$	Jones et al., 1997	1.83	Yes
Nickel	$1.80x10^{1}$	$1.59x10^{1}$	Jones et al., 1997	1.13	Yes
Zinc	$5.61x10^{2}$	$1.24x10^{2}$	Jones et al., 1997	4.52	Yes

Key
ppm: milligrams per kilogram
Hazard Quotient= maximum concentration/screening value

Table 6H: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: North Refinery Waste Pond 1

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$2.60x10^{-3}$	$1.00x10^{-3}$	Sutter and Tsao, 1996	2.60	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: Waste Pond 2

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Aluminum	7.12	$4.60x10^{-1}$	Sutter and Tsao, 1996	$1.55x10^{1}$	Yes
Chromium	1.97	$3.97x10^{-1}$	Sutter and Tsao, 1996	4.96	Yes
Copper	$9.05x10^{-2}$	$1.00x10^{-3}$	Sutter and Tsao, 1996	$9.05x10^{1}$	Yes
Lead	$9.39x10^{-1}$	$5.00x10^{-1}$	Sutter and Tsao, 1996	1.88	Yes
Nickel	$2.51x10^{-2}$	$5.00x10^{-3}$	Sutter and Tsao, 1996	5.02	Yes
Zinc	$9.87x10^{-1}$	$3.00x10^{-2}$	Sutter and Tsao, 1996	$3.29x10^{1}$	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: North Refinery Waste Ponds 3-6A and LTU Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Aluminum	$6.23x10^{-1}$	$4.60x10^{-1}$	Sutter and Tsao, 1996	1.35	Yes
Copper	$4.30x10^{-3}$	$1.00x10^{-3}$	Sutter and Tsao, 1996	4.30	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: North Refinery Waste Ponds 8 and 8a and Runoff Pond 9

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$5.10x10^{-3}$	$1.00x10^{-3}$	Sutter and Tsao, 1996	5.10	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: North Refinery Firewater Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$2.10x10^{-3}$	$1.00x10^{-3}$	Sutter and Tsao, 1996	2.10	Yes
Nickel	$5.60x10^{-3}$	$5.00x10^{-3}$	Sutter and Tsao, 1996	1.12	Yes

Key
ppm: milligrams per liter
Hazard Quotient= maximum concentration/ lowest chronic value

Table 6I: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: Skull Creek

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Aluminum	7.10×10^{-1}	4.60×10^{-1}	Sutter and Tsao, 1996	1.54	Yes
Copper	7.50×10^{-3}	1.00×10^{-3}	Sutter and Tsao, 1996	7.50	Yes
Nickel	5.10×10^{-3}	5.00×10^{-3}	Sutter and Tsao, 1996	1.02	Yes
Zinc	7.30×10^{-2}	3.00×10^{-2}	Sutter and Tsao, 1996	2.43	Yes

Key
ppm: milligrams per liter
Hazard Quotient= maximum concentration/ lowest chronic value

Table 6J: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: South Refinery Coke Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	2.80×10^{-3}	1.00×10^{-3}	Sutter and Tsao, 1996	2.80	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Plants
Site Area: South Refinery Runoff Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	3.30×10^{-3}	1.00×10^{-3}	Sutter and Tsao, 1996	3.30	Yes

Key
ppm: milligrams per liter
Hazard Quotient= maximum concentration/ lowest chronic value

Table 6K: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Aquatic Invertebrates
Site Area: North Refinery Waste Pond 1

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	2.60×10^{-3}	2.30×10^{-4}	Sutter and Tsao, 1996	1.13×10^{1}	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Invertebrates
Site Area: North Refinery Waste Pond 2

Chemical of	Maximum	Lowest Chronic	Lowest Chronic	Hazard Quotient	COPC?

Potential Concern	Concentration (ppm)	Value (ppm)	Value Source		
Mercury	$1.10x10^{-3}$	$9.60x10^{-4}$	Sutter and Tsao, 1996	1.15	Yes
Aluminum	7.12	1.90	Sutter and Tsao, 1996	3.75	Yes
Cadmium	$1.70x10^{-3}$	$1.50x10^{-4}$	Sutter and Tsao, 1996	$1.13x10^{1}$	Yes
Calcium	$3.68x10^{2}$	$1.16x10^{2}$	Sutter and Tsao, 1996	3.17	Yes
Chromium	1.97	$4.40x10^{-2}$	Sutter and Tsao, 1996	$4.48x10^{1}$	Yes
Cobalt	$1.09x10^{-2}$	$5.10x10^{-3}$	Sutter and Tsao, 1996	2.14	Yes
Copper	$9.05x10^{-2}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$3.93x10^{2}$	Yes
Iron	$4.06x10^{1}$	$1.58x10^{-1}$	Sutter and Tsao, 1996	$2.57x10^{2}$	Yes
Lead	$9.39x10^{-1}$	$1.23x10^{-2}$	Sutter and Tsao, 1996	$7.66x10^{1}$	Yes
Magnesium	$1.37x10^{2}$	$8.20x10^{1}$	Sutter and Tsao, 1996	1.67	Yes
Manganese	3.67	1.10	Sutter and Tsao, 1996	3.34	Yes
Nickel	$2.51x10^{-2}$	$5.00x10^{-3}$	Sutter and Tsao, 1996	5.02	Yes
Zinc	$9.87x10^{-1}$	$4.67x10^{-2}$	Sutter and Tsao, 1996	$2.11x10^{1}$	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Invertebrates
Site Area: North Refinery Waste Ponds 3-6A and LTU Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Calcium	$2.78x10^{2}$	$1.16x10^{2}$	Sutter and Tsao, 1996	2.40	Yes
Copper	$4.30x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$1.87x10^{1}$	Yes
Iron	1.12	$1.58x10^{-1}$	Sutter and Tsao, 1996	7.09	Yes
Magnesium	$1.64x10^{2}$	$8.20x10^{1}$	Sutter and Tsao, 1996	2.00	Yes
Manganese	1.90	1.10	Sutter and Tsao, 1996	1.73	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Invertebrates
Site Area: North Refinery Waste Ponds 8 and 8a and Runoff Pond 9

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$5.10x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$2.22x10^{1}$	Yes
Iron	$3.71x10^{-1}$	$1.58x10^{-1}$	Sutter and Tsao, 1996	2.35	Yes

Exposure Medium: Surface Water
Wildlife Species: Aquatic Invertebrates
Site Area: North Refinery Firewater Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$2.10x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao,	9.13	Yes

			1996		
Nickel	$5.60x10^{-3}$	$5.00x10^{-3}$	Sutter and Tsao, 1996	1.12	Yes
Key ppm: milligrams per liter Hazard Quotient= maximum concentration/ lowest chronic value					

Table 6L: Selection of Ecological Chemicals of Concern					
Exposure Medium: Surface Water Wildlife Species: Aquatic Invertebrates Site Area: Skull Creek					
Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$7.50x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$3.26x10^{1}$	Yes
Iron	$1.38x10^{-1}$	$1.58x10^{-1}$	Sutter and Tsao, 1996	8.73	Yes
Lead	$1.87x10^{-2}$	$1.23x10^{-2}$	Sutter and Tsao, 1996	1.53	Yes
Nickel	$5.10x10^{-3}$	$5.00x10^{-3}$	Sutter and Tsao, 1996	1.02	Yes
Zinc	$7.30x10^{-2}$	$4.67x10^{-2}$	Sutter and Tsao, 1996	1.56	Yes
Key ppm: milligrams per liter Hazard Quotient= maximum concentration/ lowest chronic value					

Table 6M: Selection of Ecological Chemicals of Concern					
Exposure Medium: Surface Water Wildlife Species: Aquatic Invertebrates Site Area: South Refinery Coke Pond					
Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Benzo(A)Anthracene	$6.00x10^{-3}$	$6.50x10^{-4}$	Sutter and Tsao, 1996	9.23	Yes
Benzo(A)Pyrene	$7.00x10^{-3}$	$3.00x10^{-4}$	Sutter and Tsao, 1996	$2.33x10^{1}$	Yes
Copper	$2.80x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$1.22x10^{1}$	Yes
Iron	$1.90x10^{-1}$	$1.58x10^{-1}$	Sutter and Tsao, 1996	1.20	Yes
Exposure Medium: Surface Water Wildlife Species: Aquatic Invertebrates Site Area: South Refinery Runoff Pond					
Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$3.30x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	$1.43x10^{1}$	Yes
Iron	$4.86x10^{-1}$	$1.58x10^{-1}$	Sutter and Tsao, 1996	3.08	Yes
Key ppm: milligrams per liter Hazard Quotient= maximum concentration/ lowest chronic value					

Table 6N: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Fish
Site Area: North Refinery Waste Pond 2

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Mercury	$1.10x10^{-3}$	$2.30x10^{-4}$	Sutter and Tsao, 1996	4.78	Yes
Aluminum	7.12	3.29	Sutter and Tsao, 1996	2.17	Yes
Cadmium	$1.70x10^{-3}$	$1.70x10^{-3}$	Sutter and Tsao, 1996	1.00	Yes
Chromium	1.97	$6.86x10^{-2}$	Sutter and Tsao, 1996	$2.87x10^{1}$	Yes
Copper	$9.05x10^{-2}$	$3.80x10^{-3}$	Sutter and Tsao, 1996	$2.38x10^{1}$	Yes
Iron	$4.06x10^{1}$	1.30	Sutter and Tsao, 1996	$3.12x10^{1}$	Yes
Lead	$9.39x10^{-1}$	$1.89x10^{-2}$	Sutter and Tsao, 1996	$4.97x10^{1}$	Yes
Manganese	3.67	1.78	Sutter and Tsao, 1996	2.06	Yes
Zinc	$9.87x10^{-1}$	$3.64x10^{-2}$	Sutter and Tsao, 1996	$2.71x10^{1}$	Yes

Exposure Medium: Surface Water
Wildlife Species: Fish
Site Area: North Refinery Waste Ponds 3-6A and LTU Pond

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$4.30x10^{-3}$	$3.80x10^{-3}$	Sutter and Tsao, 1996	1.13	Yes
Manganese	1.90	1.78	Sutter and Tsao, 1996	1.07	Yes

Exposure Medium: Surface Water
Wildlife Species: Fish
Site Area: North Refinery Waste Ponds 8 and 8a and Runoff Pond 9

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$5.10x10^{-3}$	$3.80x10^{-3}$	Sutter and Tsao, 1996	1.34	Yes

Key
ppm: milligrams per liter
Hazard Quotient= maximum concentration/ lowest chronic value

Table 6O: Selection of Ecological Chemicals of Concern

Exposure Medium: Surface Water
Wildlife Species: Fish
Site Area: Skull Creek

Chemical of Potential Concern	Maximum Concentration (ppm)	Lowest Chronic Value (ppm)	Lowest Chronic Value Source	Hazard Quotient	COPC?
Copper	$7.50x10^{-3}$	$3.80x10^{-3}$	Sutter and Tsao, 1996	1.97	Yes
Iron	1.38	1.30	Sutter and Tsao, 1996	1.06	Yes
Zinc	$7.30x10^{-2}$	$3.64x10^{-2}$	Sutter and Tsao, 1996	2.00	Yes

Key
ppm: milligrams per liter
Hazard Quotient= maximum concentration/ lowest chronic value

Table 7A: Selection of Ecological Chemicals of Concern

Chemical-Specific Risk Estimates for Representative Wildlife Species
Site Area: North Refinery

Chemical of Potential Concern	Total Dose Received (mg/kg/day)	Fraction of Home Range within Portion of Site	Total Dose Received from Portion of Site (mg/kg/day)	Representative Wildlife Species	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Acetone	$4.20x10^{1}$	1	$4.20x10^{1}$	Cottontail Rabbit	1.20	7.3	8.76	4.79	Yes
Acetone	$3.08x10^{2}$	0.52	$1.60x10^{2}$	White-tailed Deer	$5.65x10^{1}$	2.8	158.2	1.01	Yes
Xylenes (Total)	$5.44x10^{1}$	1	$5.44x10^{1}$	Short-tailed Shrew	$1.50x10^{-2}$	2.497	0.037455	$1.45x10^{3}$	Yes
Xylenes (Total)	$4.86x10^{-1}$	1	$4.86x10^{-1}$	White-footed Mouse	$2.20x10^{-2}$	2.269	0.049918	9.73	Yes
Xylenes (Total)	$1.54x10^{1}$	1	$1.54x10^{1}$	Meadow Vole	$4.40x10^{-2}$	1.908	0.083952	$1.84x10^{2}$	Yes
Xylenes (Total)	$3.62x10^{1}$	1	$3.62x10^{1}$	Cottontail Rabbit	1.20	0.835	1.002	$3.61x10^{1}$	Yes
Xylenes (Total)	$1.49x10^{1}$	1	$1.49x10^{1}$	Red Fox	4.50	0.6	2.7	5.51	Yes
Xylenes (Total)	$2.49x10^{2}$	0.52	$1.29x10^{2}$	White-tailed Deer	$5.65x10^{1}$	0.319	18.0235	7.17	Yes
Bis(2-ethylhexyl)phthalate	$1.77x10^{1}$	1	$1.77x10^{1}$	Short-tailed Shrew	$1.50x10^{-2}$	21.8	0.327	$5.40x10^{1}$	Yes
Bis(2-ethylhexyl)phthalate	$4.91x10^{0}$	1	4.91	Meadow Vole	$4.40x10^{-2}$	16.6	0.7304	6.72	Yes
Bis(2-ethylhexyl)phthalate	$9.13x10^{1}$	1	$9.13x10^{1}$	American Robin	$7.70x10^{-2}$	1.1	0.0847	$1.08x10^{3}$	Yes
Aroclor 1254	$3.63x10^{-3}$	1	$3.63x10^{-3}$	Short-tailed Shrew	$1.50x10^{-2}$	0.067	0.001005	3.61	Yes
Aroclor 1254	$1.98x10^{-2}$	1	$1.98x10^{-2}$	American Robin	$7.70x10^{-2}$	0.18	0.01386	1.43	Yes
Aluminum	$1.54x10^{2}$	1	$1.54x10^{2}$	Short-tailed Shrew	$1.50x10^{-2}$	2.295	0.034425	$4.47x10^{3}$	Yes
Aluminum	$4.08x10^{0}$	1	4.08	White-footed Mouse	$2.20x10^{-2}$	2.086	0.045892	$8.89x10^{1}$	Yes

Aluminum	$3.06x10^{1}$	1	$3.06x10^{1}$	Meadow Vole	$4.40x10^{-2}$	1.754	0.077176	$3.96x10^{2}$	Yes
Aluminum	$8.84x10^{2}$	1	$8.84x10^{2}$	Cottontail Rabbit	1.20	0.767	0.9204	$9.61x10^{2}$	Yes
Aluminum	$8.71x10^{2}$	1	$8.71x10^{2}$	Red Fox	4.50	0.551	2.4795	$3.51x10^{2}$	Yes
Aluminum	$2.10x10^{3}$	0.52	$1.09x10^{3}$	White-tailed Deer	$5.65x10^{1}$	0.293	16.5545	$6.60x10^{1}$	Yes
Aluminum	$9.54x10^{2}$	1	$9.54x10^{2}$	American Robin	$7.70x10^{-2}$	109.7	8.4469	$1.13x10^{2}$	Yes
Antimony	$5.32x10^{-2}$	1	$5.32x10^{-2}$	Short-tailed Shrew	$1.50x10^{-2}$	0.149	0.002235	$2.38x10^{1}$	Yes
Antimony	$1.26x10^{-2}$	1	$1.26x10^{-2}$	White-footed Mouse	$2.20x10^{-2}$	0.135	0.00297	4.26	Yes
Antimony	$1.98x10^{-2}$	1	$1.98x10^{-2}$	Meadow Vole	$4.40x10^{-2}$	0.114	0.005016	3.94	Yes
Antimony	$1.05x10^{0}$	1	1.05	Cottontail Rabbit	1.20	0.05	0.06	$1.75x10^{1}$	Yes
Antimony	$3.41x10^{-1}$	1	$3.41x10^{-1}$	Red Fox	4.50	0.036	0.162	2.11	Yes
Antimony	$6.47x10^{0}$	0.52	3.37	White-tailed Deer	$5.65x10^{1}$	0.019	1.0735	3.14	Yes
Arsenic	$5.55x10^{-2}$	1	$5.55x10^{-2}$	Short-tailed Shrew	$1.50x10^{-2}$	0.15	0.00225	$2.47x10^{1}$	Yes
Arsenic	$4.89x10^{-3}$	1	$4.89x10^{-3}$	White-footed Mouse	$2.20x10^{-2}$	0.136	0.002992	1.64	Yes
Arsenic	$1.25x10^{-2}$	1	$1.25x10^{-2}$	Meadow Vole	$4.40x10^{-2}$	0.114	0.005016	2.48	Yes
Arsenic	$6.02x10^{-1}$	1	$6.02x10^{-1}$	Cottontail Rabbit	1.20	0.05	0.06	$1.00x10^{1}$	Yes
Arsenic	$4.00x10^{-1}$	1	$4.00x10^{-1}$	Red Fox	4.50	0.036	0.162	2.47	Yes
Arsenic	$2.51x10^{0}$	0.52	1.30	White-tailed Deer	$5.65x10^{1}$	0.019	1.0735	1.22	Yes
Arsenic	$3.99x10^{-1}$	1	$3.99x10^{-1}$	American Robin	$7.70x10^{-2}$	5.1	0.3927	1.02	Yes
Barium	$1.68x10^{0}$	1	1.68	Short-tailed Shrew	$1.50x10^{-2}$	11.8	0.177	9.50	Yes
Barium	$3.12x10^{-1}$	1	$3.12x10^{-1}$	White-footed Mouse	$2.20x10^{-2}$	10.8	0.2376	1.31	Yes
Barium	$5.60x10^{-1}$	1	$5.60x10^{-1}$	Meadow Vole	$4.40x10^{-2}$	9	0.396	1.42	Yes
Barium	$2.70x10^{1}$	1	$2.70x10^{1}$	Cottontail Rabbit	1.20	4	4.8	5.62	Yes
Barium	$1.38x10^{1}$	1	$1.38x10^{1}$	American Robin	$7.70x10^{-2}$	20.8	1.6016	8.64	Yes
Cadmium	$1.19x10^{-1}$	1	$1.19x10^{-1}$	Short-tailed	$1.50x10^{-2}$	2.12	0.0318	3.73	Yes

				Shrew					
Cadmium	$1.22x10^{0}$	1	1.22	Cottontail Rabbit	1.20	0.709	0.8508	1.44	Yes
Chromium	$1.35x10^{0}$	1	1.35	American Robin	$7.70x10^{-2}$	1	0.077	$1.75x10^{1}$	Yes
Lead	$5.36x10^{-1}$	1	$5.36x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	17.58	0.2637	2.03	Yes
Lead	$9.57x10^{0}$	1	9.57	Cottontail Rabbit	1.20	5.8	6.96	1.37	Yes
Lead	$4.53x10^{0}$	1	4.53	American Robin	$7.70x10^{-2}$	1.13	0.08701	$5.21x10^{1}$	Yes
Manganese	$4.55x10^{0}$	1	4.55	Short-tailed Shrew	$1.50x10^{-2}$	193	2.895	1.57	Yes
Mercury	$4.56x10^{-2}$	1	$4.56x10^{-2}$	American Robin	$7.70x10^{-2}$	0.45	0.03465	1.32	Yes
Thallium	$1.22x10^{-2}$	1	$1.22x10^{-2}$	Short-tailed Shrew	$1.50x10^{-2}$	0.016	0.00024	$5.07x10^{1}$	Yes
Thallium	$4.43x10^{-4}$	1	$4.43x10^{-4}$	White-footed Mouse	$2.20x10^{-2}$	0.015	0.00033	1.34	Yes
Thallium	$2.18x10^{-3}$	1	$2.18x10^{-3}$	Meadow Vole	$4.40x10^{-2}$	0.013	0.000572	3.80	Yes
Thallium	$9.19x10^{-2}$	1	$9.19x10^{-2}$	Cottontail Rabbit	1.20	0.005	0.006	$1.53x10^{1}$	Yes
Thallium	$8.76x10^{-2}$	1	$8.76x10^{-2}$	Red Fox	4.50	0.004	0.018	4.87	Yes
Thallium	$2.28x10^{-1}$	0.52	$1.19x10^{-1}$	White-tailed Deer	$5.65x10^{1}$	0.002	0.113	1.05	Yes
Vanadium	$1.08x10^{-1}$	1	$1.08x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	0.428	0.00642	$1.68x10^{1}$	Yes
Vanadium	$1.37x10^{0}$	1	1.37	Cottontail Rabbit	1.20	0.143	0.1716	8.00	Yes
Vanadium	$1.34x10^{0}$	1	1.34	Red Fox	4.50	0.103	0.4635	2.88	Yes
Zinc	$1.70x10^{1}$	1	$1.70x10^{1}$	Short-tailed Shrew	$1.50x10^{-2}$	351.7	5.2755	3.21	Yes
Zinc	$2.03x10^{2}$	1	$2.03x10^{2}$	Cottontail Rabbit	1.20	117.6	141.12	1.44	Yes
Zinc	$1.27x10^{2}$	1	$1.27x10^{2}$	American Robin	$7.70x10^{-2}$	14.5	1.1165	$1.13x10^{2}$	Yes

Table 7B: Selection of Ecological Chemicals of Concern

Chemical-Specific Risk Estimates for Representative Wildlife Species
Site Area: South Refinery

Chemical of Potential Concern	Total Dose Received (mg/kg/day)	Fraction of Home Range within Portion of Site	Total Dose Received from Portion of Site (mg/kg/day)	Representative Wildlife Species	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Xylenes (Total)	3.34×10^{0}	1	3.34	Short-tailed Shrew	1.50×10^{-2}	2.497	0.037455	8.92×10^{1}	Yes
Xylenes (Total)	5.07×10^{-1}	1	5.07×10^{-1}	White-footed Mouse	2.20×10^{-2}	2.269	0.049918	1.02×10^{1}	Yes
Xylenes (Total)	1.24×10^{0}	1	1.24	Meadow Vole	4.40×10^{-2}	1.908	0.083952	1.48×10^{1}	Yes
Xylenes (Total)	3.78×10^{1}	1	3.78×10^{1}	Cottontail Rabbit	1.20	0.835	1.002	3.77×10^{1}	Yes
Xylenes (Total)	2.59×10^{2}	0.11	2.85×10^{1}	White-tailed Deer	5.65×10^{1}	0.319	18.0235	1.58	Yes
Bis(2-ethylhexyl)phthalate	9.90×10^{0}	1	9.90	Short-tailed Shrew	1.50×10^{-2}	21.8	0.327	3.03×10^{1}	Yes
Bis(2-ethylhexyl)phthalate	2.75×10^{0}	1	2.75	Meadow Vole	4.40×10^{-2}	16.6	0.7304	3.76	Yes
Bis(2-ethylhexyl)phthalate	5.11×10^{1}	1	5.11×10^{1}	American Robin	7.70×10^{-2}	1.1	0.0847	6.04×10^{2}	Yes
Aroclor 1254	2.84×10^{-3}	1	2.84×10^{-3}	Short-tailed Shrew	1.50×10^{-2}	0.067	0.001005	2.82	Yes
Aroclor 1254	1.54×10^{-2}	1	1.54×10^{-2}	American Robin	7.70×10^{-2}	0.18	0.01386	1.11	Yes
Aluminum	1.52×10^{2}	1	1.52×10^{2}	Short-tailed Shrew	1.50×10^{-2}	2.295	0.034425	4.42×10^{3}	Yes
Aluminum	3.57×10^{0}	1	3.57	White-footed Mouse	2.20×10^{-2}	2.086	0.045892	7.78×10^{1}	Yes
Aluminum	3.15×10^{1}	1	3.15×10^{1}	Meadow Vole	4.40×10^{-2}	1.754	0.077176	4.09×10^{2}	Yes
Aluminum	7.82×10^{2}	1	7.82×10^{2}	Cottontail Rabbit	1.20	0.767	0.9204	8.50×10^{2}	Yes
Aluminum	7.71×10^{2}	0.23	1.77×10^{2}	Red Fox	4.50	0.551	2.4795	7.15×10^{1}	Yes
Aluminum	1.84×10^{3}	0.11	2.02×10^{2}	White-tailed Deer	5.65×10^{1}	0.293	16.5545	1.22×10^{1}	Yes
Aluminum	9.28×10^{2}	1	9.28×10^{2}	American	7.70×10^{-2}	109.7	8.4469	1.10×10^{2}	Yes

				Robin					
Antimony	$1.55x10^{-1}$	1	$1.55x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	0.149	0.002235	$6.93x10^{1}$	Yes
Antimony	$3.68x10^{-2}$	1	$3.68x10^{-2}$	White-footed Mouse	$2.20x10^{-2}$	0.135	0.00297	$1.24x10^{1}$	Yes
Antimony	$5.76x10^{-2}$	1	$5.76x10^{-2}$	Meadow Vole	$4.40x10^{-2}$	0.114	0.005016	$1.15x10^{1}$	Yes
Antimony	$3.07x10^{0}$	1	3.07	Cottontail Rabbit	1.20	0.05	0.06	$5.11x10^{1}$	Yes
Antimony	$9.93x10^{-1}$	0.23	$2.28x10^{-1}$	Red Fox	4.50	0.036	0.162	1.41	Yes
Antimony	$1.88x10^{1}$	0.11	2.07	White-tailed Deer	$5.65x10^{1}$	0.019	1.0735	1.93	Yes
Arsenic	$5.88x10^{-1}$	1	$5.88x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	0.15	0.00225	$2.61x10^{2}$	Yes
Arsenic	$5.18x10^{-2}$	1	$5.18x10^{-2}$	White-footed Mouse	$2.20x10^{-2}$	0.136	0.002992	$1.73x10^{1}$	Yes
Arsenic	$1.32x10^{-1}$	1	$1.32x10^{-1}$	Meadow Vole	$4.40x10^{-2}$	0.114	0.005016	$2.63x10^{1}$	Yes
Arsenic	$6.37x10^{0}$	1	6.37	Cottontail Rabbit	1.20	0.05	0.06	$1.06x10^{2}$	Yes
Arsenic	$4.23x10^{0}$	0.23	$9.73x10^{-1}$	Red Fox	4.50	0.036	0.162	6.01	Yes
Arsenic	$2.66x10^{1}$	0.11	2.92	White-tailed Deer	$5.65x10^{1}$	0.019	1.0735	2.72	Yes
Arsenic	$4.22x10^{0}$	1	4.22	American Robin	$7.70x10^{-2}$	5.1	0.3927	$1.08x10^{1}$	Yes
Barium	$1.78x10^{1}$	1	$1.78x10^{1}$	Short-tailed Shrew	$1.50x10^{-2}$	11.8	0.177	$1.00x10^{2}$	Yes
Barium	$3.26x10^{0}$	1	3.26	White-footed Mouse	$2.20x10^{-2}$	10.8	0.2376	$1.37x10^{1}$	yes
Barium	$5.89x10^{0}$	1	5.89	Meadow Vole	$4.40x10^{-2}$	9	0.396	$1.49x10^{1}$	Yes
Barium	$2.85x10^{2}$	1	$2.85x10^{2}$	Cottontail Rabbit	1.20	4	4.8	$5.93x10^{1}$	Yes
Barium	$1.06x10^{2}$	0.23	$2.44x10^{1}$	Red Fox	4.50	2.8	12.6	1.94	Yes
Barium	$1.67x10^{3}$	0.11	$1.84x10^{2}$	White-tailed Deer	$5.65x10^{1}$	1.5	84.75	2.17	Yes
Barium	$1.46x10^{2}$	1	$1.46x10^{2}$	American Robin	$7.70x10^{-2}$	20.8	1.6016	$9.14x10^{1}$	Yes
Cadmium	$2.03x10^{-1}$	1	$2.03x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	2.12	0.0318	6.38	Yes
Cadmium	$2.11x10^{0}$	1	2.11	Cottontail Rabbit	1.20	0.709	0.8508	2.48	Yes
Chromium	$1.67x10^{0}$	1	1.67	American	$7.70x10^{-2}$	1	0.077	$2.17x10^{1}$	Yes

				Robin					
Copper	$9.32x10^{-1}$	1	$9.32x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	33.4	0.501	1.86	Yes
Copper	$6.46x10^{0}$	1	6.46	American Robin	$7.70x10^{-2}$	47	3.619	1.78	Yes
Lead	$4.98x10^{0}$	1	4.98	Short-tailed Shrew	$1.50x10^{-2}$	17.58	0.2637	$1.89x10^{1}$	Yes
Lead	$7.65x10^{-1}$	1	$7.65x10^{-1}$	White-footed Mouse	$2.20x10^{-2}$	15.98	0.35156	2.18	Yes
Lead	$1.06x10^{0}$	1	1.06	Meadow Vole	$4.40x10^{-2}$	13.44	0.59136	1.80	Yes
Lead	$8.85x10^{1}$	1	$8.85x10^{1}$	Cottontail Rabbit	1.20	5.8	6.96	$1.27x10^{1}$	Yes
Lead	$4.23x10^{1}$	1	$4.23x10^{1}$	American Robin	$7.70x10^{-2}$	1.13	0.08701	$4.86x10^{2}$	Yes
Manganese	$4.07x10^{0}$	1	4.07	Short-tailed Shrew	$1.50x10^{-2}$	193	2.895	1.41	Yes
Mercury	$5.59x10^{-2}$	1	$5.59x10^{-2}$	American Robin	$7.70x10^{-2}$	0.45	0.03465	1.61	Yes
Thallium	$4.32x10^{-2}$	1	$4.32x10^{-2}$	Short-tailed Shrew	$1.50x10^{-2}$	0.016	0.00024	$1.80x10^{2}$	Yes
Thallium	$1.12x10^{-3}$	1	$1.12x10^{-3}$	White-footed Mouse	$2.20x10^{-2}$	0.015	0.00033	3.39	Yes
Thallium	$9.32x10^{-3}$	1	$9.32x10^{-3}$	Meadow Vole	$4.40x10^{-2}$	0.013	0.000572	$1.63x10^{1}$	Yes
Thallium	$2.17x10^{-1}$	1	$2.17x10^{-1}$	Cottontail Rabbit	1.20	0.005	0.006	$3.62x10^{1}$	Yes
Thallium	$2.03x10^{-1}$	0.23	$4.67x10^{-2}$	Red Fox	4.50	0.004	0.018	2.59	Yes
Vanadium	$1.11x10^{-1}$	1	$1.11x10^{-1}$	Short-tailed Shrew	$1.50x10^{-2}$	0.428	0.00642	$1.73x10^{1}$	Yes
Vanadium	$1.42x10^{0}$	1	1.42	Cottontail Rabbit	1.20	0.143	0.1716	8.26	Yes
Zinc	$6.86x10^{1}$	1	$6.86x10^{1}$	Short-tailed Shrew	$1.50x10^{-2}$	351.7	5.2755	$1.30x10^{1}$	Yes
Zinc	$1.01x10^{1}$	1	$1.01x10^{1}$	White-footed Mouse	$2.20x10^{-2}$	319.5	7.029	1.44	Yes
Zinc	$2.37x10^{1}$	1	$2.37x10^{1}$	Meadow Vole	$4.40x10^{-2}$	268.7	11.8228	2.00	Yes
Zinc	$8.19x10^{2}$	1	$8.19x10^{2}$	Cottontail Rabbit	1.20	117.6	141.12	5.80	Yes
Zinc	$5.12x10^{2}$	1	$5.12x10^{2}$	American Robin	$7.70x10^{-2}$	14.5	1.1165	$4.59x10^{2}$	Yes

Table 8A: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Fish Consumption
Site Area: North Refinery

Chemical of Potential Concern	Representative Wildlife Species	Maximum Does Received from Consuming Whole Fish (mg/kg/day)	Maximum Dose Received from Consuming Surface Water (mg/kg/day)	Maximum Dose Received from Consuming Sediments (mg/kg/day)	Total Dose Received (mg/kg/day)	Total Dose Received Based on Fraction of year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Aluminum	Great Blue Heron	Not Detected	$8.25x10^{-1}$	$1.42x10^{3}$	$1.42x10^{3}$	$7.10x10^{2}$	2.39	$1.10x10^{2}$	$2.62x10^{2}$	2.71	Yes
Chromium	Great Blue Heron	$1.76x10^{-1}$	$2.28x10^{-1}$	$9.96x10^{1}$	$1.00x10^{2}$	$5.00x10^{1}$	2.39	1.00	$2.39x10^{0}$	$2.09x10^{1}$	Yes

Table 8B: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Fish Consumption
Site Area: South Refinery

Chemical of Potential Concern	Representative Wildlife Species	Maximum Does Received from Consuming Whole Fish (mg/kg/day)	Maximum Dose Received from Consuming Surface Water (mg/kg/day)	Maximum Dose Received from Consuming Sediments (mg/kg/day)	Total Dose Received (mg/kg/day)	Total Dose Received Based on Fraction of year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Aluminum	Great Blue Heron	$2.55x10^{-1}$	$2.61x10^{-2}$	$9.16x10^{2}$	$9.16x10^{2}$	$4.58x10^{2}$	2.39	$1.10x10^{2}$	$2.62x10^{2}$	1.75	Yes
Chromium	Great Blue Heron	$1.52x10^{-2}$	$2.20x10^{-4}$	9.16	9.18	4.59	2.39	1.00	2.39	1.92	Yes

Table 8C: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Fish Consumption
Site Area: Skull Creek

Chemical of Potential Concern	Representative Wildlife Species	Maximum Does Received from Consuming Whole Fish (mg/kg/day)	Maximum Dose Received from Consuming Surface Water (mg/kg/day)	Maximum Dose Received from Consuming Sediments (mg/kg/day)	Total Dose Received (mg/kg/day)	Total Dose Received Based on Fraction of year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Aluminum	Great Blue Heron	$8.05x10^{-1}$	$8.23x10^{-2}$	$1.01x10^{3}$	$1.01x10^{3}$	$5.04x10^{2}$	2.39	$1.10x10^{2}$	$2.62x10^{2}$	1.92	Yes
Zinc	Belted Kingfisher	$1.13x10^{1}$	$1.17x10^{-3}$	0.00	$1.13x10^{1}$	5.64	$1.48x10^{-1}$	$1.45x10^{1}$	2.15	2.63	Yes

Table 8D: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Aquatic Plants, and Benthic and Aquatic Invertebrates Consumption
Wildlife Species: Mallard Duck
Site Area: North Refinery

Chemical of Potential Concern	Dose Received from Waste Pond 1	Does Received from Waste Pond 2	Does Received from Waste Pond 3-6	Dose Received from Waste Pond 8-9	Dose Received from Firewater Pond	Average Dose Received Across All Ponds (mg/kg/day)	Total Dose Received Based on Fraction of Year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Aluminum	$8.66x10^{2}$	$2.09x10^{3}$	$8.70x10^{2}$	$6.43x10^{2}$	$4.58x10^{2}$	$9.85x10^{2}$	$4.92x10^{2}$	1.00	$1.10x10^{2}$	$1.10x10^{2}$	4.49	Yes
Chromium	$1.49x10^{1}$	$2.33x10^{2}$	7.87	1.32	$2.78x10^{-1}$	$5.14x10^{1}$	$2.57x10^{1}$	1.00	1.00	1.00	$2.57x10^{1}$	Yes
Lead	1.22	$1.58x10^{2}$	1.34	2.52	0.00	$3.26x10^{1}$	$1.63x10^{1}$	1.00	1.13	1.13	$1.44x10^{1}$	Yes
Zinc	9.56	$1.61x10^{2}$	5.29	8.66	4.55	$3.78x10^{1}$	$1.89x10^{1}$	1.00	$1.45x10^{1}$	$1.45x10^{1}$	1.30	Yes

Table 8E: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Aquatic Plants, and Benthic and Aquatic Invertebrates Consumption
Wildlife Species: Mallard Duck
Site Area: South Refinery

Chemical of Potential Concern	Dose Received from Coke Pond	Dose Received from South Runoff Pond	Average Dose Received Across All Ponds (mg/kg/day)	Total Dose Received Based on Fraction of Year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Mercury	2.64	5.44×10^{-2}	1.35	6.74×10^{-1}	1.00	4.50×10^{-1}	4.50×10^{-1}	1.50	Yes
Aluminum	3.94×10^{1}	7.59×10^{2}	3.99×10^{2}	2.00×10^{2}	1.00	1.10×10^{2}	1.10×10^{2}	1.82	Yes
Chromium	3.65	1.00	2.33	1.16	1.00	1.00	1.00	1.16	Yes

Table 8F: Selection of Chemicals of Concern

Exposure Media: Surface Water, Sediment, and Aquatic Plants, and Benthic and Aquatic Invertebrates Consumption
Wildlife Species: Mallard Duck
Site Area: Skull Creek

Chemical of Potential Concern	Dose Received from Skull Creek (mg/kg/day)	Total Dose Received Based on Fraction of Year within Refinery (mg/kg/day)	Average Body Weight (kg)	No Observed Adverse Effects Level (NOAEL) (mg/kg/day)	Weight Normalized NOAEL (mg/day)	Hazard Quotient	COPC?
Aluminum	8.97×10^{2}	4.49×10^{2}	1.00	1.10×10^{2}	1.10×10^{2}	4.09	Yes
Lead	5.21	2.61	1.00	1.13	1.13	2.31	Yes

Table 9: Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered/ Threatened Species Flag (Y or N)	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Soil, North Refinery	N	Soil Invertebrates	N	Ingestion	Sustainability of invertebrate community	Comparison of soil COPC concentrations to benchmarks.
		Terrestrial Plants	N	Root Uptake	Sustainability of terrestrial plant community	Comparison of soil COPC concentrations to benchmarks.
		Terrestrial Species	N	Ingestion, direct contact, and bioaccumulation	Sustainability of terrestrial species community	Comparison of daily doses to no observed adverse effects levels (NOEL).
Sediment	N	Aquatic Invertebrates	N	Ingestion	Sustainability of aquatic invertebrate community	Comparison of sediment COPC concentrations to screening values.
Surface Water	N	Aquatic Plants	N	Root Uptake, Leaf Sorption	Sustainability of aquatic plant community	Comparison of surface water COPC concentrations to lowest chronic values.
		Aquatic Invertebrates	N	Ingestion	Sustainability of aquatic invertebrate community	Comparison of surface water COPC concentrations to lowest chronic values.
		Fish	N	Ingestion	Sustainability of fish community	Comparison of surface water COPC concentrations to lowest chronic values.
Surface Water/ Sediment/ Fish	N	Belted Kingfisher	N	Ingestion, direct contact, and bioaccumulation	Sustainability of Belted Kingfisher community	Comparison of estimated dietary doses from fish, surface water, and sediments with no observed adverse effects levels (NOAEL).
Surface Water/ Sediment/ Fish	N	Great Blue Heron	N	Ingestion, direct contact, and bioaccumulation	Sustainability of Great Blue Heron community	Comparison of estimated dietary doses from fish, surface water, and sediments with no observed adverse effects levels (NOAEL).
Surface Water/ Sediment/ Biota	N	Mallard Duck	N	Ingestion, direct contact, and bioaccumulation	Sustainability of Mallard Duck community	Comparison of estimated dietary doses from aquatic plants, benthic and aquatic invertebrates, surface water, and sediments with no observed adverse effects levels (NOAEL).

Table 10 – Summary Of Remedial Alternatives Hudson Refinery Site

Medium	RI/FS Designation	Description
INSTITUTIONAL CONTROLS & OTHER MEDIA	NA	Institutional Controls Excavation and/or Removal and Disposal Off-site
SOIL	1	No Action
	2	Clay Cap
	3	Excavation and On-site Disposal Cell
	4	Excavation and Off-site Disposal at Permitted Facility
WASTE POND SEDIMENT	1	No Action
	2	Excavation, Stabilization and On-site Disposal Cell
	3	Excavation, Stabilization and Off-site Disposal at Permitted Facility
WASTE POND SURFACE WATER	1	No Action
	2	On-site Treatment
	3	Off-site Treatment At Regulated Facility
LIGHT NON-AQUEOUS PHASE LIQUID	1	No Action
	2	Hydrocarbon Belt Skimmers
	3	Collection Trenches with Hydrocarbon Belt Skimmers and Ex-Situ Treatment
GROUND WATER	1	No Action
	2	Ground Water Monitoring
	3	Monitored Natural Attenuation
	4	Phytoremediation with Natural Attenuation
	5	Pump and Treat Hydraulic Containment and Ex-Situ Treatment

Table 11 - Evaluation Criteria for CERCLA Remedial Alternatives

Criterion 1 - Overall Protection of Human Health and the Environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment
Criterion 2 - Compliance with ARARs evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.
Criterion 3 - Long-term Effectiveness and Permanence considers the ability of an alternative to maintain protection of human health and the environment over time.
Criterion 4 - Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
Criterion 5 - Short-term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
Criterion 6 - Implementability considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
Criterion 7 - Cost includes estimated capital, periodic, and annual operations and maintenance (O&M) costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
Criterion 8 - State/Support Agency Acceptance considers whether the DEQ and USEPA agree with the analyses and recommendations, as described in the RIA/FSA and Proposed Plan.
Criterion 9 - Community Acceptance considers whether the local community agrees with DEQ's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

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Table 12A: Comparative Analysis of Alternatives - Soil

Criteria	Alternative 1 No Action	Alternative 2 Clay Cap	Alternative 3 Excavation and On-site Disposal Cell	Alternative 4 Excavation and Off-site Disposal at Permitted Facility
OVERALL PROTECTIVENESS				
Human Health Protection from Direct Contact/ Soil Ingestion/ Inhalation of Indoor Air	No reduction in risk.	Cap reduces direct contact risk and soil ingestion risk to less than 1 x 10^{-5}. Reduction of inhalation of indoor air risk would need to be evaluated further after construction.	An on-site disposal cell would reduce direct contact, soil ingestion, and inhalation of indoor air risk to less than 1 x 10^{-5}.	Off-site disposal would reduce direct contact, soil ingestion, and inhalation of indoor air risk to less than 1 x 10^{-5}.
Environmental Protection	No reduction in risk.	Risk reduced to levels protective of ecological receptors.	Risk reduced to levels protective of ecological receptors.	Risk reduced to levels protective of ecological receptors.
COMPLIANCE WITH ARARs				
Chemical-Specific ARARs	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.
Location-Specific ARARs	No location-specific ARARs apply.	No location-specific ARARs apply.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.
Other Criteria and Guidance	Contaminants will exceed health based clean-up goals.	Would reduce both human health and ecological risks to acceptable levels.	Would reduce both human health and ecological risks to acceptable levels.	Would reduce both human health and ecological risks to acceptable levels.
LONG-TERM EFFECTIVENESS AND PERMANENCE				
Magnitude of Residual Risk Direct Contact/ Soil Ingestion/ Inhalation of Indoor Air	Current risk remains.	Direct contact and soil ingestion risk is reduced as long as cap and institutional controls are maintained. Reduction of inhalation of indoor air risk would need to be evaluated further after construction. There remains a risk from cap failure.	Reduces risk to acceptable levels (1 x 10^{-5}, HQ=1). On-site landfill will need to maintained to guarantee that risk continues to reduced.	Reduces risk to acceptable levels (1 x 10^{-5}, HQ=1). Contaminated soil will be permanently removed from the Site.
Adequacy and Reliability of Controls	Contaminants would remain on-site above risk based levels. No controls over remaining contamination. No reliability.	Reliability of cap to control direct contact and soil ingestion can be high if maintained. Reduction of inhalation of indoor air risk would need to be evaluated further after construction. Failure to maintain cap can increase potential for direct contact.	This alternative is both adequate and reliable as long as on-site landfill is maintained.	This alternative is both adequate and reliable. Contaminated soil will be permanently removed from the Site.

Criteria	Alternative 1 No Action	Alternative 2 Clay Cap	Alternative 3 Excavation and On-site Disposal Cell	Alternative 4 Excavation and Off-site Disposal at Permitted Facility
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT				
Treatment Process Used	None	None	None	None
Amount Destroyed or Treated	None	None	None	None
Reduction of Toxicity, Mobility, or Volume	None	None	Reduces toxicity and mobility as long as landfill is maintained. Does not reduce volume.	Reduces toxicity, mobility, and volume by removing contaminated soil from Site.
Irreversible Treatment	None	None	None	None
Type and Quantity of Residuals Remaining After Treatment	Contamination remains	None	None	None
SHORT-TERM EFFECTIVENESS				
Community Protection	Continued risk to community through no action.	Controllable, minor increase in dust production during cap installation.	Controllable, minor increase in dust production during soil excavation.	Limited risk to community through minor increase in dust production during soil excavation and off-site transportation.
Worker Protection	No risk to workers.	Protection required during clay cap installation.	Protection required during excavation and handling of contaminated soils.	Protection required during excavation and handling of contaminated soils.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during cap installation.	Temporary impacts during excavation and landfill construction.	Temporary impacts during excavation.
Time Until Action is Complete	Not applicable.	Cap installed in 1 year.	Excavation and on-site disposal complete in 1 year.	Excavation and off-site disposal complete in 1 year.
IMPLEMENTABILITY				
Ability to Construct and Operate	No construction or operation.	Easily constructed. Long-term maintenance of cap would be required.	Easily constructed. Long-term maintenance of landfill would be required.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to extend cap.	Adding to landfill later would be difficult once landfill is constructed, but easy to add to landfill when still open.	Easy to excavated additional soil and transport to off-site facility.
Ability to Monitor Effectiveness	5-year reviews.	Monitoring and maintenance inspections of cap will give notice of failure before significant exposure occurs.	Monitoring and maintenance inspections of landfill will give notice of failure before significant exposure occurs.	No monitoring would be required because all contaminated soil would be permanently removed from the Site.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	No approval necessary. Coordination with State	Would require coordination.	Would require coordination.

Criteria	Alternative 1 No Action	Alternative 2 Clay Cap	Alternative 3 Excavation and On-site Disposal Cell	Alternative 4 Excavation and Off-site Disposal at Permitted Facility
		necessary to implement ICs.		
Availability of Equipment, Specialists, and Materials	None required.	Readily available.	Readily available.	Readily available.
Availability of Technologies	None required.	Readily available.	Readily available.	Readily available.
COST				
Capital Cost	$0	$1,417,292	$4,280,850	$5,957,730
Annual O&M Cost	$0	$47,056	$14,269	$0
Present Worth Cost	$69,597	$1,795,403	$4,428,684	$5,996,297
State Acceptance	Not Acceptable.	Not Acceptable.	Not Acceptable.	Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.	Acceptable.	Acceptable.

Table 12B: Comparative Analysis of Alternatives – Waste Pond Sediment

Criteria	Alternative 1 No Action	Alternative 2 Excavation, Stabilization and On-site Disposal Cell	Alternative 3 Excavation, Stabilization and Off-site Disposal at Permitted Facility
OVERALL PROTECTIVENESS			
Human Health Protection from Direct Contact/ Sediment Ingestion	No reduction in risk.	An on-site disposal cell would reduce direct contact and sediment ingestion risk to less than 1 x 10^{-5}.	Off-site disposal would reduce direct contact and sediment ingestion risk to less than 1 x 10^{-5}.
Environmental Protection	No reduction in risk.	Risk reduced to levels protective of ecological receptors.	Risk reduced to levels protective of ecological receptors.
COMPLIANCE WITH ARARs			
Chemical-Specific ARARs	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.
Other Criteria and Guidance	Contaminants will exceed health based clean-up goals.	Would reduce both human health and ecological risks to acceptable levels.	Would reduce both human health and ecological risks to acceptable levels.
LONG-TERM EFFECTIVENESS AND PERMANENCE			
Magnitude of Residual Risk Direct Contact/ Sediment Ingestion	Current risk remains.	Reduces risk to acceptable levels (1 x 10^{-5}, HQ=1). On-site landfill will need to maintained to guarantee that risk continues to reduced.	Reduces risk to acceptable levels (1 x 10^{-5}, HQ=1). Contaminated sediment will be permanently removed from the Site.
Adequacy and Reliability of	Contaminants would remain on-site above	This alternative is both adequate and reliable as	This alternative is both adequate and

Criteria	Alternative 1 No Action	Alternative 2 Excavation, Stabilization and On-site Disposal Cell	Alternative 3 Excavation, Stabilization and Off-site Disposal at Permitted Facility
Controls	risk based levels. No controls over remaining contamination. No reliability.	long as on-site landfill is maintained.	reliable. Contaminated sediment will be permanently removed from the Site.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
Treatment Process Used	None.	Stabilization.	Stabilization.
Amount Destroyed or Treated	None.	21,000 cubic yards.	21,000 cubic yards.
Reduction of Toxicity, Mobility, or Volume	None.	Stabilization reduces toxicity and mobility. An on-site disposal cell will reduce toxicity and mobility as long as landfill is maintained. Stabilization may increase the volume of material due to the addition of stabilization reagents.	Off-site disposal reduces toxicity, mobility, and volume by removing contaminated sediment from Site. Stabilization reduces toxicity and mobility. Stabilization may increase the volume of material due to the addition of stabilization reagents.
Irreversible Treatment	None.	Provides for irreversible treatment.	Provides for irreversible treatment.
Type and Quantity of Residuals Remaining After Treatment	Contamination remains.	TBD.	None.
SHORT-TERM EFFECTIVENESS			
Community Protection	Continued risk to community through no action.	Controllable, minor increase in dust production during sediment excavation and stabilization.	Limited risk to community through minor increase in dust production during sediment excavation and stabilization and off-site transportation.
Worker Protection	No risk to workers.	Protection required during excavation, stabilization, and handling of contaminated sediments.	Protection required during excavation, stabilization, and handling of contaminated sediments.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during excavation, stabilization, and landfill construction.	Temporary impacts during excavation and stabilization.
Time Until Action is Complete	Not applicable.	Excavation, stabilization, and on-site disposal complete in 1 year.	Excavation, stabilization, and off-site disposal complete in 1 year.
IMPLEMENTABILITY			
Ability to Construct and Operate	No construction or operation.	Easily constructed. Long-term maintenance of landfill would be required.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Adding to landfill later would be difficult once landfill is constructed, but easy to add to landfill when still open.	Easy to excavated and stabilize additional sediment and transport to off-site facility.
Ability to Monitor Effectiveness	5-year reviews.	Monitoring and maintenance inspections of landfill will give notice of failure before significant exposure occurs.	No monitoring would be required because all contaminated sediment would be permanently removed from the Site.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.	Would require coordination.

Criteria	Alternative 1 No Action	Alternative 2 Excavation, Stabilization and On-site Disposal Cell	Alternative 3 Excavation, Stabilization and Off-site Disposal at Permitted Facility
Availability of Equipment, Specialists, and Materials	None required.	Readily available.	Readily available.
Availability of Technologies	None required.	Readily available.	Readily available.
COST			
Capital Cost	$0	$3,719,610	$4,581,330
Annual O&M Cost	$0	$14,269	$0
Present Worth Cost	$69,597	$3,867,444	$4,619,897
State Acceptance	Not Acceptable.	Not Acceptable.	Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.	Acceptable.

Table 12C: Comparative Analysis of Alternatives – Waste Pond Surface Water

Criteria	Alternative 1 No Action	Alternative 2 On-site Treatment	Alternative 3 Off-site Treatment at Regulated Facility
OVERALL PROTECTIVENESS			
Human Health Protection from Direct Contact	No reduction in risk.	On-site treatment would reduce direct contact risk to less than 1 x 10^{-5}.	Off-site treatment and disposal would reduce direct contact risk to less than 1 x 10^{-5}.
Environmental Protection	No reduction in risk.	Risk reduced to levels protective of ecological receptors.	Risk reduced to levels protective of ecological receptors.
COMPLIANCE WITH ARARs			
Chemical-Specific ARARs	No chemical-specific ARARs apply.	Contaminated waste pond surface water would be treated to meet ARARs.	Contaminated waste pond surface water would be treated to meet ARARs.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.
Other Criteria and Guidance	Contaminants will exceed health based clean-up goals.	Would reduce both human health and ecological risks to acceptable levels.	Would reduce both human health and ecological risks to acceptable levels.
LONG-TERM EFFECTIVENESS AND PERMANENCE			
Magnitude of Residual Risk Direct Contact	Current risk remains.	Reduces risk to acceptable levels (1 x 10^{-5}) through treatment.	Reduces risk to acceptable levels (1 x 10^{-5}) through treatment.
Adequacy and Reliability of Controls	Contaminants would remain on-site above risk based levels. No controls over remaining contamination. No reliability.	This alternative is both adequate and reliable.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
Treatment Process Used	None.	Treatment in on-site water treatment facility.	Treatment at off-site facility.

Criteria	Alternative 1 No Action	Alternative 2 On-site Treatment	Alternative 3 Off-site Treatment at Regulated Facility
Amount Destroyed or Treated	None.	7.5 million gallons.	7.5 million gallons.
Reduction of Toxicity, Mobility, or Volume	None.	Reduces toxicity, mobility and volume of contamination through treatment.	Reduces toxicity, mobility and volume of contamination through treatment.
Irreversible Treatment	None.	Provides for irreversible treatment.	Provides for irreversible treatment.
Type and Quantity of Residuals Remaining After Treatment	Contamination remains.	None.	None.
SHORT-TERM EFFECTIVENESS			
Community Protection	Continued risk to community through no action.	Controllable.	Limited risk to community through off-site transportation.
Worker Protection	No risk to workers.	Protection required during handling and treatment of contaminated surface water.	Protection required during handling of contaminated surface water.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during draining of pond surface water and on-site treatment.	Temporary impacts during draining of surface water.
Time Until Action is Complete	Not applicable.	On-site treatment complete in 1 year.	Off-site removal complete in 1 year.
IMPLEMENTABILITY			
Ability to Construct and Operate	No construction or operation.	Easily constructed.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to drain and treat additional surface water.	Easy to drain and transport to off-site facility additional surface water.
Ability to Monitor Effectiveness	5-year reviews.	No monitoring would be required because all contaminated surface water would be treated on-site and discharged to either Skull Creek or transported off-site for disposal.	No monitoring would be required because all contaminated surface water would be transported off-site for treatment and disposal.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.	Readily available.
Availability of Technologies	None required.	Readily available.	Readily available.
COST			
Capital Cost	$0	$345,120	$2,179,500
Annual O&M Cost	$0	$0	$0
Present Worth Cost	$3,113	$352,403	$2,186,783
State Acceptance	Not Acceptable.	Acceptable.	Not Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.	Acceptable.

Table 12D: Comparative Analysis of Alternatives – Light Non-Aqueous Phase Liquid

Criteria	Alternative 1 No Action	Alternative 2 Hydrocarbon Belt Skimmers	Alternative 3 Collection Trenches with Hydrocarbon Belt Skimmers, Ex-Situ Treatment
OVERALL PROTECTIVENESS			
Human Health Protection	No reduction in risk.	Extracting the LNAPL would reduce any human health risk from LNAPL.	Extracting the LNAPL would reduce any human health risk from LNAPL.
Environmental Protection	No reduction in risk.	Extracting the LNAPL would reduce any ecological risk from LNAPL.	Extracting the LNAPL would reduce any ecological risk from LNAPL.
COMPLIANCE WITH ARARs			
Chemical-Specific ARARs	No chemical-specific ARARs apply.	Would comply with chemical-specific ARARs.	Would comply with chemical-specific ARARs.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.
Other Criteria and Guidance	Contaminants will exceed health based clean-up goals.	Would reduce both human health and ecological risks to acceptable levels.	Would reduce both human health and ecological risks to acceptable levels.
LONG-TERM EFFECTIVENESS AND PERMANENCE			
Magnitude of Residual Risk	Current risk remains.	Reduces risk through removal of LNAPL.	Reduces risk through removal of LNAPL.
Adequacy and Reliability of Controls	Source material would remain on-site. No controls over remaining contamination. No reliability.	This alternative is both adequate and reliable.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
Treatment Process Used	None.	None.	Extracted ground water will be treated on-site prior to discharge.
Amount Destroyed or Treated	None.	None.	4,955 cubic feet.
Reduction of Toxicity, Mobility, or Volume	None.	Reduces toxicity and mobility source material through extraction. The volume of source material on-site will be transferred to an off-site facility.	Reduces toxicity, mobility and volume of contamination through treatment.
Irreversible Treatment	None.	None.	Provides for irreversible treatment.
Type and Quantity of Residuals Remaining After Treatment	Contamination remains.	None.	None.
SHORT-TERM EFFECTIVENESS			
Community Protection	Continued risk to community through no action.	Limited risk to community during extraction and off-site transportation.	Limited risk to community during extraction and on-site treatment.
Worker Protection	No risk to workers.	Protection required during handling and transportation of source material.	Protection required during handling and treatment of source material.
Environmental Impacts	Continued impact from existing conditions.	None.	None.

Criteria	Alternative 1 No Action	Alternative 2 Hydrocarbon Belt Skimmers	Alternative 3 Collection Trenches with Hydrocarbon Belt Skimmers, Ex-Situ Treatment
Time Until Action is Complete	Not applicable.	Extraction complete in 5 year.	Extraction complete in 6 months.
IMPLEMENTABILITY			
Ability to Construct and Operate	No construction or operation.	Easily constructed.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to extend extraction time or add new wells as needed.	Easy to extend extraction time, harder to extend trench once installed.
Ability to Monitor Effectiveness	5-year reviews.	No monitoring would be required because all source material would be extracted and transported off-site for disposal.	No monitoring would be required because all source material would be extracted and treated.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.	Readily available.
Availability of Technologies	None required.	Readily available.	Readily available.
COST			
Capital Cost	$0	$91,200	$228,200
Annual O&M Cost	$0	$0	$0
Present Worth Cost	$3,113	$124,260	$279,993
State Acceptance	Not Acceptable.	Acceptable.	Not Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.	Acceptable.

Table 12E: Comparative Analysis of Alternatives – Ground Water

Criteria	Alternative 1 No Action	Alternative 2 Ground Water Monitoring	Alternative 3 Monitored Natural Attenuation	Alternative 4 Phytoremediation with Natural Attenuation	Alterative 5 Pump and Treat Hydraulic Containment, Ex-Situ Treatment
OVERALL PROTECTIVENESS					
Human Health Protection	No reduction in risk.	Containment Monitoring will insure that contaminated ground water does not migrate off-site at levels higher than MCLs. Institutional controls will insure that no human exposure occurs to contaminated ground water	Will reduce ground water contamination to levels below MCLs.	Will reduce ground water contamination to levels below MCLs.	Will reduce ground water contamination to levels below MCLs.

Criteria	Alternative 1 No Action	Alternative 2 Ground Water Monitoring	Alternative 3 Monitored Natural Attenuation	Alternative 4 Phytoremediation with Natural Attenuation	Alterative 5 Pump and Treat Hydraulic Containment, Ex-Situ Treatment
		on-site.			
Environmental Protection	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.
COMPLIANCE WITH ARARs					
Chemical-Specific ARARs	No chemical-specific ARARs apply.	Would comply with chemical-specific ARARs.	Would comply with chemical-specific ARARs.	Would comply with chemical-specific ARARs.	Would comply with chemical-specific ARARs.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.	Would comply with action-specific ARARs.
Other Criteria and Guidance	None.	None.	None.	None.	None.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk	Current risk remains.	Reduces risk through containment of contaminated ground water and institutional controls.	Reduces risk through degradation of contaminates.	Reduces risk though phytoremediation and degradation of contaminates.	Reduces risk through extraction and treatment.
Adequacy and Reliability of Controls	Contaminated ground would remain on-site. No controls over remaining contamination. No reliability.	This alternative is both adequate and reliable.	This alternative is both adequate and reliable.	This alternative is both adequate and reliable.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
Treatment Process Used	None.	None.	None.	Phytoremediation.	On-site treatment of contaminated ground water.
Amount Destroyed or Treated	None.	None.	TBD.	1,478,370 cubic feet.	1,478,370 cubic feet.
Reduction of Toxicity, Mobility, or Volume	None.	None.	Reduces toxicity, mobility and volume of contamination.	Reduces toxicity, mobility and volume of contamination through treatment.	Reduces toxicity, mobility and volume of contamination through treatment.
Irreversible Treatment	None.	None.	None.	Phytoremediation would provide for irreversible treatment.	Pump and treat would provide for irreversible treatment.
Type and Quantity of Residuals Remaining After	Contamination remains.	No treatment will be performed.	No treatment will be performed.	TBD.	TBD.

Criteria	Alternative 1 No Action	Alternative 2 Ground Water Monitoring	Alternative 3 Monitored Natural Attenuation	Alternative 4 Phytoremediation with Natural Attenuation	Alterative 5 Pump and Treat Hydraulic Containment, Ex-Situ Treatment
Treatment					
SHORT-TERM EFFECTIVENESS					
Community Protection	Continued risk to community through no action.	Community protection through institutional controls and monitoring.	Community protection through monitoring.	Community protection though monitoring.	Minimal risk to community during ex-situ treatment.
Worker Protection	No risk to workers.	Protection required during monitoring.	Protection required during monitoring.	Protection required during monitoring.	Protection required during ex-situ treatment.
Environmental Impacts	Continued impact from existing conditions.	None.	None.	None.	Temporary impacts during ex-situ treatment.
Time Until Action is Complete	Not applicable.	30 years.	30 years.	30 years.	30 years.
IMPLEMENTABILITY					
Ability to Construct and Operate	No construction or operation.	Easily constructed.	Easily constructed.	Easily constructed.	Easily constructed. Would take more operation than other alternatives.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to add new wells as needed.	Easy to add new wells as needed.	Easy to add new trees and wells as needed.	Easy to extend extraction time or add new wells as needed.
Ability to Monitor Effectiveness	5-year reviews.	Easy.	Easy.	Easy.	Easy.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.	Would require coordination.	Would require coordination.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.	Readily available.	Readily available.	Readily available.
Availability of Technologies	None required.	Readily available.	Readily available.	Readily available.	Readily available.
COST					
Capital Cost	$0	$80,880	$64,440	$113,500	$1,011,980
Annual O&M Cost	$0	$29,5200	$108,000	$20,000	$190,119
Present Worth Cost	$194,173	$335,829	$870,599	$301,584	$2,394,909
State Acceptance	Not Acceptable.	Acceptable.	Not Acceptable.	Not Acceptable.	Not Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.	Acceptable.	Acceptable.	Acceptable.

Table 12F: Comparative Analysis of Alternatives – Asbestos-Containing Material

Criteria	Alternative 1 No Action	Alternative 2 Removal and Disposal at Regulated Off-site Facility
OVERALL PROTECTIVENESS		
Human Health Protection	No reduction in risk.	Removal and off-site disposal would insure that human health would be protected.
Environmental Protection	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.
COMPLIANCE WITH ARARs		
Chemical-Specific ARARs	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.
Other Criteria and Guidance	None.	None.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Magnitude of Residual Risk	Current risk remains.	Reduces risk through removal and off-site disposal.
Adequacy and Reliability of Controls	ACM would remain on-site. No controls over remaining contamination. No reliability.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT		
Treatment Process Used	None.	None.
Amount Destroyed or Treated	None.	None.
Reduction of Toxicity, Mobility, or Volume	None.	Reduces toxicity, mobility, and volume by removing contaminated soil from Site.
Irreversible Treatment	None.	None.
Type and Quantity of Residuals Remaining After Treatment	Contamination remains.	No treatment will be performed.
SHORT-TERM EFFECTIVENESS		
Community Protection	Continued risk to community through no action.	Limited risk to community through minor increase in dust production during removal and off-site transportation.
Worker Protection	No risk to workers.	Protection required during removal and off-site disposal.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during excavation.
Time Until Action is Complete	Not applicable.	3 months.
IMPLEMENTABILITY		
Ability to Construct and Operate	No construction or operation.	Easily constructed.

Criteria	Alternative 1 No Action	Alternative 2 Removal and Disposal at Regulated Off-site Facility
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to remove additional material as needed and transport to off-site facility.
Ability to Monitor Effectiveness	5-year reviews.	No monitoring would be required because all contaminated material would be permanently removed from the Site.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.
Availability of Technologies	None required.	Readily available.
COST		
Capital Cost	$0	$13,440
Annual O&M Cost	$0	$0
Present Worth Cost	$3,113	$16,523
State Acceptance	Not Acceptable.	Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.

Table 12G: Comparative Analysis of Alternatives – Coke Tar

Criteria	Alternative 1 No Action	Alternative 2 Excavation and Disposal at Regulated Off-site Facility
OVERALL PROTECTIVENESS		
Human Health Protection	No reduction in risk.	Excavation and off-site disposal would insure that human health would be protected.
Environmental Protection	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.
COMPLIANCE WITH ARARs		
Chemical-Specific ARARs	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.
Other Criteria and Guidance	None.	None.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Magnitude of Residual Risk	Current risk remains.	Reduces risk through excavation and off-site disposal.

Criteria	Alternative 1 No Action	Alternative 2 Excavation and Disposal at Regulated Off-site Facility
Adequacy and Reliability of Controls	Coke tar would remain on-site. No controls over remaining contamination. No reliability.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT		
Treatment Process Used	None.	Stabilization.
Amount Destroyed or Treated	None.	6,000 cubic yards.
Reduction of Toxicity, Mobility, or Volume	None.	Off-site disposal reduces toxicity, mobility, and volume by removing contaminated Coke Tar from Site. Stabilization reduces toxicity and mobility. Stabilization may increase the volume of material due to the addition of stabilization reagents.
Irreversible Treatment	None.	Provides for irreversible treatment.
Type and Quantity of Residuals Remaining After Treatment	Contamination remains.	TBD.
SHORT-TERM EFFECTIVENESS		
Community Protection	Continued risk to community through no action.	Limited risk to community through minor increase in dust production during excavation and off-site transportation.
Worker Protection	No risk to workers.	Protection required during excavation and off-site disposal.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during excavation.
Time Until Action is Complete	Not applicable.	3 months.
IMPLEMENTABILITY		
Ability to Construct and Operate	No construction or operation.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to excavate additional material as needed and transport to off-site facility.
Ability to Monitor Effectiveness	5-year reviews.	No monitoring would be required because all contaminated material would be permanently removed from the Site.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.
Availability of Technologies	None required.	Readily available.

Criteria	Alternative 1 No Action	Alternative 2 Excavation and Disposal at Regulated Off-site Facility
COST		
Capital Cost	$0	$619,984
Annual O&M Cost	$0	$0
Present Worth Cost	$3,113	$646,551
State Acceptance	Not Acceptable.	Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.

Table 12H: Comparative Analysis of Alternatives – Scrap Metal

Criteria	Alternative 1 No Action	Alternative 2 Removal and Salvage
OVERALL PROTECTIVENESS		
Human Health Protection	No reduction in risk.	Removal and salvage would insure that human health would be protected.
Environmental Protection	No risk to ecological receptors demonstrated.	No risk to ecological receptors demonstrated.
COMPLIANCE WITH ARARs		
Chemical-Specific ARARs	No chemical-specific ARARs apply.	No chemical-specific ARARs apply.
Location-Specific ARARs	No location-specific ARARs apply.	Would comply with location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs apply.	Would comply with action-specific ARARs.
Other Criteria and Guidance	None.	None.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Magnitude of Residual Risk	Current risk remains.	Reduces risk through removal and salvage.
Adequacy and Reliability of Controls	Non-contaminated scrap metal would remain on-site. No controls over remaining material. No reliability.	This alternative is both adequate and reliable.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT		
Treatment Process Used	None.	None.
Amount Destroyed or Treated	None.	None.
Reduction of Toxicity, Mobility, or Volume	None.	Reduces toxicity, mobility, and volume by removing contaminated soil from Site.
Irreversible Treatment	None.	None.
Type and Quantity of Residuals Remaining After	Contamination remains.	No treatment will be performed.

Criteria	Alternative 1 No Action	Alternative 2 Removal and Salvage
Treatment		
SHORT-TERM EFFECTIVENESS		
Community Protection	Continued risk to community through no action.	Limited risk to community through minor increase in dust production during removal and off-site transportation.
Worker Protection	No risk to workers.	Protection required during removal and off-site transportation.
Environmental Impacts	Continued impact from existing conditions.	Temporary impacts during removal.
Time Until Action is Complete	Not applicable.	1 month.
IMPLEMENTABILITY		
Ability to Construct and Operate	No construction or operation.	Easily constructed.
Ease of Doing More Action if Needed	May require ROD amendment if future problems arise.	Easy to removal additional scrap metal as needed and transport to off-site facility.
Ability to Monitor Effectiveness	5-year reviews.	No monitoring would be required because all scrap metal would be permanently removed from the Site.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	Would require coordination.
Availability of Equipment, Specialists, and Materials	None required.	Readily available.
Availability of Technologies	None required.	Readily available.
COST		
Capital Cost	$0	$16,500
Annual O&M Cost	$0	$0
Present Worth Cost	$3,113	$19,583
State Acceptance	Not Acceptable.	Acceptable.
Community Acceptance	Not Acceptable.	Acceptable.

Table 13: Estimated Cost for the Selected Remedy			
	Total Capital Cost	Annual O&M Cost	Present Worth Cost
Soil	$3,532,830	$0	$3,535,397
Waste Pond Sediment	$4,581,330	$0	$4,619,897
Waste Pond Surface Water	$345,120	$0	$352,403
Light Non-Aqueous Phase Liquid	$37,200	$10,800	$124,260
Ground Water	$80,880	$29,520	$335,829
Asbestos Containing Material	$13,440	$0	$16,523
Coke Tar	$619,984	$0	$646,551
Scrap Metal	$16,500	$0	$19,583
Total Cost	**$9,227,284**	**$40,320**	**$9,650,443**

Table 13A: Cost Estimate Summary for the Selected Remedy - Soil Alternative 4, Excavation and Off-site Disposal at Permitted Facility

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Institutional Controls	1	LS	$40,000	$40,000
Engineering and Design[2, 3]	1	LS	$100,000	$100,000
Permitting	1	LS	$10,000	$10,000
Utility Clear for Excavation	1	LS	$5,000	$5,000
Excavate/Transport/Place in Off-site Cell[4]	35,000	CY	$8	$280,000
Waste Disposal Tipping Fee	52,000	ton	$27	$1,404,000
Waste Disposal Environmental Fee	1,400	Load	$5	$7,000
Backfill Excavations	35,000	CY	$16	$561,750
Top Soil	11,500	CY	$13	$153,525
Establish Vegetative Cover	15	acre	$445	$6,675
Confirmation Soil Sample Analysis[5]	225	each	$455	$102,375
Surveyor	115	Day	$1,100	$126,500
Field Equipment Rental	20	Week	$460	$9,200
Construction Oversight Labor	115	Day	$1,000	$115,000
Construction Oversight Per Diem	115	Day	$100	$11,500
Construction Oversight Pickup Truck	115	Day	$100	$11,500
Subtotal Capital Costs				$2,944,025
Contingency (20%)[6]				$588,805
Total Capital Costs				$3,532,830
Periodic Cost				
5-Year Review	1	Each	$3,000	$3,000
Closure Report	1	LS	$30,000	$30,000
Subtotal Periodic Costs				$33,000
Contingency (20%)[6]				$6,600
Total Periodic Costs				$39,600
O&M Cost				
Estimated Annual O&M Cost				$0

Present Value Cost

Year	Capital Costs	Periodic Costs	Annual O&M Cost	Total Cost	Discount Factor at 7%	Total Present Value Cost at 7%
0	$3,532,830	$36,000	$0	$3,568,830	1.000	$3,568,830
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$3,600	$0	$3,600	0.713	$2,567
Total	**$3,532,830**	**$39,600**	**$0**	**$3,572,430**		**$3,571,397**

Notes:
CY = cubic yard
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology since it has been widely used, and design issues are better understood than with other invocative technologies.
4. Includes transportation to a landfill in Stillwater, OK.
5. Soil samples analyzed for metals, SVOCs and VOCs.
6. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13B: Cost Estimate Summary for the Selected Remedy - Waste Pond Sediment Alternative 3, Excavation, Stabilization and Off-site Disposal at Permitted Facility				
Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Institutional Controls	1	LS	$40,000	$40,000
Engineering and Design[2, 3]	1	LS	$100,000	$100,000
Permitting	1	LS	$10,000	$10,000
Utility Clear for Excavation	1	LS	$5,000	$5,000
Dewatering	70	Day	$865	$60,550
Water Treatment (Carbon Drums)	24	Each	$500	$12,000
Sediment Stabilization	11,000	Ton	$7	$80,300
Stabilization Reagent	11,000	Ton	$110	$1,210,000
Excavate/Transport/Place in Off-site Cell[4]	42,000	CY	$8	$336,000
Waste Disposal Tipping Fee	42,000	ton	$27	$1,134,000
Waste Disposal Environmental Fee	2,100	Load	$5	$10,500
Backfill Excavations	21,000	CY	$16	$337,050
Top Soil	8,900	CY	$13	$118,815
Establish Vegetative Cover	8	acre	$445	$3,560
Confirmation Sediment Sample Analysis[5]	140	each	$630	$88,200
Surveyor	110	Day	$1,100	$121,000
Field Equipment Rental	20	Week	$460	$9,200
Construction Oversight Labor	118	Day	$1,000	$118,000
Construction Oversight Per Diem	118	Day	$100	$11,800
Construction Oversight Pickup Truck	118	Day	$100	$11,800
Subtotal Capital Costs				$3,817,775
Contingency (20%)[6]				$763,555
Total Capital Costs				$4,581,330
Periodic Cost				
5-Year Review	1	Each	$3,000	$3,000
Closure Report	1	LS	$30,000	$30,000
Subtotal Periodic Costs				$33,000
Contingency (20%)[6]				$6,600
Total Periodic Costs				$39,600
O&M Cost				
Estimated Annual O&M Cost				$0

Present Value Cost

Year	**Capital Costs**	**Periodic Costs**	**Annual O&M Cost**	**Total Cost**	**Discount Factor at 7%**	**Total Present Value Cost at 7%**
0	$4,581,330	$36,000	$0	$4,617,330	1.000	$4,617,330
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$3,600	$0	$3,600	0.713	$2,567
Total	**$4,581,330**	**$39,600**	**$0**	**$4,620,930**		**$4,619,897**

Notes:
CY = cubic yard
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology.
4. Assumes non-hazardous off-site disposal cell. Includes transportation to a landfill in Stillwater, OK.
5. Sediment samples analyzed 1/200 cubic yards for TCLP metals, SVOCs and VOCs.
6. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13C: Cost Estimate Summary for the Selected Remedy - Waste Pond Surface Water Alternative 2, On-site Treatment

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Engineering and Design[2, 3]	1	LS	$10,000	$10,000
Permitting	1	LS	$5,000	$5,000
Filtration Units	10	Each	$2,000	$20,000
Bag Filters	1	LS	$10,000	$10,000
Carbon Drums (sets of 4)	65	Each	$2,000	$130,000
Pump Rental	40	day	$850	$34,000
Discharge Analysis	40	each	$700	$28,000
Field Equipment Rental	8	week	$325	$2,600
Construction Oversight Labor	40	Day	$1,000	$40,000
Construction Oversight Per Diem	40	Day	$100	$4,000
Construction Oversight Pickup Truck	40	Day	$100	$4,000
Subtotal Capital Costs				$287,600
Contingency (20%)[4]				$57,520
Total Capital Costs				$345,120
Periodic Cost				
5-Year Review	1	Each	$1,500	$1,500
Closure Report	1	LS	$5,000	$5,000
Subtotal Periodic Costs				$6,500
Contingency (20%)[4]				$1,300
Total Periodic Costs				$7,800
O&M Cost				
Estimated Annual O&M Cost				$0

Present Value Cost

Year	**Capital Costs**	**Periodic Costs**	**Annual O&M Cost**	**Total Cost**	**Discount Factor at 7%**	**Total Present Value Cost at 7%**
0	$345,120	$6,000	$0	$351,120	1.000	$351,120
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$1,800	$0	$1,800	0.713	$1,283
Total	**$345,120**	**$7,800**	**$0**	**$352,920**		**$352,403**

Notes:
LS = lump sum
1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology.
4. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13D: Cost Estimate Summary for the Selected Remedy - Light Non-Aqueous Phase Liquid Alternative 2, Hydrocarbon Belt Skimmers

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Institutional Controls	1	LS	$2,200	$2,000
Engineering and Design[2]	1	LS	$10,000	$10,000
Belt Skimmer	1	LS	$7,000	$7,000
Power Drop	1	LS	$5,000	$5,000
Miscellaneous supplies & equipment	1	LS	$1,000	$1,000
Labor and expenses	1	LS	$6,000	$6,000
Subtotal Capital Costs				$31,000
Contingency (20%)[3]				$6,200
Total Capital Costs				$37,200
Periodic Cost				
5-Year Review	1	Each	$20,000	$20,000
Closure Report	1	LS	$30,000	$30,000
Subtotal Periodic Costs				$50,000
Contingency (20%)[3]				$10,000
Total Periodic Costs				$60,000
O&M Cost				
Waste management & maintenance	1	Each	$9,000	$9,000
Subtotal Annual O&M				$9,000
Contingency (20%)[3]				$1,800
Estimated Annual O&M Cost				$10,800

Present Value Cost

Year	Capital Costs	Periodic Costs	Annual O&M Cost	Total Cost	Discount Factor at 7%	Total Present Value Cost at 7%
0	$37,200	$0	$0	$37,200	1.000	$37,200
1	$0	$0	$10,800	$10,800	0.935	$10,098
2	$0	$0	$10,800	$10,800	0.873	$9,428
3	$0	$0	$10,800	$10,800	0.816	$8,813
4	$0	$0	$10,800	$10,800	0.763	$8,240
5	$0	$60,000	$10,800	$70,800	0.713	$50,480
Total	**$37,200**	**$60,000**	**$54,000**	**$151,200**		**$124,260**

Notes:
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13E: Cost Estimate Summary for the Selected - Remedy Ground Water Alternative 2, Ground Water Monitoring

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Institutional Controls	1	LS	$40,000	$40,000
Well Installation	2	LS	$13,700	$27,400
Subtotal Capital Costs				$67,400
Contingency (20%)				$13,480
Total Capital Costs				$80,880
Periodic Cost				
5-Year Review	2	Each	$20,000	$40,000
Closure Report	1	LS	$30,000	$30,000
Subtotal Periodic Costs				$70,000
Contingency (20%)[3]				$14,000
Total Periodic Costs				$84,000
O&M Cost[2]				
Ground Water Sampling	1	LS	$13,000	$13,000
Laboratory Analysis	4	Each	$320	$1,280
Monitoring Report	1	LS	$6,000	$6,000
Project Administration	1	LS	$4,320	$4,320
Subtotal Annual O&M				$24,600
Contingency (20%)[3]				$4,920
Total Annual O&M Cost				$29,520

Present Value Cost

Year	Capital Costs	Periodic Costs	Annual O&M Cost	Total Cost	Discount Factor at 7%	Total Present Value Cost at 7%
0	$80,880	$0		$80,880	1.000	$80,880
1	$0	$0	$29,520	$29,520	0.935	$27,589
2	$0	$0	$29,520	$29,520	0.873	$25,784
3	$0	$0	$29,520	$29,520	0.816	$24,097
4	$0	$0	$29,520	$29,520	0.763	$22,521
5	$0	$24,000	$29,520	$53,520	0.713	$38,159
6	$0	$0	$29,520	$29,520	0.666	$19,670
7	$0	$0	$29,520	$29,520	0.623	$18,384
8	$0	$0	$29,520	$29,520	0.582	$17,181
9	$0	$0	$29,520	$29,520	0.544	$16,057
10	$0	$60,000	$29,520	$89,520	0.508	$45,507
Total	**$80,880**	**$84,000**	**$295,200**	**$460,080**		**$335,829**

Notes:
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. O&M costs represent one sampling event for COCs each year.
3. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13F: Cost Estimate Summary for the Selected Remedy - Asbestos-Containing Material Alternative 2, Removal and Disposal at Regulated Off-site Facility

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Engineering and Design[2, 3]	1	LS	$1,500	$1,500
Permitting	1	LS	$200	$200
Utility Clear for Excavation	1	LS	$250	$250
Excavate/Transport/Place in Off-site Cell[4]	10	CY	$450	$4,500
Waste Disposal Tipping Fee	1	LS	$1,200	$1,200
Confirmation Soil Sample Analysis[5]	10	Each	$15	$150
Third Party Air Monitoring	2	Day	$500	$1,000
Construction Oversight Labor	2	Day	$1,000	$2,000
Construction Oversight Per Diem	2	Day	$100	$200
Construction Oversight Pickup Truck	2	Day	$100	$200
Subtotal Capital Costs				$11,200
Contingency (20%)[6]				$2,240
Total Capital Costs				$13,440
Periodic Cost				
5-Year Review	1	Each	$1,500	$1,500
Closure Report	1	LS	$1,500	$1,500
Subtotal Periodic Costs				$3,000
Contingency (20%)[6]				$600
Total Periodic Costs				$3,600
O&M Cost				
Total Annual O&M Cost				$0

Present Value Cost

Year	**Capital Costs**	**Periodic Costs**	**Annual O&M Cost**	**Total Cost**	**Discount Factor at 7%**	**Total Present Value Cost at 7%**
0	$13,440	$1,800	$0	$15,240	1.000	$15,240
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$1,800	$0	$1,800	0.713	$1,283
Total	**$13,440**	**$3,600**	**$0**	**$17,040**		**$16,523**

Notes:
CY = cubic yard
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology since it has been widely used, and design issues are better understood than with other technologies.
4. Includes transportation to landfill in Stillwater, Oklahoma.
5. Soil Samples analyzed for presence of asbestos using PLM.
6. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13G: Cost Estimate Summary for the Selected Remedy - Coke Tar Alternative 2, Excavation and Disposal at Regulated Off-site Facility

Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Institutional Controls	1	LS	$10,000	$10,000
Engineering and Design[2, 3]	1	LS	$25,000	$25,000
Permitting	1	LS	$5,000	$5,000
Utility Clear for Excavation	1	LS	$1,500	$1,500
Excavate/Transport/Place in Off-site Cell[4]	6,000	CY	$8	$48,000
Waste Disposal Tipping Fee	9,000	Ton	$27	$243,000
Waste Disposal Environmental Fee	450	Load	$5	$2,250
Backfill Excavations	6,000	CY	$16	$96,300
Top Soil	1,613	CY	$13	$21,534
Establish Vegetative Cover	2	Acre	$445	$890
Confirmation Soil Sample Analysis[5]	60	Each	$445	$27,300
Surveyor	15	Day	$1,100	$16,500
Field Equipment Rental	3	Week	$460	$1,380
Construction Oversight Labor	15	Day	$1,000	$15,000
Construction Oversight Per Diem	15	Day	$100	$1,500
Construction Oversight Pickup Truck	15	Day	$100	$1,500
Subtotal Capital Costs				$516,654
Contingency (20%)[6]				$103,331
Total Capital Costs				$619,984
Periodic Cost				
5-Year Review	1	Each	$3,000	$3,000
Closure Report	1	LS	$20,000	$20,000
Subtotal Periodic Costs				$23,000
Contingency (20%)[6]				$4,600
Total Periodic Costs				$27,600
O&M Cost				
Total Annual O&M Cost				$0

Present Value Cost

Year	Capital Costs	Periodic Costs	Annual O&M Cost	Total Cost	Discount Factor at 7%	Total Present Value Cost at 7%
0	$619,984	$24,000	$0	$643,984	1.000	$643,984
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$3,600	$0	$3,600	0.713	$2,567
Total	**$619,984**	**$27,600**	**$0**	**$647,584**		**$646,551**

Notes:
CY = cubic yard
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology since it has been widely used, and design issues are better understood than with other technologies.
4. Includes transportation to landfill in Stillwater, Oklahoma.
5. Soil Samples analyzed for metals, SVOCs and VOCs.
6. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 13H: Cost Estimate Summary for the Selected Remedy - Scrap Metal Alternative 2, Removal and Salvage				
Description	Quantity	Unit	Unit Cost[1]	Cost
Capital Cost				
Engineering and Design[2, 3]	1	LS	$750	$750
Load/Transport/Recycle Off-site[4]	1	LS	$7,000	$7,000
Construction Oversight Labor	5	Day	$1,000	$5,000
Construction Oversight Per Diem	5	Day	$100	$500
Construction Oversight Pickup Truck	5	Day	$100	$500
Subtotal Capital Costs				$13,750
Contingency (20%)[5]				$2,750
Total Capital Costs				$16,500
Periodic Cost				
5-Year Review	1	Each	$1,500	$1,500
Closure Report	1	LS	$1,500	$1,500
Subtotal Periodic Costs				$3,000
Contingency (20%)				$600
Total Periodic Costs				$3,600
O&M Cost				
Total Annual O&M Cost				$0

Present Value Cost

Year	**Capital Costs**	**Periodic Costs**	**Annual O&M Cost**	**Total Cost**	**Discount Factor at 7%**	**Total Present Value Cost at 7%**
0	$16,500	$1,800	$0	$18,300	1.000	$18,300
1	$0	$0	$0	$0	0.935	$0
2	$0	$0	$0	$0	0.873	$0
3	$0	$0	$0	$0	0.816	$0
4	$0	$0	$0	$0	0.763	$0
5	$0	$1,800	$0	$1,800	0.713	$1,283
Total	**$16,500**	**$3,600**	**$0**	**$20,100**		**$19,583**

Notes:
CY = cubic yard
LS = lump sum

1. Costs represent estimates obtained from similar projects and/or professional experience.
2. Includes Work Plan, Safety Plan, Engineering Design, Scheduling, and Project Management.
3. A pilot test is not necessary with this technology since it has been widely used, and design issues are better understood than with other technologies.
4. Includes transportation to local recycling facility.
5. Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation.

Table 14: Cleanup Levels for Chemicals/Contaminants of Concern			
Media: Asbestos Containing Material Site Area: North Refinery Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices			
ACM	1%	NESHAPs	Not Available
Media: Soil Site Area: North and South Refineries Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices			
Chemical of Concern	Cleanup Level	Basis for Cleanup Level	Risk At Cleanup Level
Benzo(a)pyrene	4.22 mg/kg	Risk Assessment	Cancer risk = 1 x 10^{-5}
Arsenic	31.8 mg/kg	Risk Assessment	Cancer risk = 1 x 10^{-5}
Lead	1000 mg/kg	DEQ Policy	Not Available
Media: Waste Pond Sediment Site Area: North and South Refineries Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices			
Benzo(a)anthracene	42.2 mg/kg	Risk Assessment	Cancer risk = 1 x 10^{-5}
Benzo(a)pyrene	4.22 mg/kg	Risk Assessment	Cancer risk = 1 x 10^{-5}
Media: Waste Pond Surface Water Site Area: North and South Refineries Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices			
Benzo(a)pyrene	6.0 µg/L	Method Detection Limit plus 1	Cancer risk = 1 x 10^{-5}
Media: LNAPL Site Area: North Refinery Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices & Ground Water Use Restrictions			
LNAPL	1/10 foot	EPA Guidance	Not Available
Media: Ground Waster Site Area: North and South Refineries Available Use: Commercial/Industrial Controls to Ensure Restricted Use: Deed Notices & Ground Water Use Restrictions			
Benzene	5.0 µg/L	MCL	Not Available
Thallium	2.0 µg/L	MCL	Not Available
Notes: MCL= Federal maximum contaminant level mg/kg= Milligram per kilogram µg/L= Microgram per liter			

Table 15: Description of ARARs for Selected Remedy

Authority	Medium	Requirement	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Federal Regulatory Requirement	All	Occupational Safety and Health Standards (OSHA) 29 CFR 1910 and 1926	Applicable	Provides national standards for worker exposure and general safety.	All personnel performing the selected remedy will comply with the requirements of this ARAR through the implementation of a site-specific Health and Safety Plan.
Federal Regulatory Requirement	All	National Emission Standards for Hazardous Air Pollutants 40 CFR 61	Potentially Applicable	Identifies emission standards for specific hazardous air pollutants.	The selected remedy will comply with this regulation through air monitoring and/or soil sampling as appropriate.
Federal Regulatory Requirement	Waste Pond Surface Water, Light Non-Aqueous Phase Liquid, and Ground Water	National Pollutant Discharge Elimination System (NPDES) 40 CFR 122	Applicable	Regulates discharges of pollutants from any point source into waters of the United States.	When water is discharged to Skull Creek from the site the substantive requirements of this ARAR will be met.
Federal Regulatory Requirement	Ground Water	Underground Injection Control Regulations 40 CFR 144-148	To Be Considered	Assures that underground injection will not endanger drinking water sources. Provides regulations governing the use of underground injection wells including: identification of the classifications of injection wells; and the permitting, construction, operation, monitoring, testing, and reporting requirements. Also provides requirements for plugging of injection wells.	If contingency ground water remedy is implemented and underground injection is required, than the substantive requirements of this ARAR will be met.
Federal Regulatory Requirement	All	Standards for Identification and Listing of Hazardous Waste 40 CFR 261	Potentially Applicable	Provides criteria for identification of hazardous and solid wastes.	Hazardous wastes will be identified using this standard.
Federal Regulatory Requirement	All	Standards Applicable to Generators of Hazardous Waste 40 CFR 262	Potentially Applicable	Regulates the manifesting, pre-transport requirements, and record keeping and reporting for hazardous waste generators.	Handling and transportation of hazardous wastes will be performed in compliance with this ARAR.

Federal Regulatory Requirement	All	Standards Applicable to Transporters of Hazardous Waste 40 CFR 263	Potentially Applicable	Establishes standards which apply to persons transporting hazardous waste within the United States if the transportation requires a manifest under RCRA.	Handling and transportation of hazardous wastes will be performed in compliance with this ARAR.
Federal Regulatory Requirement	All	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities 40 CFR 264	Applicable	Regulations apply to owners and operators of facilities that treat, store, or dispose of hazardous waste through the use of surface impoundments, waste piles, incinerators, land treatment units, and landfills.	Treatment and disposal of hazardous wastes will be performed in compliance with this ARAR.
Federal Regulatory Requirement	All	Land Disposal Restrictions 40 CFR 268	Potentially Applicable	Identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed.	If land disposal is performed it will be performed in compliance with this ARAR.
Federal Regulatory Requirement	All	Department of Transportation 49 CFR 171 through 180	Potentially Applicable	Regulations prescribed in accordance with Federal hazardous materials transportation law shall govern safety aspects, including security, of the transportation of hazardous materials. For the purposes of this section, the term "hazardous material" and any other terms not defined in this section have the same definition as in the Hazardous Materials Regulations.	All DOT-defined hazardous materials will be handled as required by this ARAR. Transportation vehicles will be placarded appropriately and carry manifests for each load.
State Regulatory Requirement	All	Air Pollution Control OAC 252:100	Potentially Applicable	Provides for the control for specific hazardous air pollutants.	The selected remedy will comply with this regulation through air monitoring as appropriate.
State Regulatory Requirement	All	Oklahoma Hazardous Waste Management Rules OAC 252:205	Potentially Applicable	Implements the Oklahoma Hazardous Waste Management Act (OHWMA), which provide rules for the handling, transportation, treatment, storage, recycling, and/or disposal of hazardous waste regulated by the OHWMA.	Handling, treatment, disposal and transportation of hazardous wastes will be performed in compliance with this ARAR.
State Regulatory Requirement	All	Solid Waste Management OAC 252:515	Applicable	Regulates the collection, transportation, processing, and/or disposal of solid waste and/or tires.	Handling, disposal and transportation of solid wastes will be performed in compliance with this ARAR.
State Regulatory Requirement	All	General Water Quality Standards OAC	Potentially Applicable	Provides regulations for the protection, maintenance, and improvement of the	When water is discharged to Skull Creek from the site the substantive

		252:611		quality of surface, ground, and other waters of the state.	requirements of this ARAR will be met, if applicable.
State Regulatory Requirement	All	Industrial Wastewater Systems Standards OAC 252:616	To Be Considered	Establishes requirements for industrial surface impoundments, industrial tank systems and land application of industrial sludge and wastewater.	Will be applicable if industrial surface impoundments, tank systems, and/or land application is used for waste treatment at a site.
State Regulatory Requirement	Waste Pond Surface Water, Light Non-Aqueous Phase Liquid, and Ground Water	Oklahoma Water Quality Standards Implication OAC 252:690	Potentially Applicable	Establishes guidance and requirements for the implementation of Oklahoma's Water Quality Standards.	When water is discharged to Skull Creek from the site the substantive requirements of this ARAR will be met, if applicable.
State Regulatory Requirement	Waste Pond Surface Water, Light Non-Aqueous Phase Liquid, and Ground Water	Oklahoma Water Quality Standards OAC 785:45/46	Potentially Applicable	Establishes classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.	When water is discharged to Skull Creek from the site the substantive requirements of this ARAR will be met, if applicable.
Federal Regulatory Requirement	Waste Pond Surface Water, Light Non-Aqueous Phase Liquid, and Ground Water	Clean Water Act (CWA) 40 CFR 130	Applicable	Section 303 (d) Requires States to identify waters that do not or are not expected to meet applicable water quality standards with technology-based controls. Water impacted by thermal discharges are also to be identified.	When water is discharged to Skull Creek from the site the substantive requirements of this ARAR will be met.
Federal Regulatory Requirement	Ground Water	National Primary Drinking Water Regulations, including Maximum Contaminant Levels 40 CFR 141	Applicable	Establishes maximum contaminant levels (MCLs) which are health risk based standards for public water systems.	The selected remedy will comply with these regulations through containment monitoring and institutional controls.
Federal Regulatory Requirement	Waste Pond Surface Water, Light Non-Aqueous Phase Liquid, and Ground Water	National Secondary Drinking Water Regulations 40 CFR 143	To Be Considered	Establishes welfare-based secondary standards for public water systems.	The substantive requirements of this ARAR will be met if they are found to be applicable.
Federal Regulatory Requirement	All	Historic Site Preservation / Archeological and Historic Preservation (Executive Order	To Be Considered	Provides for the protection, enhancement, and preservation of sites or archeological or historic significance.	There are no identified sites of historic or archeological significance as designated by proper officials at the Site, but the substantive requirements of this

		11593) 16 USC 461 et seq, 16 USC 469 et seq, 16 USC 470 et seq 40 CFR 6.301)			ARAR will be met if they are identified in the future.
Federal Regulatory Requirement	All	Threatened and Endangered Wildlife and Plants 50 CFR 17	To Be Considered	Provides a program for conservation of threatened and endangered plants and animals and the habitats in which they are found.	There is no identified threatened or endangered species, or their habitats present at or near the Site, but the substative requirements of this ARAR will be met if these species or habitats are found it present at or near the site in the future.

Table 16: Cost Effectiveness Matrix

RELEVANT CONSIDERATIONS FOR COST EFFECTIVENESS DETERMINATION:

Alternative	Cost Effective?	Present Worth Cost	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
Soil					
1) No Action	No	$69,597	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Clay Cap	Yes	$1,795,403	Reduces risk to acceptable levels.	No reduction in TMV.	Controllable risk to workers and community; reduces other risks.
3) Excavation and On-site Disposal Cell	Yes	$2,788,163	Reduces risk to acceptable levels.	Reduces toxicity and mobility but not volume and treatment is not used.	Controllable risk to workers and community; reduces other risks.
4) Excavation and Off-site Disposal at Permitted Facility	Yes	$3,532,830	Reduces risk to acceptable levels.	Reduces toxicity, mobility, and volume by removing contaminated soil from Site. But no treatment is used.	Controllable risk to workers and community; reduces other risks.
Waste Pond Sediment					
1) No Action	No	$69,597	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Excavation, Stabilization and On-site Disposal Cell	Yes	$3,867,444	Reduces risk to acceptable levels.	Reduces toxicity and mobility through treatment, increase in volume may occur through treatment.	Controllable risk to workers and community; reduces other risks.
3) Excavation, Stabilization and Off-site Disposal at Permitted Facility	Yes	$4,619,897	Reduces risk to acceptable levels.	Reduces toxicity and mobility through treatment, increase in volume may occur through treatment.	Controllable risk to workers and community; reduces other risks.
Waste Pond Surface Water					
1) No Action	No	$3,113	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) On-site Treatment	Yes	$352,403	Reduces risk to acceptable levels.	Reduces toxicity, mobility and volume of contamination through treatment.	Controllable risk to workers and community; reduces other risks.
3) Off-site Treatment At Regulated Facility	Yes	$2,186,783	Reduces risk to acceptable levels.	Reduces toxicity, mobility and volume of contamination through treatment.	Controllable risk to workers and community; reduces other risks.
Light Non-Aqueous Phase Liquids					
1) No Action	No	$3,113	No reduction in long term	No reduction in TMV.	Continued risk to human health

			risk.		and the environment.
2) Hydrocarbon Belt Skimmers	Yes	$124,260	Reduces risk to acceptable levels.	Reduces toxicity, mobility, and volume by removing contaminated soil from Site. But no treatment is used.	Controllable risk to workers and community; reduces other risks.
3) Collection Trenches with Hydrocarbon Belt Skimmers, Ex-Situ Treatment	Yes	$279,993	Reduces risk to acceptable levels.	Reduces toxicity, mobility and volume of contamination through treatment.	Controllable risk to workers and community; reduces other risks.
Ground Water					
1) No Action	No	$194,173	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Ground Water Monitoring	Yes	$335,829	Reduces risk to acceptable levels.	No reduction in TMV through treatment.	Controllable risk to workers; reduces other risks.
3) Monitored Natural Attenuation	Yes	$870,599	Reduces risk to acceptable levels.	Reduces TMV of contamination, but not through treatment	Controllable risk to workers; reduces other risks.
4) Phytoremediation with Natural Attenuation	Yes	$301,584	Reduces risk to acceptable levels.	Reduces TMV of contamination through treatment.	Controllable risk to workers; reduces other risks.
5) Pump and Treat Hydraulic Containment, Ex-Situ Treatment	Yes	$2,394,909	Reduces risk to acceptable levels.	Reduces TMV of contamination through treatment.	Controllable risk to workers and community; reduces other risks.
Asbestos-Containing Material					
1) No Action	No	$3,113	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Removal and Disposal at Regulated Off-site Facility	Yes	$16,523	Reduces risk to acceptable levels.	Reduces TMV by removing contaminated soil from Site. No treatment is used.	Controllable risk to workers and community; reduces other risks.
Coke Tar					
1) No Action	No	$3,113	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Excavation and Disposal at Regulated Off-site Facility	Yes	$646,551	Reduces risk to acceptable levels.	Reduces toxicity and mobility through treatment, increase in volume may occur through treatment.	Controllable risk to workers and community; reduces other risks.
Scrap Metal					
1) No Action	No	$3,113	No reduction in long term risk.	No reduction in TMV.	Continued risk to human health and the environment.
2) Removal and Salvage	Yes	$19,583	Reduces risk to acceptable levels.	Reduces TMV by removing contaminated soil from Site. No treatment is used.	Controllable risk to workers and community; reduces other risks.

Notes:
No Action alternatives do not reduce risks to either human health or the environment and therefore are not considered cost effective.
TMV = Toxicity, Mobility and Volume

APPENDIX A - City of Cushing Letter of Intent for Redevelopment

CITY OF CUSHING OKLAHOMA

P. O. BOX 311 • CUSHING, OKLAHOMA 74023-0311 • (918) 225-2394

June 14, 2006

RECEIVED
JUN 15 2006
LAND PROTECTION DIVISION
DEPT OF ENVIRONMENTAL QUALITY

Ms. Amy Brittain
Land Protection Division
Oklahoma Department of
Environmental Quality
707 N. Robinson Ave
P.O. Box 1677
Oklahoma City, OK 73101-1677

Re: City of Cushing Letter of Intent for Redevelopment of the Hudson Refinery Superfund Site

Dear Ms. Brittain:

The following outlines the City of Cushing's intent for the redevelopment of the subject site. This redevelopment plan is the product of extensive and ongoing citywide community development planning, analysis of local, regional, and state trends, and the results of ODEQ testing and evaluation at the site.

Background. During 2005, the City of Cushing engaged in a comprehensive community planning effort in order to establish preferred, and realistic, goals for future development efforts and community characteristics. This process included town-hall type meetings, joint planning meetings of City Commission and appointed Boards, and professional consultant support and research.

This process yielded two primary and corollary results. The first is that Cushing is likely to be subject to and influenced by the emerging metro-growth of Tulsa, Oklahoma City, and Stillwater. Secondly, that the City's desired goal was to capitalize on and manage this growth potential in order to be a vital and high-quality choice for residential and business development while maintaining an intimate, small-town character.

From this overall vision emerged a number of implementation steps that relate to the redevelopment of the Hudson site. These include the need to revitalize the City's historic downtown, to develop significantly more commercial and retail activity, and to provide opportunities for well-planned, high-quality housing development of various types.

high-intensity development would be linked by community-scale commercial activity along Main St. (This component of development has been adopted as the 'Main St. Corridor Plan'). Housing needs are to be met through development of new, relatively large subdivisions coupled with recently expanded rehabilitation efforts in existing housing stock. Revitalization of the Downtown as the City's social and cultural hub is to be accomplished through development of a 'Town-Center' focus, comprising the Downtown, central housing areas, and the hospital complex, and linked to the commercial centers/Main St. corridor.

Role of the Hudson Site. The Hudson site occupies a critical position in the City's development plan – both physically and functionally. The site is the western entryway to Cushing, and straddles the community's primary traffic corridor, Main St. The southern portion of the site is immediately adjacent to Downtown, and provides a direct physical link to Main St. and to housing areas to the west. The northern portion provides a wide frontage along Main St. as well as a large tract of potentially developable land. This pivotal position, along with the relatively large size of the tracts involved, makes the site key to the City's development goals.

Redevelopment Plan. It is the intention of the City that the site be redeveloped as a planned component of the overall community development approach. The following reflects both that intention and the results of the site evaluation provided by ODEQ:

The southern portion of the site would be planned as a commercial/light industrial area, with the goal of high-intensity retail, corporate-type facilities, and compatible light manufacturing. This development would be designed to provide both a link and a transition to and from the downtown and Main St. This might include reconfiguration of roadways (principally Moses St.) to provide a direct traffic link.

In the northern tract, the area roughly opposite the southern tract, to a depth of approximately 1200 feet, would be designed as a similar commercial/light industrial area. These northern and southern areas together would form the large commercial and corporate anchor for the western side of town as desired in the overall community plan. The more western portion of the northern tract adjacent to Main St., to a depth of approximately 600 feet, would be designed as community-scale highway commercial and mixed-use housing. The remaining portion of the northern tract would be designed for housing subdivision and planned unit development.

An advantage to this planned approach is that it allows for phasing of development. For example, if funding limitations required it, the City would be prepared to focus development efforts on the southern tract, and reserve the northern for future use. Similarly, phasing would be possible if the pace of the development market favored one component over another.

Implementation. While it is the City's intention to develop this property in a flexible manner, reflective of developing market conditions, it is also the intention to manage and direct this development to achieve the designated goals. As a first step, the City is prepared to comprehensively rezone the site in accordance with the redevelopment plan. It is anticipated that this will occur almost immediately upon completion of ODEQ's Proposed Plan. This rezoning would be specific and detailed enough to ensure the desired development characteristics are obtained.

The City is also prepared, if it becomes necessary, to acquire all or part of the site. The City has worked with EPA for several years to develop a Prospective Purchaser's Agreement to this end. A decision on moving forward on acquisition will be based on actual redevelopment progress, including relationships with potential developers, and the timing can not be determined now.

The City has begun seeking out potential developers for this site. A key relationship has also been established with Rural Enterprises Incorporated, with that agency prepared to provide technical assistance and development project participation.

Upon completion of ODEQ's cleanup plan, the City is prepared to develop a more detailed redevelopment plan, to be completed within six months, and begin active marketing of this site. Actual redevelopment will of course be dependent on market conditions. The City is currently conducting an analysis of infrastructure requirements for the community development plan, including preparation of a corresponding CIP. This planning will include the Hudson Site, and should be completed in FY 2007.

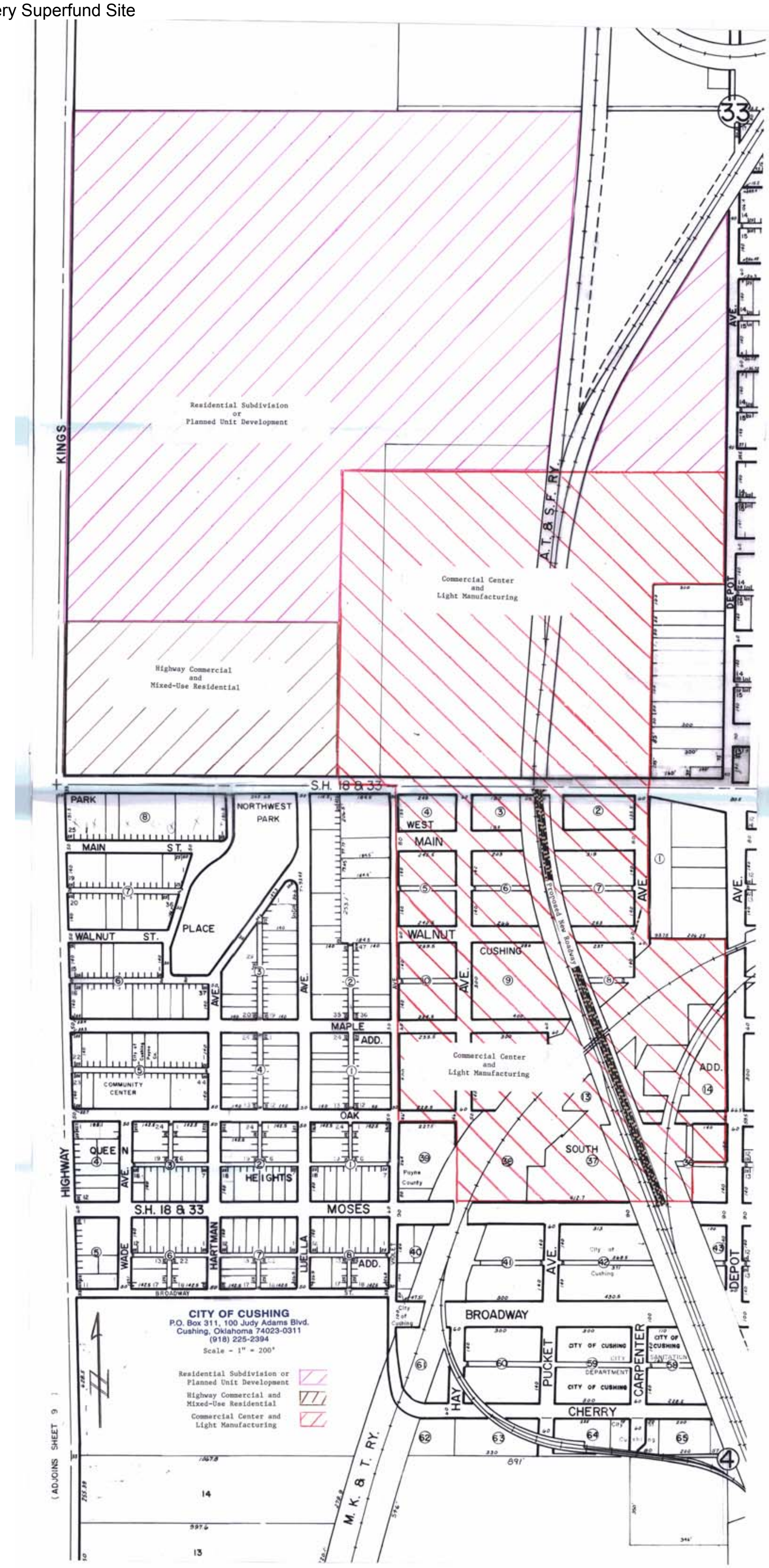
If you have any questions regarding the proposed redevelopment plan, or need additional information, please let me know.

Sincerely,

Andrew Katz
City Manager

Attachments:

- City map
- Redevelopment plan conceptual map


Residential Subdivision
or
Planned Unit Development
Commercial Center
and
Light Manufacturing
Highway Commercial
and
Mixed-Use Residential
KINGS
HIGHWAY
A. T. & S. F. RY.
DEPOT
AVE.
S.H. 18 & 33
PARK
MAIN
ST.
NORTHWEST
PARK
PLACE
WALNUT
ST.
AVE.
MAPLE
ADD.
COMMUNITY
CENTER
OAK
QUEEN
HEIGHTS
WADE
HARTMAN
LUELLA
MOSES
BROADWAY
WEST
CUSHING
SOUTH
Proposed New Roadway
HAY
PUCKET
CARPENTER
CHERRY
CITY OF CUSHING
M. K. & T. RY.
(ADJOINS SHEET 9)
CITY OF CUSHING
P.O. Box 311, 100 Judy Adams Blvd.
Cushing, Oklahoma 74023-0311
(918) 225-2394
Scale - 1" = 200'
Residential Subdivision or
Planned Unit Development
Highway Commercial and
Mixed-Use Residential
Commercial Center and
Light Manufacturing

APPENDIX B - ODEQ Concurrence with the Selected Remedy

O K L A H O M A
DEPARTMENT OF ENVIRONMENTAL QUALITY

STEVEN A. THOMPSON
Executive Director

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

BRAD HENRY
Governor

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October 24, 2007

Sam Coleman (6SF-D)
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Dear Mr. Coleman:

In response to your letter dated August 16, 2007, the Oklahoma Department of Environmental Quality (DEQ) fully supports the Draft Record of Decision for the Hudson Refinery Superfund Site. The Draft Record of Decision, which provides for excavation and off-site disposal of soil; the excavation, stabilization and off-site disposal of waste pond sediments; the on-site treatment of waste pond surface water; the use of hydrocarbon belt skimmers to recover light non-aqueous phase liquids; ground water containment monitoring; the removal of asbestos-containing material; the excavation, stabilization, and off-site disposal of coke tar material; and the removal and salvage of scrap metal, was arrived at through the concerted efforts of our two agencies.

The DEQ believes that the proposed remedy for the Hudson Refinery Superfund Site will provide long-term protection for public health and the environment.

The DEQ looks forward to our continued cooperative effort on the Hudson Refinery Superfund Site as we proceed through Remedial Design and Remedial Action.

Sincerely,

Scott Thompson
Director, Land Protection Division

823482

APPENDIX C - Administrative Record