Assessment Plan
for the
Former Indian Refinery NPL Site

Illinois Natural Resource Trustee Council:

United States Department of the Interior, U.S. Fish and Wildlife Service
Illinois Department of Natural Resources
Illinois Environmental Protection Agency

with assistance from Stratus Consulting Inc.

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Contents

Figures

Tables

Acronyms

AWR	American Western Refining LP
B&O	Baltimore and Ohio
BERA	baseline ecological risk assessment
BTEX	benzene, toluene, ethylbenzene, and xylenes
CD	consent decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
DOI	U.S. Department of the Interior
DSAYs	discounted service acre-years
EPA	U.S. Environmental Protection Agency
ERMA	Embarras River Management Association
FPA	Funding and Participation Agreement
FS	feasibility study
GWEA	groundwater equivalency analysis
HEA	habitat equivalency analysis
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geological Survey
ISWS	Illinois State Water Survey
LNAPL	light non-aqueous phase liquid
LTU	land treatment unit
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRDA	natural resource damage assessment

OPA	Oil Pollution Act
OWR	IDNR Office of Water Resources
PAH	polycyclic aromatic hydrocarbon
PRP	potentially responsible party
QAPP	Quality Assurance Project Plan
RCDP	Restoration and Compensation Determination Plan
RCRA	Resource Conservation and Recovery Act of 1976
REA	resource equivalency analysis
RI	remedial investigation
SDWA	Safe Drinking Water Act
SWMUs	solid waste management units
TRMI	Texaco Refining & Marketing Inc.
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1. Introduction

1.1 Statement of Purpose

The Illinois Department of Natural Resources (IDNR), the Illinois Environmental Protection Agency (IEPA), and the U.S. Department of the Interior (DOI) represented by the U.S. Fish and Wildlife Service (USFWS) (collectively, the Trustees), in cooperation with Chevron Corporation (Chevron), are conducting a natural resource damage assessment (NRDA) to restore natural resources, and the services they provide, that have been injured as a result of releases of hazardous substances and/or petroleum products from the Former Indian Refinery in Lawrenceville, Illinois. Chevron has been identified as a potentially responsible party (PRP) for hazardous substance and/or petroleum product releases from the site and has approached the Trustees to conduct a cooperative NRDA. Toward that end, the Trustees and Chevron negotiated and are working under a Funding and Participation Agreement (FPA) to cooperatively conduct the NRDA and develop a plan to restore the injured natural resources affected by the release of hazardous substances and/or petroleum products at the site. (A copy of the FPA is available online from the USFWS at http://www.fws.gov/midwest/LawrencevilleNRDA.) The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 USC §§ 9607 *et. seq.*], the Federal Water Pollution Control Act or the Clean Water Act (CWA) [33 USC §§ 1321 *et. seq.*], the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 CFR § 300, Subpart G], and the Oil Pollution Act (OPA) [33 USC §§ 2701 *et. seq.*] provide the Trustees authority to seek such damages and to make the public whole for the injuries to natural resources.

The Trustees prepared a Preassessment Screen following the DOI regulations at 43 CFR § 11.23. The Preassessment Screen was a review of readily available information, from which the Trustees determined that hazardous substance releases and/or petroleum product discharges[1] from the refinery were likely to have injured Trustee resources. The Trustees therefore concluded that the assessment should proceed. A copy of the Preassessment Screen is available online from the USFWS at http://www.fws.gov/midwest/LawrencevilleNRDA.

1. The term "releases" as used in this document refers to non-permitted releases [e.g., 42 USC § 9601(10)] unless otherwise specified. CERCLA Section 101(22) defines "release" as any "spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment." OPA Section 2701(7) defines "discharge" as "any emission (other than natural seepage), intentional or unintentional, and includes, but is not limited to, spilling, leaking, pumping, pouring, emitting, emptying, or dumping." For the remainder of this document, the term "releases" also includes petroleum product discharges.

This Assessment Plan also has been prepared in accordance with the DOI's NRDA regulations at 43 CFR Part 11.[2] The purpose of the Assessment Plan is to describe the Trustees' and Chevron's approach for conducting a cooperative NRDA at the Former Indian Refinery and to propose assessment work to determine and quantify injuries and damages to natural resources. The cooperative approach between the Trustees and Chevron helps to ensure that the NRDA will be completed at a reasonable cost, and that a plan for the appropriate type and amount of natural resource restoration will be developed. The cooperative approach also permits the Trustees and Chevron to capitalize on the shared experience and expertise of the respective parties to achieve less costly and more efficient restoration, so that the public will be made whole for those injuries sustained to natural resources.

The remaining sections of this chapter and subsequent chapters describe the contents of the Assessment Plan, describe the assessment area, confirm exposure of natural resources to hazardous substances and/or petroleum products released from the refinery, describe the approach to injury assessment, and describe the methods that will be used to quantify natural resource damages and restoration.

1.2 Trusteeship Authority

The President of the United States has designated state and federal natural resource trustees [40 CFR §§ 300.600 and 300.605]. Pursuant to 40 CFR § 300.605, states "shall act on behalf of the public as trustees for natural resources, including their supporting ecosystems, within the boundary of the state or belonging to, managed by, controlled by or appertaining to such state." The Former Indian Refinery and surrounding area are within the boundaries of the State of Illinois. The Directors of IEPA and IDNR have been designated as the natural resource trustees for the State of Illinois, pursuant to Section 107(f)(2)(B) of CERCLA.

The Secretary of the Interior is designated as trustee for all natural resources managed or controlled by the DOI, including their supporting ecosystems [40 CFR § 300.600(b), (b)(2), and (b)(3)]. The statutory bases for DOI's trusteeship include, but are not limited to, the Fish and Wildlife Coordination Act [16 USC § 661 *et seq.*], the Fish and Wildlife Act [16 USC §§ 742a *et seq.*], the Migratory Bird Treaty Act [16 USC § 703 *et seq.*], the Bald Eagle Protection Act [16 USC § 668 *et seq.*], the Endangered Species Act [16 USC § 1531 *et seq.*], and the CWA [33 USC § 1251 *et seq.*]. The Secretary of the Interior has delegated authority to act as trustee for fish and wildlife resources and their supporting ecosystem to the Director of the USFWS. Acting

2. The application of these regulations is not mandatory, and the Trustees have the option of diverging from them. However, assessments performed in compliance with these regulations have the force and effect of a rebuttable presumption in any administrative or judicial proceeding under CERCLA [42 USC § 9607(f)(2)(C)].

through the USFWS, DOI is authorized by CERCLA [42 USC § 9607(f)] to pursue and consent to settle claims for natural resource damages to resources under the trusteeship of DOI.

Together, the Trustees are authorized to participate in negotiations with the PRPs to obtain PRP-financed or PRP-conducted NRDAs, and, where appropriate, to agree to grant covenants not to sue [40 CFR § 300.615(d)(2)]. Further, pursuant to 43 CFR 11.32(d), a PRP may conduct all or part of a Trustee-approved Assessment Plan. The FPA between the Trustees and Chevron is the result of negotiations between the Trustees and Chevron as authorized by the NCP and 43 CFR Part 11 to prepare and implement an Assessment Plan.

1.3 Decision to Perform a Type B Assessment

43 CFR Part 11 describes two types of assessments: Type A and Type B. Trustees may select between performing a Type A or a Type B NRDA [43 CFR § 11.33]. Type A procedures are "simplified procedures that require minimal field observation" [43 CFR § 11.33(a)], while Type B procedures require more extensive field observation [43 CFR § 11.33(b)] and are implemented in multiple phases [43 CFR § 11.60(b)]. The simplified Type A models have been developed only for Great Lakes environments and coastal and marine environments [43 CFR § 11.33(a)]. These models are appropriate for discrete spills of hazardous substances and/or petroleum products up to a few days in duration, with injuries based on acute exposure via the surface water pathway only; see publication incorporated by reference at 43 CFR § 11.18(a)(5). None of these conditions apply at the Former Indian Refinery, making a Type A assessment inappropriate at this site. Furthermore, the nature of the releases and natural resource injuries require more extensive field observations, making a Type B assessment appropriate [43 CFR § 11.33(b)]. Therefore, the Trustees and Chevron are conducting a Type B assessment in this NRDA.

1.4 Natural Resource Damage Assessment Process

NRDA is a process by which trustees of natural resources determine compensation for natural resource injuries that have not been, or are not expected to be, addressed by response actions. The measure of such compensation is the "cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide" and may also include the "compensable value of all or a portion of the services lost to the public for the time period from the . . . release until the attainment of the restoration, rehabilitation, replacement, and/or acquisition of equivalent of the resources and their services to baseline" [43 CFR § 11.80(b)].

The DOI has promulgated regulations for conducting an NRDA related to hazardous substance releases at 43 CFR Part 11. The Trustees and Chevron intend to follow these NRDA regulations in the Former Indian Refinery NRDA to the extent practicable. It is anticipated that the NRDA phases will progress more quickly in some areas of the refinery and more slowly in other areas, such that not all areas will necessarily be at the same phase at the same time.

The four major phases in the Type B NRDA process are the Preassessment Phase, the Assessment Plan Phase, the Assessment Phase, and the Post-Assessment Phase.

1.4.1 Preassessment Phase

The Preassessment Phase of an NRDA is the first step in conducting an NRDA. Trustees must rapidly review available data and determine whether or not to proceed with an assessment [43 CFR § 11.13(b)], and then document this decision in a Preassessment Screen determination [43 CFR § 11.23(c)]. The Preassessment Screen for the Former Indian Refinery has been completed and is available at the USFWS web site listed in Section 1.1. In accordance with the criteria at 43 CFR § 11.23(e), the Preassessment Screen demonstrates that:

- A discharge or release of hazardous substances and/or petroleum products has occurred
- Natural resources for which the Trustees may assert trusteeship under CERCLA have been or are likely to have been adversely affected
- The quantity of the release is sufficient to potentially cause injury
- Data to perform an assessment are available or obtainable at a reasonable cost
- Response actions do not or will not sufficiently remedy the injury to natural resources without further action [43 CFR § 11.23(e)].

Thus the Trustees concluded that they should proceed with an NRDA to develop a damage claim under 42 USC § 9607.

1.4.2 Assessment Plan Phase

If the decision is made to perform an NRDA, the Trustees prepare an Assessment Plan. The purpose of the Assessment Plan is to ensure that the assessment is well-planned and conducted systematically, and that the selected methods for assessment are cost-effective [43 CFR § 11.13(c)]. According to 43 CFR Part 11, the Assessment Plan confirms exposure of natural resources to hazardous substances and/or petroleum products (Chapter 3 of this plan), describes

the objectives of any testing and sampling for injury or pathway determination (Chapter 4 of this plan), and provides a Quality Assurance Project Plan (QAPP) to ensure quality control in testing and sampling (Chapter 6 of this plan) [43 CFR § 11.31(c)(2)].

The Assessment Plan may also include a Restoration and Compensation Determination Plan (RCDP). However, if insufficient information is available to develop the RCDP at the time of Assessment Plan preparation, it may be developed at a later time before the completion of injury determination and quantification [43 CFR § 11.31(c)(4)]. This Assessment Plan contains an approach to conduct restoration planning and scaling (Chapter 5); the Trustees and Chevron will develop an RCDP at a later time.

1.4.3 Assessment Phase

The Assessment Phase is when the evaluation of injuries and damages is conducted. The parts of a Type B assessment are summarized here and described in detail in Chapter 4.

1. **Injury determination**: The first part of the assessment determines what natural resources have been injured as a result of the release of hazardous substances and/or petroleum products [43 CFR § 11.13(e)(1)]. It also involves determining the pathway, or route, through which the hazardous substances and/or petroleum products were transported from sources to the injured resource [43 CFR § 11.61(c)(3)].

2. **Injury quantification**: The second part of the assessment quantifies the determined injuries in terms of the "loss of services that the injured resource would have provided had the discharge or release not occurred" [43 CFR § 11.13(e)(2)]. The extent and degree of injuries, the ability of the resource to recover, and the reduction in services are included in the quantification of injuries [43 CFR § 11.71(c)]. The "interdependent services" provided by natural resources are identified to "avoid double counting in the damage determination phase and to discover significant secondary services that may have been disrupted by the injury" [43 CFR § 11.71(b)].

3. **Damage determination**: The third part of the assessment determines the appropriate compensation for the injuries [43 CFR § 11.13 (e)(3)]. Damages are measured as the cost of "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the natural resources and the services those resources provide" and may also include the value of the services lost to the public from the time of the release to the reestablishment of the services to baseline conditions [43 CFR § 11.80(b)].

1.4.4 Post-Assessment Phase

The Post-Assessment Phase is the final step in the NRDA process. After the assessment is complete, the Trustees produce a Report of Assessment containing the results of the NRDA [43 CFR § 11.90]. The Trustees may then seek recovery of damages from the PRP [43 CFR § 11.91], and such damages may include direct and indirect costs "necessary to complete all actions identified in the selected alternative for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources" [43 CFR § 11.83(b)]. If damages are awarded, an account is established for the damages recovered [43 CFR § 11.92], and a restoration plan is developed and implemented using the recovered damages [43 CFR § 11.93]. In this cooperative NRDA, compensation for damages will likely be in the form of habitat and resource restoration. It is anticipated that a restoration plan will be included as part of the Report of Assessment.

1.5 Natural Resource Damage Coordination with Response Actions

The NRDA is proceeding concurrently with the remedial investigation/feasibility study (RI/FS). IEPA is both a Trustee in the NRDA and the lead state official in the RI. Coordination between the RI and the NRDA includes the sharing of data, information, and expertise; consideration of planned or likely remedial actions for determining and quantifying future injuries and damages; and planning NRDA restoration actions that supplement remedial actions.

The results of the baseline ecological risk assessment (BERA) may provide useful information for the NRDA. The information from the BERA may be used to help determine the potential for injury to all of the exposed natural resources, to assess if injury may occur from residual contamination after the response, and to plan for the primary restoration actions.

The goals of such coordination between the NRDA and the RI/FS are to avoid duplication, reduce costs, and achieve common objectives where possible. At a minimum, the Trustees and Chevron intend to consider the objectives of removal actions, RI/FS activities, and remedial actions during the continued planning and implementation of the NRDA. Whenever possible, the parties will explicitly coordinate damage assessment activities with other investigations.

1.6 Public Review and Comment

The Trustees intend for this Assessment Plan to communicate the assessment approach to the public, so that the public can become engaged and actively participate in, or comment on, assessment activities. Public input may also provide the Trustees and Chevron with new information and ideas that they may incorporate into their assessment.

The Assessment Plan is available for public review and comment, as required by 43 CFR § 11.33. The public comment period will last for at least 30 days, with a reasonable extension granted, if appropriate. The public comment period begins on the date the notice of availability is published in the Federal Register. Any comments received by the Trustees, together with responses to those comments, will be included as a part of the Report of Assessment.

Comments on this Assessment Plan may be submitted in writing to:

Mr. Tom Heavisides
Contaminant Assessment Section
Illinois Department of Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271

The Assessment Plan may be modified at any stage of the assessment, as new information becomes available. However, any significant modification to the Assessment Plan will be made available for public comment and review for at least 30 days.

2. Description of the Assessment Area

The Former Indian Refinery encompasses approximately 990 acres south of the City of Lawrenceville, Lawrence County, Illinois (Figures 2.1 and 2.2). The refinery property sits, in part, in the 100-year floodplain for the Embarras River. The site is bounded by various land uses, including residential neighborhoods, cropland, floodplain forest, the Embarras River, and an unnamed northern tributary to Indian Creek (USFWS et al., 2004).

The refinery operations area is that portion of the site where refinery processes historically occurred. It includes the areas where refinery roads, buildings, tanks, pipelines, machinery, and waste disposal sites were located. Several types of habitat or areas of potential natural resource exposure to hazardous substances and/or petroleum products also occur on or near the site. The eastern portion of the refinery includes wetlands and grassland areas. In the northwestern section of the refinery, the land treatment unit (LTU) was used for the treatment of hazardous wastes (Figure 2.2). The LTU is bordered to the west by an unnamed tributary to Indian Creek. The westernmost portion of this unit is an early successional wetland (USFWS et al., 2004).

Indian Acres is a complex of wetlands located in the northeast portion of the site (Figure 2.2). It is hydraulically connected to the Embarras River and is subject to periodic flooding. This area contains floodplain forest, emergent wetlands, and seasonal ponds. Along the eastern and southern portion of the refinery is more floodplain forest, including portions of the refinery property that are not known to have been associated with refinery operations and are located in the 100-year floodplain of the Embarras River. This area includes forest, early successional fields, emergent wetlands, and several oxbow ponds (USFWS et al., 2004).

The Embarras River flows along the eastern border of the refinery property (Figure 2.1). The Embarras River near this area has been channelized for several miles to the north of the City of Lawrenceville, and then again from a point adjacent to the refinery for approximately six miles downstream to the confluence with the Wabash River. The river reach adjacent to the City of Lawrenceville and the northern portion of the site retains some small meanders (USFWS et al., 2004).

2.1 History of the Refinery

The Indian Refining Company completed and began operating the Indian Refinery in Lawrenceville in 1907. The refinery operated from 1907 to 1985, then again from 1990 to 1995. Several important innovations were introduced at the Indian Refinery, including a solvent dewaxing process that led to Havoline Wax-Free motor oil in 1929, and the development of the

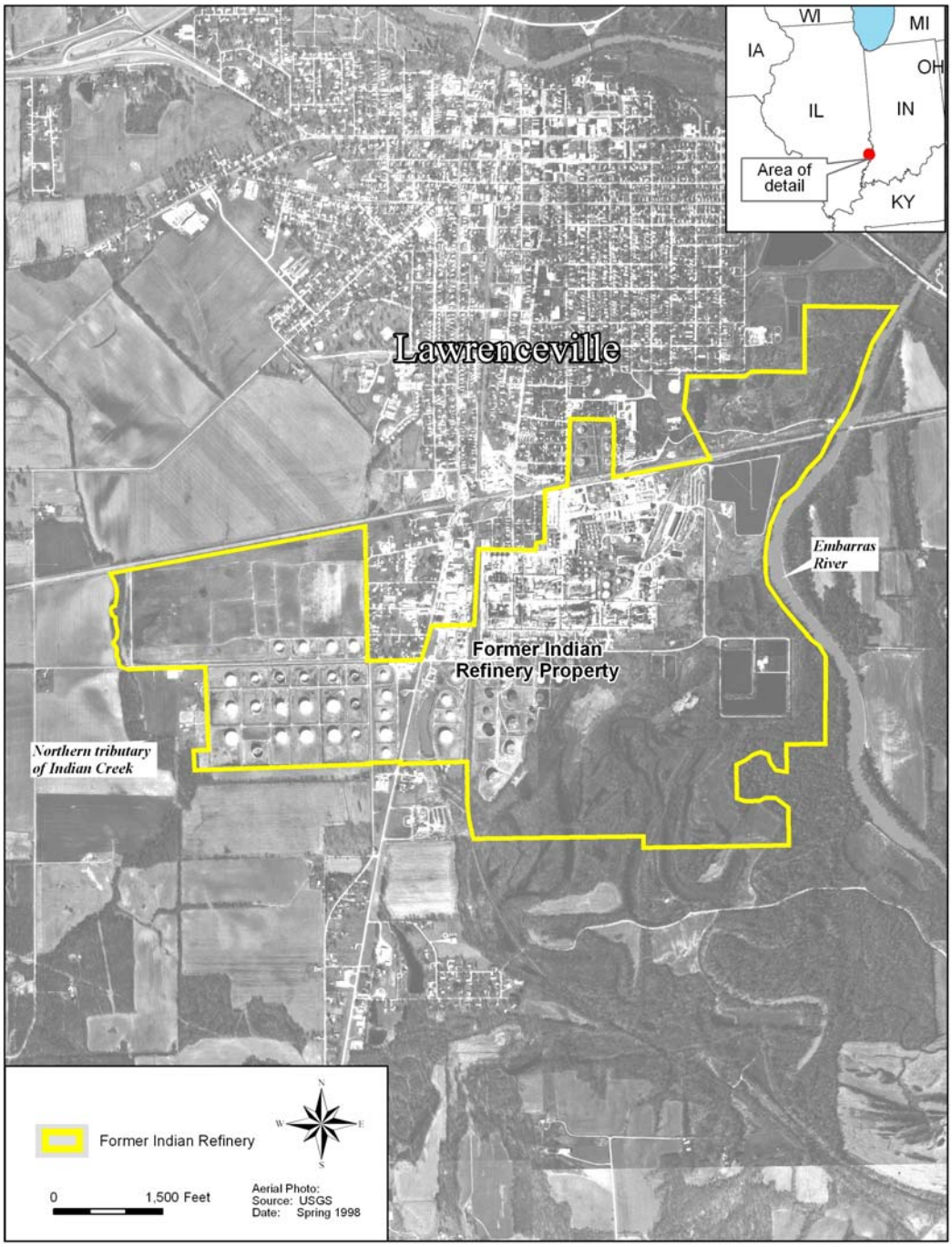

Figure 2.1. The City of Lawrenceville, Illinois, and the Former Indian Refinery property.

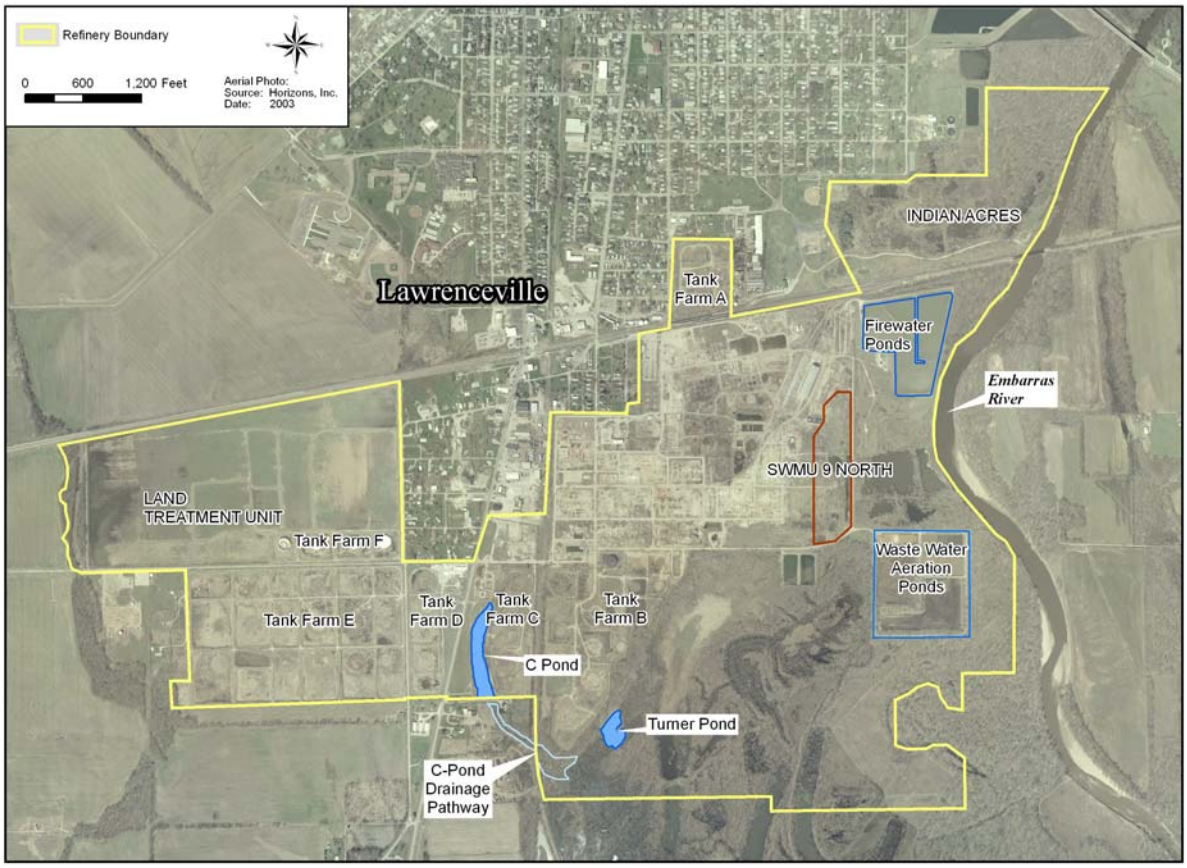

Figure 2.2. The Former Indian Refinery property in Lawrenceville.

first furfural solvent extraction in 1933. The Texas Oil Company (Texaco) purchased a controlling interest in the Indian Refining Company in 1931 and purchased the entire company in 1943 (Hinds, 2001).

The northeastern portion of the property north of the Baltimore and Ohio (B&O) Railroad, an area now known as Indian Acres (Figure 2.2), was dedicated to lube oil refining and production. In the 1950s, lubricant production at the Indian Refinery was discontinued and the manufacturing facility at Indian Acres was dismantled. A small portion of the northern part of Indian Acres was sold to the City of Lawrenceville for the construction of a wastewater treatment plant in the early 1980s (IEPA, 2000; Hinds, 2001).

The refinery continued production of gasoline and motor oils until the 1980s. It closed in 1985, reopened in 1990, and closed permanently in 1995. During the years of operation, the refinery produced various products, including liquid petroleum gas, motor gasoline, aviation gasoline, jet fuel, burner oil, diesel oil, home heating oil, fuel oil, asphalt materials, lube oil, and motor oil. Wastes generated by these operations include oily sludges, leaded tank bottoms, acidic lube oil filter clay, lime sludge, catalyst waste, and tar/asphalt wastes (IEPA, 2000).

When Texaco closed the plant in 1985, refining capacity was 65,000 barrels/day, and it was operating at 76% capacity (WSJ, 1985). The capacity increased to 86,000 barrels/day between 1990 and 1995 (Kovski, 1995). In 1985, Texaco Refining and Marketing Inc. (TRMI), a subsidiary of Texaco, closed the refinery. In 1989, Texaco and its subsidiaries sold the refinery to Castle Energy, who refurbished and reopened the refinery as Indian Refining LP in 1990, then shuttered the facility again in 1995. Castle Energy sold Indian Refining LP and its environmental liabilities to American Western Refining LP (AWR) in late 1995 (Kovski, 1995). AWR never restarted the refinery and filed for bankruptcy in 1996 (Oil & Gas Journal, 1997). In 1997, AWR scrapped the facility.

Remediation history

In 1983 and 1984, the U.S. Environmental Protection Agency (EPA) conducted a CERCLA Preliminary Assessment and Screening Site Inspection at the site. In 1985, Texaco conducted an investigation of the Indian Acres property that revealed that the area had been used as a waste disposal area for lube oil acid sludge and lube oil filter cake sludge, both of which are highly acidic wastes (U.S. EPA, 2005).

In 1986, the IEPA conducted a preliminary review and visual site inspection at the refinery pursuant to the Resource Conservation and Recovery Act of 1976 (RCRA), as amended. The review and inspection identified 33 solid waste management units (SWMUs) at the site. In May 1992, IEPA and Indian Refining signed a consent decree (CD) in which Indian Refining agreed to conduct investigations of the 33 SWMUs (U.S. EPA, 2005).

In June 1996, IEPA placed Indian Acres and the B&O Pond under a Seal Order to restrict access to these contaminated areas (U.S. EPA, 2005).

In October 1996, EPA responded to IEPA's concerns for an immediate removal action at the Hickory Street and Fourth Street properties. EPA provided oversight as Indian Refining completed a partial removal at both properties. EPA returned in October 1997 to complete the removal action at the Fourth Street property (U.S. EPA, 2005).

In November 1996, IEPA approved a Phase I Workplan for work to be completed under the 1992 Consent Decree. Indian Refining Company submitted an incomplete report in June 1997 for the Phase I and Supplemental Workplans' investigations (U.S. EPA, 2005).

Also, in November 1996, the City of Lawrenceville applied for a permit to install a 48-inch corrugated steel sewer line through the contaminated areas at Indian Acres that had been placed under Seal Order. The IEPA denied the application because they felt the sewer line would act as a conduit for promoting the migration of known contaminants within the construction area to the Embarras River (McSwiggin, 1997). In 1997, the City of Lawrenceville violated the Seal Order and installed the sewer line despite IEPA objections, providing the conduit for the migration of contaminants to the Embarras River (U.S. EPA, 2005).

In June 1997, the USFWS discovered an ongoing oil release and an associated contaminated area on the southern part of the refinery property near Tank Farm B (at and near Turner Pond, identified in Figure 2.2). Data from this release are included in Chapter 3, Confirmation of Exposure. The removal action and cleanup activities associated with this release/discharge, which were conducted by EPA, included the following actions (U.S. EPA, 2005):

- Constructing collection pits in the seep area to capture the release/discharge
- Pumping petroleum product and water from collection pits into a refinery-owned and operated onsite oil-water separator
- Removing petroleum product-soaked, contaminated soils, and placing them into one of three onsite bio-cells
- Installing a 760-foot interceptor trench (18 feet deep into a river sand substrate) and a gravity fed collection sump.

EPA completed the construction phase of the removal action and demobilized from the site in January 1998. However, the interceptor trench and sump have remained in operation. The petroleum product and water collected from the interceptor trench is pumped into a collection system and onsite oil-water separator and treatment facility, where the effluent is treated and subsequently discharged into the Embarras River pursuant to a National Pollutant Discharge Elimination System (NPDES) permit (U.S. EPA, 2005).

Demolition of aboveground assets at the refinery began in June 1998, with a demolition schedule through November 2000. In June 1999, EPA, IEPA, and Texaco Inc. entered into an administrative order on consent to perform residential area investigations, an engineering evaluation/cost analysis, and a site-wide RI/FS (U.S. EPA, 2005).

In September 2000, EPA asked IEPA to assume oversight responsibilities for the site under a separate agreement with Texaco, to be considered for signature on December 15, 2000. IEPA accepted this request and completed negotiations with Texaco with signature by December 8, 2000, on a CD. The CD was entered in the United States District Court for the Central District of Illinois on October 1, 2001. Since September 2000, IEPA has taken lead oversight responsibilities for all response activities ongoing at the site (U.S. EPA, 2005).

In June and July 2005, the City of Lawrenceville decommissioned the sewer line that was placed through Indian Acres in 1997. Several sections were removed and sealed to prevent further contaminant migration. A new sewer line was routed around areas of known contamination (SECOR International and Trihydro Corporation, 2005).

2.2 Hazardous Substances Released

The primary ongoing sources of hazardous substances at the Former Indian Refinery are the various refinery wastes or products that were deposited or spilled on site. Areas of waste disposal at the site include Indian Acres, the LTU in the northwestern area of the site, the tank farms, and other areas across the site (see Figure 2.2). In addition, petroleum product, which was most likely released from leaking tanks and pipelines, is present on top of the groundwater of the site.

The waste disposal area at Indian Acres was used for the disposal of lube oil filter clay sludge, acid sludge, and spent filter clay from the former lube oil refinery (Trihydro, 1993). Estimates of the quantity of waste disposed at Indian Acres include 4,500 cubic yards of acid sludge (Trihydro, 1993) and 73,000 cubic yards of lube oil filter clay sludge (Lange, 1986). Crause (1997) reported that leaded tank bottoms (e.g., lead-containing liquid and sludge from the bottom of storage tanks) were also disposed at Indian Acres.

The LTU (also known as the Landfarm), built in the late 1970s, was used for on-site waste processing and disposal. According to CEC (1997), TRMI operated the LTU from 1981 until 1988 and reported that the following RCRA hazardous wastes or petroleum byproducts were placed at the LTU: slop oil emulsion solids, heat exchanger bundles cleaning sludge, API separator sludge, and leaded tank bottoms. In addition, they reported having treated other tank bottoms (hazardous and nonhazardous), wastewater treatment plant sludges, oily soils and sludges, and raw water softening sludge (CEC, 1997).

The areas that formerly contained clusters of petroleum storage tanks, known as tank farms, are sources of hazardous substances as well. Tank bottoms and residual sludges were deposited on the land surrounding the tanks. Estimates of deposited waste on the tank farms include 70 cubic yards of leaded tank bottoms and 1,400 cubic yards of crude sludge placed in Tank Farm B South, 4 cubic yards of leaded tank bottoms placed in Tank Farm B North, and 170 cubic yards

of leaded tank bottoms and 2,800 cubic yards of crude sludge placed on Tank Farm E (Figure 2.2; Lange, 1986).

In 1997, the USFWS discovered that contaminated groundwater from Tank Farm B was being released into the adjacent floodplain forest wetlands. As part of the response action, a total of 10,287 cubic yards of contaminated soils were excavated from the impacted area and placed in on-site bioremediation cells located within tank berms in Tank Farm B. Approximately 11 million gallons of contaminated water was pumped to the oil/water separator during the 16 months of removal activities (USFWS, 1997b). The material released to the wetlands contained benzene, toluene, xylene, methylnaphthalene, naphthalene, 1,3,5-trimethylbenzene, and total petroleum hydrocarbons (U.S. EPA, 2005).

Soil data from the Phase I remedial investigation (Trihydro, 2005) show the presence of heavy metals, benzene, toluene, ethylbenzene, and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), and other organics in soils throughout the site. Hazardous substances and petroleum products released at the refinery include, but are not limited to, those substances and compounds shown in Table 2.1.

Table 2.1. Hazardous substances and/or petroleum products released at the Former Indian Refinery

Class of substances	Hazardous substance and/or petroleum product
Metals	Arsenic and compounds
	Chromium and compounds
	Copper and compounds
	Lead and compounds
	Manganese and compounds
	Mercury and compounds
	Zinc and compounds
Aromatic hydrocarbons	Benzene
	Ethylbenzene
	Toluene
	Xylenes
Polycyclic aromatic hydrocarbons	Acenaphthene
	Anthracene
	Benzo(a)pyrene
	Benzo(a)anthracene

Table 2.1. Hazardous substances and/or petroleum products released at the Former Indian Refinery (cont.)

Class of substances	Hazardous substance and/or petroleum product
Polycyclic aromatic hydrocarbons (cont.)	Benzo(b)fluoranthene
	Benzo(g,h,i)perylene
	Chrysene
	Fluoranthene
	Fluorene
	Indeno(1,2,3-cd)pyrene
	Naphthalene
	Phenanthrene
	Pyrene
	1-Methylnaphthalene
	2-Methylnaphthalene
Other organic contaminants	2-Butanone
	Acetone
	Bis(2-ethylhexyl)phthalate
	Cyclohexane
	Methylene chloride
	Trichlorofluoromethane

Source: Trihydro, 2005.

3. Confirmation of Exposure

This chapter presents data confirming that natural resources have been exposed to hazardous substances and/or petroleum products released from the Former Indian Refinery. The DOI NRDA regulations state that an assessment plan should confirm that:

> at least one of the natural resources identified as potentially injured in the preassessment screen has in fact been exposed to the released substance [43 CFR § 11.37(a)].

A natural resource has been exposed to hazardous substances and/or petroleum products if "all or part of [it] is, or has been, in physical contact with . . . a hazardous substance, or with media containing the . . . hazardous substance" [43 CFR § 11.14(q)]. The DOI NRDA regulations also state that "whenever possible, exposure shall be confirmed using existing data" from previous studies of the assessment area [43 CFR § 11.37(b)(1)].

Hazardous substances and/or petroleum products released from the site include aromatic hydrocarbons, PAHs, organic contaminants such as acetone, and toxic metals such as lead and chromium (see Chapter 2). The following sections provide confirmation of exposure to some of these hazardous substances and/or petroleum products in the assessment area, based on a review of the available data, including data for surface water resources, groundwater resources, geological resources (soils), and biological resources such as birds and floodplain forest vegetation.

3.1 Data Sources

The majority of the exposure data for the Former Indian Refinery has been collected in the past several years as part of remedial activities at the site. Those data have been published in multiple RI documents. SECOR International et al. (2004b) published a compendium of much of the data in 2004, and other data come from interim memoranda (e.g., SECOR International et al., 2004a). These RI data have been compiled into a comprehensive database (Trihydro, 2005), and much of the exposure data cited in this document are from that database.

In addition to RI data, there are some historical studies that provide additional data. These include IEPA's preliminary review and site inspection in 1986 (Lange, 1986), a prioritization plan for investigating SWMUs at the site (Trihydro, 1993), a 1997 Consent Decree Work Plan from CEC (1997), and the hazard ranking document that IEPA produced when they recommended that the site be listed on the NPL (Densmore, 1998). Finally, the USFWS

compiled memoranda that present information on exposure of biological resources to hazardous substances and/or petroleum products (USFWS, 1997b).

3.2 Biological Resources

3.2.1 Definition

Biological resources are defined as those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and state sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition [43 CFR § 11.14(f)].

3.2.2 Potentially injured biological resources

The riverine and floodplain forest habitats surrounding the Former Indian Refinery support a wide variety of biota that may be or have been exposed to hazardous substance and/or petroleum product releases from the refinery. Potentially injured biological resources may include, but are not limited to:

- Riverine, wetland, and floodplain forest fish and wildlife habitats
- Migratory birds
- Threatened or endangered species
- Mammalian and avian species
- Resident fish of various species
- Reptiles and amphibians
- Other aquatic flora and fauna
- Vegetation.

The eastern portions of the Former Indian Refinery lie within the Embarras River floodplain. The primary habitat in these areas is floodplain forest, with interspersed wetlands. The Phase I RI Technical Memorandum (SECOR International et al., 2004b) describes 13 delineated wetlands on the refinery property, totaling approximately 70 acres. Dominant vegetation in the floodplain forest includes silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), eastern cottonwood (*Populus deltoids*), box elder (*Acer interius*), common reed (*Phragmites australis*), and narrow-leaved cattail (*Typha angustifolia*). The leatherflower (*Clematis viorna*), a state endangered species (Table 3.1), has been identified in the floodplain forest between the refinery and the Embarras River (SECOR International et al., 2004b).

Table 3.1. Listed threatened and endangered species and species of concern in the Lawrenceville area

		State of Illinois		Federal		
Common name	**Latin name**	**Endangered**	**Threatened**	**Endangered**	**Threatened**	**Species of concern[a]**
Birds						
American bittern	*Botaurus lentiginosus*	X				
King rail	*Rallus elegans*	X				
Little blue heron	*Egretta caerulea*	X				
Northern harrier	*Circus cyaneus*	X				
Osprey	*Pandion haliaetus*	X				
Yellow-crowned night heron	*Nyctanassa violacea*	X				
Bald eagle	*Haliaeetus leucocephalus*		X		X	
Henslow's sparrow	*Ammodramus henslowii*		X			X
Least bittern	*Ixobrychus exilis*		X			
Cerulean warbler	*Dendroica cerulean*		X			X
Loggerhead shrike	*Lanius ludovicianus*		X			X
Herpetofauna						
Eastern ribbon snake	*Thamnophis sauritus*		X			
Mammals						
Indiana bat	*Myotis sodalis*	X		X		
Aquatic invertebrates – mollusks						
Fat pocketbook pearly mussel	*Potamilus capax*	X		X		
Fanshell	*Cyprogenia stegaria*	X		X		
Kidneyshell	*Ptychobranchus fasciolaris*	X				
Ohio pigtoe	*Pleurobema cordatum*	X				
Ebonyshell	*Fusconaia ebena*		X			
Spike	*Elliptio dilatata*		X			
Butterfly	*Ellipsaria lineolata*		X			
Flowers						
Leatherflower	*Clematis viorna*	X				

a. "Species of concern" is an informal term that refers to those species which USFWS Region 3 believes might be in need of concentrated conservation actions (USFWS, 2006).

Sources: USFWS, 1997a; ELM Consulting, 2002; SECOR International et al., 2004b; INHS, 2005; IDNR, 2006.

The Embarras River has been channelized for several miles both upstream and downstream of the refinery. These channelized reaches are subject to high-energy flow conditions during storm runoff, resulting in sandy substrate. The dominant fish species in the area include mosquitofish (*Gambusia affinis*), bluegill (*Lepomis macrochirus*), bullhead minnow (*Pimephales vigilax*), and several species of shiner (*Cyprinella* spp.). Other fish species found in the Embarras River near the refinery include common carp (*Cyprinus carpio*), gizzard shad (*Dorsoma cepadianum*), river carpsucker (*Carpiodes carpio*), black buffalo (*Ictiobus niger*), bigmouth buffalo (*Ictiobus cyprinellus*), and freshwater drum (*Aplodinotus grunniens*) (SECOR International et al., 2004b).

The floodplain forest habitat near the Former Indian Refinery attracts many species of birds. During the Phase I RI (SECOR International et al., 2004b), a total of 181 bird species were identified in the area of the refinery. Of the 181 bird species identified, 6 species are on the state endangered species list, including the bald eagle, which is on both the state and federal threatened species list, and 5 bird species are on the state threatened species list (Table 3.1).

Herpetofauna surveys conducted during the Phase I RI (SECOR International et al., 2004b) found seven species of frogs and toads, two salamander species, eight snake species, six turtle species, and two skinks in the floodplain forest and the grasslands at the refinery. Of these species, the eastern ribbon snake (*Thamnophis sauritus*) and the copperbelly water snake (*Nerodia erythrogaster neglecta*) were both found to be abundant in the floodplain forest ponds; the eastern ribbon snake is listed as threatened in the State of Illinois (Table 3.1), and the copperbelly water snake is protected in counties of southeastern Illinois [17 IAC 880, Section 880.70].

The Indiana bat, listed on both the state and federal endangered species lists (Table 3.1), is known to occur in Lawrence County. Suitable habitat does occur at the Former Indian Refinery (Gardner et al., 1996).

The mollusk database at the Illinois Natural History Survey (INHS, 2005) shows evidence of 27 species of mussel that have been documented in the Embarras River. Twelve mollusk species have been found living in the river. Fifteen other mollusk species were identified using evidence such as dead individuals, weathered shells, and subfossils. Weathered shells and subfossils of the kidneyshell mussel, which is endangered in Illinois, and the ebonyshell, spike, and butterfly mussels, which are threatened in Illinois (Table 3.1; IDNR, 2006), have been found in the Embarras River (INHS, 2005).

ELM Consulting (2002) conducted a mussel survey in the immediate vicinity of the refinery in 2002. They found shells from 30 different mussel species and live individuals from six species in the survey. They reported finding shells of Ohio pigtoe and kidneyshell mussels, which are endangered in Illinois, and shells of ebonyshell and spike mussels, which are threatened in Illinois (Table 3.1).

The fat pocketbook pearly mussel occurs in the Wabash River upstream and downstream of the Embarras River confluence (USFWS, 1997a). Subfossils and weathered shells of the fanshell mussel were found in the Embarras River upstream of Lawrenceville and in the Wabash River downstream of the Embarras River confluence in the 1980s (Cummings and Mayer, 1995). It is not certain if the fanshell has since been extirpated from the Embarras and Wabash rivers. Both the fat pocketbook and the fanshell are on the state and federal endangered species lists (Table 3.1).

3.2.3 Biological resources exposure

Two of the areas within the refinery property that show indications of biological resource exposure to hazardous substances and/or petroleum products from the refinery are Indian Acres and the area now known as Turner Pond (Figure 3.1).

Figure 3.2 shows a photograph of a waste disposal site in Indian Acres, with broad areas of black tarry sludge at the surface. These sludge areas are devegetated, indicating that vegetation and soil macrofauna in Indian Acres have been exposed to the tarry sludge and have been adversely impacted. Section 3.5 confirms that the soils at Indian Acres contain hazardous substances and/or petroleum products.

The USFWS (1997b) discovered a petroleum release at Turner Pond in May 1997. The release created an area of dead vegetation in the floodplain forest. The USFWS (1997b) stated that the dead vegetation zone where the spill emerged was evident in photographs from 1985. A preliminary assessment and site inspection in June 1997 revealed that the release covered approximately two acres and that a release was still ongoing at the time. According to the USFWS reports of investigation, “On 6/5/97, SA Beiriger [Special Agent Paul Beiriger] spoke to Turner [Kevin Turner, EPA’s On-Scene Coordinator] regarding the AWR discharge site. Turner mentioned that he walked approximately a half mile south of the dead zone and still found oil residue on the trees at about knee height. Turner stated that the material had made its way to the Embarras River in the past” (USFWS, 1997b).

The USFWS (1997b) stated that fluid collected from the release was either gasoline or diesel fuel. Section 3.3 confirms that water samples from this site contain hazardous substances and petroleum products.

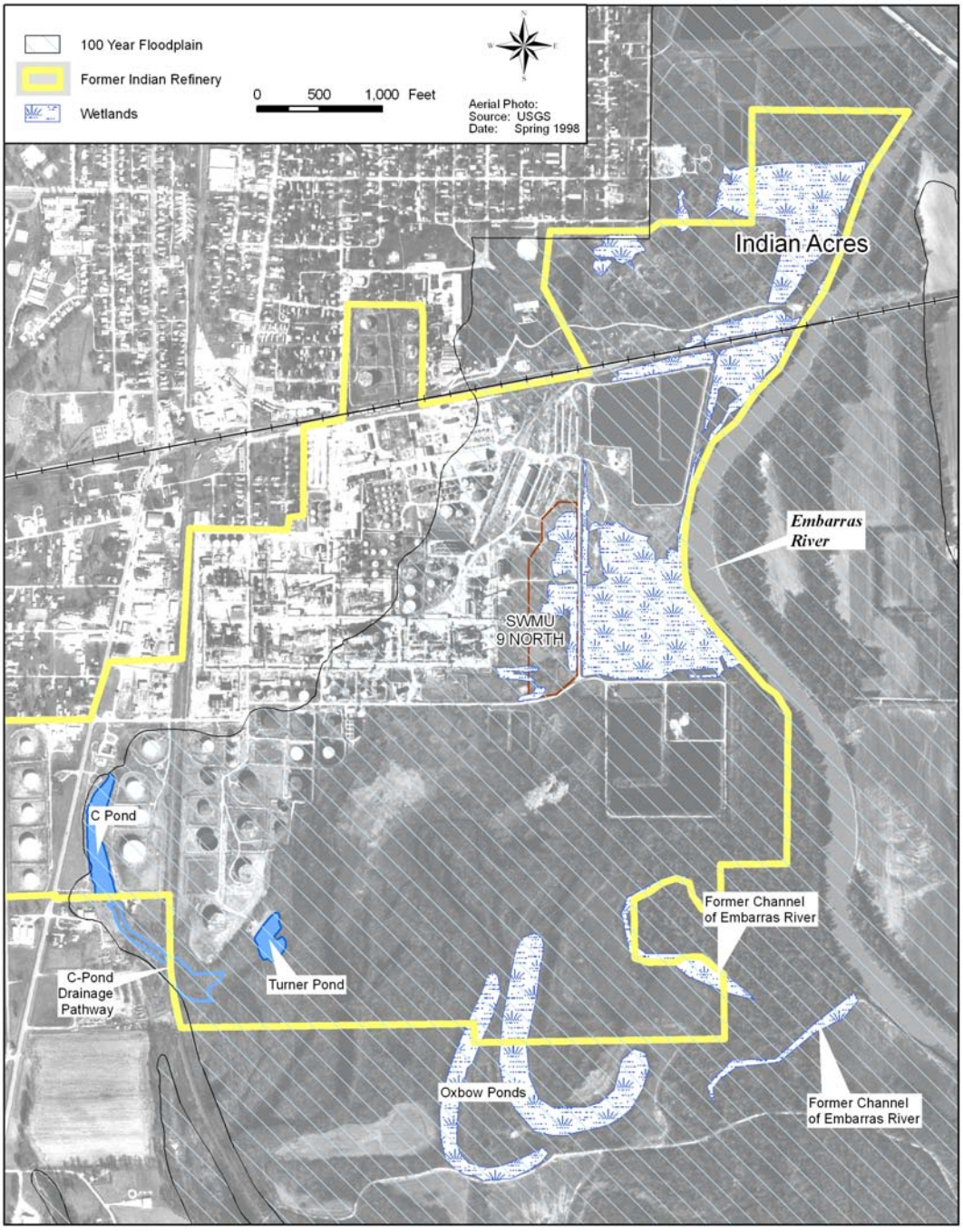

Figure 3.1. The eastern side of the Former Indian Refinery, including areas within the Embarras River floodplain. Turner Pond, the oxbow ponds, and the former Embarras River channel are ponds within the floodplain forest.

Figure 3.2. Lube oil filter clay and acid sludge disposal area in Indian Acres, July 2000 (Greg Ratliff, IEPA).

3.2.4 On-site mortality

In addition to discovering the spill in the floodplain forest, the USFWS (1997b) also discovered dead birds covered with oil at multiple locations on the refinery property in June 1997. At the time of the site inspection, USFWS investigators found 17 oiled bird remains in a large exposed oil collection pit on the eastern side of the refinery, and another four oiled bird remains at C-Pond, at the southern end of the refinery. The 21 dead birds included nine rock doves (*Columba livia),* one mourning dove (*Zenaida macroura*), two brown thrashers (*Toxostoma rufum*), two red-winged blackbirds (*Agelaius phoeniceus*), two common grackles (*Quiscalus quiscula*), two green-backed herons (*Butorides virescens*, or *B. striatus*), one redhead (*Aythya americana*), one American robin (*Turdus migratorius*), and one wood duck (*Aix sponsa*).

During a 2003 herpetological survey, ELM Consulting (2003) found approximately 61 dead birds and one dead snake trapped in a thick, black, asphaltic material located on the surface of the ground throughout Tank Farm A. The dead birds comprised four European starlings (*Sturnus vulgaris*), three northern cardinals (*Cardinalis cardinalis*), 26-29 common grackles, three house sparrows (*Passer domesticus*), five red-winged blackbirds, and 15-17 unidentifiable bird species. The dead snake was a common garter snake (*Thamnophis sirtails*).

3.3 Surface Water Resources

3.3.1 Definition

Surface water resources are defined as the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas. This term does not include groundwater or water or sediments in ponds, lakes, or reservoirs designed for waste treatment under RCRA [42 USC 6901-6987] or the CWA, and applicable regulations [43 CFR § 11.14(pp)].

3.3.2 Potentially injured surface water resources

In the assessment area, potentially injured surface water and associated sediments include, but are not limited to:

- The Embarras River from the northeastern border of the refinery at Indian Acres (Figures 2.1, 2.2, 3.1) to the confluence with the Wabash River
- An unnamed northern tributary to Indian Creek from the western border of the refinery (Figure 2.1) to the confluence with Indian Creek
- Indian Creek from the confluence with the unnamed northern tributary to the confluence with the Embarras River
- The Wabash River downstream of the confluence with the Embarras River
- Ponds and inundated areas located at Indian Acres (Figure 3.1)
- Turner Pond (Figures 2.2, 3.1)

- The inundated channel of the C-Pond drainage pathway (Figures 2.2, 3.1)
- Wetlands and oxbow ponds located within the floodplain forest adjacent to the Embarras River (Figure 3.1).

These resources provide ecological services such as habitat for aquatic biota and a water supply for riparian vegetation habitat. In addition, the surface water is a likely transport pathway for carrying contaminants downstream of the refinery. The Embarras River floods on a regular basis for weeks at a time (SECOR International et al., 2004b), inundating many areas of the former refinery, including areas of known contamination. Areas known to be inundated during Embarras River flooding include Indian Acres and the floodplain forest east of the refinery (Figure 3.1).

3.3.3 Surface water exposure

The 1997 Turner Pond release that exposed vegetation to hazardous substances and/or petroleum products (Section 3.2.3) also exposed surface water resources to hazardous substances and/or petroleum products. The USFWS (1997b) stated that fluid collected from the release was either gasoline or diesel fuel. Analysis of surface water samples collected from the spill revealed the presence of benzene, toluene, xylene, methylnaphthalene, naphthalene, 1,3,5-trimethylbenzene, and total petroleum hydrocarbons (U.S. EPA, 2005).

Surface water data from the RI show exposure of on-site surface water to hazardous substances and/or petroleum products. Table 3.2 shows some example concentrations of PAHs in surface water collected from a wetland in SWMU 9 North, the C-Pond drainage pathway, and an ephemeral pond in Indian Acres (Figure 3.1). The data shown in Table 3.2 are examples of hazardous substance and/or petroleum product concentrations measured in surface water and do not represent a comprehensive evaluation of surface water exposure resulting from site releases.

Surface water samples were collected from the Embarras River during three RI sampling events. In September 2003, three samples were collected from the eastern bank of the Embarras River immediately upstream of the wastewater aeration ponds (see Figure 2.2). In November 2003, three more samples were collected from the western bank adjacent to the wastewater aeration ponds. Finally, in September 2004, three samples were collected approximately one mile downstream of the refinery. The summary PAH data for those nine samples are shown in Table 3.3. These data do not include a consideration of baseline conditions, which are the conditions that would be present without releases from the site. The presence of PAHs in the lower Embarras River is expected due to the presence of oil production activity in southeast Illinois. Not all sources of PAHs to the Embarras River have been identified. Baseline conditions will be assessed as part of the injury assessment described in Chapter 4.

Table 3.2. Example concentrations of PAHs in surface water from three locations at the Former Indian Refinery. Concentrations in ng/L.

	Location (see Figure 3.1)		
Analyte	**SWMU 9 North wetlands**	**C-Pond drainage pathway**	**Indian Acres ephemeral pond**
Acenaphthylene	25	7.6	ND
Anthracene	170	13	0.86
Benzo(a)anthracene	32	ND	ND
Benzo(a)pyrene	67	25	33
Benzo(b)fluoranthene	36	21	22
Benzo(g,h,i)perylene	120	25	47
Benzo(k)fluoranthene	9.4	16	ND
Chrysene	320	23	81
Dibenz(a,h)anthracene	33	5.5	21
Fluoranthene	ND	16	ND
Indeno(1,2,3-cd)pyrene	30	17	16
Pyrene	56	85	4.9
Sum of listed PAHs	**898.4**	**254.1**	**225.8**

ND = not detected.

Source: Trihydro, 2005.

The data in Table 3.3 confirm exposure of the Embarras River to PAHs. Anthracene was detectable in all nine samples, and acenaphthylene and benzo(a)anthracene were detectable in six of nine samples. Fluoranthene and benzo(k)fluoranthene were detected at concentrations higher than 20 ng/L, and pyrene was as high as 19 ng/L.

3.3.4 Sediment exposure

Sediment data from the RI also show exposure of sediments at the refinery to hazardous substances and/or petroleum products. Table 3.4 shows example PAH concentrations from sediment samples collected as part of RI activities in SWMU 9 North, the firewater ponds, and the C-Pond drainage pathway (see Figure 2.2). In these samples, many different PAHs were present at detectable concentrations, indicating the exposure of these areas to hazardous substances and/or petroleum products.

Table 3.3. Average concentration of detectable PAHs in the Embarras River adjacent to and downstream of the Former Indian Refinery, 2003-2004. Three samples were collected adjacent to the refinery in September 2003; three more were collected in November 2003; and three were collected approximately one mile downstream of the refinery in September 2004.

PAH	Number of samples	Number of detections	Average concentration of detections (ng/L)	Maximum detected concentration (ng/L)
Acenaphthene	9	3	1.1	1.5
Acenaphthylene	9	6	1.7	1.9
Anthracene	9	9	1.4	3.4
Benzo(a)anthracene	9	6	2.5	4.2
Benzo(a)pyrene	9	4	10.1	16
Benzo(b)fluoranthene	9	3	8.2	8.4
Benzo(g,h,i)perylene	9	2	3.7	5.8
Benzo(k)fluoranthene	9	5	11.8	21
Chrysene	9	3	11.3	12
Fluoranthene	9	3	19.7	24
Indeno(1,2,3-cd)pyrene	9	5	2.4	4.3
Phenanthrene	9	2	9.6	12
Pyrene	9	3	18.3	19

Source: Trihydro, 2005.

The data shown in Table 3.4 are examples of hazardous substance and/or petroleum product concentrations measured in sediment and do not represent a comprehensive evaluation of sediment exposure at the site. The Report of Assessment will provide a thorough review of available data quantifying exposure to natural resources, including a consideration of baseline conditions.

3.4 Groundwater Resources

3.4.1 Definition

Groundwater is defined as water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which groundwater moves. It includes groundwater resources that meet the definition of drinking water supplies [43 CFR § 11.14(t)].

Table 3.4. Example concentrations of PAHs in sediment from three locations at the Former Indian Refinery. Concentrations in mg/kg dry weight.

	Location		
Analyte	**SWMU 9 North**	**Firewater Ponds[a]**	**C-Pond Drainage Pathway**
1-Methylnaphthalene	ND	0.17	0.022
2-Methylnaphthalene	0.36	0.45	0.035
Acenaphthene	0.21	0.045	0.022
Acenaphthylene	1.5	0.18	0.051
Anthracene	6.5	2.2	0.12
Benzo(a)anthracene	1.4	0.51	0.29
Benzo(a)pyrene	2.3	0.52	0.32
Benzo(b)fluoranthene	1.8	0.42	0.29
Benzo(b)pyridine	0.23	0.0061	0.0085
Benzo(g,h,i)perylene	2.1	0.35	0.31
Benzo(k)fluoranthene	0.73	0.39	0.21
Chrysene	6.7	2.7	0.42
Dibenz(a,h)anthracene	0.72	0.096	0.082
Fluoranthene	2.3	0.31	0.21
Fluorene	0.2	0.21	ND
Indeno(1,2,3-cd)pyrene	0.68	0.28	0.2
Naphthalene	0.26	0.34	0.041
Phenanthrene	0.55	0.76	0.065
Pyrene	1.4	0.39	0.36
Sum of listed PAHs	**29.9**	**10.3**	**3.1**

ND = not detected.

a. The firewater ponds are shown in Figure 2.2.

Source: Trihydro, 2005.

3.4.2 Potentially injured groundwater resources

Groundwater in the Lawrenceville area provides drinking water to many private wells. In addition, the City of Lawrenceville pumps groundwater from a well field approximately five miles east of the Former Indian Refinery. Shallow groundwater underlies most of the assessment area and is a potentially injured natural resource. In addition, the groundwater acts as a potential hazardous substance transport pathway to surface water resources, such as the Embarras River and the Indian Creek tributary that border the site to the east and the west, respectively, and to the floodplain forest habitat surrounding the southern and eastern portions of the site.

3.4.3 Groundwater exposure

Groundwater underlying the Former Indian Refinery has been monitored extensively as part of RI activities. Light non-aqueous phase liquid (LNAPL) was found on top of the groundwater at multiple wells at the refinery, indicating migration of petroleum products from the refinery to the groundwater. These wells generally were not sampled for dissolved hazardous substances. However, dissolved hazardous substances such as metals and BTEX were found in many wells where LNAPL did not prevent sampling. SECOR International et al. (2004b) created a preliminary map of contaminated groundwater plumes at the facility. These plumes are included in the RI database (Trihydro, 2005) and are presented in Figure 3.3.

Summaries of some concentrations of hazardous substances and/or petroleum products measured in the groundwater are provided in Table 3.5. The data shown in Table 3.5 are examples of hazardous substance and/or petroleum product concentrations measured in groundwater and do not represent a comprehensive evaluation of groundwater exposure at the site. The Report of Assessment will provide a thorough review of available data quantifying exposure to groundwater.

3.5 Geologic Resources

3.5.1 Definition

Geologic resources are defined as those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of groundwater and surface water resources [43 CFR § 11.14(s)].

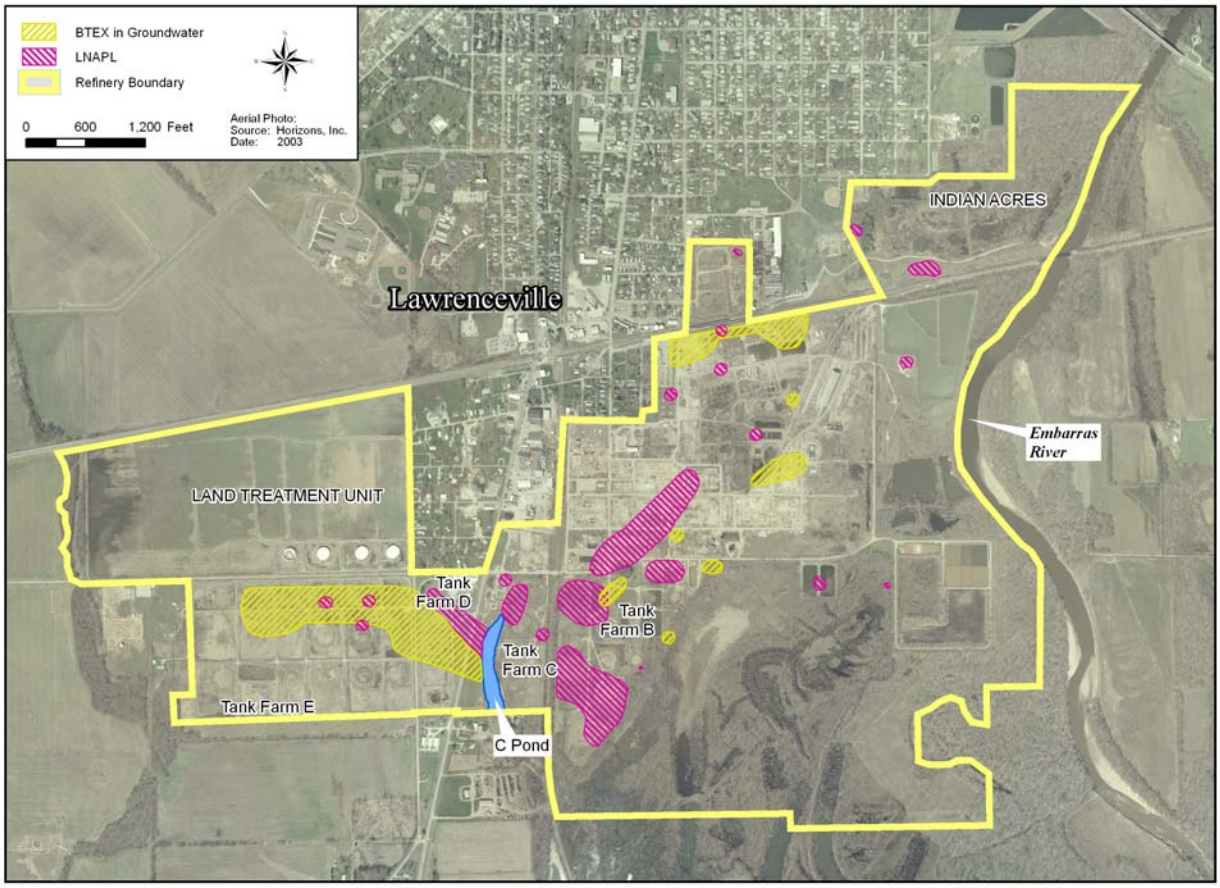

Figure 3.3. LNAPL and BTEX plumes in groundwater under the Former Indian Refinery, as designated by SECOR in the Phase I RI.

Sources: SECOR International et al., 2004b; Trihydro, 2005.

Table 3.5. Selected hazardous substances and/or petroleum products in groundwater under the Former Indian Refinery. For sample sites that have had multiple detections for a given analyte, the average detected concentration is provided.

Location	Well ID	Analyte	# samples	Concentration (mg/L)
Near the refinery boundary	P-MW-10	Benzene	8	0.035
		Phenol	1	0.0064
	P-MW-12	1,1-Dichloroethylene	5	0.023
		Benzene	10	0.05
		Pentachlorophenol	3	0.03
		Phenol	1	0.004
	P-MW-5	Benzo(a)pyrene	1	0.00049
	P-MW-7	Benzene	1	2.3
		Phenol	1	0.023
	P-MW-8	Benzene	2	0.030
Tank Farm B	TANKB-MW-01	Benzene	4	1.35
		Phenol	3	0.033
	TANKB-MW-04	Benzene	4	0.113
		Ethylbenzene	2	1.05
		Phenol	1	0.0044
	TANKB-MW-10	Benzene	1	0.086
		Phenol	1	0.016
Tank Farm C	TANKC-MW-01	Benzene	3	0.14
	TANKC-MW-04	Benzene	3	1.14
	TANKC-MW-09	Benzene	2	3.55
		Ethylbenzene	2	9.1
		Toluene	2	38.5
		Xylenes	2	59
Tank Farm D	TANKD-MW-02	Benzene	5	3
		Toluene	5	1.5
	TANKD-MW-05	Benzene	1	0.1
	TANKD-MW-10	Benzene	1	2.3
		Ethylbenzene	1	1.1
	TANKD-MW-11	Benzene	1	3.6
		Ethylbenzene	1	1.4

Table 3.5. Selected hazardous substances and/or petroleum products in groundwater under the Former Indian Refinery (cont.). For sample sites that have had multiple detections for a given analyte, the average detected concentration is provided.

Location	Well ID	Analyte	# samples	Concentration (mg/L)
Tank Farm E	TANKE-MW-01	Benzene	5	10
		Ethylbenzene	5	2
	TANKE-MW-02	Benzene	5	3.2
	TANKE-MW-03	Benzene	5	9.2
		Ethylbenzene	5	2.4
		Toluene	5	7
	TANKE-MW-08	Benzene	5	0.63
	TANKE-MW-09	Benzene	5	2.3
		Toluene	5	1.7
	TANKE-MW-10	Benzene	2	0.068
	TANKE-MW-11	Benzene	1	0.19
	TANKE-MW-14	Benzene	1	0.67
		Ethylbenzene	1	1.4
	TANKE-MW-15	Benzene	1	0.28

Source: Trihydro, 2005.

3.5.2 Potentially injured geologic resources

Geologic resources at the site include potentially injured soils on site and within the floodplain forest habitat surrounding the site. These soils are important in providing a medium for vegetation, invertebrates, microbes, and other biota. Under flooding conditions, contaminated floodplain soils can expose aquatic biota and/or surface water resources to hazardous substances. In addition, soils can serve as a pathway to groundwater via percolation of hazardous substances from contaminated surface soils to the underlying aquifer.

3.5.3 Geologic resources exposure

Waste disposal at Indian Acres (see Figure 3.1) has resulted in exposure of soils to hazardous substances and/or petroleum products. In addition to showing exposure of biota, Figure 3.2 also shows that soils in Indian Acres have been exposed to contaminant releases. Table 3.6 shows concentrations of metals and PAHs in soil samples from the tarry waste in Indian Acres. The IEPA (Densmore, 1998) reported PAH concentrations up to 180 mg/kg for benzo(a)pyrene, 170 mg/kg for benzo(a)anthracene, 510 mg/kg for chrysene, and 80 mg/kg for phenanthrene (Table 3.6).

RI data collected in June 2003 from soils in SWMU 9 North (Figure 3.1) also indicate exposure to hazardous substances and/or petroleum products. Table 3.7 shows concentrations of metals, PAHs, and/or BTEX in three example soil samples collected from the top 3 ft of soil. Sample U9N-SB010, collected from a depth of 2-3 ft, contained 6,370 mg/kg lead, 546 mg/kg zinc, and approximately 80 mg/kg total PAHs. Sample U9N-SB012, collected at the surface, contained 638 mg/kg lead, 425 mg/kg manganese, 277 mg/kg zinc, and approximately 62 mg/kg total PAHs. Sample U9N-SB014, collected from a depth of 1-2 ft, contained 359 mg/kg lead, 497 mg/kg manganese, 136 mg/kg total PAHs, and 4.2 mg/kg total BTEX (Table 3.7).

The data shown in Table 3.7 are examples of hazardous substance and/or petroleum product concentrations measured in soils at the site and do not represent a comprehensive evaluation of soil exposure. The Report of Assessment will provide a thorough review of available data quantifying exposure to natural resources.

3.6 Conclusions

The previous sections provide analytical chemistry data and other evidence from the site that confirm exposure of natural resources to hazardous substances and/or petroleum products released from the Former Indian Refinery. Resources that have been exposed to hazardous substances and/or petroleum products include biological resources such as the vegetation and biota in floodplain forest and wetland habitats, and biota exposed directly to oil and asphaltic material on the site. Surface water (including sediments), groundwater resources, and soils have also been exposed to hazardous substances and/or petroleum products at the site. A more thorough review of the data sources (Section 3.1) will occur as part of the injury assessment, and the exposure data contained within those data sources will be used in this NRDA.

Table 3.6. Indian Acres tarry waste sample data

Sample ID	Analyte	Concentration (mg/kg dry weight unless otherwise specified)
X111	Acetone	1.2
	Carbon disulfide	0.018
	2-butanone	0.83
	2-hexanone	0.36
	4-methyl-2-pentanone	0.017
	Chrysene	510
	Benzo(a)anthracene	150
	Benzo(a)pyrene	180
	pH (std units)	1.1
X115	Acetone	1.7
	Chrysene	430
	Benzo(a)anthracene	170
	pH (std units)	1
X120	Acetone	2.3
	2-butanone	1.5
	Phenanthrene	80
	Chrysene	170
	Cadmium	2.9
	pH (std units)	1

Source: Densmore, 1998.

Table 3.7. Example concentrations (mg/kg dry weight) of hazardous substances and/or petroleum products in three samples of SWMU 9 North soils

	Analyte	U9N-SB010	Qualifier	U9N-SB012	Qualifier	U9N-SB014	Qualifier
Metals	Chromium, total	44.4	J	139		20.6	J
	Lead, total	6,370	J	638		359	J
	Manganese, total	191	J	425		497	J
	Zinc, total	546	J	277		84.2	J
PAHs	1-Methylnaphthalene	NA		NA		38	J
	2-Methylnaphthalene	3.1	J	1.8		52	
	Acenaphthene	0.44	J	ND(12)		ND(23)	
	Anthracene	1	J	ND(12)		ND(23)	
	Benzo(a)anthracene	6.4	J	2.9		2.4	
	Benzo(a)pyrene	18	J	6.1		1.3	
	Benzo(b)fluoranthene	ND(2)	UJ	3.9		1.7	
	Benzo(g,h,i)perylene	6.6	J	4.1		ND(23)	
	Chrysene	16	J	29		14	
	Dibenz(a,h)anthracene	1.9	J	3.2		ND(23)	
	Dibenzofuran	0.37	J	ND(12)		ND(23)	
	Fluoranthene	1.2	J	1		ND(23)	
	Fluorene	0.56	J	ND(12)		1.4	
	Indeno(1,2,3-cd)pyrene	1.6	J	1.3		ND(23)	
	Naphthalene	0.88	J	ND(12)		6.6	
	Phenanthrene	3.5	J	5		12	
	Pyrene	18	J	3.5		6.5	
	Sum of listed PAHs	79.6		61.8		135.9	
BTEX	Benzene	ND(0.0092)		0.0029		0.21	J
	Ethylbenzene	ND(0.0092)		0.012		0.88	J
	Toluene	ND(0.0092)		0.01		0.16	J
	Xylenes	ND(0.0092)		0.061		2.9	J
	Sum of BTEX	ND		0.0859		4.2	

ND = not detectable (detection limit); NA = not analyzed; J = estimated value; UJ = not detectable.

Source: Trihydro, 2005.

4. General Assessment Approach

The NRDA regulations at 43 CFR Part 11 specify three stages of the assessment: injury determination, injury quantification, and damage determination. This NRDA will follow the guidance in the regulations.

This chapter first explains the details of the three stages of an assessment according to the regulations (Sections 4.1 and 4.2). It then discusses equivalency models that will be used to scale appropriate restoration projects to offset the injury resulting from hazardous substance and/or petroleum product releases (Section 4.3). Chapter 5 provides details about the assessment approach for specific areas and specific resources at the Former Indian Refinery, based on the framework presented in this chapter.

4.1 Definitions

This section presents the resource-specific injury definitions contained in the DOI regulations for conducting an NRDA. The DOI NRDA regulations define injury as "a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a . . . release of a hazardous substance, or exposure to a product of reactions resulting from the . . . release of a hazardous substance. As used in this part, injury encompasses the phrases 'injury,' 'destruction,' or 'loss'" [43 CFR § 11.14(v)]. Since assessment procedures set forth in 43 CFR Part 11 are not mandatory and the regulations do not exclude the use of other injury definitions [43 CFR § 11.10], other definitions of injury such as injuries to wildlife from loss of habitat may also be applied.

In general, injuries in the assessment will be quantified in comparison to baseline conditions, and compensation (restoration) will be based on the results of the injury assessment. Baseline conditions are defined as "the conditions that would have existed at the assessment area had the discharge of oil or the release of the hazardous substances under investigation not occurred" [43 CFR § 11.14(e)].

4.1.1 Surface water injury

The DOI NRDA regulations define surface water resources as surface water and suspended, bed, and bank sediments [43 CFR § 11.14(pp)]. The relevant definitions of injury to surface water resources include:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411-1416 of the Safe Drinking Water Act (SDWA), or by other federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)].

- Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

- Concentrations and duration of hazardous substances sufficient to have caused injury to groundwater, air, geologic, or biological resources, when exposed to surface water [43 CFR § 11.62(b)(1)(v)].

The relevant injury thresholds for surface water in the assessment area may include hazardous substance and/or petroleum product concentrations in excess of the EPA aquatic life criteria (Section 304 of CWA) and/or the Illinois aquatic life standards for surface water [35 Ill. Adm. Code 302]. Currently, there are no promulgated criteria that can be used as a threshold for injury to surface water for many of the hazardous substances and/or petroleum products released from the site, and there are no promulgated criteria for hazardous substances or petroleum products in sediment. Chapter 5 describes a toxicological data analysis for hazardous substances and petroleum products released from the site that will be used to determine injury to surface water and sediment.

4.1.2 Groundwater injury

Groundwater resources include water beneath the surface of land or water and the rocks or sediment through which it moves, and include any groundwater that meet the definition of drinking water supplies [43 CFR § 11.14(t)], which are any raw or finished water sources that may be used by the public or by one or more individuals [43 CFR § 11.14(o)].

The relevant injury definitions for groundwater resources include the following:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [43 CFR § 11.62(c)(1)(i)].

- Concentrations and duration of hazardous substances sufficient to have caused injury to other resources when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

The Trustees and Chevron will define specific groundwater injury thresholds as part of the assessment. Relevant injury thresholds for groundwater may include concentrations in excess of Sections 1411-1416 of the SDWA and/or Illinois Class I drinking water standards for groundwater [32 Ill. Adm. Code 620]. However, many of the hazardous substances and/or petroleum products to which groundwater is exposed at the Former Indian Refinery are immiscible with and less dense than water, and therefore float on top of the groundwater. Monitoring wells with floating LNAPL product on the groundwater are often not sampled, as the process of pumping the well could mix more contaminants into the groundwater. Therefore, groundwater injury criteria for the site may include the presence of LNAPL on top of the groundwater, as well as concentrations of hazardous substances and/or petroleum products in the groundwater exceeding relevant criteria.

4.1.3 Geologic resources injury

Geologic resources include soils, sediments, rocks, and minerals that are not included in the definitions of ground and surface water resources [43 CFR § 11.14(s)]. The relevant injury definitions for geologic resources include the following:

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62(e)(9)]
- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62(e)(10)]
- Concentrations of substances sufficient to have caused injury to surface water, groundwater, air, or biological resources, when exposed to geologic resources [43 CFR § 11.62(e)(11)].

Currently there are no promulgated criteria that can be used as soil injury thresholds for many of the hazardous substances and petroleum products released from the site. Chapter 5 describes a toxicological data analysis on the hazardous substances and/or petroleum products released from the site that will be used to determine injury to soils.

4.1.4 Biological resources injury

Biological resources include fish, wildlife, vegetation, and other biota. More specifically, biological resources relevant to the Former Indian Refinery include freshwater aquatic species including fish, shellfish, and aquatic plants; terrestrial species including plants, birds, and wildlife; game, nongame, and commercial species; and threatened, endangered, and state sensitive species [43 CFR § 11.14(f)].

The relevant injury definitions for biological resources include the following:

- Concentrations of substances sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(i)]

- Concentrations of substances sufficient to exceed action or tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 USC 342, in edible portions of organisms [43 CFR § 11.62(f)(ii)]

- Concentrations of substances sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban consumption of such organism [43 CFR § 11.62(f)(iii)].

Mortality is known to have occurred at the site as a result of hazardous substance and/or petroleum product releases (Chapter 3). The applicability of the other definitions of injury to biota will be addressed during the assessment and will be included in the Report of Assessment.

4.2 Assessment Stages

The purpose of the assessment phase is to:

1. Determine whether injuries to natural resources have occurred [43 CFR § 11.62]

2. Identify the environmental pathways through which injured resources have been exposed to hazardous substances and/or petroleum products released from the site [43 CFR § 11.63]

3. Quantify the degree and extent (spatial and temporal) of injury in terms of a reduction of the quantity and quality of services from baseline conditions [43 CFR § 11.70]

4. Establish appropriate compensation for those injuries [43 CFR § 11.80].

As noted previously, it is anticipated that compensation for hazardous substance and/or petroleum product releases at the Former Indian Refinery will be in the form of habitat restoration in the vicinity of Lawrenceville.

The NRDA regulations at 43 CFR Part 11 list several steps that should be taken during the assessment phase of a Type B NRDA. The remainder of this section describes the details of the assessment stages according to the NRDA regulations. Chapter 5 then explains how these steps will be undertaken in the Former Indian Refinery NRDA.

4.2.1 Injury determination

According to the DOI NRDA regulations, injury determination includes the following two components:

1. **Determination that injury has occurred.** The assessment determines whether injuries that meet the definitions of injury (see Section 4.1) have occurred.

2. **Pathway determination.** The assessment determines whether sufficient exposure pathways exist (or have existed) by which hazardous substances and/or petroleum products are (or were) transported in the environment, resulting in natural resource exposure to those substances [43 CFR § 11.63]. Pathways can be determined using a combination of information about the nature and transport mechanisms of the hazardous substances and/or petroleum products, potential pathways, and data documenting the presence of the hazardous substances and/or petroleum products in the pathway resource.

4.2.2 Injury quantification

Quantification of injuries to natural resources is conducted to provide information that is relevant to quantifying damages. Injury quantification includes several components:

1. **Characterization of baseline conditions.** The injuries determined in the injury determination phase are quantified in terms of changes in natural resources and the services they provide from baseline conditions [43 CFR § 11.71(b)(2)]. The DOI NRDA regulations suggest using historical data to evaluate baseline conditions, if they are available [43 CFR § 11.72(c)]. Where historical data are not available, data from control areas may be used [43 CFR § 11.72(d)].

2. **Quantification of spatial and temporal extent of injuries.** Contaminant data and historical records can help determine the spatial and temporal extent of injuries to natural resources. Tools such as geographic information systems may be used to facilitate spatial quantification.

3. **Quantification of service losses.** The natural resource services lost as a result of the hazardous substances and/or petroleum product releases are quantified by comparison to services provided under baseline conditions [43 CFR § 11.71(b)].

4. **Estimation of recovery to baseline.** An estimate is needed of the time required for the recovery of injured resources and the services they provide to baseline levels. This evaluation includes an estimate of recovery time if no actions beyond response actions are taken, and estimates of recovery time under possible alternatives for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources [43 CFR § 11.73].

4.2.3 Damage determination

Determination of damages may include the following:

1. **Valuation of natural resources.** Cost estimation or valuation methodologies are used to estimate the value of the resources and/or services lost because of injury [43 CFR § 11.83].

2. **Selection of alternatives for restoration.** Alternatives for potential restoration options to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources are developed and selected [43 CFR § 11.82].

3. **Development of the RCDP**. The RCDP lists possible restoration alternatives and the methodologies for determining the costs of different alternatives and the compensable value of the services lost to the public [43 CFR § 11.81]. If existing data are insufficient for developing the RCDP when the Assessment Plan is published, it may be published separately after the injury assessment is completed [43 CFR § 11.81(c)].

The selection of restoration alternatives to compensate for losses caused by the injuries requires a means of ensuring that the scale of the restoration projects is commensurate with the amount of past and future injuries resulting from the hazardous substance and/or petroleum product releases. This NRDA will use habitat equivalency analysis (HEA), resource equivalency analysis (REA), and groundwater equivalency analysis (GWEA) to determine the appropriate amount and type of restoration to compensate for natural resource injuries, as described in Section 4.3.

4.3 Equivalency Analyses

This cooperative assessment will use service-to-service or resource-to-resource scaling approaches (HEA, REA, GWEA), wherein restoration alternatives are selected and scaled such that services or resources of the same type, quality, and value as those lost to injury are provided by the selected restoration. Natural resource services are defined as the physical, chemical, and biological processes through which ecosystems support and sustain all life, including human life (Allen et al., 2005). Example resource services include physical habitat, nutrient and energy cycling, food web interactions, flood control, groundwater recharge, and recreation [43 CFR § 11.71(e)]. The injury assessment provides the degree and spatial and temporal extent of resource service losses, and the HEA, REA, and GWEA models provide a method for determining equivalent restoration to offset the injuries.

The three types of equivalency analyses are described in the three following sections.

4.3.1 Habitat equivalency analysis

HEA was developed by the U.S. National Oceanic and Atmospheric Administration (NOAA) and has been applied by many natural resource trustees to determine the amount of restoration needed to compensate for losses of natural resources resulting from oil spills, hazardous substance releases, or physical injuries such as vessel groundings or construction impacts from remedial activities. Restoration is scaled so that the natural resource service gains provided at compensation sites equal the cumulative service losses at the injured site, where services are defined as the physical, chemical, or biological functions that one resource provides for another (NOAA, 2000; Allen et al., 2005; Cacela et al., 2005). Thus, HEA is used to determine the amount of restoration that is required to compensate for past, current, and future (i.e., residual to any cleanup) injuries.

A benefit of HEA is that it explicitly creates a connection between services lost because of injury and services gained through restoration. The connection provides a clear demonstration to the public that the trustees have fulfilled their mandate of compensating the public for the interim losses of natural resources and their services. The implicit assumption of HEA is that the public can be compensated with direct service-to-service scaling, where the services provided by proposed restoration actions are of similar type, quality, and value as the services lost because of injury (NOAA, 2000; Allen et al., 2005).

HEA is based on the ecological and human use services that habitat provides, such as physical habitat, food web interactions, and recreation [43 CFR § 11.71(e)]. Injuries are quantified as the percent of services provided by natural resources that are lost as a result of the hazardous substance release. IDNR ecologists and other experts with knowledge of the aquatic and

terrestrial ecology of the lower Embarras River valley will assist the Trustees and Chevron in quantifying these natural resource services near the refinery. The Trustees and Chevron will review toxicological literature and determine a method for scaling service loss based on concentrations of hazardous substances in surface water, sediment, and soil as well as other relevant information (see Chapter 5).

The information required to quantify the habitat service loss (or HEA "debits") includes (1) time periods of injury, including evaluation of the effect of response activities and scenarios for future losses if necessary; (2) spatial extent of injury; (3) quantification of lost services over space and time compared to baseline conditions; and (4) a discount rate (typically 3%). Debits are commonly expressed in units that describe space, time, and discount rate. A typical HEA unit is discounted service acre-years (DSAYs).

In the scaling calculations, the Trustees and Chevron will incorporate temporal information, including what level of service loss may have existed in the past, and how quickly the natural resources are expected to recover to baseline conditions in the future under different remediation scenarios. For past losses, losses will be quantified starting when the release began or December 1980 (CERCLA enactment), whichever is later. To assess future recovery to baseline, estimates of potential RI/FS response actions will be used to predict a rate of recovery. However, a record of decision detailing the selected remedy for cleanup at the Former Indian Refinery is not anticipated before 2008. Therefore, the Trustees and Chevron may evaluate different potential response action scenarios to estimate the duration of injury and the recovery to baseline conditions.

Quantifying habitat service gain (or HEA "credits") is similar to quantifying HEA debit, except that service increases resulting from resource restoration are estimated, rather than service losses resulting from injuries. The Trustees and Chevron will calculate the spatial extent of restoration, the time period required for natural resource services to be restored, quantification of increased services provided over time, and a discount rate. The number of DSAYs of HEA debit should be offset by an equivalent number of DSAYs of habitat restoration credit.

As a hypothetical example, suppose the available data indicate that releases of hazardous substances and/or petroleum products from the refinery result in a 25% loss of services in 100 acres of floodplain forest habitat from 1981 through 2000, and the habitat then improved to baseline conditions between 2001 and 2006. Using a 3% discount rate, the debit over this 25-year period is calculated as 846 DSAYs. A hypothetical restoration project covering 38 acres of floodplain forest habitat that increases services from 25% to 100% between 2006 and 2010, and is protected to ensure that services remain at 100% beyond 2010, would provide 846 DSAYs of credit, thereby offsetting the injury.

4.3.2 Resource equivalency analysis

REA is based on balancing resources lost due to injury (debit) with resources gained due to restoration (credit). In most respects, it is identical to HEA. However, the units are different, because injury debit and restoration credit are scaled to a specific resource (e.g., migratory birds) rather than to natural resource services provided in a particular habitat. Thus, REA scales restoration on a resource-to-resource basis.

The information required to quantify the resource service loss or REA debit includes (1) time periods of losses encompassing past and future losses, (2) quantification of lost services as number of organisms lost over time compared to baseline conditions, and (3) a discount rate (typically 3%). Debits are commonly expressed in units that describe the amount of lost resource, a time period, and the discount rate. For example, if migratory birds have been injured, REA debits might be calculated in units of discounted service bird-use years.

Quantifying resource service gain or REA credits is similar to quantifying REA debit. The amount of the resource that is restored, the time period required for restoration, the increased services provided over time, and a discount rate are used to calculate the service gains to the resource provided by the selected restoration. Using the migratory bird example above, the number of discounted service bird-use years of resource service loss is offset by an equivalent number of discounted service bird-use years of restoration.

4.3.3 Groundwater equivalency analysis

GWEA is functionally equivalent to HEA, with different units to account for the fact that groundwater is three-dimensional and mobile. Debits are commonly expressed in units that describe the amount of injured groundwater (volume, flux, or both), a time period, and the discount rate. For example, if a volume of groundwater contaminated by hazardous substance and/or petroleum product releases is estimated on an annual basis, the GWEA debits can be expressed in units of discounted service acre-feet years. As with the HEA and REA models, the number of discounted service acre-feet years of groundwater service loss is offset by an equivalent number of discounted service acre-feet years of groundwater restoration.

5. Specific Assessment Approaches

The Trustees and Chevron will conduct the injury and damage assessment in different areas at the Former Indian Refinery using different methods, based on which equivalency model (HEA, REA, GWEA) is appropriate for each area. Section 5.1 provides an introduction to the specific assessment approaches that will be used. Section 5.2 discusses the approach that will be taken to evaluate natural resource service loss based on physical and chemical conditions at the site. Section 5.3 discusses the application of HEA to several different areas at the site. Sections 5.4 and 5.5 discuss the assessment of areas to be assessed using REA and the assessment of groundwater using GWEA, respectively. Finally, Section 5.6 discusses the approach that will be used for restoration planning.

5.1 Introduction

The equivalency models that will be used in specific areas for specific resources depend on the nature of the injuries and on how the injuries can best be quantified against baseline conditions, which are the conditions that would be present but for the hazardous substance and/or petroleum product releases being assessed. Areas that were part of refinery operations and processing such as buildings, roads, tank farms, and other physical structures, are within the "industrial footprint" of the refinery and therefore provide few habitat-based natural resource services under baseline conditions. Injuries in these areas are best quantified in terms of lost individual resources, rather than lost habitat. Areas near the refinery but outside the industrial footprint would be expected to provide all of the natural resource services that are found in similar habitats absent the release of hazardous substances and/or petroleum products. In these areas, injuries can be quantified in terms of habitat services lost, rather than on a resource-specific basis.

Within the industrial footprint, natural resources (particularly biota) may still be exposed to releases of hazardous substances and/or petroleum products, such as birds coming into contact with oily waste. In this case, a specific natural resource has been injured, but the injury occurred in an industrial area that is not intended to be wildlife habitat. Injuries within the industrial footprint areas are referred to as "resource-based" injuries and will be assessed using REA. Section 5.4 provides more detail on the use of REA in resource-based areas.

Areas outside of the refinery's industrial footprint, including the Embarras River and areas within the refinery property that are in the Embarras River floodplain forest, would provide ample habitat to biological resources under baseline conditions. Hazardous substances and/or petroleum products that are released or transported to these areas can adversely affect the natural resource services that the habitat provides, including adversely affecting the biota within the

habitat. These "habitat-based" areas will be assessed using HEA. Section 5.3 provides more detail on the use of HEA in habitat-based areas.

5.2 Evaluating Natural Resource Services

This section describes the approaches and, where available, the methods that will be used to assess natural resource service losses from injury and gains from restoration.

5.2.1 Determining baseline services

This site became a refinery in the early 1900s, and as such no quantitative baseline data exist before the release of hazardous substances and/or petroleum products. Therefore, the Trustees and Chevron will use data and other information from control areas to characterize baseline conditions if appropriate control areas can be found. As the DOI NRDA regulations indicate, control areas will be selected based on their similarity to the assessment area and lack of exposure to the release [43 CFR § 11.72(d)(1)].

Baseline conditions are not equivalent to pristine conditions, but are the conditions that would be present without the releases of hazardous substances and/or petroleum products from the refinery. The refinery is most likely not the sole source of hazardous substances and/or petroleum products in the Lawrenceville area. Oil and gas wells, pipelines, other industry, and urban activities are all potential contributors of contaminants in the area. In addition, some releases of hazardous substances and/or petroleum products from the refinery were permitted under state and federal programs such as the NPDES. The Trustees and Chevron will cooperatively evaluate data to define appropriate baseline conditions for the assessment. Some potential options and data sources for determining appropriate baseline include:

- State water quality assessments
- State soil surveys
- Local biological resource inventories
- Upstream reference sites
- Paired watershed reference sites.

The Trustees and Chevron will describe the selected baseline conditions in the Report of Assessment.

5.2.2 Estimating natural resource service loss

Natural resource service loss for specific areas at the site will be estimated from available site-specific data on hazardous substance and/or petroleum product concentrations in environmental media and other relevant data and information, such as pathways, exposure, toxicity, ecological receptors, visual observations, and historical releases. Available data on hazardous substance and/or petroleum product concentrations at the site will be particularly important in developing service loss estimates. These data will be compared to toxicity benchmarks or injury thresholds, and the results of this comparison will be used as one of the inputs for estimating service losses at each area.

Where chemistry data are unavailable or insufficient, additional chemistry or biological survey data may be collected to resolve data uncertainties. More likely, service loss may be estimated based on reasonable worst-case scenarios and best professional scientific judgment. The "worst-case" scenario refers to the upper bound of injuries that may be occurring at any given area within the site. While using reasonable worst-case scenarios at areas across the site will likely overestimate the injuries and resultant restoration overall, this overestimation is necessary to address the uncertainty of injury quantification at each area.

Some basic guidelines that the Trustees and Chevron may use to assign service loss based on available information at the site include the following:

- If hazardous substance and/or petroleum product concentrations do not, have not, and are not expected to exceed baseline concentrations, there is no service loss.

- If petroleum product or tar covers the ground surface and no vegetation is growing, service loss is 100%.

- The basic toxicological dose-response relationship applies when assigning service loss, i.e., the higher the concentrations of hazardous substances and/or petroleum products, the higher the service loss. Specific quantitative relationships between concentrations of hazardous substances and/or petroleum products and service losses may be developed based on available toxicity information.

The quantification of service losses from chemical concentrations will address several questions, including:

- Which contaminants released at the site have an additive or interactive toxicological mechanism and should therefore be evaluated collectively?

- How do chemical concentrations in surface water, sediment, and soil relate to reductions in service flows? Specifically, what concentrations of the hazardous substances and/or

petroleum products are sufficient to induce a complete (100%) loss of services? What are the maximum concentrations at which service losses are 0%? How are the uncertainties in site characterization data and/or the concentration-toxic response relationship incorporated into the service loss quantification?

- How should qualitative information such as historical refinery practices or visual observations be incorporated into the scaling of service flow losses?

The specific methodology for combining all of the relevant information into service loss estimates for each area will be developed cooperatively by the Trustees and Chevron. It is anticipated that the relative importance of hazardous substance and/or petroleum product concentration data in estimating service loss percentages will vary from area to area at the site depending on factors such as the completeness of the available concentration data and the other information that is available.

There may be relatively high levels of uncertainty when estimating service loss in some locations at the site. There are areas of the refinery for which there are few chemical data, and there are many areas for which the chemical data are restricted to a single sampling event. In addition, the toxicology data for many of the hazardous substances and/or petroleum products, such as PAHs, include a wide range of values showing potential effect levels for ecological receptors at the site. The Trustees and Chevron will include as much data as possible when developing service loss estimates; however, in the event that there are areas, time periods, and/or specific resources for which data are unavailable or uncertain, the Trustees and Chevron will work cooperatively to estimate service loss based on a professional estimate of a reasonable worst-case scenario.

The specific methods used to estimate service loss from the available site information will be developed as part of the injury assessment, using the guidelines and concepts described above. In the Report of Assessment, the Trustees and Chevron will present in detail the approach used to quantify the degree and spatial and temporal extent of service loss at the Former Indian Refinery. Should the Trustees and Chevron be unable to agree on a reasonable worst-case scenario for service loss at parts of the site, the Trustees may conduct additional, more detailed injury assessment studies, and if so, the Trustees may publish an amendment to this Assessment Plan describing such studies.

5.2.3 Estimating natural resource service gain

The process of estimating natural resource service gain from restoration projects will be based on evaluations that are specific to restoration alternatives. The Trustees and Chevron will first estimate the current level of natural resource services provided at the proposed restoration site(s). IDNR ecologists and other experts will assist the Trustees and Chevron in producing a detailed

ecological history of the Embarras River floodplain near Lawrenceville (e.g., Basinger and Edgin, 2005), providing a basis for estimating historical services, services under ideal conditions, and services under current conditions. Site visits, maps, and inventories of biota will also be used to estimate natural resource services at proposed restoration sites.

The Trustees and Chevron will then estimate for each restoration project what the final percentage of natural resource services provided is likely to be, how long it will take to reach the maximum services provided, and whether there are time periods during construction and post-construction phases in which an intermediate level of services is provided. Factors that will be considered to produce these estimates include the goals of the restoration project, the probability of attaining those goals, and the final outcome of the project if the goals are achieved. Section 5.6 provides more detail on restoration planning factors that will be considered when estimating service gain.

The specific methods used to estimate service gain from restoration projects will be developed as part of the assessment. In the Report of Assessment, the Trustees and Chevron will present in detail the approach used to quantify the degree and spatial and temporal extent of service gain from the selected restoration projects.

5.3 Assessment of Habitat-Based Areas

Injuries and service losses in habitat-based areas will be evaluated according to the type of habitat. The Trustees and Chevron have identified several broad categories of habitat for assessment of injuries resulting from hazardous substance and/or petroleum product releases from the Former Indian Refinery, including riverine habitat such as the Embarras and Wabash rivers and other smaller streams/creeks; southern Illinois floodplain forest, including embedded wetland areas; and fields in early successional stages to becoming floodplain forest. The following sections describe the injury assessment for these habitats, including determination of baseline conditions, injury thresholds, and data to be used in the assessment.

5.3.1 Riverine habitat: Embarras River, Wabash River, and smaller creeks

The riverine habitat within the assessment area, including the Embarras and the Wabash rivers, is defined for the purposes of this NRDA as the area within the banks of the river. Examples of other riverine habitats in the assessment area potentially include Indian Creek, the unnamed northern tributary of Indian Creek that runs along the western border of the refinery property, and the C-Pond drainage pathway that flows southeast from south of C-Pond to the Embarras River floodplain forest (see Figures 2.1 and 3.1).

The Trustees and Chevron will evaluate whether baseline conditions for the Embarras River and the northern tributary of Indian Creek can be characterized as being similar to conditions immediately upstream of the refinery, and whether baseline conditions on the Wabash River can be characterized as being similar to conditions immediately upstream of the Embarras River confluence. Appropriate baseline data may be evaluated as part of the assessment.

Data that will be reviewed for injury determination, pathway determination, and injury quantification in riverine habitats may include the following:

- Surface water and sediment chemistry data collected as part of the RI activities
- Biological survey data collected as part of the RI activities
- Historical water quality, sediment quality, and biological data collected before the RI
- New surface water, sediment, and biological data, if any, collected as part of this NRDA
- NPDES water quality violations for the various past and current NPDES discharge permits held by the refinery
- Information on historical refinery operations and waste disposal practices
- Embarras River floodplain water and sediment chemistry data and flood frequency data from the U.S. Geological Survey (USGS) and/or other relevant Illinois agencies such as the Illinois State Water Survey (ISWS), Illinois State Geological Survey (ISGS), and the IDNR Office of Water Resources (OWR).

Additional data collection may include water, soil, sludge, and/or petroleum product chemical analyses from refinery and non-refinery areas that are potential sources of contaminants to the Embarras River, either via a direct runoff pathway, or via runoff of flood waters from contaminated floodplain areas.

Injury determination and quantification in riverine habitat will be based in part on toxicological evaluation of the hazardous substances and/or petroleum products released into the riverine environments. Contaminant concentration thresholds will be developed for the determination of injury and for consideration in the development of service loss estimates. In general, the injury quantification will include an estimate of the surficial area (i.e., acreage) of riverine habitat that has been injured, the degree of injury (i.e., the level of service loss), the temporal extent of injury, and any changes in the level of injury that may have occurred over time. Injury quantification will also include estimates of future injury, based on reasonable worst-case scenarios, that will be incurred until response actions, restoration, or natural recovery (if applicable) return the site to baseline conditions.

The quantification of riverine habitat injury will be used to estimate the debit in a HEA model, based on the relationship between injury and service loss (Section 5.2). The HEA model for riverine habitat will include credits for proposed restoration projects to offset the injury. The Report of Assessment will include the details of the riverine habitat HEA.

5.3.2 Floodplain forest habitat

Areas to the east and south of the industrial footprint of the refinery consist of Embarras River floodplain forest habitat (Figure 3.1). Floodplain forests occupy low-lying areas adjacent to streams and rivers that are third-order or greater and are subject to periodic flooding and cycles of sediment erosion and deposition. They are characterized by poor drainage and low permeability soils (CTAP, 1997). A typical floodplain forest often consists of many small patches of vegetation of different species and successional ages. Mature floodplain forests typically contain different woody species, including a tree canopy with a mixture of shade-tolerant and shade-intolerant species; shrubs, vines, and herbaceous species; and standing dead trees and fallen logs (Basinger and Edgin, 2005).

The floodplain forest near the Former Indian Refinery includes open wetlands interspersed within the areas of forest canopy. Rather than evaluate the wetlands separately, the Trustees and Chevron will consider floodplain forest habitat as including both continually inundated wetlands and episodically inundated forest. This definition will apply to both the injury (debit) and restoration (credit) analyses in the HEA.

Baseline conditions for the floodplain forest may be characterized based on the condition of floodplain forest areas outside the influence of the refinery, if sufficient data exist to characterize these areas. Determining an appropriate baseline for the floodplain forest will be included as part of this assessment.

Potentially affected areas in the Embarras River floodplain forest include much of the area on the east side of the refinery, as well as the areas east and southeast of the refinery property between the refinery process area and the west bank of the Embarras River (see Figures 2.2 and 3.1). Specifically, this includes most of Indian Acres, the floodplain east of the Indian Acres boundary, areas on the eastern side of the refinery between (but not including) the firewater ponds and the wastewater aeration ponds, the floodplain south and east of the refinery process area, Turner Pond, lime sludge area ponds, settling ponds, oxbow ponds, and the former Embarras River channel (Figures 2.2 and 3.1).

Injury determination in the floodplain forest habitat will include an evaluation of injury to surface water and sediment in the wetlands and ponds, injury to soils in the forest areas, and injury to vegetation, biota, and ecological habitat in both the forested and wetland areas.

Information that will be reviewed for injury determination, pathway determination, and injury quantification of floodplain forest habitat may include the following:

- Soil, surface water, and sediment chemistry data collected as part of the RI activities
- Prey and vegetation tissue data collected as part of the RI activities
- Biological survey data collected as part of the RI activities
- Historical soil quality, water quality, sediment quality, and biological data collected before the RI, including documentation of the release into the area now known as Turner Pond
- Information on historical refinery operations and waste disposal practices
- Embarras River floodplain water and sediment chemistry data and flood frequency data from the USGS.

Additional data collection may include analysis of water, soil, sludge, and/or petroleum products in areas that are potential sources of contaminants to the floodplain forest, as well as additional soil, water, and/or sediment samples collected from within the floodplain forest habitat itself.

The floodplain forest habitat injury quantification data will be used to estimate the debit in a HEA model, based on the relationship between injury and service loss (Section 5.2). Injury quantification will also include estimates of future injury, based on reasonable worst-case scenarios, that will be incurred until response actions, restoration, or natural recovery (if applicable) return the site to baseline conditions. The HEA model for floodplain forest habitat will include credits for proposed restoration projects to offset the injury. Guidelines for selecting restoration projects are included in Section 5.6. The Report of Assessment will include the details of the floodplain forest habitat HEA.

5.3.3 Successional field habitat

For the purposes of this NRDA, successional field habitat refers to areas that lie within the floodplain and are currently open fields in early succession to floodplain forest. The lime sludge area is a successional field in the floodplain that fits this description.

Information that will be reviewed for injury determination, pathway determination, and injury quantification of successional field habitat may include the following:

- Soil, surface water, and sediment chemistry data collected as part of the RI activities
- Prey and vegetation tissue data collected as part of the RI activities
- Historical soil quality and biological data collected before the RI
- Information on historical refinery operations and waste disposal practices.

Additional data collection may include the analysis of water, soil, sludge, and/or petroleum products in areas that are potential sources of contaminants to the successional field habitat, as well as additional soil, water, and/or sediment samples collected from within the successional field habitat itself.

In general, the injury quantification in the successional field habitat will include an estimate of the surficial area (i.e., acreage) of habitat that has been injured, the degree of injury (i.e., the level of natural resource service loss), the temporal extent of injury, and any changes in the level of injury that may have occurred over time. Injury quantification will also include estimates of future injury, based on reasonable worst-case scenarios, that will be incurred until response actions, restoration, or natural recovery (if applicable) return the site to baseline conditions. A successional field HEA model will include the service loss based on the results of the injury quantification and the service gain based on proposed restoration of similar habitat. The Report of Assessment will contain the details of the injury assessment, service loss, and HEA model.

5.4 Assessment of Resource-Based Areas

The injury assessment for resource-based areas, or areas within the industrial footprint of the refinery, will focus on exposure of biota to hazardous substances and/or petroleum products, e.g., biota such as resident and migratory birds that have perished on the refinery property after being exposed to contamination. The objective of the injury assessment for the resource-based areas is to quantify the type and number of biota that have been injured by the releases of hazardous substances and/or petroleum products in the industrial footprint area.

Baseline conditions for resource-based areas will be defined as part of the assessment. It is likely that baseline conditions will be defined as the absence of the hazardous substances and/or petroleum products in the industrial footprint area to which biota are exposed.

Data that will be reviewed for injury determination, pathway determination, and injury quantification may include the following:

- Reports and memoranda documenting adverse effects, including mortality, to biota exposed to hazardous substances and/or petroleum products within the industrial footprint of the refinery
- Models quantifying total avian mortality based on a known quantity of dead birds found at the site, including methods of estimating the number of unrecovered dead birds and the number of birds adversely affected but not killed on-site
- Soil, surface water, and sediment chemistry data collected as part of the RI activities
- Prey and vegetation tissue data collected as part of the RI activities
- Biological survey data collected as part of the RI activities
- Historical soil quality, water quality, sediment quality, and biological data collected before the RI
- Information on historical refinery operations and waste disposal practices.

Injury quantification in resource-based areas will focus on the known or estimated number of organisms affected by hazardous substances and/or petroleum products in the industrial areas of the refinery. The exact method of quantifying injury from resource-based areas will be determined as part of this NRDA and described in the Report of Assessment. To avoid double-counting, the Trustees and Chevron will be careful not to include any injured biota that are accounted for as part of the injury quantification of habitat-based areas.

The injury quantification data for resource-based areas will be used to estimate the debit in a REA model. Injury quantification will also include estimates of future injury, based on reasonable worst-case scenarios, that will be incurred until response actions, restoration, or natural recovery (if applicable) return the site to baseline conditions. The REA model will include restoration projects that benefit the injured resources and offset the injury. The Report of Assessment will include the details of the REA model for resource-based areas.

5.5 Assessment of Groundwater

Injury assessment of groundwater will be conducted separately from the assessment of habitat- and resource-based areas.

The Trustees and Chevron will define baseline groundwater conditions as part of the assessment. It is likely that baseline conditions will be characterized by groundwater quality at wells on or near the site that have not been exposed to hazardous substance and/or petroleum product releases from the refinery.

Most of the available groundwater data has been collected recently as part of the RI activities, but some groundwater data may be available or inferred from historical documentation. Information that will be reviewed for groundwater injury determination, pathway determination, and injury quantification may include the following:

- Groundwater monitoring data collected as part of the remedial activities at the site
- Information on the physical characteristics of the aquifer underlying the refinery, including the results from pump tests, slug tests, and contouring of potentiometric surfaces
- Historical groundwater quality data collected before the RI
- Reports and memoranda that provide data that may be used to infer groundwater quality, such as the reports detailing the plume emanating from Tank Farm B and entering the wetland that became Turner Pond in the floodplain forest
- Information on historical refinery operations and waste disposal practices.

The results of the injury quantification to groundwater will be used as input to a GWEA. The objective of the GWEA will be to determine the type and amount of groundwater restoration or increase in groundwater services that are required to offset the groundwater injuries. The injury quantification will include an estimate of the amount of groundwater that has been injured, the amount of time that the groundwater has been injured, and the level of service loss associated with the injury. Injury quantification will also include estimates of future injury, based on reasonable worst-case scenarios, that will be incurred until response actions, restoration, or natural recovery (if applicable) return the site to baseline conditions. The metrics that will be used for groundwater quantification will be determined to allow for quantification of increases in groundwater services from restoration. The exact approach to groundwater injury quantification, groundwater restoration projects, and the GWEA model that attempts to ensure that restoration is commensurate with injury, will be explained in detail in the Report of Assessment.

5.6 Restoration Planning

This section describes the approach to restoration planning that the Trustees and Chevron will use to identify and select restoration projects that will compensate for natural resource service

losses. At this time, the Trustees and Chevron are not able to prepare a complete RCDP, which is identified in the DOI NRDA regulations as a possible component of an Assessment Plan [43 CFR § 11.81]. A primary purpose of an RCDP is to identify potential restoration alternatives, select the preferred alternative(s), and estimate the cost for the preferred alternative(s) [43 CFR § 11.81(a)(1)]. Since injuries and associated service losses have not yet been determined or quantified, the Trustees and Chevron are unable to identify and select the preferred restoration alternative(s) to address injuries and service losses. Therefore, the Trustees and Chevron will prepare an RCDP after the injury assessment is complete [43 CFR § 11.81(d)(1)]. The information presented in this chapter describes the overall approach that the Trustees and Chevron will take in restoration planning.

5.6.1 Planning process

The Trustees and Chevron are committed to developing a plan for restoring injured resources and their services to baseline conditions and for compensating for the interim losses that have occurred until the time that restoration to baseline occurs. They will consider a range of potential restoration alternatives to accomplish these goals, including actions to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources [43 CFR §11.82(b)(1)]. Actions to replace or acquire the equivalent of the injured resources could include on-site or off-site habitat restoration/rehabilitation, or the purchase of vulnerable lands or conservation easements for resource protection and management.

The restoration planning process will employ the following steps:

1. **Solicit ideas for potential projects**. The Trustees and Chevron will solicit ideas for potential habitat restoration projects from people and organizations known to have an interest in habitat restoration in southern Illinois. Example organizations to be solicited may include state agencies such as the Illinois Natural History Survey and the Illinois Nature Preserves Commission, local organizations and agencies such as the City of Lawrenceville and the Embarras River Management Association (ERMA), and groups such as The Nature Conservancy, Ducks Unlimited, and the Audubon Society.

2. **Develop evaluation factors to assess potential projects.** Factors will be developed that will be used to evaluate each restoration alternative. A list of evaluation factors to consider is included in Section 5.6.2. This list may be refined during the assessment.

3. **Evaluate potential restoration project suitability.** The restoration alternatives will be compared to the evaluation factors and ranked accordingly. Based on this ranking, the preferred alternative(s) will be selected.

4. **Select an appropriate scale.** The appropriate scale of the selected alternative(s) will be determined based on calculated HEA and REA credits necessary to offset injury.

5.6.2 Evaluation factors

Both the DOI NRDA regulations [43 CFR § 11.82] and the NOAA NRDA regulations [15 CFR § 990.54, 55] discuss potential restoration project selection criteria. At 43 CFR § 11.82(d), the DOI NRDA regulations provide criteria for consideration in evaluation restoration alternatives:

> "*Factors to consider when selecting the alternative to pursue*. When selecting the alternative to pursue, the authorized official shall evaluate each of the possible alternatives based on all relevant considerations, including the following factors:
>
> (1) Technical feasibility, as that term is used in this part.
>
> (2) The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.
>
> (3) Cost-effectiveness, as that term is used in this part.
>
> (4) The results of any actual or planned response actions.
>
> (5) Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.
>
> (6) The natural recovery period determined in 11.73(a)(1) of this part.
>
> (7) Ability of the resources to recover with or without alternative actions.
>
> (8) Potential effects of the action on human health and safety.
>
> (9) Consistency with relevant federal, state, and tribal policies.
>
> (10) Compliance with applicable federal, state, and tribal laws."

Based on the above factors, the Trustees and Chevron have agreed to a more detailed list of restoration factors (Table 5.1) that will be considered when evaluating restoration alternatives.

Table 5.1. Restoration factors to consider when evaluating restoration alternatives

Factor	Interpretation
Complies with applicable/relevant federal, state, local, and tribal laws, regulations, and policies [43 CFR § 11.82(d)(9) and (10)]	▸ Project must be legal.
Protects public health and/or safety [43 CFR § 11.82(d)(8)]	▸ Project does not jeopardize public health and/or safety.
Is coordinated with planned response actions [43 CFR § 11.82(d)(4)]	▸ Project does not conflict with planned response actions and will not be undone or harmed by response actions.
Minimizes collateral injury [43 CFR § 11.82(d)(5)]	▸ Project does not cause additional natural resource injury, service loss, or environmental degradation; collateral injuries that may be caused by the project are minimal compared to the benefits achieved. Projects that avoid collateral injury will be given priority. ▸ Project reduces exposure to hazardous substances and reduces the volume, mobility, and/or toxicity of hazardous substances. Projects may be ranked by degree of expected reductions of one or both of these factors.
Is acceptable to the public	▸ Project meets a minimum level of public acceptance; project is not a public nuisance. Degree of public acceptance/support can also be used as a criterion following initial screen of projects.
Is technically feasible [43 CFR § 11.82(d)(1)]	▸ Project has a high likelihood of success. This factor will be evaluated in more depth for projects that are initially believed to be feasible. Reliable methods/technologies known to have a high probability of success will be considered. ▸ Projects incorporating experimental methods, research, or unproven technologies may be ranked lower.
Restores, rehabilitates, and/or replaces habitats of injured resources (including groundwater) and the services that the habitats provide	▸ Projects may be evaluated based on the degree to which they restore, rehabilitate, and/or replace habitat for injured resources. Habitat protection/restoration may be a preferred means of restoring injured resources. ▸ Projects may also include consideration of on-site resources and habitats.

Table 5.1. Restoration factors to consider when evaluating restoration alternatives (cont.)

Factor	Interpretation
Addresses in-kind habitat in the same watershed	▸ Project restores, rehabilitates, and/or replaces in-kind habitat in the same watershed. Acquiring the equivalent may also be a viable option.
Addresses habitat for which the PRP has no current liability and that will be protected from future hazardous substance and/or petroleum product releases	▸ Project restores habitat that does not contain hazardous substances for which the PRP is responsible. ▸ Project restores habitat that is likely to provide the restored natural resource services in perpetuity.
Provides benefits not being provided by other restoration projects being or having the potential of being planned/implemented/funded under other programs	▸ Project will only be implemented with NRDA funding. Although the Trustees will make use of restoration planning efforts by other programs, preference is given to projects that would not otherwise be implemented without NRDA restoration funds.
Addresses/incorporates restoration of "preferred" trust resources or services	▸ Project restores preferred specific habitats, species of special concern, living resources, native species, groundwater, etc. Trustees will develop a list of priorities based on the resource types injured and degree of injury.
Generates collateral benefits	▸ Project generates secondary or cascading benefits to ecological resources and economic benefits, such as enhancing the public's ability to use, enjoy, or benefit from the environment. ▸ Project benefits more than one injured resource or service. Projects that benefit a single group or individual may be ranked lower.
Provides long-term benefits	▸ Project is persistent rather than short-term.
May be scaled to appropriate level of resource injury or loss	▸ Project can be scaled to provide restoration of appropriate magnitude. Small projects that provide only minimal benefit relative to lost injuries/services, or overly large projects that cannot be appropriately reduced in scope are less favored.
Is consistent with regional planning	▸ Project does not conflict with regional planning (e.g., project supports species recovery plans); project is administratively feasible.

Table 5.1. Restoration factors to consider when evaluating restoration alternatives (cont.)

Factor	Interpretation
May be considered	
Is cost-effective [43 CFR § 11.82(d)(2) and (3)]	▸ Project has a high ratio of expected benefits to expected costs. This may be assessed as relative to other projects that benefit the same resource. Also applies to costs of long-term operation, maintenance, and monitoring.
Provides benefits sooner [43 CFR § 11.82(d)(6) and (7)]	▸ Project will achieve expected results sooner than resource would achieve the result through natural recovery (and remediation) and sooner than other projects that benefit the same resource. The sooner restoration is achieved, the better.
Targets a resource or service that is unable to recover to baseline without restoration action, or that will require a long time to recover naturally (e.g., > 25 years) [43 CFR § 11.82(d)(6) and (7)]	▸ Project targets resources/services that will be slow to recover without active restoration. These projects will be favored over projects that target resources/services that will soon recover naturally.

6. Quality Assurance Project Plan

Any field studies conducted as part of this NRDA will follow the QAPP published in Appendix C of the RI/FS work plan (SECOR International and ELM Consulting, 2002), for those sections of the QAPP that are applicable to the NRDA. In the event that additional studies are undertaken for which the RI/FS QAPP is not sufficient, an amended QAPP may be released as part of an amendment to this Assessment Plan, as specified in 43 CFR § 11.32(e).

References

Allen, P.D., D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In *Economics and Ecological Risk Assessment: Applications to Watershed Management,* R.J.F. Bruins and M.T. Heberling (eds.). CRC Press, Boca Raton, FL, pp. 165-184.

Basinger, M. and R. Edgin. 2005. Draft 3 – Floodplain Forest Services "White Paper." Prepared for the Lawrenceville Natural Resource Damage Assessment Technical Work Group. September.

Cacela, D., J. Lipton, D. Beltman, J. Hansen, and R. Wolotira. 2005. Associating ecosystem service losses with indicators of toxicity in habitat equivalency analysis. *Environmental Management* 35(3):343-351.

CEC. 1997. Consent Decree Work Plan Phase I and Supplemental Work Plan, Lawrenceville Refinery (December 1996-February 1997). Prepared by Chemical & Environmental Consultants, Laramie, WY, for Indian Refining Company, Lawrenceville, IL.

Crause, T. 1997. Letter re: Applicability of the CERCLA Petroleum Exclusion for waste deposited at the Texaco Refinery Site in Lawrenceville, Illinois. To Jeanne Griffin, U.S. EPA, Chicago, IL. May 20.

CTAP. 1997. Embarras River Area Assessment Volume 3 – Living resources. Critical Trends Assessment Program, Illinois Department of Natural Resources, Springfield.

Cummings, K.S. and C.A. Mayer. 1995. The Distribution and Status of Six Federally Endangered Mussels (Unionidae) in Illinois. Illinois Natural History Survey, Center for Biodiversity, Champaign.

Densmore, M. 1998. HRS Documentation Record, Indian Refinery, Lawrenceville, Illinois. Illinois Environmental Protection Agency, Springfield.

ELM Consulting. 2002. Index of Biotic Integrity and Freshwater Mussel Survey of the Embarras River near Lawrenceville, Illinois. Submitted to ChevronTexaco. August 22.

ELM Consulting. 2003. Documentation of Bird and Snake Mortality, Tank Farm A, Former Indian Refinery, Lawrenceville, Illinois. Draft. ELM Consulting, Barrington, IL.

Gardner, J.E., J. Hofmann, and J.D. Garner. 1996. Summer distribution of the federally endangered Indiana bat (*Myotis sodalis*) in Illinois. *Transactions of the Illinois State Academy of Science* 89(3,4):187-196.

Hinds, J. 2001. Indian Refining Company, Incorporated Havoline Motor Oil (through 1962). The Texas Company/Texaco Inc. (through 1985) Company History Timeline. Available: http://www.oldgas.com/info/texacohist.html. Accessed October 11, 2005.

IDNR. 2006. 2006 endangered and threatened species list. Illinois Endangered Species Protection Board. Available: http://dnr.state.il.us/espb/datelist.htm. Accessed March 1, 2006.

IEPA. 2000. Lawrence County site on superfund list: Site along Embarras River has a long, complicated history. Illinois Environmental Protection Agency. Available: http://www.epa.state.il.us/environmental-progress/v25/n4/lawrenceville.html. Accessed October 24, 2005.

INHS. 2005. INHS mollusk collection database. Illinois Natural History Survey. Available: http://ellipse.inhs.uiuc.edu:591/INHSCollections/mollsearch.html. Accessed March 1, 2006.

Kovski, A. 1995. Castle signs new deal to sell Indian Plant. *Oil Daily* 45(224):1.

Lange, R.M. 1986. Preliminary Review and Visual Site Inspection (Lawrenceville/Texaco). Illinois Environmental Protection Agency, Springfield. August 5.

McSwiggin, T.G. 1997. Letter re: City of Lawrenceville Storm Sewer Replacement Project, NPDES Permit No. ILS000002. Denial of NPDES Permit to City of Lawrenceville, IL.

NOAA. 2000. Habitat Equivalency Analysis: An Overview. Prepared by Damage Assessment and Restoration Program, National Oceanic and Atmospheric Administration, Department of Commerce. March 21, 1995. Revised October 4.

Oil & Gas Journal. 1997. Assets of the idle. *Oil & Gas Journal* 95(38):43. September 22.

SECOR International and ELM Consulting. 2002. Remedial Investigation/Feasibility Study Work Plan, Former Indian Refinery, Lawrenceville, Illinois. Prepared for Chevron Texaco Inc., Ventura, CA. December.

SECOR International and Trihydro Corporation. 2005. Summary Report for Area North of Indian Acres: City Storm Sewer Investigation, Former Indian Refinery Site, Lawrenceville, Illinois. Submitted by Chevron Environmental Management Company, on behalf of Texaco Inc., San Ramon, CA. March 3.

SECOR International, Trihydro, and ELM Consulting. 2004a. Interim Technical Memorandum: Indian Acres, Former Indian Refinery, Lawrenceville, Illinois. Submitted by Chevron Environmental Management Company on behalf of Texaco, Inc., San Ramon, CA. March.

SECOR International, Trihydro, and ELM Consulting. 2004b. Technical Memorandum: Phase I Remedial Investigation, Former Indian Refinery Site, Lawrenceville, Illinois. Volume 1 of 5: Text, Figures, Tables, Appendix A. Submitted by Chevron Environmental Management Company, on behalf of Texaco Inc., San Ramon, CA. August 13.

Trihydro. 1993. Prioritization Plan for Investigating Solid Waste Management Units: Lawrenceville Refinery. Submitted to Indian Refining Company, Lawrenceville, IL. Revised August 18.

Trihydro. 2005. Former Indian Refinery Remedial Investigation database; maintained by Trihydro, Inc., Laramie, WY.

U.S. EPA. 2005. NPL Fact Sheets for Illinois: Indian Refinery – Texaco Lawrenceville. Available: http://www.epa.gov/R5Super/npl/illinois/ILD042671248.htm. Accessed October 24, 2005.

USFWS. 1997a. Region 3 Endangered Species: Fat Pocketbook (*Potamilus capax*). U.S. Fish and Wildlife Service. Available: http://www.fws.gov/midwest/Endangered/clams/fatpo_fc.html. Accessed February 28, 2006.

USFWS. 1997b. Report of Investigation: American Western Refining Company; re: Lawrenceville Refinery. U.S. Fish and Wildlife Service.

USFWS. 2006. Region 3 Species of Concern. U.S. Fish and Wildlife Service. Available: http://www.fws.gov/midwest/Endangered/lists/concern.html. Accessed February 28, 2006.

USFWS, IDNR, and IEPA. 2004. Final Preassessment Screen Determination for the Former Indian Refinery NPL Site. U.S. Fish and Wildlife Service, Rock Island, Illinois; Illinois Department of Natural Resources, Illinois Environmental Protection Agency, Springfield, IL. September.

WSJ. 1985. Texaco Inc. is closing two oil refineries in Illinois and Texas. *Wall Street Journal.* New York. March 8.