June 1, 2004

DRAFT TECHNICAL MEMORANDUM: REASONABLE WORST CASE ANALYSIS INJURY ASSESSMENT FOR BAYOU VERDINE AND COON ISLAND LOOP

1.0 INTRODUCTION

This document presents an analysis of the natural resource injuries, including ecological service losses, which may be attributed to releases of hazardous substances into the Calcasieu Estuary system by Conoco Inc. and Sasol North America Inc. (hereafter, the PRPs). This analysis is part of a natural resource damage assessment in which injuries to natural resources and services are identified and provides the basis for determining the need for and the type and amount of restoration required to compensate the public for those losses. The analysis was developed by the Louisiana Department of Environmental Quality (LDEQ), the Louisiana Department of Wildlife and Fisheries (LDWF), the U.S. Fish and Wildlife Service (USFWS), acting on behalf of the U.S. Department of the Interior, and the National Oceanic and Atmospheric Administration (NOAA) (collectively, the Trustees) in their capacity as natural resource trustees[1] and working in cooperation with the PRPs. The analysis constitutes the Trustees' determination and quantification of natural resource injuries and losses under CERCLA for releases of hazardous substances by Conoco and Sasol North America into this system. The analysis does not address natural resource injuries or service losses that may have resulted from releases of hazardous substances into the estuary by any other party.

In developing this analysis, the parties' general approach was to first examine the nature and extent of the contamination in the estuary that could be attributed to hazardous substances released by either Conoco or Sasol. This examination resulted in the identification of areas of potential concern. The next step was to evaluate the potential for natural resource injuries in these areas based on the presence of hazardous substances released from Conoco or Sasol at levels of concern (i.e., concentrations with potential to adversely affect natural resources or services). Areas in which PRPs' contaminants posed little or no potential for injury to natural resources or services were excluded from further analysis. A "reasonable worst case" (RWC) approach was used to estimate injuries/losses in situations where a potential for natural resource injury or loss existed and where restoration would reasonably be expected. Data from site-specific studies as well as results of studies reported in the scientific literature were used to identify and estimate natural resource injuries. In the event of technical uncertainty conservative assumptions or inputs (i.e., those leading to higher estimates of injury) were used in the analysis in lieu of conducting additional studies.

The Trustees and PRPs formed a technical workgroup to evaluate and estimate potential natural resource injuries from the PRPs' releases as part of the cooperative assessment process. The workgroup used historical data, scientific literature on contaminant effects, and the results of a Baseline Ecological Risk Assessment (BERA) developed for Bayou Verdine. The BERA for Bayou Verdine (ENTRIX, 2001a) was conducted by the PRPs under oversight by Environmental Protection Agency (EPA) and LDEQ (in its remedial role) and with assistance of the Trustees. The workgroup also considered the results of a BERA developed by EPA for the Calcasieu Estuary beyond Bayou Verdine (covering the upper end of Moss Lake northward to the saltwater barrier) (MacDonald, et al. 2002a). That BERA was based on the data resulting from the extensive Remedial Investigation undertaken by EPA for the larger Estuary (MacDonald, et al 2002b)

[1] The Louisiana Department of Natural Resources (LDNR) is also a designated state natural resource trustee in Louisiana but, because this analysis addressed areas outside Louisiana's defined coastal zone, LDNR did not directly participate in its development. The Trustees, however, coordinated with and kept LDNR informed of the process to ensure that there were no impacts to trust resources in the State's defined coastal zone.

Although the workgroup developed this analysis collectively, it is the Trustees' sole responsibility to ensure that the outcome of the process is consistent with the goals of the natural resource damage assessment (NRDA) process. The injury determinations identified herein, therefore, are those of the Trustees.

2.0 BACKGROUND

This section identifies the area of concern and describes the nature of the contaminants within the scope of this analysis.

2.1 Area of Interest

Bayou Verdine is a channelized bayou approximately 7 km in length located southwest of the city of Westlake. The headwaters of Bayou Verdine originate in agricultural areas north of the town of Mossville, and the bayou terminates at the northern tip of Coon Island Loop. The bayou is approximately one to three meters in depth, and approximately ten meters wide. The land around Bayou Verdine is characterized by undeveloped, mixed rural, residential, commercial, and heavy industrial use; however, industrial applications predominate in the southern section of the bayou. Permitted industrial discharges to Bayou Verdine under NPDES include those outfalls located on property owned or utilized by Sasol North American Inc. (Sasol) formerly CONDEA Vista Company (CONDEA), Conoco Inc. (Conoco) Lake Charles refinery, and PPG. Conoco and PPG each have material transport, storage, or discharge activities that potentially impact middle to lower Bayou Verdine and/or Coon Island Loop. (EPA, 2003)

Industrial development along Bayou Verdine has had a significant impact on the local system. During the 1950s, the southernmost 1,000 meters of the bayou were rerouted to the west when Olin Corporation (Olin) built the West Pond over the original bayou. The former route of Bayou Verdine downstream of I-10 was to the east of its present course; however, the confluence with the Coon Island Loop was near its present mouth (PRC 1994). Following the initial plant build-up, the only reported dredging on Bayou Verdine was performed by PPG in the North Dock Area (at the confluence of Bayou Verdine and the Coon Island Loop) in 1992 and involved dredging the area to a depth of 6 meters to accommodate barge traffic (PRC 1994).

Coon Island Loop connects with the Calcasieu ship channel at the southern end of Coon Island. The western arm of the loop is an active shipping channel that is periodically dredged. The eastern arm of the loop is approximately one to three meters in depth and is not used by commercial vessels. The area surrounding Coon Island Loop is very industrialized, supporting several major facilities as well as oil and gas production. The area includes some marsh habitat. Coon Island Loop has only one tributary, Bayou Verdine, which flows into the northern portion of the loop, entering at PPG's docking facilities and the turning basin.

2.2 Industrial Overview of Bayou Verdine

2.2.1 Conoco

Conoco is a petroleum refinery located primarily on the north and east side of Bayou Verdine to the north of I-10 (Figure 2.1). The facility covers approximately 675 acres, 75 of which are occupied by the refinery process areas. Conoco's facilities border reaches to the north and east of the bayou and have been in operation since 1942.

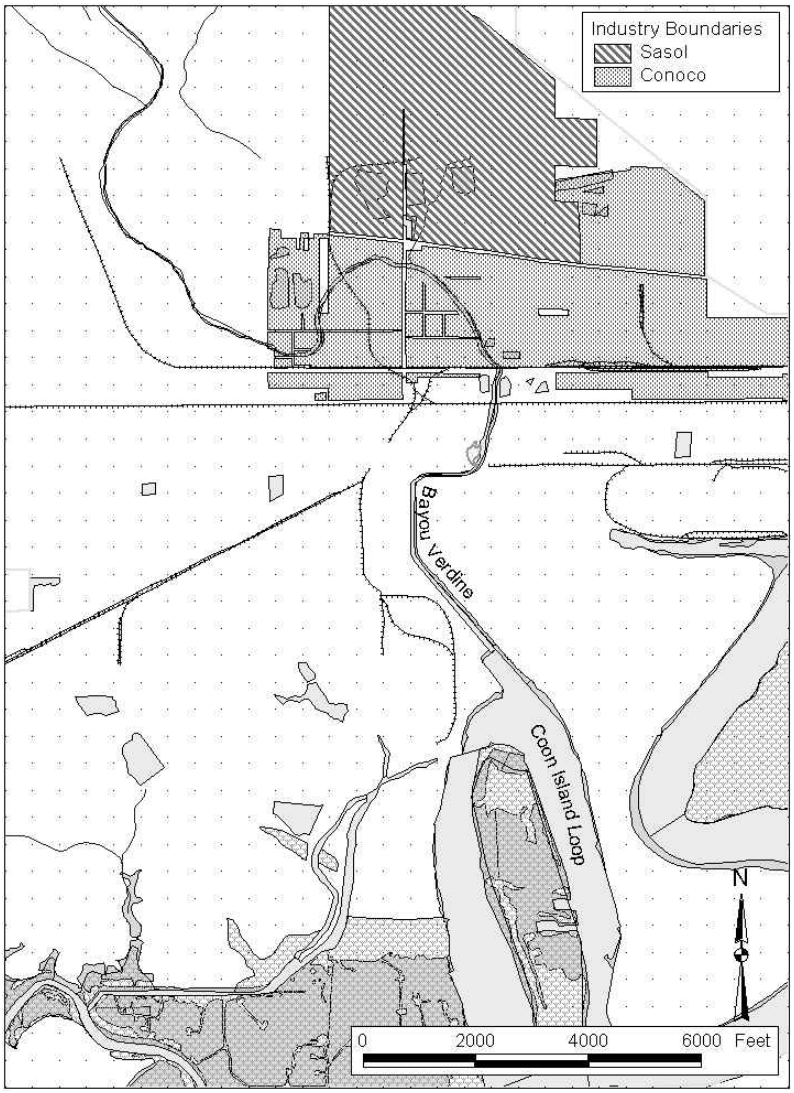

Figure 2.1. Bayou Verdine & Coon Island Loop, Calcasieu River, Calcasieu Parish, LA.

The Lake Charles Refinery is Conoco's largest, with a 226,000 barrel-per-day capacity. The refinery processes both heavy, high-sulfur crude and low-sulfur crude, and produces a full range of fuel products. It also provides the feedstock for Excel Paralube, Conoco's joint venture facility that produces high-quality lubricating base oils representing approximately 10 percent of U.S. lubricating base oil production. Conoco has recently upgraded the Lake Charles Refinery to process synthetic crude oil from the Petrozuata heavy-oil joint venture in Venezuela.
Conoco (NPDES Permit No. LA0003026) is authorized to discharge into Bayou Verdine through outfalls 001, 002, 004, 006, 007, 008, and 009. Discharge through outfalls 003 and 005 enters the Calcasieu River. Historical discharge exceedances and spills into Bayou Verdine include EDC, crude oil, diesel, hexavalent chromium, and cobalt among others. With the exception of outfalls 001, 002, and 006, discharge is primarily surface water runoff. However, outfalls 001, 002, and 006 receive process wastewater or overflow from waste treatment or storage areas (e.g., outfall 006 receives overflow from the wastewater sedimentation pond) and are more likely to generate streams with contaminated effluent.

2.2.2 Sasol North America

In 2001, Sasol purchased the former CONDEA companies that include the facility in Lake Charles located north of Conoco. The facility began operations as early as 1965 under a division

of Conoco. It was purchased by Vista Chemical Company in 1984 and then by CONDEA in 1991. CONDEA had two outfalls permitted under NPDES Permit No. LA0003336. Both outfalls discharge into Reach 2 of Bayou Verdine (Figure 8-2, Curry et al 1997). Outfalls 001 and 001B received flow from the Alcohol Unit, East Lake Charles Chemical Plant Sanitary Sewers, Ethoxylate Unit, Normal Paraffin Unit, stormwater, Ethylene Unit, Steam Plant, Linear Alkyl Benzene Plant, Vinyl Chloride Monomer Plant, and blowdown (Curry et al 1997). Exhibit 8-4 summarizes sources to outfall 001**.**

Exhibit 8-4

Vista NPDES Compliance History (Vista Chemical Corporation Facility Profile Sheet. DPRA, October 31, 1995)

Date	Parameter	Deviation
5/84 *	EDC	+68.06 lbs/day
10/84*	EDC	+234.46 lbs/day
1/85*	EDC	+283.56 lbs/day
2/84*	EDC	+179.86 lbs/day
8/88	EDC	+13.06 lbs/day
10/88	EDC EDC	+3.9 lbs/day +0.75 lbs/day
1/89	EDC	+3.88 lbs/day
2/89	Benzene Toluene	+5.31 lbs/day +0.91 lbs/day
3/89	EDC Oil & grease	+4.59 lbs/day 48 mg/l
5/89	EDC	+4.06 lbs/day
6/89*	EDC	Unknown
7/90	EDC	+7.05 lbs/day
12/90*	EDC	+2.66 lbs/day
1/91*	EDC	Unknown
6/91*	EDC Benzene Oil & grease	4.78 lbs/day Unknown Unknown
7/91*	EDC	266 lbs
12/91	Chromium Zinc Chloroform Toluene Benzene Methyl chloride	Unknown Unknown Unknown Unknown Unknown Unknown
1/92*	Phenol	Unknown
9/92	EDC	+7.46 lbs/day
3/93*	EDC	Unknown
11/93	EDC	+5.59 lbs/day
12/93	EDC	2.06 lbs/day
3/94*	EDC	+167.86 lbs/day
9/94	EDC	+10.13 lbs/day

***Source of parameter was assumed to be outfall 001 on this date.**

Outfall 001 is monitored for TSS, BOD, TOC, ammonia, benzene, toluene, 1,2-dichloroethane, chloroform, methylene chloride, sodium hydroxide, total chromium, total zinc, and temperature and has a flow of approximately 1,650 gpm (Curry et al 1997). Outfall 001B, via the Vista West Ditch to Bayou Verdine in Reach 2, was designated as the emergency outfall for all of the above. Vista also lists 10 stormwater runoff outfalls but indicated that none of them met the definition of an outfall for which a permit is required (Curry et al 1997).

2.3 Areas of Natural Resource Injury Concern

The analysis used to identify the area associated with potential natural resource injuries resulting from the PRPs' releases is based on information currently known to the Trustees. Because much of this information arises from recent, comprehensive investigations of the estuary conducted or supported by EPA, the PRPs, and the Trustees, there is technical confidence that the areas identified via this assessment are appropriate for evaluating injury to natural resources and services associated with the PRPs' hazardous substance releases.

As revealed by exceedance records and spill reports, the Conoco and Sasol facilities released a number of different constituents, most notably heavy metals (e.g., zinc), some volatile organic compounds (e.g., benzene), and semi-volatile compounds (e.g., polycyclic aromatic hydrocarbons, or "PAHs"). PAH compounds, lead, zinc, and nickel at concentrations exceeding contaminant screening guidelines (Buchman, M.F., 1999) were identified in Bayou Verdine sediments, in the small marsh south of I-10, west of the bayou. Information concerning the types of contaminants that were released by the PRPs and by other facilities to the Calcasieu Estuary was previously summarized in a report to NOAA (Curry et al, 1997; EPA, 2003).

All available relevant sediment, toxicity and tissue data resulting from remedial investigations conducted by EPA for the Calcasieu Estuary site (MacDonald et al., 2002a) and by the PRPs for Bayou Verdine (PPG 1996; Conoco and Sasol, 2000), as well as other historical information on the presence of contaminants in the estuary, were assembled into a relational database/GIS at http://response.restoration.noaa.gov/cpr/watershed/calcasieu/calc_html/calcenv.html

The Trustees used the GIS database to compare contaminant concentrations from the two relevant sediment quality guidelines to those measured in the sediment to determine the geographic extent of the potential for natural resource injuries. The Trustees then determined the total acreage impacted by the contaminants exceeding these guidelines.
Evaluation of the available data indicates that the potential for injury to natural resources from hazardous substances released by these PRPs is limited to Bayou Verdine, Coon Island Loop and associated wetland areas, and to the biota utilizing these areas (see Section 2.2 for further explanation). The basis for this determination includes:

- Geographic Isolation – While many of these contaminants were released by other facilities into other portions of the Calcasieu estuary, Bayou Verdine is geographically isolated from the greater estuary (Figures 2.2 & 2.3);

- High levels of zinc, characteristic of the PRP releases, are largely found in sediments within Bayou Verdine and, to a lesser extent, in sediments within Coon Island Loop. High zinc concentrations serve as a marker for defining the extent of contamination from these PRPs.

The Trustees found little to no potential for resource injuries or losses in other portions of the estuary attributable to the PRPs' releases. Using zinc as a marker indicated that the potential for natural resource injury due to the distribution of PRP- related contaminants in sediments has

been determined to be largely limited to Bayou Verdine and Coon Island Loop. Other areas potentially affected by releases from these PRPs, such as Conoco's marine terminal dock on the Clooney Island Loop of the Calcasieu River, do not exceed sediment quality guidelines and thus do not contribute to natural resource injuries in the estuary. Therefore, areas beyond Bayou Verdine, Coon Island Loop, and associated wetlands, were not considered in the following analysis. Potential injuries to natural resources in other portions of the estuary exposed to hazardous substances released by other parties is not discussed further in this document.

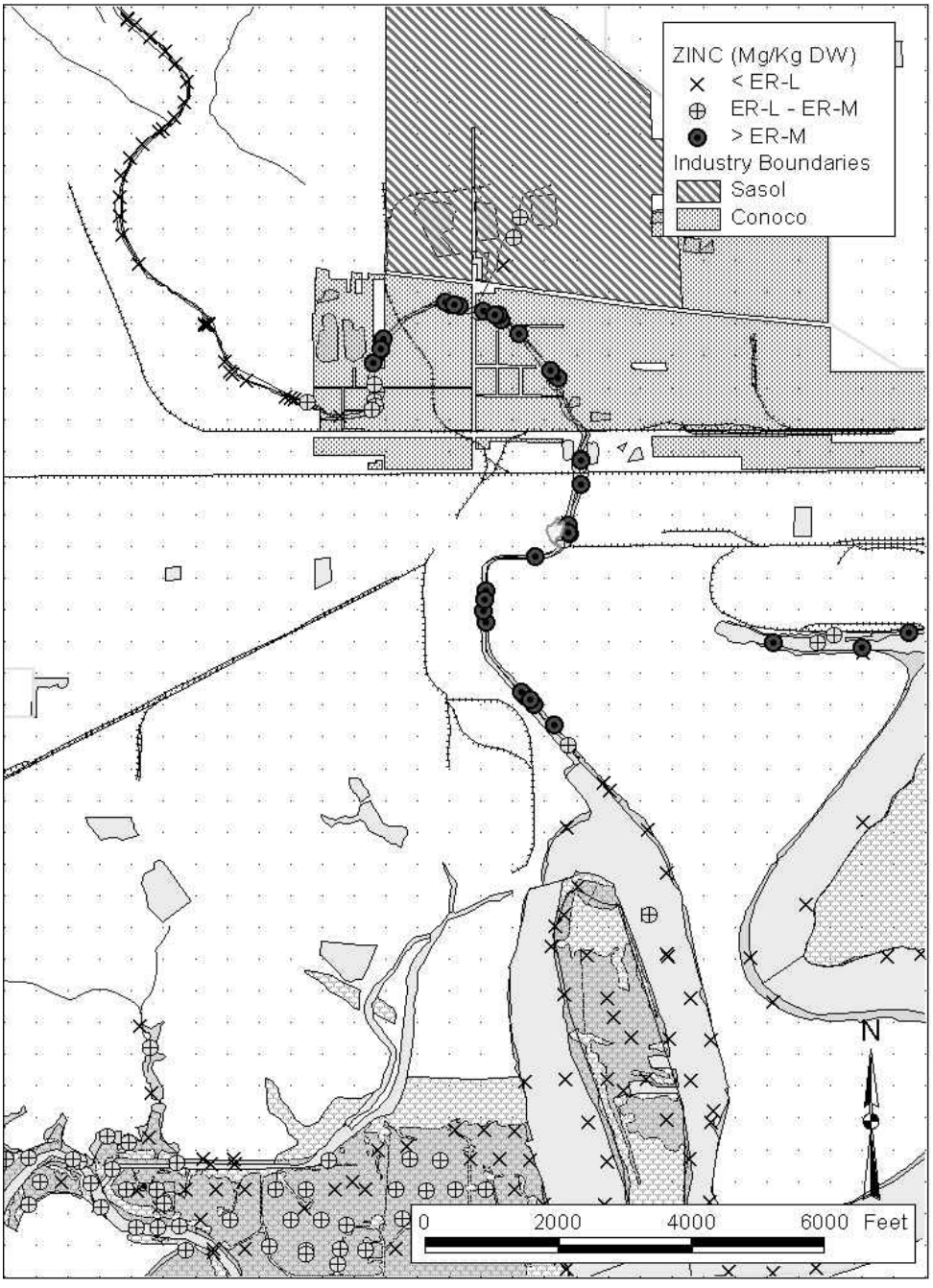

Figure 2.2. Zinc contamination distribution in Bayou Verdine & Coon Island Loop, Calcasieu River, Calcasieu Parish, LA.

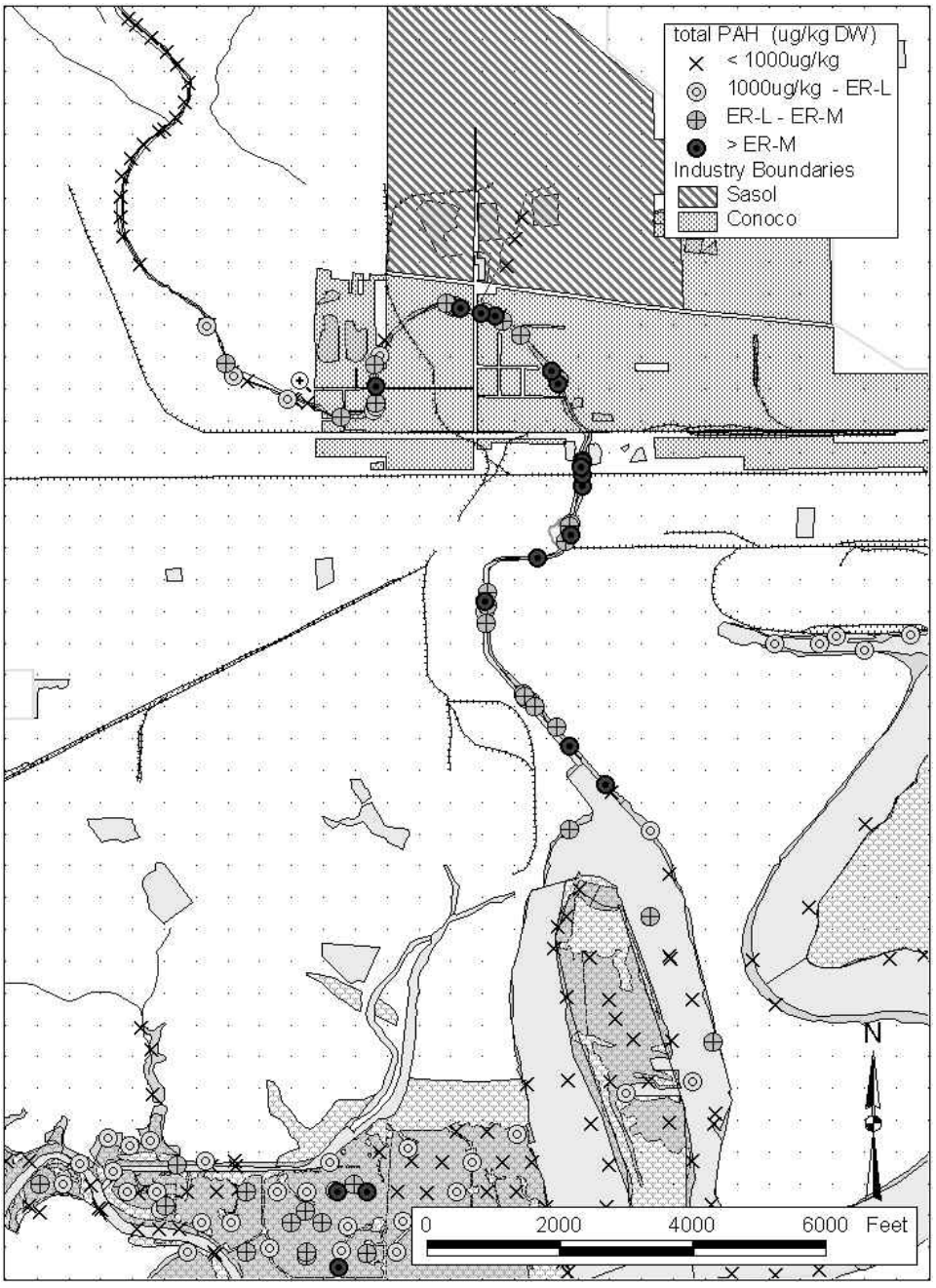

Figure 2.3. Total polycyclic aromatic hydrocarbon (tPAH) contamination distribution in Bayou Verdine & Coon Island Loop, Calcasieu River, Calcasieu Parish, LA.

3.0 SCREENING OF POTENTIAL INJURY CATEGORIES

The preliminary evaluation of potential injury to natural resources and services is discussed below. In this part of the process, the Trustees considered whether the levels of contaminants in Bayou Verdine and Coon Island Loop were sufficient to cause harm to natural resources or resource services in these areas. For purposes of this evaluation, the Trustees considered (1)

sediments and their associated benthic communities; (2) surface waters and their associated planktonic organisms; (3) higher tropic level organisms (i.e., fish, birds, etc.) and (4) any recreational use of area natural resources by humans.

3.1 Sediments/Benthos

The Trustees considered whether the contaminant levels present in the sediments of Bayou Verdine and Coon Island Loop were sufficient to cause harm to the organisms living within, upon, or closely associated with those sediments, or otherwise adversely affect ecological services from this habitat. Organisms common to the area were evaluated in this analysis, including invertebrates and fish species that are considered predominantly demersal species (e.g., flatfishes). The sediments in Bayou Verdine and, to some extent Coon Island Loop, contain several contaminants at concentrations greater than screening levels, such as NOAA's Effects Range Median (ER-M), which commonly screen for possible harmful effects to aquatic organisms.

The Trustees compared mean quotients of PAH and metal concentrations from individual sample locations to scientifically recognized screening values: the mean quotients of Effects Range Low (ERL) and Effects Range Medium (ERM) guidelines developed by NOAA (Buchman, M.F., 1999). The ERL and ERM values are highly predictive numerical indicators of adverse effects to sediment-dwelling organisms due to ingestion and bioaccumulation of contaminants. Adverse biological effects may occur at contaminant concentrations ranging between the ERL and the ERM (MacDonald, et al 1998). Above the ERM, adverse effects are highly probable. The Trustees' assessment further assumed that these contaminants are available for uptake by sediment-ingesting organisms. Data indicate that the probability of observing toxicity to sediment dwelling organisms generally increases with an increased frequency of exceedances of both individual ERMs and mean ERM quotients. This supports the inclusion of the category of benthos and benthic habitat as a potential injury for these areas.

Additionally, bulk sediment toxicity tests, which expose biota to sediments taken from Bayou Verdine, have been conducted at various times since the late 1980's. Results of these tests have consistently shown significant toxicity to exposed organisms. The BERA for Bayou Verdine found that contaminants, primarily non-polar organic compounds such as PAHs, contributed to the observed toxicity in its sediment (ENTRIX, 2001a). Therefore, benthic resources were identified as a potential injury category and retained for further analysis.

3.2 Surface Water Column/Planktonic Organisms

The Trustees evaluated the potential for injury to planktonic organisms living in the water column due to contamination in these areas. Plankton consists of a diverse group of organisms inhabiting the water column that lack the ability to effectively move against currents and are, therefore, transported by water movement. Most species classified as plankton are either herbivorous or are lower trophic level predators.

Some early studies found a few contaminants at levels exceeding water quality criteria at a limited number of stations in Bayou Verdine and Coon Island Loop (ChemRisk, 1994). In Bayou Verdine, some of these observations showed concentrations of nickel and zinc exceeding EPA's chronic marine ambient water criteria for protection of aquatic organisms in surface waters and revealed copper levels exceeding the EPA acute ambient water criterion. In Coon Island Loop, lead surface water concentrations were found to exceed the chronic marine ambient water criteria for protection of aquatic organisms. Surface water samples collected in 1999 and 2000 for Bayou Verdine's BERA indicated that concentrations of contaminants were below the established water quality criteria for the protection of aquatic life and, as such, not at levels

indicative of potential injury (ENTRIX 1999). Based on this recent data, the Trustees found the potential for any ongoing or present injury to planktonic organisms directly exposed to the contaminants released by these PRPs to be negligible. Further, planktonic organisms have brief life cycles and can effectively recruit from adjacent waters. When water column contamination drops below levels of concern, planktonic organisms naturally recover to baseline conditions very rapidly. Thus, based on the available evidence, the Trustees concluded that these water column organisms are most likely at baseline conditions in these areas.

The Trustees also examined the potential for interim water column losses due to past injury back to 1981 (the year in which CERCLA was enacted). Although past injuries and interim losses may have in fact occurred, quantifying any such loss in retrospect is difficult given the limited supporting data available for the period prior to 1999. Additionally, in considering whether to address past losses, the Trustees recognized that the water quality standards used to evaluate the potential for injury to planktonic organisms are technically conservative (i.e., are more likely to over-estimate potential risk). The Trustees also considered the nature of the exposure to planktonic organisms. Unlike benthic organisms, which are relatively sedentary, plankton drift with water currents, causing their opportunity for exposure to contaminants in the water column in these areas to be more temporary in nature than for benthic organisms. This further reduces the likelihood that significant losses of planktonic organisms occurred in the past. Finally, the contaminants released by these PRPs tend to be hydrophobic and partition into the sediments, rather than remain in the water column. Based upon the previously listed reasons, the Trustees found no significant potential for injury to water column organisms in the past.

As a final consideration, the Trustees recognized that most potential restoration undertaken to compensate for benthic injury would ecologically benefit other resources, including water column organisms. The potential for providing multiple benefits (including water column benefits) will be considered in evaluating restoration activities required to address benthic injury, in order to compensate for injury.

Because contaminant levels in surface waters do not currently pose a risk of injury to plankton, and historical data suggest a relatively small potential for past injury, the Trustees have determined that no further evaluation of injury to water column organisms is warranted.

3.3 Higher Trophic Level Organisms

Higher trophic level organisms include animals such as piscivorous fish, mammals and birds. Potential injuries to such organisms may occur through direct exposure to contaminants, or indirect exposure through the consumption of contaminated prey.

The direct exposure route is frequently the most significant source of contaminants to fish, rather than piscivorous birds or mammals, because fish are continuously exposed through the surface waters and sediments that comprise their habitat. However, because no water column contaminant concentration exceeded its respective AWQC value, only sediment exposure is relevant. Like the evaluation of potential for injury to planktonic organisms, the contaminant levels in surface waters in Bayou Verdine and Coon Island Loop are below levels likely to cause injury to fish species. Fish species (e.g., blue catfish, flatfishes) that live closely associated with the sediments, and that may have been injured by direct contact with metals and PAH-contaminated sediments, are treated as part of the benthic community and are, therefore, encompassed in the analysis of injury to benthic resources.

None of the contaminants linked to PRPs releases and present at high concentrations in the sediments of Bayou Verdine and Coon Island Loop (i.e., PAHs or Zn) tend to biomagnify significantly (increase in concentration from one trophic level to the next). Therefore, the

potential for injury to higher trophic level organisms via indirect exposure to contaminants through their food chain (i.e., through consumption of lower level consumers of prey items from Bayou Verdine and the Coon Island Loop sediments) is much lower than if there were significant concentrations of contaminants that tend to biomagnify. The BERA for Bayou Verdine evaluated the risk of injury following indirect exposures to representative bird and other wildlife species in this area. The Great Blue Heron, Belted Kingfisher, American Coot, Muskrat, and Mink were specifically considered in that BERA and served as surrogates for other potentially affected, upper trophic species. The BERA evaluation for Bayou Verdine concluded that the potential risk to these organisms from the contamination present in Bayou Verdine is negligible (ENTRIX, 1999). The exception is sediment probing birds and other avian guilds with foraging strategies that routinely ingest contaminated sediments or insects emerging from those sediments (e.g., black-necked stilts, spotted sandpipers, snowy egrets, green-backed herons, tri-colored herons, barn swallows, etc.). The Trustees believe the potential for injury to these species is low and potential injuries do not support the increased assessment costs to generate a claim. The Trustees recognized that most potential restoration projects undertaken to compensate for benthic injuries would also ecologically benefit other resources, including birds.

The BERA for Bayou Verdine (ENTRIX, 1999) did not address the risks to biota from the contamination in Coon Island Loop. Risk to higher-level organisms from contamination in Coon Island Loop was, however, addressed in the BERA conducted by EPA for the larger Calcasieu study area. This BERA (EPA, 2002) indicates that the contaminants of concern in Coon Island Loop are primarily PAHs and PCBs. Conoco and Sasol are not linked to PCB releases into Calcasieu Estuary, and thereby are not linked to any potential injury to higher trophic level organisms from PCBs. The analysis of potential injury to higher trophic levels from PAHs in the Coon Island Loop shows the same result as for Bayou Verdine itself, i.e., that PAHs present a low potential for injury to these resources.

Because available information indicates that neither the Bayou Verdine nor the Coon Island Loop contamination pose significant risk for injury to higher trophic level organisms, the Trustees omitted these organisms from further injury evaluation relating to PRP releases.

3.4 Human Recreation

Natural resources support many recreational activities or other public uses potentially affected by contamination. The Trustees considered area-supported recreational uses including fishing, swimming and water skiing, wildlife viewing, and boating, but found no information indicating services of this nature have been lost or diminished due to any contaminant released by the PRPs.

No advisories exist with respect to swimming or any other contact recreational activities in Bayou Verdine or the Coon Island Loop (LDEQ, 2001). Although sediment contamination present in Bayou Verdine may have the potential to inhibit contact recreation in that area, public access to Bayou Verdine is extremely limited. Barges present at its confluence with Coon Island Loop normally preclude anyone from entering Bayou Verdine via water. Terrestrial access to the bayou is also restricted through surrounding land largely comprised of private industrial properties. Further, no public boat launching sites or other types of public access points are found along the bayou. Therefore, there is little likelihood of lost recreational use of surface waters due to the contamination in Bayou Verdine. The lower level of contamination present in Coon Island Loop sediments does not appear to affect surface water contact recreation.

An informational advisory on recreational fishing is in place for the entire Calcasieu estuary, including Bayou Verdine and the Coon Island Loop. This advisory is based on the presence of hexachlorobenzene, hexachloro-1,3-butadiene, and PCBs in fish (LDEQ, 2001), and the risks

associated with human consumption of these fish. None of the contaminants supporting the advisory are among those known or potentially released by Conoco or Sasol North America. Under these circumstances, no compensation would be due from these PRPs for any recreational fishing losses occurring as a result of the advisory.

Based on this analysis, the Trustees have concluded that no recreational losses of any significance are likely to have occurred due to the releases of Conoco or Sasol North America. This determination is consistent with the Human Health Risk Assessment (HHRA) conducted for Bayou Verdine (ENTRIX 2001a).

4.0 ESTIMATION OF INJURY TO SEDIMENT HABITAT/BENTHOS

After establishing the occurrence of injury to benthic resources, it is necessary to quantify the amount of that injury or loss. The Habitat Equivalency Analysis (HEA) method was chosen to achieve that purpose. The HEA method quantifies both natural resource and ecological service losses and habitat restoration required to compensate for those losses. Inputs necessary to conduct the analysis were developed by the workgroup. Rather than perform further site- or resource-specific studies to confirm and provide additional data for use in quantifying the injury, the workgroup elected to use a Reasonable Worst Case (RWC) approach in the analysis. In the RWC approach, existing site-specific data as well as those reported in the scientific literature for contaminants of concern are used to define the parameters needed to estimate injury via the HEA. Where technical uncertainty exists, in lieu of conducting specific injury studies to address the uncertainty, conservative inputs or assumptions (those leading to higher estimates of injury) are used in the analysis. This approach results in an estimate of injury that the parties could reasonably expect would either be confirmed by or reduced if specific injury studies were conducted. It may also result in a higher compensatory restoration estimate than may be strictly required, however, overall cost to PRPs may be less as the PRPs avoid the cost of additional studies that may not result in significantly reducing the amount of the restoration (and the costs of restoration) determined necessary to compensate for losses.

4.1 Benthic Injury Estimates for Use in Habitat Equivalency Analysis

The HEA method is essentially an accounting procedure that allows parties to identify the scale of a restoration option required to compensate for assessed resource injuries. To use the HEA method, information or estimates of the ecological service losses that define the injury are required to estimate restoration requirements. The approach is also used to evaluate the adequacy of appropriate restoration options**.**

For each area of benthic habitat classified as injured (see Section 4.1.1), an estimate of the extent of injury is made through an assessment of real and potential ecological service losses[2]. Because the amount of benthic community injury or service losses will vary according to the nature and extent of sediment contamination and remedial options implemented, injury estimation involves detailed considerations. This process is accomplished through identification of the area potentially injured by remedial activities or chemical contamination and, for each area, determining the likely severity of injury based on the available scientific information on potential effects. The severity of injury is then used to estimate the percent of benthos services lost due to the presence of elevated concentrations of site-related chemicals.

Benthos is a broad term that describes aquatic invertebrate organisms living on or in the sediments of an aquatic ecosystem. Benthic organisms often feed on organic detritus that is

2 These losses include those fish species closely associated with the sediments, as discussed in Section 3.3.

mixed with the top few centimeters of sediment or is trapped in the silty fines that cover the sediment surface. Most other trophic niches (herbivores, predators, scavengers, etc.) are also represented in the benthic community. Benthic communities constitute an important part of the estuarine food web by utilizing sediment-bound nutrients and organic substances that are not generally available to epiphytic or pelagic organisms. The ecological services provided by benthos that can be affected by site contaminants include:

- **Food and Production:** Benthic populations include both meiofauna and macrofauna that are classified into groups based on their relationship with the sediments. These relationships include either burrowing (infaunal), deposit feeders or epibenthic species. Benthic organisms are generally fast growing, adaptable and serve as an important basal component of the estuarine food web. Infaunal and epibenthic organisms utilize nutritional resources (i.e. bacteria, algae, and partially decomposed organic detritus) that are not available to larger organisms. Benthic organisms serve as an important food source for fish, crabs and shrimp that use the estuary. The productivity of this habitat affects all trophic levels in the estuary by providing the nutritional base for the developing stages of many finfish, shellfish, and some birds.

- **Conditioning & Improvement of Habitat:** Many benthic species burrow through the sediments, increasing the oxygen content of deeper sediments and thereby allowing other organisms and aerobic bacteria to inhabit deeper sediment layers. In addition, the excavation of sediment re-introduces nutrients found at greater depths to the surface where grazers and deposit feeders can utilize them. The ingestion of sediments by deposit feeders occasionally results in the complete reworking of bottom sediments several times within a year.

- **Decomposition and Nutrient Cycling:** A complex community of bacteria, meiofauna and macrofauna contributes to the reduction and decomposition of organic matter and debris within the sediments. The process of decomposition is important for the cycling of carbon and nutrients back through the aquatic food web.

Thus, the benthic community provides important ecological services primarily related to food production, decomposition and energy cycling. These services contribute to the productivity of the system and affect nearly all organisms within an estuarine system. Adverse impacts to benthic resources have the potential to impact biota in all trophic levels of the estuary by reducing the overall productivity of the system.

4.1.1 Geographical Strategy for Estimating Benthos Injury

In developing injury estimates for benthic resources, the workgroup divided the area of interest into two main subareas, (1) Bayou Verdine (including associated aqueous portions of adjacent wetlands) and (2) Coon Island Loop. There are two chief considerations responsible for this approach. First, as discussed in the following sections, the levels of contamination and apparent injury are very different between the two areas. Second, implementation of different remedial actions is expected in these two areas. The effect of such actions is very important in determining the injuries that will occur and in defining the losses that will continue until baseline conditions are reached.

4.1.2 Bayou Verdine Benthos Injury Estimate

Results of Bayou Verdine sediment toxicity tests conducted in 1988-1989 (Redmond et al., 1996), as well as those conducted as part of the recent BERA for Bayou Verdine (ENTRIX, 2001a), indicate that the contamination present in bayou sediments is causing severe injury to the benthos. Most of these tests resulted in mortality to all the test organisms. Although some

organisms live in these sediments, the Trustees and PRPs conservatively agreed to consider this area as suffering a complete loss of benthic services (e.g., 100% injury). This level of injury is assumed to have been constant in the past, and is assumed to remain at this level until the contaminated sediments are removed, as is currently planned for the PRP-contaminated portion of Bayou Verdine. After removal of the contaminated sediments, a gradual return to full service flows is assumed. The recovery of benthos from dredging depends on numerous factors, including the time of year sediment removal occurs relative to the biological cycle for larval recruitment. Although some studies suggest that benthic recovery occasionally occurs within a few months to around a year (Swartz et al., 1980; Kenny and Rees, 1994; Van Dolah et al., 1984), the Trustees recognized that recovery may take longer and are assuming that full recovery would occur within two years.

The total contaminated portion of the bayou is approximately 17 acres in size. An adjacent area of wetlands is also included in this analysis and is approximately 1.5 acres. The above analysis assesses the benthos injury as 100% loss of benthic services over 18.5 acres of Bayou Verdine and associated wetlands, with losses treated as constant until the contamination is removed as a result of the remedy and full service levels return two years later.

4.1.3 Coon Island Loop Benthos Injury Estimate

The level of contamination in Coon Island Loop sediments is less than that of Bayou Verdine, and sediment toxicity test results for the former area indicate a lesser degree of benthos injury. Trustees commonly use contaminant exceedences of sediment quality guidelines (SQGs) as indicators of potential injury to exposed benthic resources. SQGs represent sediment benchmark concentrations known or suspected to give rise to adverse effects on benthic populations**.** Recent studies (Long et al., 1998; Long and MacDonald, 1998) have shown that the probability of sediment toxicity, an important indicator of benthic injury, is correlated with the mean ER-M quotient. Because there are a number of contaminants present with the potential for synergistic or antagonistic interactions, the Trustees decided to use a SQG summary statistic to delineate different zones of assumed injury. This summary statistic is calculated by first dividing the sum of the ratios of the contaminant concentration by the ER-M for each contaminant and then dividing that value by the total number of contaminants evaluated. Delineating the benthic injury into different zones was judged an appropriate approach for this situation due to the presence of multiple contaminants contributing to benthos injury (Figure 4.1). However, this method may not be appropriate at other sites and under other circumstances[3]. It should also be noted that all 34 hazardous substances detected at the site were used in calculating the ER-M quotient, though PAHs and zinc contributed most significantly to observed toxicity.

Appropriately conservative estimates of injury were developed for the different ranges of mean ER-M quotients using best professional judgment of the technical workgroup based upon available data, including the results of site-specific toxicity tests and information resident in the scientific literature. The ranges of mean ER-M quotients, derived from all of the contaminants measured in Coon Island Loop, and the levels of injury assigned by the workgroup are presented in Table 4.1.

3 For example, if a site had a few contaminants at high levels relative to their ER-Ms, and many other contaminants at low levels compared to their ER-Ms, the resulting mean ER-M quotient might suggest a lower level of injury than is actually present. The Trustees considered the potential for this effect in the Coon Island Loop, as well as other factors, in deciding to use this approach here.

Table 4.1 - Benthos Injury Levels for Coon Island Loop

Mean ER-M Quotient	Assigned Injury Level
1.51 to 1.73	74%
0.51 to 1.50	46%
0.11 to 0.50	30%
0-0.10	0%

No dredging (natural recovery) in the Coon Island Loop is expected to be chosen as the remediation remedy since natural attenuation is occurring at an acceptable rate. However, portions of Coon Island Loop are dredged to maintain access to PPG marine docks and barge terminal. Consistent with a US Army Corps of Engineers permit sediment in these areas is periodically removed and managed in confined disposal facilities thus eliminating exposure of benthic resources. The Trustees recognize that this activity will further expedite the remediation. Therefore, the Trustees developed injury estimates from the present time until contamination levels in the biologically active sediment layer decline to a mean ER-M quotient of 0.10 or less. Based on sedimentation rates extrapolated from Mueller, C. S., et al., (1987), complete recovery to full benthic service flows is conservatively assumed to occur in 2023.

The Trustees also needed to develop estimates for past trends in benthic resource injury levels. Data collected for PPG between 1992 to 1994 (NOAA 2002) were used to develop a trend of injury dating to the present. Prior to 1992, there is little available information to assist in estimating injury. Therefore, in the absence of data needed to develop an injury trend, the Trustees use the same injury value back in time from 1993 to the 1981 (i.e., “flatline” injury back in time) (Figure 4.2). The Trustees further divided Coon Island Loop into two areas: 1) the dredged channel (a lesser quality habitat) totaling approximately 57 acres and 2) the shallow portion of Coon Island Loop, totaling approximately 254 acres (Table 4.2). The results of the benthos injury analysis for Coon Island Loop and Bayou Verdine are presented in Table 4.2. No data for the Coon Island Loop channel were obtained in 2000, necessitating the estimation of injury to the channel from the injury trend for the shallow portion of Coon Island Loop for that

year.

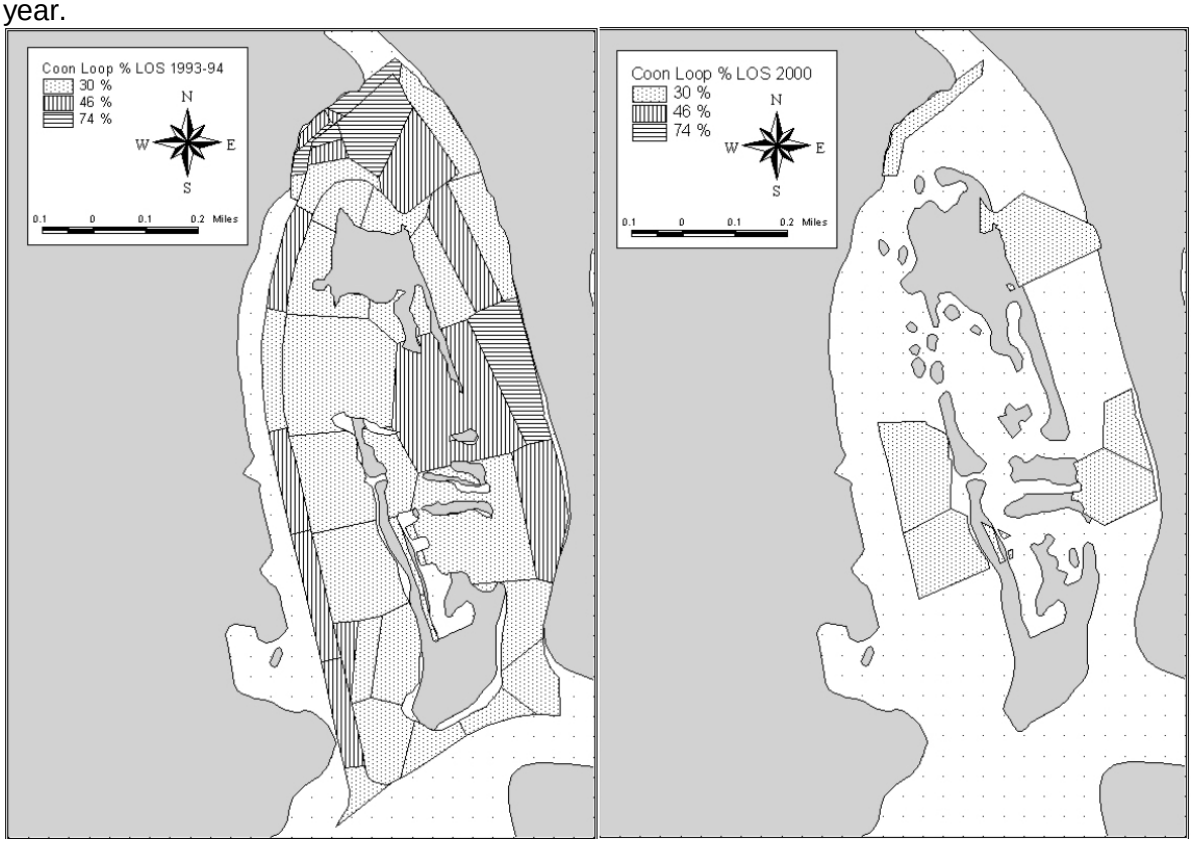

Figure 4.1. Coon Island Loop % Loss of Service (LOS), 1993 & 2000

Equivalent Injured Acres is a ratio used to compare relative habitat productivity of an injured habitat to that of the restoration target habitat, allowing for the quantification of replacement ('equivalent') acres necessary to achieve restoration goals. Comparing DSAYs of different habitat types is like comparing apples to oranges. The equivalent injured acres technique allows the user to compare relative productivity of differing habitat types and results in the calculation of 'equivalent' acres of the desired habitat type. For the estimation of restoration in Bayou Verdine and Coon Island Loop, injuries were assessed for open water although the restoration target habitat was estuarine marsh. Therefore it was necessary to convert habitat scale through the equivalent injured acres approach. Creation or enhancement of wetlands has frequently been utilized in past NRDA cases as compensation for injury to water bottoms and intertidal areas due to the capacity of wetlands to replace lost services, and the difficulty in creating water bottom habitat from other habitats with out the loss of important resources and services that those habits provide. A conversion factor of 10 acres of water bottom to 1 acre of marsh was used based on recommendations from an expert panel and prior NRDA experience.

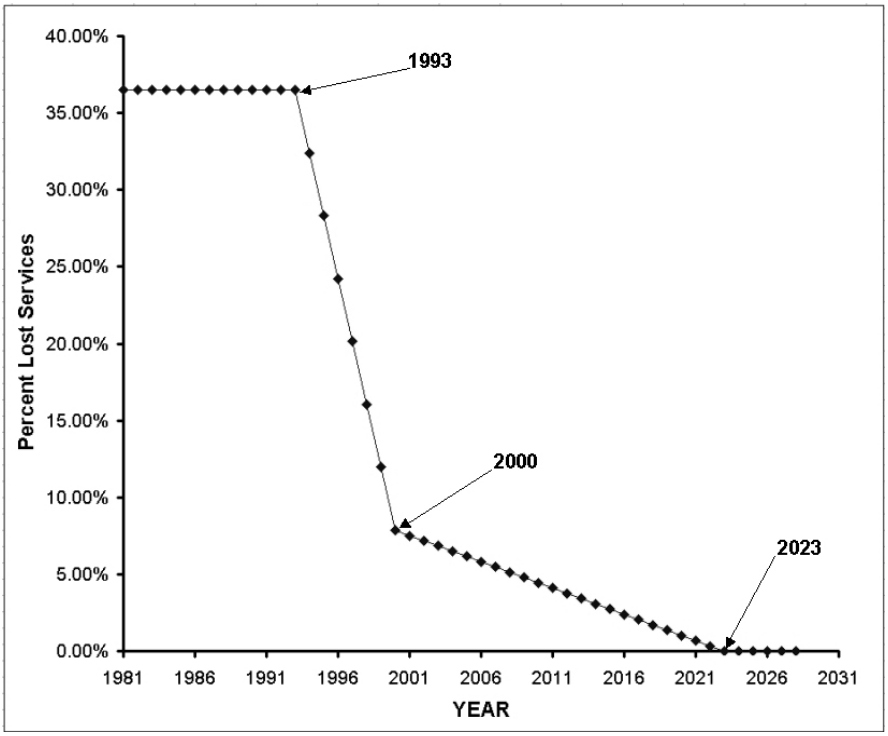

Figure 4.2 Example of Injury Curve (Coon Island Loop)

Table 4.2. – Benthos Injury Analysis

Area Name	Area (acres)	Injury (ca. 1992) % LOS	Injury (2000) % LOS	Time to recovery	EqDSAYs Lost
Bayou Verdine	17.6	100%	100%	2 years after dredging	132.3
Bayou Verdine Wetland	1.5	100%	100%	2023	59.6
Coon Island Loop Channel	57	48.5%	7.9%	2006 (2 yrs after maintenance dredging)	172.2
Coon Island Loop	254	36.5%	7.9%	2023	571.2

5.0 SUMMARY OF INJURY ANALYSIS

The Trustees determined that the assessment of natural resource injury due to releases of hazardous substances from the PRPs should be focused on benthic habitat and community services in Bayou Verdine and the Coon Island Loop. An RWC analysis was conducted to determine the interim loss of ecological services due to the effects of elevated concentrations of PRPs' contaminants on the benthos in these areas. The RWC analysis used historical data as well as data collected for both the PRPs' BERA for Bayou Verdine and EPA's BERA to quantify the injury to benthos based on sediment benchmark concentrations known or suspected to give rise to adverse effects on benthic populations. The RWC analysis incorporated technical judgments and assumptions that are protective of the public's interests, based on an understanding of the likely remedial approaches to be taken for the areas of interest. The results of this analysis are shown above in Table 4.2.

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