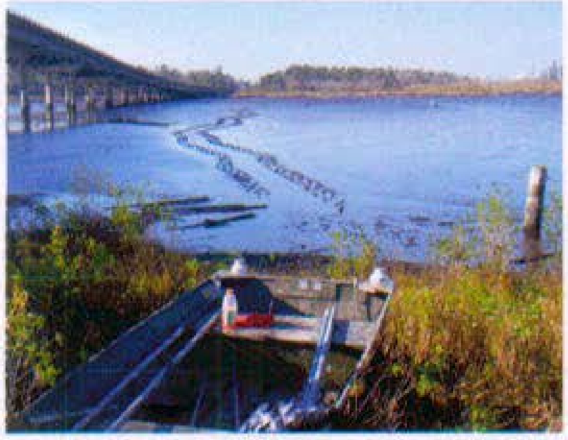
Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume I of X
Text and Tables
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

CDM
8140 Walnut Hill Lane, Suite 1000
Dallas, Texas 75231
tel: 214 346-2800
fax: 214 696-5373

August 29, 2003

Mr. John Meyer
Remedial Project Manager
U.S. Environmental Protection Agency
Region 6, Project Management Section (6SF-LP)
1445 Ross Avenue
Dallas, Texas 5202

Subject: Calcasieu Estuary - Final Remedial Investigation Report Deliverable

Dear Mr. Meyer:

Enclosed are three copies of the Calcasieu Estuary Final Remedial Investigation Report deliverable. Each copy consists of text pages, Tables, Figures and document covers/spines revised per our meeting on Monday August 25. Document revisions were in response to comments received during public review. Revised sections include the Executive Summary, Sections 7, 8, 10 and 15, Tables 2-1, 7-2 and 10-2, and Figures 2-5 and 7-2.

Three sets of electronic copies (compact disk copies) are also attached. The revised sections have been linked, and these copies replace the Draft Final electronic copies.

If you have any questions regarding this deliverable, please feel free to call me at (214) 346-2874. We look forward to continuing our support to EPA on this work assignment.

Very truly yours,

M S Goldberg

Mitchell S. Goldberg
Senior Project Manager

cc: Project File

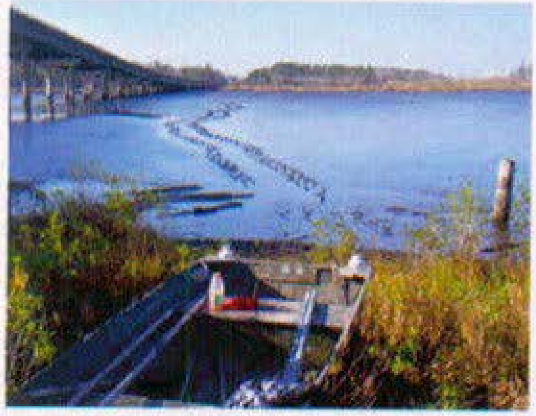
3282-941-CO-EPOU-17203

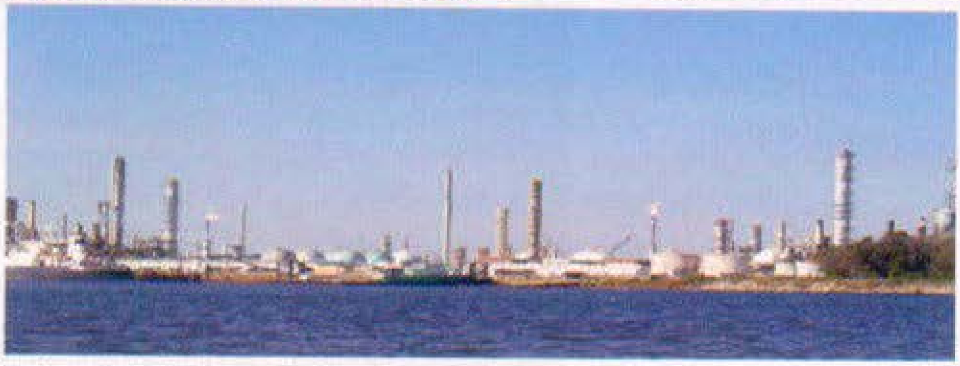
CDM

Calcasieu Estuary Remedial Investigation Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003





Executive Summary
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

3282-941-RTZ-RIRTZ-13767

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

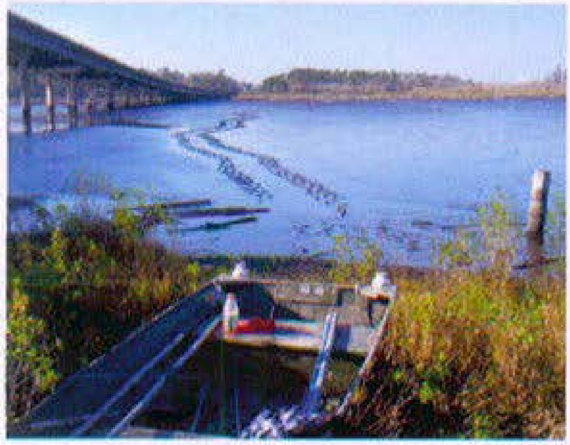
VOLUME I OF X
TEXT AND TABLES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume II of X
Figures
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

VOLUME II OF X
FIGURES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003

Volume III of X
Figures
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

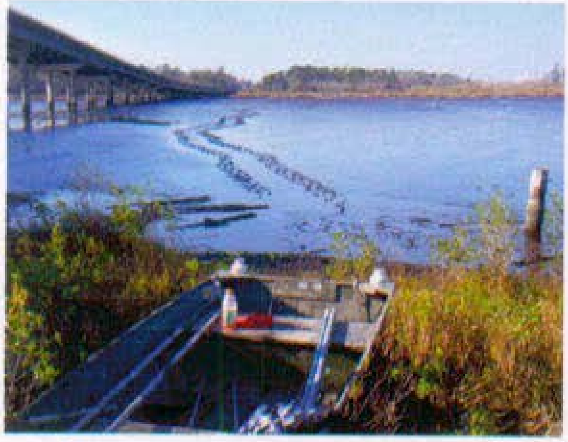
VOLUME III OF X
FIGURES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume IV of X
Figures
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

VOLUME IV OF X
FIGURES

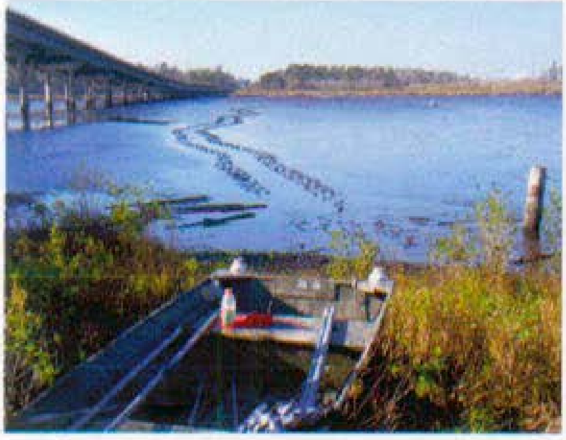
CDM

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume V of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

VOLUME V OF X
APPENDICES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003

Volume VI of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

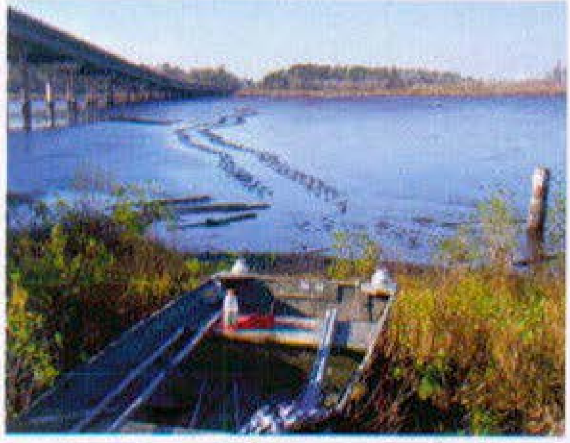
VOLUME VI OF X
APPENDICES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume VII of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

VOLUME VII OF X
APPENDICES

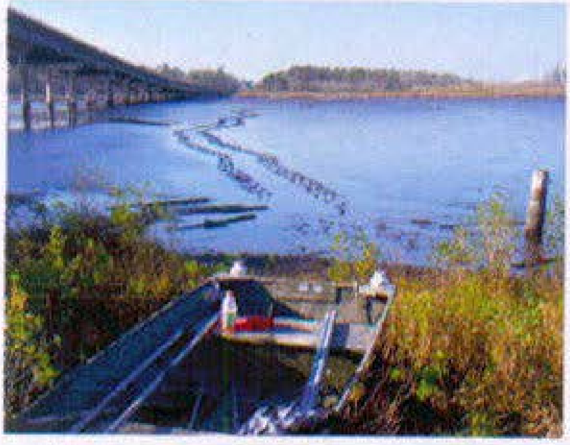
CDM

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume VIII of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

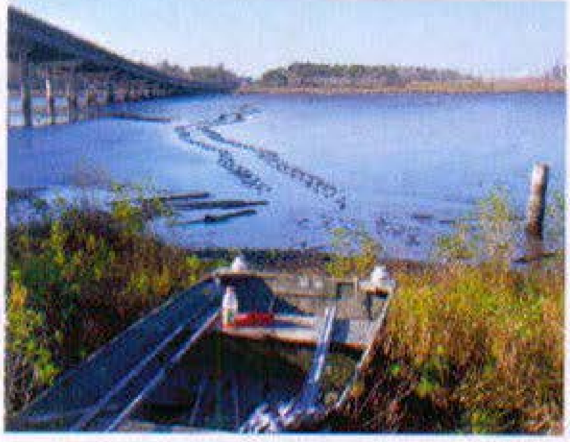
VOLUME VIII OF X
APPENDICES

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume IX of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY
REMEDIAL INVESTIGATION REPORT
LAKE CHARLES, LA

VOLUME IX OF X
APPENDICES

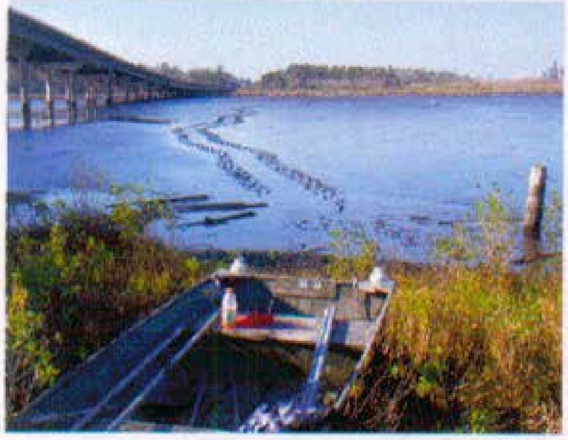
CDM

CDM

Calcasieu Estuary Remedial Investigation
Lake Charles, Louisiana

Final Remedial Investigation Report

August 2003



Volume X of X
Appendices
U. S. EPA Contract No. 68-W5-0022
Work Assignment No.: 941-RICO-06ZZ

FINAL

CALCASIEU ESTUARY REMEDIAL INVESTIGATION REPORT LAKE CHARLES, LA

VOLUME X OF X
APPENDICES

Executive Summary

U.S. Environmental Protection Agency (EPA) Region VI committed funding during 1999 under the EPA's Region VIII Response Action Contract (RAC) to conduct a remedial investigation (RI) portion of a RI/feasibility study (FS) for the Calcasieu Estuary in Calcasieu Parish, Louisiana. The RI was authorized to investigate the potential for impact to human health and the environment resulting from documented uncontrolled releases of organic and inorganic contaminants to the Calcasieu Estuary. This report is the result of three years of site characterization, data evaluation, technical analysis, and reporting, through the cooperation of numerous federal and state agencies, including EPA, and EPA's contractor CDM, U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and the Louisiana Department of Environmental Quality.

This executive summary contains 15 sections that summarize the background and history (Section ES-1 and ES-2), the RI planning and implementation phases of work (Section ES-3 and ES-4), data evaluation and analysis for the reference area and four specific areas of concern (AOCs) (Section ES-5 through ES-11), summaries of the ecological and human health risk assessments (Section ES-12 through 14), and overall summary and conclusions (Section ES-15). Tables and figures that support the discussion are included in the text.

ES-1 Introduction

ES-1.1 General

The Calcasieu Estuary is located in the southwestern corner of Louisiana, predominately in Township 10 South, Range 9 West (Figure ES-1). The study area covers approximately 50 square kilometers (km^2) of the Calcasieu River basin, and extends from a constructed saltwater barrier on the Calcasieu River north of the city of Lake Charles, Louisiana south to Moss Lake, approximately 24 km south of Lake Charles. The estuary is created by saltwater migrating north from the Gulf of Mexico via the Calcasieu River Ship Channel and freshwater draining toward the Gulf from numerous inland rivers, bayous, and lakes. The estuary supports a diverse aquatic ecosystem, which is surrounded by a typical industrialized city.

As noted above, the RI/FS process for the Calcasieu Estuary was initiated by EPA Region VI under EPA's Region VIII Response Action Contract (RAC) No. 68-W5-0022, Work Assignment No. 941-RICO-06ZZ. EPA is addressing threats to human health and the environment related to uncontrolled releases of organic and inorganic chemicals to the estuary under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). CERCLA provides the federal government with authority to develop long-term solutions for those sites that pose unacceptable levels of risk to human and ecological receptors and to arrange for the restoration of damaged natural resources and determine distribution of cost of the actions to potentially responsible parties through cost recovery. It is important to note, however, that the Calcasieu Estuary is not a Superfund site by virtue of listing on the National Priorities List (NPL). Instead, CERCLA provisions allow for sites to progress through, but not beyond, the RI/FS process without a Hazard Ranking System (HRS) score

ES-1.2 Objectives of the RI

The RI objectives were:

- Define the nature and extent of chemical contamination in sediment, surface water, and biota within the Calcasieu Estuary

- Estimate the risk to ecological and human risk receptors in the Calcasieu Estuary

To meet these objectives, the RI included two phases of investigation, and ecological and human health risk assessments, as described in Section ES-4. The human health risk assessment estimated risk to residential, commercial/industrial worker, and recreational user populations, as discussed in Section ES-14. The ecological risk assessment used a weight of evidence approach including, hazard quotients, sediment quality triad data, and food chain modeling to estimate potential risk to ecological receptors (Section ES-13).

ES-1.3 Site History and Historical Site Characterization

Industrial development dominates much land within and around the Calcasieu Estuary. This development dates back to the late 1800s and is directly related to improvements of the Calcasieu River and subsequently the Calcasieu River Ship Channel. Major industry, including chemical manufacturing and petroleum refining companies first appeared in the Calcasieu Parish vicinity during the early 1920s, with the discovery of nearby petroleum and natural gas reserves. In 1938, Calcasieu River was expanded to include an inland ship channel from Lake Charles to the Gulf of Mexico. World War II and post-war years were a catalyst for further industrial development in the Calcasieu Estuary. Abundant raw materials, like crude oil and natural gas, coupled with acreage, water resources for manufacturing, and a commercially navigable access artery for ships and barges led to rapid industrial development.

Exhibit ES-1 summarizes the major industrial facilities located in the vicinity of the Calcasieu Estuary.

Exhibit ES-1 Major Industrial Facilities in the Study Area

Operating Facilities		
Conoco Refinery	PPG Industries	Firestone
Citgo Refinery	Citgo Lubricants Plant	Citgo Propylene Fractionation Unit (PFU)
PPG Industries	CertainTeed	OxyChem/Equistar
W.R. Grace	Montell Inc.	LA Pigment
Entergy Inc.	Westlake Petrochemicals	Westlake Polymers
Tetra Inc.	Lyondell/Olin	Sasol Condea Vista

During the 1990s, many of the larger industrial facilities changed ownership or expanded. The region's industrial base has continued to grow, and today the Calcasieu Estuary supports more than 10 major petroleum refining and chemical manufacturing operations, producing a wide range of industrial chemicals, petroleum products, and commercial feedstock. In addition, the waterways of the estuary continue to support recreational activities, commercial fishing, materials transport, and a diverse ecosystem.

Industrialization is commonly associated with stresses on the environment, and the Calcasieu Estuary is no exception. A number of environmental investigations have been performed throughout the Calcasieu Estuary since the late-1980s to evaluate environmental stressors. Numerous reference documents have been used and cited in the development of this RI report. Exhibit ES-2 summarizes the documents used in this RI report. The reports are publicly available through LDEQ or EPA Region VI.

Exhibit ES-2 Previous Reports in the Study Area

Historical Report	Area Evaluated	Author / Year Completed
Ecosystem Analysis of the Calcasieu River/Lake Complex	Calcasieu River, including the RI Study Area	McNeese / 1987
Calcasieu Estuary Water Sampling Program	Calcasieu River, including the RI Study Area	LDEQ / 1987-1996
Toxics Study of the Lower Calcasieu River March 1990	RI Study Are	RTI / 1990
Bayou d'Inde Expanded Site Inspection - Final Report	Bayou d'Inde	PRC / 1993
Sediment and Surface Water Sampling and Analysis in Bayou Verdine and Coon Island Loop of the Calcasieu River	Bayou Verdine, Coon Island Loop, and Calcasieu River	ChemRisk Division / 1994
Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling Report	Bayou d'Inde, PPG Canal, and Calcasieu River	ChemRisk / 1995
Findings Report for the Focused Site Assessment - Bayou d'Inde	Bayou d'Inde	Fluor Daniel / 1997
Calcasieu River Estuary Biological Monitoring Program: Annual Report April 1997 – January 1998 (Year 9)	RI Study Area	LDEQ / 1997

Bayou Verdine Investigation, Nature and *Extent Investigation*	Bayou Verdine	Entrix 1999

Detailed information on these reports, including a summary of the scope of the investigation, analytical protocols and detections, as well as figures showing the sample locations for each study is provided in Appendix A.

ES-2 Environmental Setting

ES-2.1 General

The estuary is the lower portion of the Calcasieu River drainage basin. The Calcasieu River begins in the hills west of Alexandria (in the vicinity of Kisatchie National Forest in Vernon Parish, LA, approximately 120 km to the northeast of the RI study area), and flows south into Calcasieu Lake, eventually emptying to the Gulf of Mexico.

The Calcasieu Estuary is located within the West Gulf Coastal Plain physiographic province. Geologically, the local area is comprised of young unconsolidated Quaternary (Pleistocene-age) sediments. Structurally, the area is a geosyncline that receives large quantities of sediment from multiple river discharges (Louisiana Geological Survey [LGS] 1984). Local soils and sediments typically consist of interbedded sands, gravels, silts, and clays.

Environmental Setting of Calcasieu Estuary

- Energy Areas
- Areas of Concern
- Reference Areas
- Regional Fauna and Flora
- Hydrogeology
- Dredging History
- Climate

ES-2.2 Energy Systems within the Estuary

Calcasieu Estuary is a complex interconnected system of bayous, marshes, open flats, and shallow lakes and dredged ship channels. To understand and evaluate flow characteristics and chemical fate and transport, an understanding of energy systems within the estuary is needed. The energy of a specific area influences surface water variability, sediment nature, and stability. Depositional environment, surface water conditions, and stability of the sediment in each area can be used to describe the behavior of the system. Further, there are areas within the estuary that are considered atypical with respect to their associated physical or chemical characteristics; this system is categorized as "other". Exhibit ES-3 summarizes the distribution of energy systems in the RI study area. A brief discussion of each follows. The four AOCs presented in this exhibit are discussed in section ES-2.3.

Exhibit ES-3 Energy System Distribution in the Calcasieu Estuary Study Area

Energy System	Bayou d'Inde	Bayou Verdine	Upper Calcasieu	Lower Calcasieu
Bayou	✓	✓	✓	✓
Marsh	✓		✓	
River			✓	
Shallow Lake			✓	✓

Ship Channel	✓	✓
Other		✓

Bayou

The bayou is the natural tributary to the estuary. The system is typically a low-flow system that serves ultimately as a sediment exporter. Sediments tend to be silty sands to clays and generally become finer upstream. Sediments are generally stable in the upper reaches of the bayou where vegetation is more prevalent, and tidal surge tends to be lowest. Sediment stability tends to be lower in shallow segments of the bayou, or where sediments are disturbed by traffic or intermittent higher flow rates.

Marsh

Estuarine marshes are typically sediment sinks. They are low energy, vegetated, and generally sheltered, slow draining basins. They receive and generally contain finer-grained sediments due to lower flow rates and increased sheltering vegetation along their margins. The low water levels within these marshes make them susceptible to dewatering under wind forcing conditions.

Shallow Lake

Shallow lakes differ from the marshes in overall size. The shallow lakes are generally 1 to 3 meters (m) deep, with an area of greater than 0.5 km^2. Vegetation within the shallow lakes is generally less than that of the marshes overall; however, substantial biota habitat is present in some areas. The salinity typically varies from intermediate to saline. As with the marshes, the shallow lakes are net sediment sinks.

Ship Channel

This energy system is a high flow, deep, wide channel (40 to 75 m wide and 10 to 15 m deep), routinely dredged to maintain shipping lanes for large, deep draft vessels. The area is a conduit for increased flood tide surge (flow from the Gulf of Mexico), and salinity is typically brackish. Flow within the ship channel is generally in the thousands of cubic meter per second compared to the single digit range reported for the upper river and bayous.

River

The river energy system is the undredged segment of the Calcasieu River, upstream of Lake Charles. The river resembles the low flow bayou, however, larger overall. The river is larger, 15 to 25 m wide and 4 to 5 m deep. The flow is proportionately greater as well. Salinity tends to be fresh to intermediate; however, it is still susceptible to tidal surge and wind forcing.

Other

The other designation is used to describe the Indian Marais Lagoon located on the edge of the Lower Calcasieu ship channel (Figure ES-2). The lagoon is partially open to ship channel flow and currents. It is bermed and does not receive significant overland run-off. The feature is not a shallow lake due to its size and lack of vegetation and habitat. Instead, it more resembles a marsh. However, it is classified separately as it is connected to the ship channel and is a potential sediment source.

ES-2.3 Estuary Areas of Concern

An overview of the characteristics and a description of the physical parameters of each of the energy systems present in the portions of the estuary identified as AOC is provided below. The four AOCs are Bayou Verdine, Bayou d'Inde and Upper and Lower Calcasieu. These AOC boundaries were developed in the early stages of the RI and were used to group regions of the estuary to aid in evaluation and management of the study area (Figure ES-2). Detailed findings for these AOCs are presented in Sections ES-7 through ES-10.

Four Areas of Concern:

- Bayou Verdine
- Bayou d'Inde
- Upper Calcasieu
- Lower Calcasieu

Bayou Verdine

Bayou Verdine is located between the City of Westlake and the community of Mossville, and north-northwest of Lake Charles in Calcasieu Parish, Louisiana (Figure ES-2). Bayou Verdine is approximately 7 km long and is the only major tributary to Calcasieu River-Coon Island Loop (Curry et al 1997). Its headwaters are fresh, and, as the water travels downstream, it mixes with intermediate to saline water of the Calcasieu River to the south. Water depths in Bayou Verdine range from 0.1 to 6 m, and are the deepest at the mouth in the area of PPG's North Dock area.

The land around Bayou Verdine is characterized by undeveloped land, mixed rural, residential, commercial, and heavy industrial use; however, industrial applications predominate in the southern section of the bayou. Several permitted industrial outfalls discharge to Bayou Verdine under Nation Pollution Discharge Elimination System (NPDES), as well three drainage ditches; Vista West Ditch, Faubacher Ditch , and Kansas City Southern Railroad (KCSRR) West Ditch, all of which drain industrial properties.

Bayou Verdine is classified exclusively as a bayou energy system. The bayou is a net sediment exporter, receiving runoff and sediments from the undeveloped land to the northwest and from industrial areas. At the confluence of Bayou Verdine and Coon Island Loop, the bayou discharges into a moderately swift, deep channel, which is a conduit for brackish to saline water from the ship channel (Figure ES-2). The engineered confluence is wider than the natural opening and allows for greater tidal influence and storm surge up the bayou.

Bayou d'Inde

Bayou d'Inde is located in the northern portion of the Calcasieu Estuary, west of the City of Lake Charles, Louisiana (Figure ES-2). Bayou d'Inde's headwaters originate in the western part of Sulphur, Louisiana and flow primarily east-southeast through heavy commercial and industrialized areas before emptying into the ship channel southwest of Coon Island. Bayou d'Inde is approximately 15 km long and is a major tributary of the Calcasieu River. It has a drainage area of over 1,000 acres (PRC 1993). Bayou d'Inde headwaters are typically fresh. Its sinuous flow path passes near and through several small fringe marshes near Maple Fork Bayou.

The confluence of Bayou d'Inde and the ship channel is a large shallow flat area called Lockport Marsh. Lockport Marsh is a low-lying, intermediate to brackish broad shallow area with water depth generally less than 1 m. The area is categorized as a marsh to depict characteristics within protected areas. Parts of Lockport Marsh are also subjected to scouring due to storm surge and wind forcing.

The land around Bayou d'Inde includes undeveloped wooded marshland, rural residential, commercial, and heavy industrial properties. Rural residential and undeveloped woodland areas border the bayou northwest and upstream of the industrial area. Heavy industry dominates the area bounded by the PPG Canal and highway LA-108. Several of these industries have outfalls permitted under NPDES.

Bayou d'Inde contains two energy systems; bayou and marsh. Sediments within Bayou d'Inde are generally silty sands. This appears to be the combined result primarily of overland soil erosion and deposition of reworked material from the ship channel in the lower section. Bayou d'Inde sediments are generally coarser than Bayou Verdine, due in part to the broader confluence with the ship channel and deeper (dredged) bayou.

Development along Bayou d'Inde has altered the natural setting in the industrial area. Industrial discharges (current and historic), accidental releases, and storm water runoff have contributed to organic and inorganic impacts to surface water, sediment, and biota within the bayou.

Upper Calcasieu

The Upper Calcasieu AOC is defined as that region of Calcasieu Estuary that extends from the saltwater barrier on the Calcasieu River (north of Lake Charles), through Lake Charles, west to Clooney Island Loop, and southwest to Coon Island Loop (Figure ES-2). Coon Island Loop connects with the ship channel near the I-210 Bridge. The Upper Calcasieu area is approximately 25 km in length (Figure ES-2).

Water in Upper Calcasieu is intermediate to brackish and tidally influenced (up to 15 cm). Salinity stratification is noted during periods of the year, controlled primarily by density driven flow as a result of tidal influence and the saltwater barrier. From October to February, periods of generally high water levels, the gates are open, allowing free flow of water. When closed, the saltwater barrier effectively protects the upper Calcasieu River from saltwater intrusion.

Land use in the Upper Calcasieu AOC is primarily rural residential, municipal, and industrial. Tributaries include Bayou Verdine and Contraband Bayou. Bayou Verdine receives discharge from several major industrial properties, as noted above, and discharges at the northern end of Coon Island Loop. Contraband Bayou receives Lake Charles municipal wastewater discharge and enters the ship channel between Clooney and Coon Island Loops.

Upper Calcasieu is a diverse segment of the estuary that consists of an element of every energy system present in Calcasieu Estuary. The AOC contains natural river, marshes, shallow lake areas, bayou, and shipping channel. Sediment character is as diverse as the energy systems.

Lower Calcasieu

The Lower Calcasieu study area comprises the portion of Calcasieu Estuary from the I-210 Bridge, just south of Coon Island Loop, to the outlet of Moss Lake; a distance of approximately 15 km (Figure ES-2). Lower Calcasieu is predominated by the ship channel, which is interconnected with shallow lakes and small lagoons. The ship channel is 125 m wide and 15 m deep and is routinely dredged (USACE 1976); however, the dredged portion is not included in the study area. Prien Lake is located on the east side of the ship channel; the mouth of the lake is located across from Lockport Marsh. Prien Lake lies within the old channel of the Calcasieu River. Indian Marais Lagoon is a 230,000-kiloliter capacity impoundment and associated drainage canal that exists along the west side of the ship channel midway between Prien Lake and Moss Lake. Moss Lake flows into the ship channel from the west and is fed by Bayou Olsen. Bayou Olsen drains the area south and west of Bayou d'Inde.

Much of the land use in the Lower Calcasieu AOC is undeveloped, but several industrial facilities have outfalls to the ship channel between Prien Lake and Moss Lake. The ship channel is used extensively throughout Lower Calcasieu, providing transport to over 40 million tons of product annually.

Four energy systems exist in Lower Calcasieu: shallow lakes (Prien and Moss Lakes), low-flow bayou (Bayou Olsen), the ship channel, and Indian Marais Lagoon. Overall, Lower Calcasieu is tidally influenced, with 6 to 12 inches of daily fluctuation (USACE 1976). Salinity in the area is typically higher resulting from is southernmost location.

ES-2.4 Reference Areas

A total of five areas were identified to represent reference conditions within the Calcasieu River watershed and surrounding environments. The areas are all south of the study area and include:

- Johnsons Bayou
- Willow Bayou
- Bayou Bois Connine
- Grand Bayou
- Bayou Choupique

The reference areas represent the bayou energy system. Salinities vary in the reference areas as they do in the study area, subjected to the same wind forcing, tidal surge and temperature driven density changes. Sediments composition is similar as well. Reference areas were added to the RI to provide "background" bayou areas for comparison. All five of these reference areas are relatively pristine and have been virtually unaffected by industrial activities (Ramelow et al. 1987).

ES-2.5 Regional Flora and Fauna

Calcasieu Estuary provides habitat to abundant wildlife, both aquatic and terrestrial. Critical habitat has not been designated for biota in the study area. The bottom hardwoods and cypress region includes the Calcasieu River around Lake Charles (Neyland 2000). Other trees common to the area include live oak, cottonwood, and willow. The region is also used as pastureland, and for the cultivation of rice and soybean crops. Marsh vegetation is typically brackish and common herbaceous plants include: *Spartina alterniflora, Distichlis spicata, Juncus* sp. and *Scirpus* sp (Neyland 2000).

The marshes and swamps of southern Louisiana are home to a variety animals, including white-tailed deer, and a few black bears. Resident small animals include muskrat, mink, raccoon, wildcat, gray fox, beaver, otter, weasel, opossum, cottontail, marsh rabbit, and gray squirrel.

Species of migratory wildfowl are abundant in the estuary. Many species of ducks and geese spend the winter on the tidal marshes along the Gulf Coast. Common water fowl include the laughing gull, royal tern, brown pelican, and black skimmer. Birds found in the marshes include the marsh wren, seaside sparrow, red-winged blackbird, Wilson snipe, woodcock, and species of sandpipers.

Alligators are common in the southern Louisiana swamps; one was noted in the Lower Calcasieu study area during the RI. Other reptiles in the state include turtles, lizards, and both poisonous and nonpoisonous snakes. The poisonous snakes found in Louisiana are the coral snake, western pygmy rattler, canebrake rattler, copperhead, and water moccasin.

Among the great variety of fish include red snapper, menhaden, gar, redfish, drum, sheepshead, jewfish, blue, jack, blue cat, yellow cat, paddlefish or spoonbill cat, striped bass, mullet, and sea trout. Many of these species are fished commercially in the estuary. Local crusteacean include blue crab and grass shrimp.

Correspondence with the U.S. Fish and Wildlife Service (USFWS) in 2001 notes that "there are no federally-listed threatened, endangered, or candidate species within the proposed project area" (USFWS 2001). However, the state bird, the brown pelican, is on the federal endangered species list and has been observed in the study area.

ES-2.6 Hydrogeology

Significant groundwater exists below the site. The shallow aquifer is comprised of unconsolidated sand units referred to as the 10-, 20-, and 36-foot sands (LGS 1984). Groundwater in this aquifer is unconfined and occurs as shallow as 0.3 to 1 m below ground surface (bgs). Recharge to the shallow aquifer is from infiltration of precipitation, impoundment leakage and commingling of surface water. Groundwater flow, fluctuation, and quality may influence surface water that intercepts the shallow groundwater across the study area (PRC 1993, PRC 1994).

Water levels in the shallow aquifer and surface water are tidally influenced with up 0.3 m of daily fluctuation. The groundwater quality is typically poor and unsuitable for domestic use. The major regional, hydrologic units for potable water in the Lake Charles area are the 200-, 500-, and 700-foot sands of the Chicot aquifer. The Chicot aquifer is the primary source of groundwater for public supply, irrigation and industrial use in the area. Recharge to the Chicot aquifer is primarily through infiltration of precipitation.

ES-2.7 Dredging History

Calcasieu Estuary has undergone significant engineering modifications centered on creation of the ship channel to allow larger barges and ships access to Lake Charles. Because of channel development, saltwater intrusion into the upper reaches of the estuary became a problem; thus, the saltwater barrier was constructed north of Lake Charles on the Calcasieu River.

ES-2.8 Climate

The climate in Calcasieu Parish is humid and temperate and is influenced by its proximity to the Gulf of Mexico. The average year-round temperature is 68°F, with an average daily high of 78°F and an average daily low of 58°F. The hottest months are July and August, while the coolest months are January and February respectively (NOAA 2002). The average annual precipitation is 54.05 inches. May, June, and July are typically the wettest months, whereas March and October are the driest months. The average wind speed is 8.6 miles per hour, from the south. Hurricane season officially runs from June to November, and this area is vulnerable.

ES-2.9 Demographics

Calcasieu is one of 64 parishes (counties) in Louisiana. Calcasieu Parish has a land area of 2,775 km^2 and is part of the Lake Charles metropolitan area, with a census

2000 population of 183,577-ranked 7th in the state (U. S. Bureau of the Census 2000). The largest employers in 2000 were the educational, health, and social services industry, 19.9 percent; the manufacturing industry, 14.9 percent; the retail trade industry, 11.5 percent; the art, entertainment, recreation, accommodation, and food services sector, 11.5 percent; and construction industry, 9.3 percent. Other principal cities and towns in the parish include Sulphur, Westlake, and Mossville

ES-3 Site Conceptual Model

ES-3.1 General

A site conceptual model (SCM) was developed to portray the dynamic nature of Calcasieu Estuary that includes numerous perennial wetland bayous and tributaries, marshes, and ship channel in a heavy industrial setting. The SCM is intended to describe the nature of the different environs of the estuary; identify the interrelationships between soil, sediment, surface water, and groundwater impacts to the system; and identify potential ecological and human receptors. Figure ES-3 presents a schematic overview of the estuary systems that exist in Calcasieu. It should be noted that the figure is intended to present general conditions schematically and does not represent a specific region of the estuary.

The term estuary is used to describe, "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage" (Pritchard 1967). Of the four types of estuaries defined by Pritchard, the Calcasieu Estuary is considered a drowned river valley system, which is "a wide coastal plain; only a portion of the area affected by tides [eg.] is estuarine, based on salinity diluted by freshwater"(Pritchard 1967).

Based on published information, the Calcasieu Estuary is classified as vertically homogeneous. The influence of strong winds and tidal energy, in conjunction with the generally shallow depth (about 2 m with the exception of the ship channel), result in a relatively high-energy environment with vertical mixing.

ES-3.2 Exposed Populations

Both humans and ecological receptors are important considerations in the SCM. Pathways of exposure and the relationships between receptors and affected media are discussed below.

Ecological Receptors
Identified exposure routes are those exposure pathways considered complete for receptors in the area and include ingestion of sediments by detritivores and bottom dwellers, ingestion of contaminated prey items by ecological receptors, and inhalation and direct contact with the surface water micro layer. Ecological pathways are

evaluated in Section ES-13. Additional detail on development of these pathways and receptors can be found in the, the Baseline Ecological Risk Assessment (BERA) Problem Formulation (CDM 2001).

Human Receptors
Potential human exposure to contaminants is presented in Section ES-14 of this document. Exposure routes of primary interest here are the direct contact (both human and ecological receptors), human consumption of impacted fish and shellfish, both by subsistence and recreational fishing receptors.

ES-4 Data Collection, Analysis, and Interpretation

ES-4.1 Data Collection

Phases I and II of the RI sampling are described in the following sections, including data collection, determination of COPC, analytical methods, and data usability and data analysis.

Phase I of the RI
Phase I of the RI was designed to determine the nature and extent of organic and inorganic contamination within the Calcasieu Estuary and to support risk characterization. This phase of investigation was conducted on an AOC-by-AOC basis.

Phase I was initiated with a detailed evaluation of the existing chemical data maintained by EPA and NOAA. Pre-1992 data, although maintained by EPA and NOAA, were not used in the RI planning because of unknown quality. These data were used to determine the occurrence, concentration, and mean and mean variance of COPCs as well as the number of samples with previously detected analytes. Data were also used to ascertain the number of samples needed for a statistically valid sampling program based on confidence interval/relative error ranges of 70/30 percent and 80/20 percent, which equate to 0.7 and 0.8 statistical power, respectively. Given a mean and a standard deviation, an iterative set of three equations, as described by Gilbert (1987), was used to calculate the number of samples required to achieve the pre-specified confidence and precision.

The number of samples calculated using the above-referenced method was then input into EPA's fully-integrated environmental location decision support (FIELDS) software to identify sample locations. Randomness was introduced through the selection of a random starting node within a grid cell.

Phase I RI sampling was conducted from December 1999 through March 2000. Field samples consisted 535 surface (0 to 10-cm) sediment samples, 16 multi-depth (0 to 10, 10 to 20, and 20 to 30-cm) sediment samples, and 65 surface water (mid-depth of the water column) samples throughout the estuary. Phase I data reduction and analysis identified the need for a second phase of sampling to minimize data gaps existing in Phase I, including resampling areas to obtain delineation and support the ecological risk assessment.

Phase I included an ecological assessment site reconnaissance was conducted April 2000 through May 2000. Forty-nine tissue sample locations were determined in the field based upon locations where fish are typically caught or collected in the various AOCs. Multiple locations were sampled in three of the four AOCs to determine a spatial distribution of some species. Bayou Verdine was not samples for tissue, because of Conoco's independent work.

Reference areas were also located. Data collected from a suitable reference areas would allow comparisons to be made between the Calcasieu Estuary and an area unaffected by industrial development. Three sediment and 1 surface water sample as well as 15 tissue samples were collected from reference areas.

Phase II of the RI

Phase II of the RI was a more focused characterization of contaminant levels in sediment, porewater, and biota tissue (i.e., fish and invertebrates), as well as evaluation of sediment toxicity, porewater toxicity, and benthic invertebrate community structure.

Several data gaps were identified in the Phase I data. Phase II surface sediment samples were collected at pre-selected locations to refine the horizontal extent of contamination around specific sites in the estuary and verify reported detections and non-detections. Thirty-three locations were sampled for nature and extent delineation purposes during Phase II (December 2000).

Sediment quality triad (SQT) integrates information on sediment toxicity, chemistry, and benthic community structure in an integrated weight-of-evidence approach (Ingersoll et al. 1997). The SQT provides for evaluation of the risks to sediment-dwelling organisms that are associated with exposure to contaminated sediments through whole-sediment and porewater toxicity effects on benthic invertebrate community. One hundred SQT locations were sampled (Section ES-12). Sediment chemistry and benthic community structure were determined at all 100 locations, whereas only 50 locations had matching porewater chemistry.

The Phase II tissue sampling (October 2000 and December 2000) was based on BERA and HHRA data needs to determine the type of species and the quantity to be collected. The types and quantity of species to be collected were based upon evaluating the feeding ecology of the fish and wildlife focal species and their likely foraging areas.

All tissue sample locations (724 samples), with the exception of blue crab locations, were paired as closely as possible to SQT locations. Whole body samples from each prey group were used for the BERA, whereas a subset of fish was filleted for the HHRA.

All sampling was conducted in accordance with the procedures specified in the Phase I Sampling and Analysis Plans (CDM 1999a-d), and Phase II Sampling and Analysis Plan (CDM 2000b).

ES-4.2 Determination of Contaminants of Potential Concern

COPCs are determined in the RI as those chemicals that exist at concentrations or impart unacceptable risk to human health or the environment. Initially, a statistical evaluation of historical data was used to determine COPCs for sediment, surface water, and tissue. After Phase I, retained COPCs were re-evaluated. In addition, initial preliminary remediation goals (PRGs) for protection of human health were developed based on data collected in Phase I. PRGs were estimated by re-arranging the hazard or risk equation to solve for concentration. An acceptable hazard quotient was set to one, and the acceptable risk level was set to 10^{-5}.

Table ES-1 lists the presently known COPCs for the Calcasieu Estuary based upon ecological and human health risks.

ES-4.3 Analytical Program

A variety of parameters were measured to evaluate the estuary, as well as determine the nature and extent of contaminants in sediment, surface water, and tissue. Table ES-2 lists the media and analytical protocol (i.e., analytes and methods). All Phase I and Phase II analytical methods were selected in accordance with the investigation's DQOs. Physical and chemical analyses were performed using validated and standard methods in the environmental laboratory industry, including

- Conventionals (physical parameters in sediment, surface water, porewater, and tissue)
- Inorganics (metals, TCLP, acid volatile sulfide and simultaneously extracted metals [AVS/SEM] in sediment, surface water, porewater, and tissue)
- Organics (VOCs, SVOCs, herbicides, pesticides, PCBs, PCB congeners TPHs, dioxins/furans in sediment, surface water, porewater, and tissue)
- Sediment toxicity tests (10 and 28-day survival tests at the 100 SQT locations)
- Microtox® (at the 100 SQT locations)

- A 28-day bioaccumulation test was conducted at 10 SQT locations
- Porewater toxicity tests

In addition, a benthic macroinvertebrate community survey was conducted across the entire estuary at the 100 SQT locations. An index of biotic integrity (IBI) was used to characterize benthic condition of the estuary. EPA conducted a parallel toxic inventory evaluation (TIE) study of whole sediment under the Clean Water Act at SQT selected locations. TIE evaluations typically consist of three phases: (1) characterize the physical/chemical properties of the toxicants; (2) identify the toxicants (typically non-polar organics, ethylene diamine triacetic acid (EDTA), chelatable metals, and ammonia); and (3) perform a final confirmation through a weight-of-evidence approach to effluent testing.

All fish selected for the HHRA, after collection and prior to filleting, were evaluated by the USFWS using the BEST program. Under the BEST program, USFWS examined fish for deformities, skin lesions, or tumors on the surface and within the specimen in accordance with several USGS/BRD guidance documents (USGS/BRD 1999 and USGS/BRD 2000). Results of USFWS's evaluations were not available for inclusion in this RI.

ES-4.4 Data Quality Assessment

The data used in this RI/FS and associated risk assessments were assessed through a data evaluation program that includes data validation and data evaluation in accordance with EPA's nationally recognized guidelines. Prior to data use, this evaluation ensures quality of the data used is defined and that a known confidence in data usability is ensured in accordance with procedures outlined in the DQOs, and quality assurance project plan (QAPP) (CDM 1999a-d and 2000b).

During this data validation/evaluation process, individual sample results are accepted, rejected, or qualified. Data that meet all the validation criteria are accepted as unqualified and were used without discretion. Data that are rejected (R) for not meeting one or more of the validation criteria were not used. Some data fall into the gray area between accepted and rejected. These data are qualified as estimated.

In Phase I, sample data from over 1,500 samples and 172 SDGs from six different CLP and subcontract analytical laboratories were received, reviewed, validated, and evaluated. Nearly 6,000 individual samples from Phase II were evaluated. Seventeen percent of these 6,000 samples were validated. Most data gathered from the RI investigation were determined usable via this data validation program.

ES-4.5 Data Analysis

The primary goal of the RI is to assess whether, and to what extent, sediments and surface water are contaminated or have the potential to adversely affect the environment or human health (EPA 1994). After the data were segregated by AOC and energy area, summary statistics were generated for each of the data sets using Microsoft Excel and the Caltrans Data Analysis Tool (DAT). The Caltrans DAT calculates summary statistics for data sets that include not detected data using regression on order statistics (ROS).

Then, multivariate analyses were completed. Multivariate refers to the analysis of data consisting of two or more random variables. Multivariate analysis was used for the RI data sets because the complex interactions between variables are difficult to isolate and study individually. Data sets were statistically analyzed using principal components analysis (PCA). PCA reduced the multidimensionality of the data sets by organizing multivariate data set into correlated factors. Exhibit ES 4-1 summarizes the data sets created for surface (0 to 10 cm) sediment.

Exhibit ES 4-1 Surface Sediment (0 to 10 cm) Data Sets for PCA

PCA Data Set	Area of Concern	Energy Area	Samples [1]	Constituents [2]
1	Bayou d'Inde	Bayou	100	140
2	Bayou d'Inde	Marsh	161	144
3	Bayou Verdine	Bayou	78	90
4	Lower Calcasieu	Bayou	18	33
5	Lower Calcasieu	Other	7	48
6	Lower Calcasieu	Shallow Lake	76	75
7	Lower Calcasieu	Ship Channel	52	63
8	Upper Calcasieu	Bayou	9	33
9	Upper Calcasieu	Marsh	8	35
10	Upper Calcasieu	River	12	32
11	Upper Calcasieu	Shallow Lake	46	79
12	Upper Calcasieu	Ship Channel	54	75
13	Reference Area	Bayou	18	37
	TOTAL		639	

[1] Number of samples with a result for at least one constituent in the AOC/Each data set.
[2] Number of constituents (variables) with a least 3 detections.

The above steps were necessary to accommodate the holes in the data sets due to samples not being analyzed for every constituent (i.e., sampling for only dioxin/furans at selected locations). The PCAs were conducted using SYSTAT Version 10.0 (SPSS Software).

The data were also compared to background or reference area concentrations using statistical tests. The Wilcoxon Rank Sum (WRS) test evaluates whether there is a statistically significant difference between the medians of two data sets (i.e., the null hypothesis [H_0] that the populations from which the two data sets have been drawn have the same mean is tested against the alternative [H_A] that the populations have different means). The WRS Test is described in Gilbert (1987) and EPA (1992). The test was conducted on sediment samples using the computer program SYSTAT Ver.10.

The WRS test was selected (over the parametric *t* test equivalent) because the population distributions were unknown and the sample data sets were generally insufficient to recognize the shapes of the population distributions. In addition, the WRS test is capable of handling the moderate number of nondetect values present in the sample data sets, which is characteristic of the Calcasieu Estuary data set.

ES-5 Chemical Fate and Transport

An understanding of the fate and transport processes acting on the COPCs in the Calcasieu Estuary is critical when predicting the distribution of the COPCs between different media in the environment (i.e. sediment, water, soil, and air) under various conditions (pH, salinity, etc.).

As the conditions change in the estuary, the distribution of the COPCs in the media and the form of the COPCs can change (i.e., the oxidation state, molecular configuration, ionic charge, aqueous species), which can affect the mobility and toxicity of the compounds. Key geochemical processes affecting the rate of migration of the COPCs are adsorption and desorption, volatilization/condensation, precipitation and co-precipitation, and degradation/transformation. Additional processes impacting fate and transport processes in the estuary include: flushing/physical transport and chemical fate/transformation.

Important fate and transport processes acting on COPCs in the study area and the environmental factors influencing these processes are as follows:

- Adsorption is one of the most important fate and transport processes in the estuarine environment. It is influenced by salinity, pH, and grain size of the adsorbing sediments. It is a significant process for dioxins, pesticides, PCBs, SVOCs, and some metals.

- Precipitation/co-precipitation is an important removal process for some metals (chromium, copper, lead, and zinc). Co-precipitation tends to be led by the oxidation of iron (II) to iron (III) and is influenced by the presence of iron oxyhydroxides.

- Precipitation is controlled in estuaries by pH, oxidation-reduction potential, and salinity (via salting out). Precipitation of oxides typically occurs in oxygenated, turbulent areas (flood tidal zones) while precipitation of sulfides occurs in anoxic low energy areas, such as marshes.

- Volatilization is important for VOCs. Volatilization is controlled by the turbulence of the water and the wind speed at the surface of the water. Volatilization is greatest in turbulent waters with high wind speeds. High turbulence areas within an estuary occur in the areas influenced by tidal energy while low turbulence areas are in marsh areas and embayments.

- Biotransformation is important for soluble organic compounds and compounds with easily broken bonds, such as aromatic compounds.

- Aerobic biotransformation is important in turbulent oxygenated waters, such as tidal zones, while anaerobic biotransformation is important in low energy marshes and embayments.

The residence time of a COPC within an estuary depends on the flushing time of the estuary and on the degree of attenuation imparted on the COPC by fate and transport processes.

ES-6 Reference Areas

Before evaluating the nature and extent of COPCs in the estuary, the chemistry of background or reference areas must be understood. A total of five areas were selected to represent reference conditions within the Calcasieu Basin. These areas included Choupique Bayou, Grand Bayou, Bayou Bois Connine, Willow Bayou, and Johnsons Bayou (Figure ES-4). Within the five areas, 18 reference sites were selected using a stratified random sampling design, whereby each of the five reference sub-areas (strata) are sampled individually by simple random sampling. The reference areas were selected for minimal sediment contamination while having similar sediment characteristic as the Calcasieu Estuary study area.

Because the reference sites were stratified into five different reference sub-areas, it was first necessary to determine whether all of the reference sites could be considered to come from the same population. The nonparametric one-way Analysis of Variance (ANOVA) is a commonly used statistical method to compare two or more groups, in this case reference sites, collectively. The nonparametric ANOVA is also called the Kruskal-Wallis test. For comparative purposes, only chemical constituents in the sediments were examined, because surface water tends to be fairly variable both spatially and temporally.

The Kruskal-Wallis test is described in detail in Gilbert (1987) and EPA (1992). The test was conducted on reference area sediment samples using the computer software SYSTAT Ver 10.

The results of the Kruskal-Wallis test indicate that measured concentrations are representative of variation in natural background, and since no significant differences exist for most chemical constituents, the five reference areas are considered similar and can be combined for the purpose of comparison with the other Calcasieu Estuary study areas/energy systems.

ES-7 Bayou d'Inde - Nature and Extent

This section summarizes the COPCs found in Bayou d'Inde AOC and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability, and chemical fate and transport.

ES-7.1 Summary of the RI Evaluations

Bayou d'Inde is divided into five geographic areas; four reaches in the bayou energy system and the marsh areas. Marshes are present in Reaches 1 and 2. The reaches are presented in Figure ES-5. Bayou d'Inde below highway LA-108 (Reach 2) can be characterized as a moderately-saline to saline, broad channelized ship channel with significant industrial development. The upper reach of Bayou d'Inde (Reach 4) is a less saline, steep-sided, narrow and vegetated low-flow system. The drainage area for the upper reach (Reach 4) is generally rural residential. The majority of Bayou d'Inde from Reaches 1 through 3 receives surface runoff and wastewater discharge from several industrial facilities (e.g., PPG, Westlake Polymers, Firestone, Citgo Lubricants Plant, Citgo PFU and Equistar [formerly OxyChem]). Point and non-point sources are present in Reaches 1 through 3. Introduction of contaminants to the system appears to occur due to industrial release in three specific areas; (1) between Little Bayou d'Inde and highway LA-108 Bridge, (2) through anthropogenic release to Maple Fork Bayou, and (3) from industrial release to the PPG Canal.

Potential Sources to Bayou d'Inde:

Citgo, Equistar, Firestone, Westlake Polymers, and PPG

Contaminants of primary interest in Bayou d'Inde are those contaminants that increase human health or ecological risk. The occurrence of COPCs varies across Bayou d'Inde. The following is an overview of the condition of each of the four reaches and associated marshes, within Bayou d'Inde.

The majority of contaminants and generally the greatest concentrations are found in Reach 1 of Bayou d'Inde and Lockport Marsh. PPG operates three major process areas in the immediate vicinity: the Chlor-Alkali plant; the Derivatives plant and the Chlor-Alkali/Silicas area. All process areas drain to the PPG Canal. Further, three offsite facilities, Cetainteed, Jupiter and Big Three Industries also discharge to the PPG Canal. The non-PPG permitted design flows account for 1 MGPD of a 233 MGPD design flow capacity for the PPG Canal.

COPCs in Bayou d'Inde:

Dioxin/Furans,
PCBs,
Mercury,
HPAHs, LPAHs,
BEHP, HCB, and HCBD

Dioxin/furans are predominant in Reaches 1 through 3, Lockport Marsh and Maple Fork Bayou Marsh (the location of sample BIR3018) (Figure ES-6. Dioxin/furan concentrations are comparable where bayou and marsh locations are present. Dioxin/furan contamination is widespread throughout Bayou d'Inde. Primary impacted areas are in lower Reach 3 and Reach 1. No documented sources of dioxin/furans were noted in the regulatory record, however, it is noted that incomplete or uncontrolled combustion of PCBs may result in the production of dioxin or furan compounds and industrial incinerators in the area are used to burn chlorinated wastes.

Exhibit ES-6 summarizes the most significant AOIs by geographic location in the estuary, followed by COPC concentration compared to estuary-wide data population 95 percent UCL concentration, a general sediment stability ranking, potential contaminant sources to the study area, and a ranking of ecological risk (from the BERA) posed by sediment to the benthic invertebrate community. Human health risks are of equal importance. With PCBs and dioxin/furans in fish and shellfish being the primary drivers of risk to humans, any AOI with these associated COPCs contributes to total site risk.

Use of the 95 percent UCL is a standard statistical approach to identify the maximum values in a population. The data from all of the AOCs and individual energy systems were combined to generate the estuary-wide population statistics provided in Appendix J. The 95precent UCL was used to provide a collective summary of the entire study area, AOC boundaries notwithstanding. The statistical output is provided for all compounds, summation data is provided for total HPAHs, total LPAHs, and 2,3,7,8-TCDD TEQ.

It should be noted that Figure ES-6 presents only selected COPC data that exceed the 95 percent upper confidence limit (UCL) of the mean, in an effort to summarize the highest concentrations COPCs exclusively in Bayou d'Inde in a single figure. More detailed COPC occurrence is discussed in the RI report.

PCBs tend to occur in two primary groupings, those grouped with PCB-118 and those with PCB-15. The PCB-118 group appears to originate in lower Reach 3 and extends through to the middle Reach 2 marsh area (BIR3046). The PCB-15 impacted areas begin at PPG Canal and are prevalent up to BIR3046 in middle Reach 2 marsh and extend downstream through Reach 1 to the ship channel. Lockport Marsh contains the highest detection of PCBs at location BIR2018, near the mouth of PPG Canal. The occurrence of PCBs in Lockport Marsh is within the bermed area. No documented PCB releases were noted in the regulatory record, however it is important to note that processes which combine carbon and chlorine at elevated temperatures may generate PCBs as a by-product (Hulting 2002).

Mercury tends to be found from Maple Fork Bayou through Reach 1 to the ship channel. The concentrations, however lower, extend into upper Reach 2. Mercury concentration is highest in the marshes. Potential sources to Lockport Marsh include the former PPG mercury-cell settling pond that was operated in the late 1960s. The pond was an unlined impoundment within the PPG Canal drainage area. Further, high, localized detections within Lockport Marsh may be due to the use of mercury manometers on local gas wells by the oil field industry. These manometers contain elemental mercury and are sometimes damaged or broken on-site, causing mercury release.

HPAHs are found in the highest concentration in Reach 1, Lockport Marsh, Maple Fork Bayou marsh (BIR3018) and the eastern Reach 2 marsh (BIR3036). PPG Canal, Maple Fork Bayou, lower Reach 3 and highway LA-108 appear to be the sources of these PAHs. Elevated concentrations are noted in the marshes upstream of PPG Canal and may indicate overflow conditions to this area and/or oil field-related activities. HPAHs tend to be slightly higher in concentration in the marshes than in the bayou sediments, overall. No known sources exist on Maple Fork Bayou, although numerous industrial pipelines, a highway and a railroad spur cross Maple Fork near the highest detections, release from these operations are unknown.

LPAH distribution is not as widespread in Bayou d'Inde as HPAHs. The LPAHs tend to be found in Lockport Marsh and concentrations are generally higher than HPAHs. The second highest concentration of LPAHs is in Maple Fork Bayou, in lower Reach 3 and near LA-108 in Reach 2. In general, LPAHs tend to increase with depth. Potential LPAH sources include feedstock compounds used in the processes at Citgo (LDEQ 1991).

BEHP is found throughout Bayou d'Inde and in Reaches 2 and 3. BEHP appears to accumulate in the Reach 2 marshes (predominantly the Middle and Lower Reach 2 marshes, areas identified by BIR3054 and BIR3062, respectively) in this area. However, in Reach 1 where significant levels of BEHP are found, the bayou contains the majority of the contaminant, not the marsh. The concentrations in the bayou are greater than the Lockport Marsh by an order of magnitude in Reach 1. The overall distribution of BEHP suggests that the compound is greatly influenced by the presence of suspended or colloidal phase material in the water column. The distribution of BEHP indicates the greatest degree of transport of any COPC in Bayou d'Inde and suggests that its concentration in sediment is an indicator of low surface water flow velocity (high settling rate) and high organic or detritus material, either particulate or suspended. Physical data to support flow velocity estimates in Reach 1 include the large population of soft-shell crabs that reside there. Species profile for crabs indicate their preference for slow moving, organic-rich waters.

ES-7.2 RI Conclusions for Bayou d'Inde AOC

The general distribution of COPCs in Bayou d'Inde is complex, given the multiple sources and flow dynamics. Industrial releases to Reaches 1 and 3 are a significant component of surface water flow volume in Bayou d'Inde. Permitted and unpermitted discharges mix with surface water in the bayou that migrate up and downstream via, natural pathways, wind and tidal fluctuation. Large storms may push water and sediment upstream in Bayou d'Inde perhaps explaining the isolated occurrence of COPCs in Reach 4.

In the upstream region, Reach 4, the level of contamination is minimal; the primary contaminants noted are LPAHs, mercury, copper, BEHP, and PCBs. The detections were noted downstream of I-10 and in the lower portion of Reach 4 near Little Bayou d'Inde.

Reach 3 contained a number of COPCs and concentrations in the area tend to be the second highest observed in all of Bayou d'Inde. Two areas of possible sources were noted, the area near Citgo outfall 001 and near the LA-108 Bridge. Primary COPCs in Reach 3 are dioxin/furans, PCBs, BEHP, HPAHs, LPAHs, and mercury.

Reach 2 COPCs are essentially the same as Reach 3, however, PCBs mercury, HPAHs, and BEHP tend to dominate. Reach 2 marshes tend to show the highest concentrations for metals, dioxin/furans and most HPAHs. Concentrations tend to be about the same in the marshes and the bayou for PCBs and tend to be lower in the marshes in Reach 2 for LPAHs. The HPAH compound 1,2-BPA is absent from Reach 2 marshes even though 1,2-BPA is present in the bayou in Reaches 2 and 3, indicating rapid salting-out (chemical precipitation) upon release in lower Reach 3.

Reach 1 was the area with the greatest number of compounds detected and the highest COPC concentrations. Reach 1 COPCs are dioxin/furans, PCBs, BEHP, mercury, HPAHs, LPAHs, HCB, and HCBD.

Overall, contaminants appear to be highest in Reach 3, Maple Fork Bayou, Reach 1, and Lockport Marsh. The contaminant suite in each of these areas is similar, and may represent some source and transported sediment overlap. The data suggests that fine or suspended particle transport is active in Bayou d'Inde. Flocculation and suspended particle binding may be prevalent for some compounds (LPAHs, BEHP, and some metals). Distribution and concentration gradients of many of the COPCs indicate sediment movement into the marshes, however this is not the case for all compounds. Overall, sediment stability tends to be moderate to poor. Open areas of Lockport Marsh are susceptible to sediment mobilization. Reaches 2 and 3 tend to be net sediment exporters. Sediment stability with in the fringe marshes in Reach 2 is typically good. Potential for mobilization from the marshes immediately upstream of PPG Canal is moderate given the increased flow potential in Reach 1. It appears that re-suspension of fine grained material (organic or inorganic) facilitates physical transport throughout Bayou d'Inde.

ES-8 Bayou Verdine - Nature and Extent

This section summarizes the COPCs found in Bayou Verdine AOC and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability, and chemical fate and transport.

ES-8.1 Summary of the RI Evaluations

Bayou Verdine is divided into five geographic reaches to facilitate data presentation and discussion (Figure ES-7). Bayou Verdine can be characterized as a moderately saline, channelized, low-flow system with significant industrial inflow in the lower three reaches (Reaches 1 through 3). The upper reaches (Reaches 4 and 5) are generally a less-saline, shallow and narrow vegetated low-flow system.

The drainage area for the upper reaches is generally rural to agricultural. The lower reaches of Bayou Verdine (Reaches 1 through 3) receive surface runoff and wastewater discharge from several industrial facilities (Sasol, Conoco, Lyondell, KCSRR and PPG). Contaminants appear to enter the bayou as overland flow or through outfalls. The lower three reaches of Bayou Verdine are subjected to daily tidal fluctuation, tidal storm surge, and seasonal salinity and flow fluctuations.

The greatest extent and concentration of contaminants are seen in Reaches 1 and 2, generally from the Vista West Ditch to below I-10 and from middle Reach 1 to the mouth of Bayou Verdine. The primary contaminant group is HPAHs, however Reach 2 is impacted by dioxin/furans and various VOCs. Concentrations of HPAHs are high as are VOCs, while dioxin/furans are moderately low, see Figure ES-8.

COPCs in Bayou Verdine:

PAHs,
Dioxin/Furans,
Metals,
EDC,
and various other Chlorinated Hydrocarbons

It should be noted that Figure ES-8 presents only selected COPC data that exceed the 95 percent UCL of the mean, in an effort to summarize the highest concentrations COPCs exclusively in Bayou Verdine in a single figure. More detailed COPC occurrence is discussed in the RI report.

LPAHs are found near the Conoco Lube Tank Farm in Reach 3. Concentrations are moderately high in this area and exceed levels noted historically. Zinc is the only metal that is consistently elevated above levels noted in the reference area. Zinc is found throughout Reaches 2 and 3 from New Trousdale Road to the Vista West Ditch.

Contaminant occurrence indicates that several sources are present throughout Bayou Verdine. The upstream reaches are relatively un-impacted by industry. The Conoco Lube Tank Farm area appears to be the source of LPAHs and minor HPAHs in Reach 3.

Reach 2 is primarily impacted by releases through the Vista West Ditch and Vinyl Chloride Monomer (VCM) wastewater treatment unit discharge, Fabaucher Ditch, releases via Conoco outfalls 001 and 004, and releases through KCSRR Ditch. Reach 2, near the I-10 Bridge is the most heavily impacted segment of Bayou Verdine.

Reach 1 appears to be impacted by releases through outfalls that discharged to the upper third of the reach from I-10 through the PPG Derivatives Area (Plant B). Potential sources include the former Conoco, Olin, and Lyondell outfalls that discharge into Bayou Verdine below I-10. Releases to the lower reaches (Reaches 1 and 2) appear to come from PPG outfall 004 and activities (periodic spills and releases) at the North Dock area.

ES-8.2 RI Conclusions for the Bayou Verdine AOC

The primary COPCs in Bayou Verdine are HPAHs, LPAHs, VOCs, dioxin/furans, and zinc. Minor PCBs, SVOCs, and pesticides are also present. Contaminants appear to be deposited into the bayou as dissolved constituents, much of which becomes locally adsorbed to sediments or particulate material. Distribution of these contaminants suggests that COPCs adsorb to sediment or particulates and may then be transported away from the area where the contaminants first entered the bayou.

Concentrations of HPAHs are similar to those observed in previous studies. Vertically, the concentrations of HPAHs tend to be highest in the 15 to 30-cm interval upstream, in Reaches 3 and 4. Meanwhile, HPAHs tend to be highest in the upper (0 to 15-cm) interval in Reaches 1 and 2.

LPAHs tend to be higher in concentration, however they appear to be occurring in Reach 3 more prevalently than in 1993/1994. It should be noted that the maximum detected value was from BVR2007, upstream of I-10, concentrations in Reach 3 were elevated but not as extreme as this maximum. Vertical distribution is similar to the HPAH distribution.

Historically, dioxin/furans were not analyzed, however dioxin sediment core analyses indicate that only the shallow interval (0 to 15-cm) is impacted, dioxin was not detected at depth.

PCBs were detected in previous studies throughout Reaches 1 and 2, the highest concentrations were noted at the KCSRR Ditch and near the PPG outfall 004 at the mouth of Bayou Verdine. This distribution correlates with current RI findings.

VOCs consisted primarily of EDC (i.e., 1,2-dicholorethane) and a suite of other chlorinated hydrocarbons including PCE, TCE, 1,2-DCE, chlorobenzene, 4-bromofluorobenzene, dibromofluoromethane and dichloromethane. The greatest concentration of EDC was found near the Vista West Ditch. The EDC appears to be concentrated in a small area, perhaps present as dense non-aqueous liquid (DNAPL) resting on top of a shallow clay layer. It has been reported that a shallow clay layer dips to the west (dipping upstream from the Vista West Ditch) possibly influencing the upstream extent of the EDC plume. Other noted VOCs extend throughout Reach 2. Concentrations of these other VOCs are moderately high, ranging up to 50,000 µg/kg. RI results are higher, compared to historic concentrations.

PAHs, SVOCs, and dioxin/furans are compounds that partition readily to sediments. The attraction to TOC particles or sediment sorption sites is generally strong. There is competition for available sorption sites, and a hierarchy among these chemical groups exists. Typically, compounds with higher partitioning coefficients will accumulate at higher concentration in the sediments or suspended particulate matter. Partitioning coefficients are most important for the following: HPAHs, dioxin/furans, PCBs, pesticides, LPAHs, and SVOCs. Partitioning is less important for most VOCs.

Once adsorbed, the compounds tend to migrate with the matrix material. Reductions in salinity can lead to increased turbulence and suspension of colloidal phase material. This effect can lead to re-suspension of contaminants. Likewise, physical transport of sediment by bed load shear forces appears to be occurring.

The predominantly silty sand media in Reaches 1 through 3 appears to be subjected to fresh and saline water inflow (some as significant, periodic events) that have been shown to affect sediment bed stability. Organic matter is known to promote flocculation of suspended sediments in estuarine waters (Eisma 1986) and this combined with inflow of freshwater (enough to reduce salinity to below 3 ppt) has been shown to facilitate sediment particle re-suspension. This results in transport of charge-stabilized colloidal suspensions to downstream portions of the bayou or estuary (Johnson and Leenheer 1989). Distribution of contaminants near the larger outfalls indicates that this phenomenon may be having an effect. The surface water salinities noted indicate that the conditions are right, and there appears to be localized decreases in many contaminant concentrations at the confluence of these freshwater outfalls or ditches. The sediment concentrations generally increase within 100 to 200 m of the confluence.

Surface water salinity is variable, both spatially and temporally. Salinity observations during the RI ranged from 0 to 21 ppt. In Bayou Verdine, the impact of freshwater inflow from Fabaucher and Vista West Ditch is seen to locally reduce salinity from 15 ppt to 4 ppt. These areas correspond to broad distribution of PAHs, dioxin/furans, indicating that re-suspension and partitioning is occurring throughout this area.

Sediment transport is evidenced by the broad distribution of HPAHs from New Trousdale Road in Reach 3 to the mouth of Bayou Verdine at Coon Island Loop. While multiple sources exist, the broad distribution (observed at BVR3001, BVR3007, BVR2002, BVR2007, BVR1002, BVR1B1CS and BVR1011) along the length of the bayou is indicative of contaminant transport and sediment movement.

The combined processes of adsorption of organic compounds onto suspended particles, salinity-induced flocculation of suspended particles and salting out from the aqueous phase effectively removes many hydrophobic COPCs from the water column. This correlates with the RI data where none of the primary COPCs were noted in surface water.

Tidal driven flow also appears to strongly affect contaminant distribution. Tidal surge has the combined effect of increased turbulence and shear forces facilitating physical transport and the conveyance of more saline waters into the bayou. Tidal surge associated with coastal storm systems generally create or add to a vertically stratified salinity regime whereby the lower saline body moves upstream while the freshwater layer at the top of the water column moves seaward. These same conditions tend to create strong shear forces along the sediment surface (Grabemann *et al* 1997). The areas most likely affected by tidal surge are Reaches 1 and 2. Reach 1 is closest to the ship channel and its geometry is such that there are no barriers to prevent storm surge in the lower 1,500 m (from Coon Island Loop to I-10). Tidal surge reworking of the sediment is apparent by variable grain size. Sediments in Reaches 1 and 2 are predominantly silty sands.

Multiple sources appear to have contributed to the contamination seen in Bayou Verdine. The data indicates that the release of PAHs, dioxins, and zinc are higher in shallow surface sediments indicating recent deposition versus burial of impacted sediments by clean sediments.

Releases from process areas or outfalls mix with the moderately saline waters of Bayou Verdine, where contamination partitions to the solid or particulate material present. Initial deposition is likely localized, however, tidal surge or freshwater inflow from process waters tends to facilitate sediment transport. The distribution in Reach 2 is an excellent example of how effective freshwater inflow, turbulent flow bed mixing, and particle re-suspension can be in transporting contamination over a relatively large area. The resulting direction of movement is downstream. The addition of tidal surge conditions (increased salinity and re-suspension of sediments) sets the stage for impacted sediment transport to the Calcasieu Ship Channel.

ES-9 Upper Calcasieu Nature and Extent

This section summarizes the COPCs found in Upper Calcasieu AOC and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability, and chemical fate and transport. Upper Calcasieu is divided into five energy systems: bayou, marsh, river, shallow lake, and ship channel. The energy systems are presented in Figure ES-9.

ES-9.1 Summary of the RI Evaluations

Contraband Bayou represents the bayou system in Upper Calcasieu and is a moderately saline low-flow bayou. Low salinity marsh areas are present in the river above Lake Charles. The shallow lakes areas include Lake Charles, the West Slip of Clooney Island Loop, and the eastern portion of Coon Island Loop; they are confined and shallow low-flow systems, with generally limited circulation. The ship channel includes the main ship channel from the I-210 Bridge to Lake Charles and the slightly smaller limbs of Clooney Island Loop and western Coon Island Loop.

The areas that define the Upper Calcasieu portion of the estuary represent a mixture of land uses and energy systems. The portions of the river above Lake Charles are considerably less saline and are protected somewhat from storm surge and tidal influence, which increase salinities throughout the rest of the estuary. Lake Charles and the natural river segment between Lake Charles and the saltwater barrier experience seasonal salinity shifts, and the installation of the saltwater barrier is evidence of the severity of saltwater intrusion in the region.

Industrial facilities (Lyondell, Conoco, and PPG) in Coon Island Loop and Clooney Island Loop release surface runoff and wastewater discharge to Upper Calcasieu AOC. Contraband Bayou receives effluent from the Lake Charles POTW. Additional non-point sources are present throughout. Primary introduction of contaminants to the system appears to occur in Clooney Island Loop and Coon Island Loop.

Contaminants of primary interest in Upper Calcasieu are those contaminants that increase human health or ecological risk. The varied settings of Upper Calcasieu result in rather isolated occurrence of COPCs. The majority of contaminants and generally the highest concentrations are found in the shallow lake portion of Coon Island Loop and the Clooney Island Loop West Slip area. Discharges from Lyondell, Conoco and PPG have impacted these sediments with PAHs, dioxin/furans, and various metals.

Potential Sources to Upper Calcasieu:

Lyondell (formerly ARCO, Olin),
Conoco
PPG, and
Lake Charles POTW

ES-9.2 RI Conclusions for the Upper Calcasieu AOC

The distribution of COPCs in Upper Calcasieu is generally limited to Clooney Island Loop, Coon Island Loop, and the ship channel between them. Evidence of flow driven transport is noted in the ship channel, with limited constituents noted upstream. The presence of COPCs in the remainder of Upper Calcasieu, e.g., the bayou, river, marsh energy areas, and Lake Charles are minimal. Contaminants in Clooney Island Loop and Coon Island Loop appear to impact the region of Upper Calcasieu from the ship channel at Coon Island Loop up to the confluence with Lake Charles.

COPCs in Upper Calcasieu:

HPAHs, LPAHs, Dioxin/Furans, PCBs, Copper

COPCs of interest in Clooney Island Loop are PAHs (HPAHs and LPAHs), dioxin/furans, copper, and Aroclor 1254 (Figure ES-10). The highest concentrations are found in the West Slip area through the Conoco Dock area. The primary contaminants in the Coon Island Loop shallow lake area are low-level concentration of metals, noted throughout the shallow lake area. Limited various low-level HPAHs were also noted. It should be noted that HPAH distribution indicates extensive salting out of these contaminants from their entry into Coon Island Loop and the concentrations seen in the adjacent ship channel portion of Coon Island Loop. Historic data indicates that this distribution is consistent for the shallow lake area.

It should be noted that Figure ES-10 presents only selected COPC data that exceed the 95 percent UCL of the mean, in an effort to summarize the highest concentrations COPCs exclusively in the Upper Calcasieu AOC in a single figure. More detailed COPC occurrence is discussed in the RI report.

Distribution of the highest concentration of HPAHs is found in Clooney Island Loop from the West Slip area to the Conoco Dock area (sample location UCR2026). The concentrations decrease at UCR2026, but the extent of HPAH contamination in surface sediments continues well into the ship channel.

In general, PAH distribution in Upper Calcasieu sediment tends to concentrate in the shallow lake energy system. HPAH distribution extends to the area between Coon Island Loop and Contraband Bayou. This distribution appears to be due to the physical transport and settling of adsorbed particulate matter.

A limited number of detections, some with elevated concentrations of BEHP, were noted in the upper Coon Island Loop area near the confluence of Bayou Verdine. Lead detections correlated with these BEHP concentrations and although lead levels were not particularly elevated, they appear to be associated with BEHP deposition.

Potential sources to contamination in Upper Calcasieu are the distribution, storage, and transportation of products and waste in these three industrial areas. The elevated concentrations at the Conoco Docks are consistent with product storage and distribution activities associated with the site, as well as the site releases history. Elevated concentrations at the Lyondell/ARCO outfall 019 may indicate either repeated small quantity releases or impacted sediment accumulation in this area as available data does not indicate major releases through this outfall. Releases through PPG outfalls 002 through 004 are documented and appear to have contributed to current sediment quality. Impacted groundwater in the area may have been an additional source of contaminants to the estuary.

Low-level concentrations between the West Slip and the confluence of Clooney Island Loop with the main ship channel, the main ship channel between Clooney Island Loop and Lake Charles, and the area between Coon Island Loop and Contraband Bayou are indicative of adsorbed particle transport. The distribution indicates surge driven sediment transport.

Available information indicates that the PAHs entering the upper portion of Coon Island Loop readily salt out upon contact with waters of the loop. The data suggests that the HPAHs are generally immobile, with LPAHs having a slightly greater lateral distribution.

Overall, the highest COPC concentrations appear to occur in the West Slip of Clooney Island Loop and the eastern portion of Coon Island Loop. The data indicates that moderate fine or suspended particle transport is occurring in the ship channel portions of Clooney Island Loop and Coon Island Loop in Upper Calcasieu. Distribution and concentration gradients of the COPCs indicate sediment accumulation in the shallow lake portions of Clooney Island Loop and Coon Island Loop. Overall, sediment stability tends to be moderate. It appears that re-suspension of fine grained material (organic or inorganic) facilitates physical transport throughout Upper Calcasieu.

ES-10 Lower Calcasieu - Nature and Extent

This section summarizes the COPCs found in Lower Calcasieu AOC and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability, and chemical fate and transport. Lower Calcasieu is divided into four energy systems: bayou, shallow lake, other (Indian Marais Lagoon), and ship channel. The energy systems are presented in Figure ES-11.

ES-10.1 Summary of the RI Evaluations

Bayous Olsen and Guy represent the bayou system in Lower Calcasieu. Both bayous are saline, low-flow systems. Bayou Guy receives runoff from predominantly rural residential areas. Bayou Olsen receives industrial discharge from W. R. Grace Inc. and rural residential runoff. Both systems are net sediment exporters, and receiving bodies are Moss Lake for Bayou Olsen and the Old Calcasieu River channel below Prien Lake to Bayou Guy. The shallow lake areas include Prien Lake and Moss Lake; they are semi-confined shallow

Potential Sources to Lower Calcasieu:

Citgo, Montell USA, LA Pigments, Westlake Ethylene and Polyethylene, Westlake Styrene and Westlake Marine Terminal low-flow systems with limited circulation. Moss Lake tends to have the larger opening to the ship channel. The ship channel system includes the main ship channel from the I-210 Bridge south the southern end of Moss Lake. The areas that define Lower Calcasieu represent a mixture of land uses and point and non-point contaminant sources. Additional input to the Lower Calcasieu system includes flow from Upper Calcasieu, Bayou Verdine, and Bayou d'Inde sources. The most significant introduction of contaminants to the system appears to occur near the Citgo facility. The accumulation of low-level sediments in the bend south of Indian Marais Lagoon may come from any of the various sources upstream. Presence of material in this area appears to be the result of velocity drops and sediment particle settling.

COPCs in Lower Calcasieu:

Dioxins/Furans, HPAHs, LPAHs, BEHP and various metals

Contaminants of primary interest in Lower Calcasieu are those contaminants that increase human health or ecological risk. The layout of Lower Calcasieu tends to lead to somewhat isolated occurrence of COPCs. Overall, the most impacted area within Lower Calcasieu is the Indian Marais Lagoon. (Figure ES-12). The majority of contaminants and highest concentrations are found in the lagoon. Former discharge has impacted lagoon sediments. Primary COPCs are PAHs and selected metals, primarily lead, copper, chromium, and zinc.

It should be noted that Figure ES-12 presents only selected COPC data that exceed the 95 percent UCL of the mean, in an effort to summarize the highest concentrations COPCs exclusively in the Lower Calcasieu AOC in a single figure. More detailed COPC occurrence is discussed in the RI report.

The shallow lake areas, specifically Prien Lake, tend to have broad distribution of moderate-, to low-level concentrations of dioxins/furans, PAHs and some metals. Copper, lead, mercury, nickel, and zinc were present in Prien Lake in the surface water. Sediment concentrations were similar to background values. Copper exceeded the ambient water quality criteria set for acute and chronic marine exposure and chronic freshwater exposure limits. Mercury exceeded the chronic ambient water quality criteria for freshwater systems.

Data from the ship channel portion of Lower Calcasieu had limited detections of dioxins/furans, PAHs, BEHP, and mercury. The distribution is primarily associated with the Citgo facility and the Indian Marais Lagoon. Distribution appears to represent some degree of sediment transport downstream of the potential sources, e.g., the Citgo outfalls 004 and 006 or the Indian Marais Lagoon, to a shallow shelf on the eastern side of the ship channel where velocities appear to decrease and settling occurs.

ES-10.2 RI Conclusions for the Lower Calcasieu AOC

The distribution of COPCs in Lower Calcasieu is mostly concentrated in the Indian Marais Lagoon and is present in generally disperse, low-level concentrations in the ship channel and Prien Lake. Minor distribution of PAHs and various metals are present in Moss Lake.

Evidence of flow-driven transport is noted in the ship channel, with select COPC distribution noted between LCR1055 to LCR1036 (from Citgo facility to the ship channel bend south of the Citgo facility) and in Prien Lake. Distribution of dioxins/furans and BEHP in Prien Lake appear to be the result of sediment accumulation in the southern end of the lake. The specific origin of the COPCs is unknown, but based upon observed surface water circulation patterns associated with Prien Lake, it is likely that the contaminants have originated outside of the lake. The presence of COPCs in the remainder of Lower Calcasieu, e.g., the Bayou Guy, Bayou Olsen, and Moss Lake, are minimal.

COPCs of interest in Lower Calcasieu are PAHs (HPAH and LPAH), dioxins/furans, and various metals. The highest concentrations are found in the Indian Marais Lagoon, and lower levels of a subset of COPCs are noted in Prien Lake. It should be noted that minor sediment transport and deposition appears to be occurring downgradient of the Citgo facility and within Prien Lake. Limited historic data is available for use in evaluating sediment stability over time. Vertical core data indicates that recent releases of various constituents have deposited in Indian Marais Lagoon. Likewise, cores indicate the sediment scouring has occurred in Indian Marais Lagoon. PAH data in the subsurface indicates material is present in the shallow surface sediments, but that concentration levels are lower than in the past. Subsurface data is limited to the Indian Marais Lagoon in Lower Calcasieu.

In general, PAH and dioxin/furan distribution in Lower Calcasieu sediment tends to be concentrated in the Indian Marais Lagoon. Minor miscellaneous detections are also noted in the shallow lakes, primarily Prien Lake. Minor PAH distribution extends a short distance to the area downstream of the Citgo facility within the ship channel. This distribution appears to be due to physical transport of fine-grained material and subsequent settling due to velocity drops in downstream bends of the ship channel. Concentrations indicate that the ship channel effectively exports much of the sediment that enters.

Overall, contaminants appear to be highest in the Indian Marais Lagoon, with lesser contribution for Bayou d'Inde and outfalls within the area (e.g., Citgo or upstream industrial releases to Upper Calcasieu).

The data suggests that moderate fine or suspended particle transport is occurring, with limited deposition occurring within the ship channel near station LCR1033.

Overall, sediment stability appears to be dynamic. Current conditions have led to accumulation; however, the site is susceptible to storm surge scouring. It appears that material moves out of the lagoon into the ship channel during periods of high flow and that once material enters the ship channel the compounds are carried out of the system. The data indicate that in Lower Calcasieu deposition along the shoulder of the ship channel is minor; the ship channel is an effective sediment exporter.

ES-11 Nature and Extent of Biota Contamination

Tissue samples from a variety of aquatic biota were collected and analyzed for COPCs. This section discusses the tissue data by AOC and by biota group. The four AOCs in the estuary are Upper Calcasieu, Bayou d'Inde, Lower Calcasieu, and the reference area. Bayou Verdine is not included in this evaluation, as it was evaluated independently by Conoco. A description of the 11 biota groups evaluated is presented as Exhibit ES-3.

Exhibit ES-3 Description of Biota Groups for the Calcasieu Estuary

Type	Group	Description of Group	Size Class (cm)
Fish	1	Small sedentary species – low trophic level (<2.5)	<15 cm
Invertebrates	1A	Small sedentary bivalves	<7.5 cm
Invertebrates	1B	Small sedentary crustaceans	<7.5 cm
Invertebrates	2A	Small migratory crustaceans	<12.5 cm
Invertebrates	2B	Large migratory crustaceans	>12.5 cm
Fish	2A	Small migratory species - low trophic level (<2.5)	<15 cm
Fish	2B	Small migratory species - high trophic level (>2.5)	<15 cm
Fish	3A	Medium migratory species - low trophic level (<2.5)	15 to <30 cm
Fish	3B	Medium migratory species – high trophic level (>2.5)	15 to <30 cm
Fish	4A	Large migratory species - low trophic level (>2.5)	30 to 90 cm
Fish	4B	Large migratory species - high trophic level (>2.5)	30 to 90 cm

In addition, the relationships between COPC concentrations in sediment and in biological tissues are evaluated for small sedentary bivalves (Group 1A biota) that are directly and continuously exposed to potentially contaminated sediments. These relationships are expressed as biota-sediment accumulation factors (BSAFs) that are based on the following equation:

$$BSAF = \text{COPCs concentration in biota} / \text{COPCs concentration in sediment}$$

COPC concentrations are expressed as mg/Kg dry weight sediment and mg/Kg wet weight biota. The BSAFs presented in this section are not normalized for biota lipids or for sediment organic carbon content. BSAFs are not calculated for other biota groups because of more less direct contact with potentially contaminated sediments. For example, most fish accumulate contaminants as a result of direct water contact rather than sediment exposure. Also, other mobile invertebrates (e.g., crustaceans) will be exposed to sediments over a wider spatial area. The mobility of these types of organisms precludes an accurate determination of relationships between COPCs concentrations in sediment and biota.

Site-wide Results for Biota Groups 2A - 4B

Site-wide results include the results of sampling of migratory/mobile biota throughout the study area. This approach is appropriate because little difference was observed in the tissue COPCs concentrations of Groups 2, 3, and 4 migratory/mobile fish and crustaceans. The site-wide results are presented by COPCs class and by mobile/migratory biota group (Exhibit ES-4).

Exhibit ES-4 Site-wide Summary of Biota Tissue Data, Groups 2A to 4B

Biota Group	Metals	SVOCs/PAHs	PCBs	Pesticides	Dioxins/ Furans
2A Invertebrates	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	9 DET, MFD = benzaldehyde at conc ~RA	MFD = PCB-118 at conc >> RA	ND, and ND in RA	10 DET, MFD = 2,3,7,8-TCDF at conc >>RA
2B Invertebrates	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	3 DET, MFD = benzaldehyde at conc< RA	MFD = Aroclor 1254 (ND in RA) and PCB-118	MFD = DDT and beta-BHC	8 DET, MFD = 2,3,7,8-TCDF at conc > RA
2A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	2 DET, MFD = benzaldehyde at FD and conc~RA	MFD = Aroclor 1254 (ND in RA) and PCB-118 at conc ~ to RA	Few DET at low FD and conc	18 DET, MFD = 2,3,7,8-TCDF at conc ~ RA
2B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	6 DET, MFD = benzaldehyde	MFD = Aroclor 1254 and PCB-118	MFD = beta-BHC and DDE	21 DET, MFD = 2,3,7,8-TCDF
3A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	5 DET, MFD = benzaldehyde at conc ~RA	MFD = Aroclors 1254 and 1260 at conc ~ RA and PCB-118 at conc > RA	8 DET, MFD = DDD and beta-BHC	20 DET, MFD = 2,3,7,8-TCDF at conc < RA
3B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	7 DET, MFD = benzaldehyde at conc ~RA	MFD = Aroclors 1254 and 1260 at conc > RA and PCB-118 at conc ~ to RA	8 DET, MFD = beta-BHC	7 DET, MFD = 2,3,7,8-TCDF at conc ~ RA
4A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	4 DET, MFD = benzaldehyde. Only 1 SVOC detected in RA	MFD = Aroclors 1254 and 1260 (only 1254 DET in RA) and PCB-118 at conc > RA	Few DET at FD<50%, MFD = DDE and beta-BHC	FD ~ RA, but at conc > RA
4B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	Several DET, MFD = benzaldehyde, BEHP, and diethylphthalate	MFD = Aroclors 1254 and 1260 at FD and conc ~ RA and PCB-118 at conc > RA	Few DET at low FD and conc, MFD = beta-BHC, pesticides ND in RA	10 DET, MFD = 2,3,7,8-TCDF at conc > RA

MFD = Most frequently detected "X", DET = Number of analytes detected, RA = reference area
Conc = concentrations, FD = frequency of detection, < = less than,
> = greater than, >> = much greater than, and ~ = Similar to

In general, there is little difference in the types of analytes detected and the most frequently detected analytes from one biota group to another. These summary data encompass all the data from the three areas and, where available, the reference area.

In a few cases, comparisons of the summary data from the three areas to reference area data indicate significant differences. Two types of differences are observed. Contamination of reference areas by unknown sources can be concluded where reference area COPCs concentrations exceed the area concentrations in similar biota. This situation is observed occasionally with benzaldehyde and infrequently with 2,3,7,8-TCDF. On the other hand, significant AOC contamination can be interpreted where the concentrations of COPCs in AOC biota substantially exceed those of reference area biota. This case is observed more commonly with the PCB congener PCB-118 and 2,3,7,8-TCDF. These COPCs were commonly detected in AOC biota at concentrations that substantially exceeded those of the reference area. These are important findings because of the high toxicity and bioaccumulation potential of these COPCs. In general, the frequencies of detection and the concentrations of other COPCs, such as metals, were similar in both the reference area biota and the AOC biota, based on the overall data for all three AOCs.

In summary, only relatively minor differences are observed in the COPC concentrations in tissues taken from the AOCs and the reference area for the migratory or mobile biota. Therefore, area-specific data for these more mobile organisms are unlikely to provide useful information with regard to the identification of source areas or areas in need of remediation. Instead, area-specific data are best evaluated for less mobile organisms, primarily biota from Groups 1, 1A, and 1B. These data are summarized below.

AOC-Specific Results for Biota Groups 1, 1A, and 1B
The results summarized in this section are based on sedentary or less mobile organisms. These organisms, especially the invertebrates in Groups 1A and 1B, have more constant and direct contact with potentially contaminated sediments. Tissue COPC concentrations for these organisms are, therefore, more likely to be better linked to sediment quality, as indicated by COPCs concentrations. Because the sediment quality and tissue COPCs concentrations have direct association, these data are presented on a by-area, as well as a by-COPCs and by-biota group basis.

As shown in the summary presented below (Exhibit ES-5), there are some important findings based on location-specific data. Results for Group 1 sedentary fish reveal several locations where the frequency of detection and/or the mean concentration of metals COPCs exceed that of the reference area. This is true for Lower Calcasieu, Bayou d'Inde, and Upper Calcasieu. The most important finding within this group is the high mean concentration of mercury in Upper Calcasieu relative to the mean for the reference area. A second important finding is revealed by the comparison of the number of dioxin/furan compounds detected in each area. Twenty-one of these compounds were found in Lower Calcasieu while 25 and 18 were detected in the Bayou d'Inde and Upper Calcasieu, respectively. In contrast, only six dioxin/furan compounds were detected in the reference area. Comparisons of location-specific data for SVOCs/PAHs, PCBs, and pesticides reveal only relatively minor differences between reference area results and results from other AOCs.

Exhibit ES-5 Site-wide Summary of Biota Tissue Data, Groups 1, 1A, and 1B

Biota Group	Areas of Concern	Metals	SVOCs/ PAHs	PCBs	Pesticides	Dioxins/ Furans
1 Fish	LC	FD>RA (Ni) Conc>RA (Hg, Se, Zn)	9 DET, MFD = benzaldehyde (FD and conc<RA) and phenol. HCBD DET but not in RA.	Aroclor 1254 (FD~RA, conc<RA) and 18 congeners (FD and conc ~RA) DET.	endosulfan sulfate DET but not in RA. None DET in LC also found in RA.	21 DET, MFD = 2,3,7,8-TCDF.
	BI	FD>RA (As, Cr, Cu, Pb, Hg, Ni, Se, Zn). Conc >RA (Cr, Cu, Pb, Hg, Se, Zn).	9 SVOCs/1 PAH DET. Benzaldehyde MFD, but conc <RA.	Aroclor 1254 and 19 congeners DET. Aroclor 1254 FD >>RA, conc > RA. Congeners FD~RA.	3 DET at low FD and conc.	25 DET. Of 6 also DET in RA, FD~RA, conc >RA.
	UC	FD>RA (none), conc >RA (As, Pb, Zn). Mean conc Hg 2X RA mean.	5 SVOCs DET, MFD = 2- and 4-methylphenol (neither DET in RA). Phenol FD and conc>RA	Aroclor 1254 only Aroclor DET, at conc>RA. MFD congener = PCB-118, conc of congeners <RA	Not Detected	18 DET at low FD and conc. MFD=2,3,7,8-TCDF (mean=0.307 pg/g), ~RA
	RA	Similar elements DET	See above	See above	Few DET	6 DET
1A Bivalves	LC	FD >RA (none), conc >RA (Cu, Se, Zn).	3 SVOCs/3 PAHs DET. MFD = benzaldehyde and BAP	No Aroclors DET. MFD congener = PCB-118.	Not Detected	21 DET, FD~RA, conc>RA
	BI	FD>RA (none), conc >RA(Cu, Hg, mHg, Ni, Se, Zn).	1 SVOC/18 PAHs DET	Aroclor 1254 and 1260 DET, MFD congener = PCB-118. Congener FD~RA, conc >RA.	12 DET, MFD = beta-BHC. None DET in BI were DET in RA.	24 DET, FD~RA, mean conc >RA.
	UC	MFD=As, Cr, Cu, Hg, mHg, Ni, Se, Zn	5 SVOCs/18 PAHs DET, MFD = BAP (mean=1.066 ug/Kg)	Aroclors 1254 and 1260 FD<10%. Congeners not analyzed	14 DET, MFD=DDE (max=2.7 ug/Kg)	13 DET, compounds ~ RA
	RA	No sample collected	NS	6 DET	4 DET	11 DET
1B Crusta-ceans	LC	DET = Cu, Pb, Hg, Se, Zn.	Not Detected	Not Detected	3 DET	Not Analyzed
	BI	MFD = As, Cu, Pb, Hg, Ni.	No SVOCs DET, 18 PAHs DET	Aroclors 1254 and 1260 DET, MFD congener = PCB-129.	12 DET, MFD = beta-BHC.	34 DET, MFD = 2,3,7,8-TCDF.
	UC	MFD = As, Cu, Hg, Ni	No SVOCs, 18 PAHs	Aroclor 1254 and 1260, No congeners analyzed	3 DET	13 DET
	RA	NS	NS	NS	NS	NS

MFD = Most frequently detected
analytes detected
Upper Calcasieu
FD = frequency of detection

LC = Lower Calcasieu
BI = Bayou d'Inde
Conc = concentrations
NS = Not sampled

"X" DET = Number of
RA = reference area UC =
RA = reference area
< = less than

> = greater than >> = much greater than ~ = similar to

Biota-Sediment Relationships for Group 1A Biota

Geometric mean biota-sediment relationships for Group 1A shellfish (Bayou d'Inde and Upper and Lower Calcasieu) and Group 2A crustaceans (reference area), expressed as BSAFs rounded in most cases to two significant digits. The ranges of these BSAFs are presented below for each class of COPCs (e.g., metals, PAHs) or for an individual PAH where only one PAH was detected in both sediment and biota. The number of samples refers to paired (co-located) samples of both sediment and biota. Appendix H presents all COPCs-specific and AOC-specific BSAFs for Group 1A biota based by sample.

Lower Calcasieu (Group 1A shellfish - 1 sample)

Geometric mean BSAFs for metals other than mercury range from 0.0006 (lead) to 1.5 (zinc). Geometric mean BSAFs for mercury and methyl mercury are 0.013 and 0.4, respectively. Geometric mean BSAFs for PAHs range from 0.0023 (benzo(k)fluoranthene) to 0.0045 (benzo(a)pyrene).

Bayou d'Inde (Group 1A shellfish - 1 sample)

Geometric mean BSAFs for metals other than mercury range from 0.0002 (lead) to 0.05 (cadmium). Geometric mean BSAFs for mercury and methyl mercury are 0.060 and 9.3, respectively. The geometric mean BSAF for phenanthrene is 0.098.

Upper Calcasieu (Group 1A shellfish - 5 samples)

Geometric mean BSAFs for metals other than mercury range from 0.0056 (lead) to 1.0 (silver). Geometric mean BSAFs for mercury range from 0.007 to 0.28 in the five samples. Geometric mean BSAFs for PAHs range from 0.01 (benzo(a)pyrene and indeno(1,2,3-cd)pyrene) to 0.06 (anthracene).

Reference area (Group 2A crustaceans - 1 sample)

Group 1A shellfish were not sampled in the reference area. Data on Group 2A crustaceans, which are more mobile than Group 1A shellfish, are used to generally describe the sediment/biota relationships within the reference area. PAHs were not detected in the reference area. Geometric mean BSAFs for metals other than mercury range from 0.02 (lead) to 1.09 (cadmium). The geometric mean BSAF for mercury is 0.105. These data probably do not describe the sediment/biota relationships as well as the data based on Group 1A shellfish because of crustacean mobility. However, most of the Group 2A crustaceans sampled in the reference area are not expected to range widely over the estuary and are in fact likely to remain within the described reference area. These biota are, therefore, considered reasonable representatives of benthic biota having direct contact with reference area sediments.

BSAF Summary

COPCs that are easily bioaccumulated and not easily or rapidly depurated are expected to accumulate to the highest concentrations in exposed biota. Such COPCs include mercury and, for Group 1A bivalves, PAHs. Mercury can be converted to methyl mercury in sediment and in biological tissues, so mercury BSAFs can be viewed somewhat similarly to methyl mercury BSAFs. It is noted, however, that methyl mercury is more rapidly accumulated and accumulates to a higher degree than inorganic mercury. The highest overall BSAF was determined for methyl mercury in Bayou d'Inde (9.3). With a very few exceptions, geometric mean BSAFs for most other metals remained below 1.0. In most cases, the lowest geometric mean BSAFs were for lead, which is not unexpected given the low solubility and bioavailability of lead in sediments. BSAFs for PAHs generally remained low, in all cases less than 0.1. Other than the single high geometric mean BSAF for methyl mercury in Bayou d'Inde (9.3), the BSAFs determined for this site appear to be similar to those determined for other contaminated sites where BSAFs commonly approximate unity (1.0) for most COPCs.

The BSAFs presented here can be used to evaluate in a general sense the bioavailability of site COPCs. The identification of COPCs that occur in forms that are accumulated in biological tissues is reflected in the BSAF data presented. Also, these BSAFs can be used as input parameters to food chain modeling to derive predicted COPCs doses via ingestion of food items. This use is relevant only if it is determined that food chain modeling is indicated for this site.

ES-12 Toxicity Testing and Benthic Community Survey

This section summarizes the data generated from sediment and porewater toxicity tests. A total of 100 sediment samples were collected from the Calcasieu Estuary in November and December of 2000. A more comprehensive interpretation of these tests can be found in the BERA (CDM 2002c).

Sediment is a major repository for many of the more persistent chemicals that are introduced into surface waters and provides habitat for many aquatic organisms. In the aquatic environment, most anthropogenic chemicals and waste materials, including toxic organic and inorganic chemicals, eventually accumulate in sediment.

Concentrations of contaminants in sediment may be several orders of magnitude higher than in the overlying water. However, bulk sediment concentrations may not always be strongly correlated to bioavailability. Because relationships between concentrations of contaminants in sediment and their bioavailability are poorly understood, determining effects of contaminants in sediment on aquatic organisms requires controlled toxicity and bioaccumulation tests and measures of effects on benthic communities inhabiting sediments (SETAC 1997).

The testing was explicitly designed to provide the information that is required to evaluate the risks to sediment-dwelling organisms that are associated with exposure to contaminated sediments.

Whole-Sediment Hyalella Azteca Toxicity Tests

Whole-sediment toxicity tests were conducted on 100 samples with the amphipod *Hyalella azteca* following procedures outlined in ASTM (2000), EPA (2000), and Ingersoll *et al.* (1997). Exposures were conducted for 10 and 28 days, and endpoints measured at the end of these exposures included survival and length of amphipods. Mean survival of amphipods in the control sediment for both the 10 and 28-day (d)tests was at or above 92 percent for the first and second batches of samples. However, wide ranges in mean survival and length of amphipods were observed with exposure to the Calcasieu sediments in the 10 and 28-d tests. In both the 10 and 28-d tests, survival of amphipods exposed to Calcasieu sediments ranged from 0 to 100 percent.

Whole-Sediment Toxicity Test Using *Ampelisca Abdita*

Amphipods were exposed to test sediments for 10 days under static conditions, following ASTM procedures. The results were then put into three categories, low risk (survival > 55 percent), indeterminate risk (Survival 49.4 percent – 55.5 percent), and high risk (Survival < 49.4 percent). The results show that out of 100 percent of the samples tested, 46 percent of the samples tested had a survival rate of greater than 55 percent The majority of the mortality was experienced in Bayou d'Inde (21 out of 31).

Bioaccumulation Tests Using *Nereis Virens*

Bioaccumulation is the net accumulation of a substance by an organism as a result of uptake from an environmental source. A 28-d bioaccumulation test was conducted with site sediment from 12 locations (within the Calcasieu Estuary and the reference areas using the polychaete *Nereis virens* as the test organism. The polychates were allowed to live in 2 cms of sediment for 28 days, then removed, cleaned, frozen, and sent for analysis. Survival data for the *Nereis virens* in the bioaccumulation tests in the laboratory control sediment were 99 percent. Survival of *Nereis virens* in the site sediments ranged from 87 percent (sample station 00BI2-ST030-NSD-010) to 98 percent.

Bioaccumulation tests were conducted at six whole sediment sample locations in Bayou d'Inde. COPCs detected in the test organisms and sediments were total PCB congeners, dioxin/furans, and SVOCs. Metals detected in test organism were all within the range of metals detected in tissue from the reference areas.

Solid-Phase Microtox® Toxicity Tests

The Microtox® Solid-Phase Toxicity test (SPT test) was conducted on 100 whole sediment samples collected during the Phase II sampling. The SPT test determines the bioavailability of chemicals in sediment by exposing bioluminescent bacteria (*Vibrio* *fisheri*; B-NRL 1117, Azur Environmental, Carlsbad, CA) directly to sediment suspended in solution for a period of 25 minutes (Johnson 1998; Johnson and Long 1998). A log-linear model was then used to calculate EC-50 values. The bioluminescence of bacteria at the start of the exposures was always within the acceptability limits for the test (90 to 110 percent in the control). Therefore, the Microtox® tests met the acceptability criteria recommended in Johnson and Long (1998).

A wide range in the EC50 values was observed with exposure to the Calcasieu sediments in the Microtox® test (0.15 to 37). The results were put into three categories, low risk (EC-50 less than 1.12), indeterminate risk (EC-50 between 1.12 and 1.26), and high risk (EC-50 greater than 1.26). The results indicate that exposure to whole sediments from the Calcasieu estuary poses variable risks to the microbial community, with the highest posed to the microbial community in Bayou Verdine, followed by Bayou d'Inde, and Lower Calcasieu. (CDM 2002c).

Porewater Toxicity Testing

Fifty of the 100 stations were selected for porewater toxicity evaluation to determine if there were adverse effects to survival, growth, and reproduction of aquatic plants, benthic invertebrate, and benthic or pelagic fish associated with porewater from contaminated sediments from the Calcasieu Estuary. The three tests that were conducted and their endpoints included:

- **Porewater toxicity testing with Algal zoospores** – 96-hour (h) porewater toxicity test determined with Algal zoospore using sea lettuce, *Ulva fasciata, thalli*; endpoint: germination or growth

- **Porewater toxicity testing with sea urchins** – 30-minute or 48-h toxicity test determined using the sea urchin *Arbacia punctulata*; endpoint: fertilization test and the embryological development

- **Porewater toxicity testing with redfish embryos** – 48-h porewater toxicity tests with redfish (*Sciaenops ocellatus*) embryos; endpoint: hatching success and survival

When considered together, the three lines of evidence indicate that exposure to porewater is generally not adversely affecting the survival, growth, and reproduction of aquatic plants, benthic invertebrate, and benthic or pelagic fish.

Benthic Community Survey

Estuaries of southwestern Louisiana may be characterized as vertically well mixed, with wide annual salinity fluctuations, weak tidal flushing, fine sediments (often approaching 100 percent silt/clay content), and widespread low oxygen of bottom waters during warm months (Gaston and Nasci 1988). There were 3,408 macrobenthic organisms identified during the present study, distributed among 62 taxa. Most of the organisms were annelids (26 taxa; 77.8 percent of the specimens) and arthropods (22 taxa; 11.3 percent of the specimens). Only 11 taxa of molluscs were collected (7.7 percent of the specimens). No echinoderms were collected. Nemerteans, hydroids, and urochordates made up the remaining organisms (3.3 percent).

Abundance data for this study were comparable to values reported for the region by previous investigators (Gaston and Nasci 1988, Gaston and Young 1992). Data by station, however, ranged widely in the current study. For instance, many of the samples from Bayou d'Inde had very few organisms or very low mean total abundance per site, while one station on that bayou supported 4,258 organisms/0.5 m^2). Gaston and Young (1992) also reported that many sites in Bayou d'Inde were devoid of macrofauna and attributed this paucity to contaminant effects. They also collected fewer organisms in Bayou d'Inde than elsewhere (Bayou Verdine and Contraband Bayou).

Highest densities of macrobenthos occurred at reference sites (Choupique Bayou = 2,267/0.5 m^2; Johnson Bayou = 2,651/0.5 m^2) and Moss Lake (3,140/0.5 m^2), Prien Lake (2,207/0.5 m^2), upper Calcasieu River - Clooney Island to Coon Lake (2,059/0.5 m^2), and lower Bayou d'Inde - (2,049/0.5 m^2). Lowest densities of macrobenthos occurred in upper Bayou d'Inde (56/0.5 m^2), lower Bayou d'Inde (123 organisms/0.5 m^2), lower Bayou d'Inde - lower PPG Canal (130/0.5 m^2), and a reference site in Grand Bayou (141/0.5 m^2).

The IBI was assessed by region to make predictions of likelihood of contaminant effect on macrobenthic communities. Lowest values for the index (i.e., likelihood of contaminant effect) occurred at sites in upper Bayou d'Inde, middle Bayou d'Inde, and lower Bayou d'Inde; Bayou Olsen; and Coon Island Loop. Most of these sites supported very few organisms; and nearly all of the specimens collected were indicators of the highest levels of contamination.

Highest values for the IBI (i.e., low levels of contamination) occurred at reference sites on Johnsons Bayou, two sites in Clooney Island Loop and single sites in Moss Lake, Prien Lake, upper Calcasieu River, lower Bayou d'Inde, and Coon Island Loop. Most of these sites supported a moderate diversity of species and relatively high abundances of macrobenthos.

Toxicity Identification Evaluation

Phase II sediment samples were collected from seven locations in support of EPA Region 6 TMDL study as part of the current 303(d) listing. The purpose of the TMDL is to determine the pollutant loading that a water body can assimilate without exceeding the water quality standard for that pollutant. In support of the TMDL, a TIE was performed. The TIE method aids the TMDL determination by identifying which compound(s) result in toxicity to test organisms (AppendixI).

Toxicity results indicate that six of the seven sediments exhibited toxicity to both species. TIE findings for amphipods and mysids are generally in good agreement, and the results are consistent with sediment toxicity results. TIE results also indicate that specific contaminant classes caused acute toxicity and that sediment loads (via porewater flux) may be considered sources that may contribute to toxicity in the water column. The TIE study provides evidence relating site-specific contaminants and contaminant classes to observed adverse effects in benthic species. The TIE results may be applied to determine load limit requirements for protection of benthic habitat.

ES-13 Baseline Ecological Risk Assessment Summary

This section summarizes the evaluation of the risks to ecological receptors (i.e., aquatic organisms and aquatic-dependent wildlife) posed by exposure to water, sediment, or biota in the study area. More specifically, risks to the microbial community associated with exposure to COPCs in whole sediments were evaluated. In addition, risks to the aquatic plant community associated with exposure to COPCs in surface water or porewater from Calcasieu Estuary sediments were assessed. The risks to the benthic invertebrate community associated with exposure to COPCs in whole sediments and porewater were also evaluated. Furthermore, risks to benthic and pelagic fish associated with exposure to COPCs in surface water, porewater, whole sediments, and prey organisms were assessed. Finally, risks to aquatic-dependent wildlife (i.e., birds and mammals) were evaluated based on their potential exposure to COPCs in prey organisms.

ES-13.1 Study Objectives

The primary objectives of this study were to:

- Determine if adverse effects on ecological receptors are occurring, or are likely to be occurring, within the Calcasieu Estuary
- Evaluate the nature, severity, and area extent of any such effects
- Identify the COPCs that are causing or substantially contributing to effects on aquatic receptors

A step-wise approach was used to assess the risks to aquatic organisms (i.e., microorganisms, aquatic plants, benthic invertebrates, and/or fish) and aquatic-dependent wildlife associated with exposure to COPCs. The five main steps include:

- Identification of assessment endpoints, risk questions and testable hypotheses, and measurement endpoints
- Collection, evaluation, and compilation of the relevant information on environmental conditions in the Calcasieu Estuary

- Assessment of the exposure of aquatic organisms and aquatic-dependent wildlife to COPCs
- Assessment of the effects of COPCs on aquatic organisms and aquatic-dependent wildlife
- Characterization of risks to the aquatic organisms and aquatic-dependent wildlife

Assessment endpoints, risk questions and testable hypotheses, and measurement endpoints were identified. The assessment endpoints that were considered in the BERA included:

- Activity of the aquatic microbial community
- Survival, growth, and reproduction of aquatic plants
- Survival, growth, and reproduction of benthic invertebrates
- Survival, growth, and reproduction of benthic and pelagic fish
- Survival and reproduction of aquatic-dependent birds
- Survival, growth, and reproduction of aquatic-dependent mammals

ES-13.2 Integrated Risks to Aquatic Receptors

The results of this investigation indicated that exposure to COPCs is adversely affecting a variety of ecological receptors in the Calcasieu Estuary. More specifically, activity of the microbial community has been impaired in portions of the estuary due to exposure to sediment-associated COPCs. In addition, the survival, growth, and/or reproduction of aquatic plants have also been adversely affected in portions of the estuary through exposure to COPCs in surface water and porewater. Furthermore, exposure to whole sediments or porewater have been adversely affected the survival, growth, and/or reproduction of benthic invertebrates. Finally, the survival, growth, and/or reproduction of benthic fish have been impaired due to exposure to COPCs in whole sediments and/or porewater (Figures ES-13 to ES-15 summarize the risks to each receptor group throughout the Calcasieu Estuary).

For each of the four aquatic receptor groups, the information for various measurement endpoints and lines of evidence were integrated by calculating a final risk score for each location sampled. Subsequently, the final risk scores that were calculated for the various receptor groups for each location were averaged to obtain an overall risk score for the four-receptor groups for each location. Then, risks to microorganisms, plants, benthic invertebrates, and fish were classified into three categories for each location, based on the overall risk score that was calculated. Locations with overall risk scores of <2, 2 to 3, and >3 were classified as posing low, indeterminate, and high risks to aquatic receptors, respectively. In this way, it was possible to integrate information on the risks posed to multiple aquatic receptors by exposure to COPCs in the estuary.

The results of this assessment indicated that risks to aquatic receptors are generally low throughout the Calcasieu Estuary. Of the 634 locations that were sampled within the three AOCs, 377 (59 percent) were classified as posing low risks to microorganisms, aquatic plants, benthic invertebrates, and/or fish. By comparison, 11 percent (69 of 634) and 30 percent (188 of 634) of the locations sampled were classified as posing indeterminate and high risks, respectively . Among the three AOCs, the highest risks to aquatic receptors were evident in Bayou d'Inde. Risks to aquatic receptors were classified as low throughout the reference areas.

In general, there was good correspondence among the risk classifications for the four groups of aquatic receptors. For example, risks were classified as low within the three AOCs for 58 percent of the locations sampled for fish to 72 percent of the locations sampled for aquatic plants. With the exception of microorganisms, the frequency of classification of indeterminate risks was generally low (i.e., 5 to 9 percent) for the various receptor groups. Similarly, the frequency of classification of high risks was comparable for three of the four aquatic receptor groups (i.e., 23 to 37 percent, with microorganisms being the exception). Risks to the microbial community were generally classified as being lower than those for the other three aquatic receptor groups because confidence in the information on the selected measurement endpoints tended to be lower for microorganisms. The degree of correspondence among the risk classifications for the various receptor groups is illustrated in Figures ES-16 to ES-19. These figures also show that correspondence was lower in certain locations, particularly within the more contaminated areas within the estuary (e.g., Clooney Island barge slip, Lockport Marsh).

Upper Calcasieu River AOC – In general, risks to aquatic receptors were low throughout the Upper Calcasieu, as indicated by the average overall risk score of 0.81 that was calculated for this AOC. Of the 155 locations that were sampled within this AOC, 131 (85 percent) were classified as posing a low risk to microorganisms, aquatic plants, benthic invertebrates, and/or fish. Nevertheless, 15 percent (i.e., 24 of 155) of the locations within this AOC were classified as posing indeterminate (5 percent; 7 of 155) or high (11 percent; 17 of 155) risks to aquatic receptors. All of the locations that posed a high risk to aquatic receptors were encountered in the Clooney Island Loop (n=7) or the Coon Island Loop (n=10). The locations that posed the highest risk to aquatic receptors included the Clooney Island barge slip, the northern and north eastern portions of Clooney Island Loop, the northern and central portions of Coon Island Loop, and the mouth of Bayou Verdine (Figure ES-20).

Bayou d'Inde AOC – Risks to aquatic receptors were generally as high within Bayou d'Inde. The average overall risk score that was calculated for this reach was 2.4 (n=

316). Forty-nine percent of the locations sampled within the AOC (i.e., 156 of 316) were classified as posing a high risk to microorganisms, aquatic plants, benthic invertebrates, and/or fish. By comparison, 33 percent (i.e., 104 of 316) and 18 percent (i.e., 56 of 316) of the locations sampled were classified as posing low or indeterminate risks to aquatic receptors, respectively. The locations that posed the highest risk to aquatic receptors (i.e., overall risk score >3) were collected in the lower portion of upper Bayou d'Inde (i.e., between the CitCon facility and the highway LA-108 Bridge), the mainstem and wetland areas within middle Bayou d'Inde, throughout Lockport Marsh, the lower and middle portion of PPG Canal, and lower Bayou d'Inde mainstem in the vicinity of the confluence with PPG Canal and throughout the mainstem (Figure ES-13).

Middle Calcasieu River AOC (aka Lower Calcasieu) - Risks to aquatic receptors were generally classified as low with Lower Calcasieu. An average overall risk score of 0.73 was calculated for this portion of the study area. Based on the results that were obtained for microorganisms, aquatic plants, benthic invertebrates, and/or fish, 87 percent of the locations sampled (i.e., 142 of 163) within this AOC were classified as posing a low risk to aquatic receptors. Nevertheless, 13 percent (i.e., 21 of 163) samples from this AOC were classified as posing indeterminate (4 percent; 6 of 163) or high (9 percent; 15 of 163) risks to aquatic receptors. The samples that posed the highest risk to aquatic receptors were collected along the western shoreline of the middle Calcasieu River in the vicinity of the Citgo property, in Indian Marais Lagoon, Prien Lake and the central portions of Moss Lake (Figures ES-13 and ES-14).

Reference Areas - Risks to aquatic receptors were classified as low for all of the locations sampled within the reference areas. An average overall risk score of 0.55 was calculated for this portion of the study area (Table 13-6). All of the locations sampled were classified as posing low risks to aquatic receptors (Figure ES-15).

Contaminants of Concern - In this the BERA, the COPCs that were considered to be causing or substantially contributing to adverse effects on aquatic receptors were termed COCs. The results of this assessment indicated that there are a number of substances that are adversely affecting microorganisms, aquatic plants, benthic invertebrate and/or fish. In surface water, ammonia, dissolved copper, and total and dissolved nickel are considered to be COCs. In whole sediments, the COCs are considered to include metals (chromium, copper, lead, mercury, nickel, and zinc); 18 individual PAHs; total LMW-PAHs; total HMW-PAHs; total PAHs; total PCBs; aldrin; dieldrin; BEHP; HCB; HCBD; and, TCDD TEQs. The porewater COCs are considered to include hydrogen sulfide, total nickel, total zinc, 1-methlynaphthalene, benz(a)anthracene, and benzo(a)pyrene.

All of these substances occurred in whole-sediment, surface-water, and/or porewater samples from the Calcasieu Estuary at concentrations in excess of those observed in samples from reference areas and in excess of the selected benchmarks. In addition, the concentrations in the effects distribution (i.e., toxic samples) were generally higher than the concentrations in the no effects distribution (i.e., non-toxic samples) for one or more of the measurement endpoints (e.g., survival of *Ampelisca abdita* in 10-d toxicity tests). This latter evaluation was conducted to assess concordance between the chemistry and biological effects data. Many of these substances or groups of substances also accumulated in the tissues of polychaetes (*Nereis virens*) in 28-d bioaccumulation tests and were shown to be associated with toxicity to amphipods (*Ampelisca abdita)* in toxicity identification evaluations.

ES-13.3 Assessment of Risks to Aquatic-Dependent Wildlife

The risks to five groups of aquatic-dependent wildlife posed by exposure to COPCs in the Calcasieu Estuary were assessed. The receptor groups included sediment probing birds, carnivorous wading birds, piscivorus birds, piscivorus mammals, and omnivorous mammals. For each receptor group, an assessment was conducted to determine if adverse effects are occurring, or are likely to be occurring, in the Calcasieu Estuary. To the extent possible, the nature, severity and areal extent of such effects were evaluated, and the COPCs contributing to such effects were identified (i.e., COCs).

The risks to sediment probing, carnivorous wading, and piscivorus birds from exposure to contaminated aquatic prey were assessed for the Calcasieu Estuary. A conservative, deterministic screening ERA identified AOCs and COCs in the Calcasieu Estuary (Appendix G). The COCs identified in the deterministic assessment for birds included TCDD-TEQs, selenium, mercury, total PCBs, and lead.

The results of the assessment for aquatic-dependent birds indicated that there is a high risk that small hypothetical sediment probing birds will be adversely affected by exposure to selenium in the middle Calcasieu River. The risk of adverse effects are indeterminate for average-sized and small sediment probing, carnivorous wading, and piscivorus birds exposed to lead and TCDD-TEQs in all AOCs and selenium in AOCs other than the middle Calcasieu River. Mercury poses a low risk to average-sized and small sediment probing, carnivorous wading, and piscivorus birds, except for Bayou d'Inde where it poses indeterminate risks to small piscivorus birds. Accordingly, selenium, lead, mercury, and TCDD-TEQs were identified as COCs in the Calcasieu Estuary for aquatic-dependent birds.

The risks to piscivorus and omnivorous mammals from exposure to contaminated aquatic prey were assessed for the Calcasieu Estuary. A conservative, deterministic screening ERA identified AOCs and COCs in the Calcasieu Estuary. The COCs identified in the deterministic assessment for mammals included TCDD-TEQs, selenium, mercury, and PCBs.

The risk characterization results showed that there is a low probability that exposure to methylmercury, TCDD-TEQs, and selenium will cause adverse effects to piscivorus and omnivorous mammals foraging in the Calcasieu Estuary. There is also a low probability of adverse effects to omnivorous mammals exposed to total PCBs. However, there is a high risk that total PCBs are causing adverse effects to average-sized and small piscivorus mammals inhabiting the Bayou d'Inde AOC. Based on the deterministic ecological risk assessment, total PCBs pose low risks to piscivorus mammals in other parts of the estuary. Accordingly, total PCBs were identified as COCs in the Calcasieu Estuary for aquatic-dependent mammals.

ES-13.4 Conclusions of the Ecological Risk Assessment

In accordance with EPA (1997) guidance, the BERA of the Calcasieu Estuary was conducted following an eight-step process. The first two of these steps (i.e., the SERA) was completed in 1999 (CDM 1999). The results of the final six steps of the process are described in the BERA. The HHRA describes the risks to human health associated with exposure to COPCs in the Calcasieu Estuary (CDM 2002b).

The results of this assessment indicated that the presence of COCs in surface water, whole sediments, porewater, and/or the tissues of aquatic organisms pose a risk to ecological receptors. Exposure to contaminated sediment and porewater pose risks to microorganisms, aquatic plants, benthic invertebrates, and/or fish throughout portions of the Calcasieu Estuary. Consumption of contaminated fish and shellfish also poses risks to aquatic dependent wildlife, including sediment-probing birds, carnivorous wading birds, piscivorus birds, omnivorous mammals, and/or piscivorus mammals. Collectively, the information compiled, evaluated, and analyzed to support the BERA provides a weight-of-evidence that clearly demonstrates that the presence of ammonia; hydrogen sulfide; metals (chromium, copper, lead, mercury, nickel, and zinc); PAHs (1,1-biphenyl, 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene, total LMW-PAHs, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, pyrene, total HMW-PAHs, and total PAHs); PCBs (total PCBs), chlorinated benzenes (HCB and HCBD); phthalates (BEHP); OC pesticides (aldrin and dieldrin) and PCDDs and, PCDFs (total 2,3,7,8-TCDD TEQs) in environmental media pose unacceptable risks to ecological receptors. The information contained in this BERA and companion documents (i.e., CDM 2001; 2002c) is intended to support decisions regarding the need for remedial actions within the Calcasieu Estuary.

ES-14 Human Health Risk Assessment

This assessment quantifies potential carcinogenic and noncarcinogenic health risks from exposure to contaminants in the Calcasieu Estuary, following the Risk

Assessment Guidance for Superfund (RAGS; EPA 1989a). This assessment evaluates both current and future risks to individuals living and working near the estuary based on the assumption of no remediation or institutional controls (i.e., baseline conditions). The baseline risk estimates, developed using conservative or health protective assumptions, are used to determine which contaminants and exposure pathways pose the greatest risk, and whether remediation is likely to be required, and to provide a baseline against which any future remedial action can be evaluated.

ES-14.1 Overview of Risk Assessment Approach

In the HHRA for the Calcasieu Estuary, contaminants in sediment, surface water, fish tissue, and shellfish tissue were quantitatively evaluated for potential health threats to human receptors via the ingestion and dermal pathways. Recreational users, commercial fishers, and residential fish and shellfish consumers were evaluated under present and potential future land use conditions. The estimates of risk and hazard and the greatest chemical contributors to these estimates are presented and discussed.

COPCs were selected based on screening levels that are presented in the HHRA (CDM 2002b). The chemicals of potential concern included SVOCs, pesticides, PCBs, dioxins/furans, and inorganic analytes. The essential nutrients (i.e., calcium, magnesium, potassium, and sodium) were not quantitatively addressed as their potential toxicity is significantly lower than other inorganics at the site, and most existing toxicological data pertain to dietary intake.

Exposure routes and human receptor groups were identified, and quantitative estimates of the magnitude, frequency, and duration of exposure were made. Exposure points were estimated using the minimum of the 95 percent UCL and the maximum concentration. Chronic daily intakes for the ingestion route were calculated for reasonable maximum exposures.

In the toxicity assessment, current toxicological human health data (i.e., reference doses and slope factors) were obtained from various sources. Risk characterization involved integrating the exposure and toxicity assessments into quantitative expressions of risks/health effects. Specifically, chronic daily intakes were compared with concentrations known or suspected to present health risks or hazards. The carcinogenic risks and noncarcinogenic hazard index values calculated for the site are based on the reasonable maximum exposure (RME; the highest exposure reasonably expected to occur at a site). The intent is to estimate a conservative exposure case that is still within the range of possible exposures.

In accordance with NCP Section 300.430 (e)(2) for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-6} and 10^{-4}. Per RAGS

Part B: Development of Risk-Based Preliminary Remediation Goals (EPA 1991c), for noncarcinogenic effects, it is generally appropriate to assume a hazard index equal to 1 as the threshold values for potential human health impacts.

ES-14.2 Summary of Site Risks

The carcinogenic risks and noncarcinogenic hazards for sediment and surface water exposures in the Calcasieu Estuary fell within EPA's target risk range of 10^{-4} to 10^{-6} and below a hazard index of 1. However, the carcinogenic risks and noncarcinogenic hazards for fish and shellfish consumption exceeded EPA's target risk range and hazard index.

Estuary-wide Risk Drivers:

Shellfish Tissue
- PCBs
- Dioxin/Furans
- Arsenic
- Pesticides

Fish Tissue
- Dioxin/Furans
- Arsenic

Total excess lifetime cancer risks from consumption of fish and shellfish from the estuary were above the range of 10^{-6} to 10^{-4}. The cancer risks associated with fish and shellfish ingestion from the areas of Bayou d'Inde, Upper Calcasieu, and Lower Calcasieu were all above 1 x 10^{-4} (1 in 10,000) for residential exposure and 1 x 10^{-3} (1 in 1,000) for subsistence exposure. The highest cancer risks were associated with ingestion of fish and shellfish ingestion from Bayou d'Inde. The chemicals that contributed most significantly to risk estimates include PCBs, dioxins/furans, arsenic, and pesticides in shellfish tissue and dioxins/furans and arsenic in fish tissue. Several pesticides, including aldrin, dieldrin, heptachlor epoxide, heptachlor, and BHCs, also contributed to the total cancer risk estimate.

Total excess lifetime cancer risks from ingestion of dioxins/furans in fish and shellfish from Bayou Verdine were also above the range of 10^{-6} to 10^{-4}. The cancer risk estimates were 1 x 10^{-4} (1 in 10,000) for residential exposure and 6 x 10^{-4} (6 in 10,000) for subsistence exposure. The estimated risks for residential fish/shellfish consumption were dominated by fish ingestion (1 x 10^{-4} for fish ingestion, 2 x 10^{-6} for shellfish ingestion). Similarly, for subsistence fish/shellfish ingestion, the estimated risks were due primarily to fish ingestion (5 x 10^{-4} for fish ingestion, 7 x 10^{-5} for shellfish ingestion). Only dioxin/furan concentrations were used to estimate these risks. Risks associated with other chemicals present in fish and shellfish were estimated in ENTRIX (2001) for Bayou Verdine. When the risks associated with dioxin/furan are added to the risks from the ENTRIX report, the total cancer risks for all chemicals in fish/shellfish are 4 x 10^{-4} for residential consumption and 2 x 10^{-3} for subsistence consumption.

The total hazard indices for both residential and subsistence fish/shellfish consumption from Bayou d'Inde, Upper Calcasieu, and Lower Calcasieu were all greater than the threshold of one for noncancer effects. These hazard indices indicate that there is a potential for noncancer health effects to occur from ingestion of fish and shellfish from these AOCs. The chemicals that contributed most significantly to the noncancer hazard index include PCBs and manganese in shellfish tissue and PCBs in fish tissue. PCBs may adversely affect the eyes, skin, and nails of individuals consuming fish and shellfish from the estuary at the rates assumed in this risk assessment. In addition, elevated levels of PCBs may cause immunological and developmental effects. Manganese may impact the nervous system of shellfish consumers.

As in any risk assessment, the estimates of potential health threats (carcinogenic risks and noncarcinogenic health effects) have associated uncertainties. The key uncertainties in this assessment that could influence the risk estimates are the following:

- Chemical concentrations in the estuary are likely to fluctuate and decrease over time. The risk estimates assume long-term (i.e., up to 30 years) exposure to a constant concentration and, therefore, may overestimate risks.
- Some of the risks noted in the assessment were based on limited data (e.g., limited tissue samples for dioxins/furans analysis). Additional data may need to be collected to provide technical support for any cleanup decisions that are based primarily on these chemicals in fish/shellfish tissue.
- For several COPCs, concentrations measured in reference area samples were similar to or higher than concentrations measured in the Calcasieu Estuary. Cancer risks estimated for dioxins/furans in reference area biota represent 5 to 44 percent of the risks estimated for dioxins/furans in the estuary, depending on the AOC. Cancer risks estimated for arsenic in reference area biota were higher than those estimated for the estuary.
- There is some uncertainty in the toxicity value for dioxin/furans. EPA has proposed a cancer slope factor for dioxins/furans that is seven times higher than the value applied here to 2,3,7,8-TCDD equivalents. Risks associated with these chemicals could be almost an order of magnitude higher.

As a result of these uncertainties, this risk assessment should not be construed as presenting absolute risks or hazards. Rather, it is a conservative analysis intended to indicate the potential for adverse impacts to occur based on a reasonable maximum exposure.

ES-15 Comprehensive Summary of the RI

Industrial development, including chemical manufacturing and distribution, and petroleum refining has been prevalent in the Lake Charles area since the early 1920s and has impacted the estuary through the release of hazardous chemicals. Additionally, facility discharges, urban and agricultural activities, dredging, storm water runoff, and accidental releases have contributed to contaminated surface water and groundwater in and around the industrial areas. These same activities also have resulted in contaminated sediments within the various surface waters in the estuary. Further, fish and shellfish within the estuary have been impacted by industrial contaminants, prompting the State of Louisiana to issue health advisories related to the consumption of fish and shellfish in the Calcasieu Estuary (LDEQ 1999 and Louisiana Department of Health and Hospitals [LDHH] 2000).

Localized hot spots occur throughout the study area and are the result of historical spills, releases, and/or current activities attributed primarily to industries surrounding the Calcasieu Estuary. The RI summary has attempted to narrow the original study area, which started at the saltwater barrier and extended south to Moss Lake to more focused Areas of Interest (AOIs). The AOI are based on the frequency of detects and the elevated concentration of COPCs and the result of the PCA as discussed in Sections 7 through 10.

ES-15.1 Summary of AOIs Using 95 Percent UCL Exceedences

Exhibit ES-6, (located at the end of this section) summarizes the most significant AOIs by geographic location in the estuary, followed by COPC concentration compared to estuary-wide data population 95 percent UCL concentration, a general sediment stability ranking, potential contaminant sources to the study area, and a ranking of ecological risk (from the BERA) posed by sediment to the benthic invertebrate community. Human health risks are of equal importance. With PCBs and dioxin/furans in fish and shellfish being the primary drivers of risk to humans, any AOI with these associated COPCs contributes to total site risk.

Use of the 95 percent UCL is a standard statistical approach to identify the maximum values in a population. The data from all of the AOCs and individual energy systems were combined to generate the estuary-wide population statistics provided in Appendix J. The 95precent UCL was used to provide a collective summary of the entire study area, AOC boundaries notwithstanding. The statistical output is provided for all compounds, summation data is provided for total HPAHs, total LPAHs, and 2,3,7,8-TCDD TEQ.

This summary organic data are shown graphically on Figure ES-21. Inorganic data are shown on Figure ES-22. These figures and Exhibit ES-6 present the data points where the 95 percent UCL was exceeded for the select group of compounds. They illustrate the areas impacted by the highest concentrations measured in the estuary (i.e., the areas of highest risk to human and ecological receptors). They show correlation to physical conditions that influence contaminant occurrence and transport with the estuary as a whole. The COPC list presented is based on those compounds that are most prevalent, most concentrated and/or are a concern from human health and ecological risk perspectives.

It is important to note that the AOIs described below are not the only areas in the Calcasieu Estuary that warrant consideration under the CERCLA process, but they are the locations where the most significant risk reduction could be accomplished. The graphical presentation is not based on clean-up standards (site-specific standards have not been established in this report), but on standard statistical approaches to enable stakeholders and risk managers to evaluate the status of the study area as a whole. The following paragraphs discuss each AOI presented in Exhibit ES-6.

Clooney Island Loop West Slip

The Clooney Island Loop West Slip area sediments are impacted by PAHs (high [HPAHs] and low [LPAHs] molecular weight), BEHP, mercury, zinc, and Aroclor-1254. Each of these compounds exceeds the estuary-wide population 95 percent UCL. The highest concentrations are located in the West Slip area at UCR2028, and UCR2026 at the Conoco Dock. This AOI has also been identified as a high risk to benthic invertebrate and fish (CDM 2002c). Overall, sediment stability tends to be moderate, however, there is potential for the sediments to mobilize, particularly under heavy storm conditions. The sources of contaminants within this AOI are primarily attributed to Lyondell/Olin and Conoco. Conoco, through transport, is potentially responsible for PAHs in the northern Clooney Island Loop area. Elevated concentrations appear to be associated with current and historical outfall discharge, uncontrolled releases, as well as various non-point source releases associated with industrial operations.

Coon Island Loop (PPG North Dock Area and western portion of the Loop)

Various PAHs, BEHP, metals, and PCBs were noted in the upper Coon Island Loop area near the confluence of Bayou Verdine and the Coon Island Loop turning basin. Lateral distribution extends approximately 1200 m downstream along the western Coon Island Loop from the mouth of Bayou Verdine. A metal that exceeds the 95 percent UCL is lead, which is detected mid-way through the loop to station UCR 1-13-SD; however, it is also a background metal.

Potential sources are the distribution, storage, and transportation of products and associated wastes generated locally by PPG. Releases through the PPG outfalls 002 through 004 and the North Dock area are documented and may have contributed to current sediment quality, as well as impacted flow from Bayou Verdine. Additionally, oil field activities on on the Olin Chemical owned Coon Island may be a potential source of PAHs and lead.

The BERA (CDM 2002c) indicates this is a high-risk area for benthic invertebrates and fish. The HHRA also indicates high risk from PCB and dioxin/furans, which exist in this area.

Overall, sediment stability in this region of Coon Island Loop appears to be moderate with a potential to remobilize. Sediment migration would be drawn to the deeper ship channel and shallow lake areas, particularly under heavy storm conditions.

Bayou Verdine Reach 1

The primary contaminants in the lower portion of Bayou Verdine include HPAHs, BEHP, PCBs, dioxin/furans, and metals. Contaminant extent is concentrated around I-10 and PPG outfall 004 located upstream of the North Dock area. Reach 1 has historically received discharge from multiple industrial outfalls. It may also be impacted by releases associated with the KCSRR drainage ditch and/or runoff from I-10. Release from these process areas mix with the saline waters of Bayou Verdine contaminants noted in overlapping areas. PAH distribution appears to be due primarily to "salting-out". The PAH concentrations tend to indicate that localized areas with higher concentrations are present along Reach 1. The NPDES compliance data does not indicate significant release to these areas; therefore, the drainage ditches and upstream impacts (i.e., Condea Vista, Conoco, Tetra Technologies, Lyondell) are the suspected sources of COPCs this area. Reach 1 sediments contamination may be related to industrial spills, released through impacted subsurface soil or other media discharge.

Sediment stability in Reach 1 of Bayou Verdine is susceptible to tidal surge or storm scouring. While multiple sources exist, the broad distribution along the length of Reach 1 is indicative of contaminant transport and sediment movement. Based on this assumption, the sediment stability for this portion of Bayou Verdine is considered low. In addition, ecological risk evaluations conducted for Conoco (Entrix 2001) indicate that this area is a high-risk area for benthic invertebrates and fish. Existing PCBs and dioxin/furans are attributable to unacceptable risk to humans via fish/shellfish consumption (CDM 2002b).

Bayou Verdine Reach 2

The contaminants that exceed the 95 percent UCL in Reach 2 of Bayou Verdine include LPAHs, EDC, and zinc. PCBs and PAHs were detected in previous studies and in the RI throughout Reach 2; however, the concentrations do not exceed the 95 percent UCL. The data indicates that most contaminant concentrations are higher in shallow surface sediments, indicative of recent deposition. Reach 2 has received discharge from multiple industrial outfalls (i.e., CONDEA Vista and Conoco). Surface run-off from industrial ditches and the distribution of contaminants indicate that the in-flow alters distribution locally. Release may also be impacted in lower Reach 2 by release associated with the KCSRR drainage ditch and/or runoff from I-10.

Tidal surge or high freshwater inflows tend to facilitate sediment transport in Reach 2. Based on this transport mechanism and shallow sediment concentrations, the sediment stability within this area is moderate. In addition, ecological risk evaluations conducted for Conoco (Entrix 2001) indicate that this area is a high-risk area for benthic invertebrates and fish.

Bayou Verdine Reach 3

The primary contaminants that exceed the 95 percent UCL in Reach 3 of Bayou Verdine are PAHs, PCBs, zinc, and VOCs (EDC). LPAHs in Reach 3 tend to be more concentrated than other areas throughout the estuary. Vertically, the concentrations of PAHs consisting of LPAHs and HPAHs tend to be highest in the subsurface in Reach 3. Sediment transport is evidenced by the broad distribution of PAHs from New Trousdale Road downstream in Reach 3. Primary contaminant sources to Reach 3 appear to be the Conoco Lube Tank Farm and CONDEA Vista via the Vista West Ditch. While multiple sources exist, the broad distribution along the length of the bayou is indicative of moderate contaminant transport and sediment movement. Potential sources include CONDEA Vista and Conoco.

Bayou d'Inde - Lockport Marsh

The primary contaminants that exceed the 95 percent UCL in Lockport Marsh include dioxin/furans, PCBs, BEHP, HPAHs, LPAHs, copper, mercury, lead, and zinc. The potentially responsible industries discharging these contaminants include PPG, and the oil and gas industry. The areas with significant contamination are generally within the upper, bermed portion of Lockport Marsh. The distribution of most contaminants throughout Lockport Marsh indicate a similar pattern. Mercury and BEHP distribution in Lockport Marsh varies.

The BERA (CDM 2002c) identifies areas throughout Lockport Marsh as high-risk to benthic invertebrates and fish. The presence of elevated PCBs and dioxin/furans suggest unacceptable contribution to human health risk (CDM 2002b).

Sediment stability is poor in the lower portion of the area, outside of the levees. Circulation through the area can be substantial and contaminant distribution indicates that impacted sediments have been transported out of the area. Overall, Lockport Marsh is not considered a significant sink for contaminated sediments exported by upper reaches. The upper portions of Lockport Marsh appear to receive contaminant input from PPG Canal and sediment stability in these areas is moderate. Protection by the levees however, would be compromised by high storm surges or flooding. Release to Lockport Marsh appears to be primarily from waste storage or discharge activities.

Bayou d'Inde Reach 1

Reach 1 was the Bayou d'Inde area with the greatest number of detections and the highest COPC concentrations. Reach 1 contaminants that exceed the 95 percent UCL include dioxin/furans, PCBs, BEHP, mercury, lead, and zinc. The HPAHs, LPAHs, HCB, and HCBD concentrations are also elevated, however, they are not shown on Figure 15-1. The contaminant concentrations and distribution in this reach warrant further evaluation.

The major potential source of contaminants within Reach 1 is PPG. Reach 1 also appears to receive minor amounts of impacted sediment (primarily BEHP and possibly Aroclor-1254) from upper reaches. Reach 1 may, under specific flow conditions, act as a sink for contaminated sediments exported by upper reaches. The primary contaminant source to Reach 1 is the PPG Canal. Sediment stability in Reach 1 is generally considered low and storm surges or wind forcing would likely mobilize sediments.

The BERA (CDM 2002c) identified areas throughout Reach 1 as high-risk to benthic invertebrate and fish. The presence of elevated PCBs and dioxin/furans suggest unacceptable contribution to human health risk (CDM 2002b).

Bayou d'Inde Reach 2 Bayou and Marshes

The Reach 2 COPCs that exceed the 95 percent UCL include metals, PCBs, and dioxin/furans. The contaminant concentrations of metals are highest for copper, chromium, mercury, lead, and zinc. Reach 2 marshes tend to exhibit the highest concentrations for metals, dioxin/furans, and most HPAHs. Lead and zinc do not exceed the 95 percent UCL for the marshes; however, they are present in Reach 2 of the bayou at elevated concentrations.

Similarly, the HPAH compound 1,2-BPA is absent from Reach 2 marshes even though 1,2-BPA is present in the bayou, possibly indicating rapid chemical precipitation when it was released. Potential sources of contaminants within Reach 2 include Citgo, Westlake Polymers, Equistar, and PPG. Reach 2 appears to receive impacted sediment from Reach 3 industrial releases. Reach 2 bayou is a net sediment exporter and its marshes act as sinks for contaminated sediments exported by Reaches 2 and 3. Evidence of flow both up and down stream is noted for Reach 2, specifically from contaminant gradient and compound presence.

Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution. Sediments may be mobilized by storm surges or wind forcing throughout lower Reach 2.

The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrate and fish. The presence of elevated PCBs and dioxin/furans suggest unacceptable contribution to human health risk (CDM 2002b).

Bayou d'Inde Reach 3

Reach 3 contained a limited number of COPCs that exceed the 95 percent UCL, specifically PCBs, copper, zinc, and lead. However, concentrations of PAHs, BEHP, mercury, and dioxin/furans in Reach 3 tend to be the second highest of all detections observed in Bayou d'Inde. Two areas of possible contaminant sources are observed; the area between the Citgo outfall 001 and the Firestone outfall 001, and the area between OxyChem outfall 001 and Westlake outfall discharge point near former outfall 002B located near the LA-108 Bridge.

Reach 3 is a net sediment exporter. Reach 2 marshes appear to receive contaminated sediments exported by Reach 3. Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution, and is likely mobilized by barge traffic near the docks at LA-108. Further, it appears likely that the shallow depth of Reach 3 makes the area susceptible to turbulence driven mixing due to strong winds or tidal forces.

The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish. The occurrence of PCBs and dioxins/furans supports unacceptable risk identified in the HHRA (CDM 2002b).

Maple Fork Bayou

Contaminants that exceed the 95 percent UCL in Maple Fork Bayou include Aroclor-1254, chromium, and zinc. Mercury and dioxin/furans are also present at elevated levels. No major contaminant sources are known to exist for Maple Fork Bayou. Anthropogenic releases from the railroad and industrial pipelines that cross Maple Fork Bayou appear to be a possible contaminant source. Contaminant concentrations indicate local release within the bayou.

Maple Fork Bayou appears to be a net sediment exporter. Sediment stability in Maple Fork Bayou is moderate given the limited temporal data available to evaluate the contaminant entry into Maple Fork Bayou. Storm surge or wind forcing may mobilize sediments.

The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish.

Indian Marais Lagoon

The primary contaminants in Indian Marais Lagoon that exceed the 95 percent UCL include PAHs (HPAH and LPAH), PCBs, lead and zinc. Vertical core data indicate that sediment scouring has occurred in Indian Marais Lagoon.

The leading potential source of contaminants appears to be the former waste handling activities in the Indian Marais Lagoon. Overall, sediment stability appears to be low to moderate. Current conditions have led to sediment accumulation, however, historically the site has been susceptible to storm scouring. It appears that material moves out of the lagoon into the ship channel during periods of high flow or heavy rainfall.

The BERA (CDM 2002c) has indicated that Indian Marais Lagoon is a high risk area for benthic invertebrate and fish.

Clooney Island Loop East
Sources of contaminants within this area potentially include Lyondell/Olin and Conoco. However the highest concentrations do not exceed the 95 percent UCL. Low-level contaminants include BEHP, dioxin/furans, copper, and Aroclor-1254. This distribution appears to be due to the physical transport and settling of adsorbed particulate matter. Overall, sediment stability tends to be moderate. It appears that re-suspension of fine grained material facilitates physical transport throughout the Clooney Island Loop. Concentrations appear to be associated with release from current and historical outfalls as well as various non-point source releases associated with these operations.

Coon Island Loop East
The primary contaminants in the eastern Coon Island Loop shallow lake include chromium, lead, and copper. It should be noted that significant HPAH concentrations are detected at the mouth of Bayou Verdine adjacent to this area. However, distribution gradients indicate salting-out of these PAHs as they enter Coon Island Loop. Lateral extent of PAHs is limited as distance increases from the mouth of Bayou Verdine. The extent of elevated metals within this area is greater than PAHs. The highest lead and chromium concentrations are detected mid-way through the loop to station UCR 1-23-SD. The source of these contaminants is not fully understood, Overall, sediment stability is moderate, however, there is potential for the sediments to mobilize, particularly under heavy storm conditions. The data suggest that particle deposition and secondary re-mobilization may occur, which tends to move sorbed metals laterally.

The BERA (CDM 2002c) indicates this is a high-risk area for benthic invertebrates and fish.

ES-15.2 Conclusions

Calcasieu Estuary represents a mixture of land uses and energy systems. It is a complex system consisting of numerous perennial wetland bayous and tributaries in a heavy industrial setting. Development along the banks of the estuary has resulted in point and non-point discharge to the system that has detrimentally impacted sediments and surface water to a point where sediments pose an unacceptable risk in a number of areas to ecological and human receptors.

The figures in this section illustrate the primary areas impacted by the highest concentrations. They show correlation to physical conditions that influence contaminant occurrence and transport with the estuary as a whole. The summary is based on those compounds that are most prevalent; most concentrated and/or are a concern from a human health or ecological risk perspective.

The estuary is worth improving and protecting through, at a minimum, implementation of short term and long term management practices. Remedial measures are believed to be warranted in some areas (e.g., Lockport Marsh, Bayou d'Inde, and the Olin West Slip). Active remedial strategies in selected areas would likely catalyze sustainability of the estuary. Further, active remedial strategies may be mutually beneficial; e.g., removal of elevated COPCs for risk minimization and channel improvement for flood control and improved navigation. In addition to diverse habitat and fauna and flora, the estuary supports a number of recreational activities and commercial operations that without environmental diligence will suffer in the short and long term.

Exhibit ES-6 Areas of Interest and Chemicals of Concern for the Calcasieu Estuary - Conclusions

Areas of Interest	PAHs	SVOCs[1]	VOCs	*Metals*[2]	PCBs	2,3,7,8-TCDD TEQ	Sediment Stability	Potential Sources	Human Health Risk Subsistence/Residential	BERA RISK
Upper Calcasieu										
- Clooney Island West Slip	A	A	B	A (Hg, Zn)	A	B	2	*Lyondell/Olin, Conoco*	High/Indeterminate	High
- Clooney Island Loop (East)	C	B	B	B	B	B	2	Conoco, Lyondell		High
- Coon Island Loop (East, shallow lake)	B	B	B	A (Cr, Pb); C (Cu)	B	B	2	PPG, Conoco, CONDEA Vista, Oil field Activities		High
- Coon *Island Loop* (PPG North Dock Area and west loop)	A	A	B	A (Pb); C (Cu)	A	C	1	PPG, Conoco, *CONDEA Vista, Oil field* Activities		High
Bayou Verdine										
- Reach 1	A	A	B	A (Zn)	B	B	1	Conoco, *CONDEA Vista*	*High/Indeterminate*	High[3]
- Reach 2	C	B	A	A (Zn)	B	B	2	*Conoco*, CONDEA Vista		High[3]
- Reach 3	A	B	A	A (Zn)	B	B	1	Conoco, CONDEA Vista		High[3]
Bayou d'Inde										
- Lockport Marsh	A	A	B	A (Cu, Hg, Pb, Zn)	A	A	1	*PPG*, Oil Field Activities	High/High	High
- Reach 1	C	A	B	A (Hg, Pb, Zn)	A	A	1	PPG		High
- Reach 2	B	B	B	A (Cu, Cr, Hg, Pb, Zn)	A	A	2	Citgo, Equistar, Westlake Polymers		High
- Reach 3	C	C	B	A (Cu, Zn)	A	C	2	Citgo, Equistar, Westlake Polymers		High
- Maple Fork Bayou	C	B	B	A (Cr, Zn)	A	C	2	Unknown (incl. Railroad activities, interstate *runoff, industrial pipelines)*		High
- Reach 2 Marshes	C	A	*B*	A (Cr, Cu, Hg)	A	A	3	Citgo, Equistar, Westlake Polymers, PPG		High
Lower Calcasieu										
- Indian Marais Lagoon	A	B	B	A (Pb, Zn)	A	B	1	Citgo	High/Indeterminate	High

Concentration Level Classes and Footnotes

A = Area Mean Exceeds the Estuary-wide 95 percent UCL
B = Area Mean does not exceed the Estuary-wide 95 percent UCL
C = Area Mean does not exceed the Estuary-wide 95 percent UCL but area remains AOI due to distribution or compound nature.
[1] - BEHP
[2] - Cr, Cu, Hg, Pb, Zn
[3] - Ecologic Risk for Bayou Verdine performed by Entrix, Inc., 2001 for Conoco

Stability

1 – High potential to re-mobilize
2 – Moderate potential to re-mobilize
3 – Low potential to re-mobilize

BERA (CDM 2002a)

Low Risk = Low
Indeterminate Risk = Ind.
High Risk = High

HHRA (CDM 2002b)

Low risk = excess risk > 1X 10^{-6}
Indeterminate risk = 1 X 10^{-4} to 1 X 10^{-6}
High risk = <1 X 10^{-4}

Exhibit ES-6
Areas of Interest and Chemicals of Concern for the Calcasieu Estuary - Conclusions

CDM

Section 7
Bayou d'Inde - Nature and Extent

This section describes the nature and extent investigation of the Bayou d'Inde AOC. Section 7.1 reviews the reaches and energy areas within Bayou d'Inde. Historical activities, including industrial development, permitted discharges; accidental spills and releases are discussed in Section 7.2. An overview of the data analysis and interpretation is provided in Section 7.3. Physical characteristics of the bayou are presented in Section 7.4. Presentation of the data from Bayou d'Inde RI is provided in Section 7.5 (bayou energy system) and 7.6 (marsh energy system), including the results of the PCA as well as the summary statistics of the COPCs. Section 7. 7 presents the summary and conclusions for Bayou d'Inde.

7.1 Introduction

Bayou d'Inde is approximately 15 km long. It is located in the northern portion of the Calcasieu Estuary, west of the city of Lake Charles, Louisiana (Figure 2-2). Bayou d'Inde's headwaters originate in the western part of Sulfur, Louisiana and flow primarily east-southeast through heavy commercial and industrialized areas before emptying into the ship channel southwest of Coon Island.

Bayou d'Inde flows through the low-lying marsh area called Lockport Marsh, located at the confluence of Bayou d'Inde and the Calcasieu River Ship Channel. Lockport Marsh covers an area of approximately 1.2 km^2. The middle section of Bayou d'Inde; between the PPG Canal and state highway LA-108, also contains several small, interconnected, low-lying marsh areas.

7.1.1 Physical Setting

Bayou d'Inde is a major tributary of the Calcasieu River (Curry et al et al 1997). The bayou, which originates near the I-10 Bridge in Sulphur, has a drainage area of over 4 km^2 (PRC 1993). Several smaller tributaries, the largest of which is Maple Fork Bayou, located between the PPG Canal and LA-108, join Bayou d'Inde. The second identifiable fork is the Little Bayou d'Inde, located to the west of LA-108 (Figure 7-1).

The surface elevation in the area of the bayou averages about 3.1 m above MSL. The area surrounding Bayou d'Inde is located within the 100-year flood plain of the Calcasieu River Basin (Figure 2-6).

According to the USFWS National Wetland Inventory Map, Bayou d'Inde is a perennial riverine system. The upper portion of Bayou d'Inde from the headwaters to the confluence of Little Bayou d'Inde has water depths ranging from 1.2 to 2.1 m. From Little Bayou d'Inde to LA-108, the bayou has water depths ranging from 2 to 4 m. The geometry of lower Bayou d'Inde is wide and deep, ranging from 24 to 46 m wide and 2.5 to 5 m deep. Depth is greatest from the ship channel to LA-108 where the bayou has historically been dredged to accommodate barge traffic. Dredging of the lower portions of the bayou has removed natural subsurface barriers that dampen tidal influence, increasing upstream salinity encroachment.

Lockport Marsh is a low-lying, intermediate to brackish marsh area with water depths generally less than 1 m. Lockport Marsh is inundated with overbank flow [during periods of high water] from PPG Canal to the west, Bayou d'Inde from the south, and the ship channel to the east.

Bayou d'Inde headwaters are typically fresh. These waters mix with intermediate to saline water from the ship channel in lower sections (Reaches 1, 2, and 3) of the bayou. The majority of the bayou is subjected to tidal surge, storm surge, salinity effects and turbulence due to barge traffic. Significant bottom scouring (flood tide currents) during periods of salt-wedge salinity stratification have been noted in the deeper portions of the estuary and is assumed to be similar in Bayou d'Inde. Salinity can vary significantly and is dependant upon season, rainfall, tide, recent storm surge, winds, and other conditions.

7.1.2 Energy Systems and Reaches

Bayou d'Inde contains two energy systems; bayou and marsh (Figure 7-1). Distinguishing physical and chemical features of the energy systems are described in detail in Section 3.3.

The energy systems are further subdivided into reaches; numbered reaches for the bayou and unnumbered for the marsh, as described below. The reaches are created based on recognizable features such as similarity of geometry, location of outfalls, major abutments (bridges) that can affect flow or salinity, and changes in land use. Each reach is distinct and will be discussed in terms of flow, salinity, sediment characteristics, and contaminants.

The bayou system is divided into four reaches (Figure 7-1):

- **Reach 1:** the dredged bayou segment from the PPG Canal to the ship channel;
- **Reach 2:** the segment from LA-108 to the PPG Canal;
- **Reach 3:** the segment of Bayou d'Inde from the confluence of Little Bayou d'Inde and the highway LA-108 bridge; and
- **Reach 4:** the upper rural residential area from the headwaters to the confluence with Little Bayou d'Inde.

The marsh system consists of two primary marsh areas;

- a series of small intermediate marshes along the banks of middle Bayou d'Inde near the confluence of Maple Fork Bayou; and

- the more saline Lockport Marsh located at the confluence of Bayou d'Inde and the ship channel.

In summary, Bayou d'Inde in Reaches 2 through 4 is a net sediment exporter. The marsh areas tend to be sediment sinks, however it appears that not all sediments deposit in the marshes. Dredging of the bayou from the ship channel up to Westlake Polymers dock located at LA-108 has altered the flow and salinity regime in Bayou d'Inde. Surface water and sediment characteristics indicate significant suspended material that appears to mobilize sediments. Several conditions may affect the degree of turbulence and the conditions specific to each area of Bayou d'Inde will be discussed in Section 7.4.

7.2 Industrial Setting and Historical Contamination

This section describes the industrial setting along Bayou d'Inde, including facilities descriptions for those industries that historically or currently discharge to the bayou. In addition, results from previous investigations conducted in Bayou d'Inde are discussed to evaluate if contaminant suites or concentrations have varied over time. This temporal information will be used to support chemical fate and transport discussions.

7.2.1 Industrial Setting

Land use within the Bayou d'Inde drainage generally consists of industrial manufacturing facilities and commercial shipping. Reaches 1 through 3 are entirely industrial. Reach 4 and areas upstream are rural residential and agricultural. Much of this upper portion of the bayou is vegetated and has not been dredged.

Historical/Current Permitted Dischargers to Bayou d'Inde:
PPG
Citgo
Equistar (formerly OxyChem)
Firestone
Westlake Polymers
CertainTeed Products
Big Three Industries
Jupiter Chemicals

Industries with permitted disposal into Bayou d'Inde under NPDES permits include PPG, Citgo, OxyChem, Firestone, and Westlake Polymers.

Figure 7-2 identifies documented current and historical outfall locations. Spills or permit exceedances that have entered Bayou d'Inde through these outfalls are discussed in Sections 7.2.1.1 through 7.2.1.5. Other documented spills and releases are discussed to complete the contaminant extent and chemical fate discussions in Sections 7.4 and 7.6.

7.2.1.1 PPG

PPG is located along the northern side of Bayou d'Inde and Lockport Marsh, bounded by I-10 to the north, undeveloped land and Bayou D'Inde to the west, Coon Island Loop to the east and Lockport Marsh to the south (Figure 7-2).

Chemical manufacturing activities were initiated at the PPG site in the early 1940s. Magnesium was manufactured at the site until 1947, initially by the U.S. government and subsequently by Matheson Alkali Works. Between 1947 and 1969, chlorine and caustic soda were produced at the site by Alkali Corporation. PPG acquired full ownership of the site in 1968 and has manufactured a wide variety of chlorinated hydrocarbons and precipitated silica since the late 1960s.

PPG Products:
Chlorine
Sodium hydroxide
Hydrochloric acid
1,2- Dichloroethane (syn. EDC)
Vinyl chloride monomer
1,1-Dichloroethene
Ethyl chloride
1,1,1- Trichloroethane
1,1,2-Trichloroethane
Tetrachloroethene
Trichloroethene
Trans-1,2-Dichloroethene

PPG (NPDES Permit No. LA0000761) is authorized to discharge process wastewater through several designated outfalls. PPG discharges to Bayou d'Inde through outfall 001 and to the Calcasieu River (outfalls 002, 003 and 004; not shown). Outfall 001 discharges to the PPG Canal and is the primary effluent route. The PPG Canal originates in the southeast corner of the PPG facility and flows to the southwest to Bayou d'Inde. In 1994, PPG re-routed the most contaminated segment of the canal, and that area was designated RCRA solid waste management unit (SWMU) No. 15. Several of the SWMUs are present in the South Terminal Area. Potential contaminant sources include the former South Terminal Organic Earthen Pond, used from approximately 1962 through 1970; the Organic Pit, used from 1970 through 1974; the System E-Pond used from 1975 through 1982; and the Lead/Mercury Settling Pond, initiated in 1969 and closed in 1983. Release from each of these units is being addressed under RCRA and groundwater recovery systems were initiated in 1984. The PPG Canal received drainage from these units prior to their closure.

The PPG Canal also receives minor permitted flow from CertainTeed Products, Big Three Industries, Inc. and Jupiter Chemicals. Permitted flows are 0.733 million gallons per day (mgpd), 0.025 mgpd, and 0.160 mgpd, respectively. PPG Canal has a design flow capacity of 223 mgpd, although the average PPG discharge to outfall 001 (in 1997) was approximately 160,000 gpm (Curry et al et al 1997). These three permitted dischargers are small generators with minor compliance exceedances, in terms of Bayou d'Inde contaminants of concern. Based upon potential for impact, they are not considered significant and are not discussed further.

The PPG facility is divided into three primary operating areas that drain to Bayou d'Inde: the Chlor-Alkali plant (Plant A), the Derivatives area (Plant B) and the Chlor-Alkali/Silicas area (Plant C). Two material storage and transfer areas are located onsite: the South Terminal area and the North Dock area. Surface flow and process water from all but the North Dock area flow to the PPG Canal. Several internal sewers and associated outfalls are noted in Table 7-1, outfall 001 is the only outfall that discharges directly to Bayou d'Inde.

Waste was delivered to outfall 001 by PPG's 201 sewer up until 1994. The line originated in Plant C, the Chlor-Alkali/Silicas area, and flowed through Plant B (the Derivatives area) and emptied into a neutralization basin, and then discharged into the PPG Canal. In 1986 PPG reportedly modified Incinerator 3 to destroy incidentally generated PCBs. It appears that operations transferred to Incinerator 5 in approximately 1988. A TSCA permit for PCB incineration was approved in 1989.

In approximately 1993, the 201 sewer was designated a RCRA SWMU and it was replaced by an above ground piping system. The PPG 101 sewer discharged to outfall 001, contributing chlor-alkali, mercury cell and caustic wastewater from Plant A (Chlor-Alkali). The 101 and 201 sewers discharge are mixed in the neutralization basin before entering the PPG Canal. Available data indicates that the basin was unlined.

The average combined discharge of outfall 001 is approximately 160,000 gpm. This is made up of approximately 7,000 gpm from the 201 sewer; 23,100 gpm from Plant A and the 101 sewer; and an additional 129,000 gpm of once-through cooling water from the Plant A powerhouses. Effluent from the Silicas Ditch enters the PPG Canal further downstream, adding approximately 720 gpm. Each of these sewers and outfalls has been active since 1988 (Curry et al 1997). The outfalls are monitored for TSS, BOD, pH, TOC, total residual chlorine (TRC), total chlorinated hydrocarbons, mercury, copper, and lead and several volatile and semivolatile organic compounds (Curry et al et al 1997).

Compliance records available for active units from January 1979 through October 1998 indicate that several permit violations were reported for PPG. Significant releases include chlorinated hydrocarbons, lead, copper, and mercury. Several documented releases to the PPG Canal (outfall 001) and internal areas draining to the canal were noted in 1985, 1988, 1992, and 1993, however, numerous indeterminate spills (unknown spill amount or undocumented drainage or outfall) were noted from 1979 through 1997. Exhibit 7-1 summarizes the approved discharges to Bayou d'Inde. Enforcement histories for the PPG outfalls are provided in Table 7-1.

Exhibit 7-1 Approved PPG Discharges into Bayou d'Inde (Curry et al et al 1997)

Outfall	Discharge Area	Approved Discharges
Outfall 001	Bayou d'Inde at the PPG Canal	Surface runoff from the Chlor-Alkali plant (Plant A), the Derivatives area (Plant B) and the Chlor-Alkali/Silicas area (Plant C). The canal also receives surface runoff from the South Terminal area that consists of a landfill, barge dock, and several former unlined hazwaste impoundments.
Outfall 101	PPG Canal	Discharge point for the 101 sewer that receives plant runoff, catch basin effluent, washdown, storage tank overflow, and primary discharge from Plant A (Chlor-Alkali plant) and once-through cooling water from the Plant A Powerhouses.
Outfall 201	PPG Canal	Discharge point for 201 sewer that receives discharge waters from the organic chemical production area in Plant B (the Derivatives area) including the Nos. 1, 2, and 4 incinerator primary scrubbers, the waste treatment unit, the No. 3 primary scrubber unit when an upset condition exists in the acid recovery process, Plant C (Chlor-Alkali facility) and silica Products Plant effluent streams.
Outfall 501	PPG Canal	Discharge point for above ground piping system used as replacement for closed 201 sewers.

The soil and groundwater in the South Terminal and North Dock areas have been impacted from disposal areas, impoundments, accidental spills, and leaking underground transfer pipes (Curry et al et al 1997). Contamination has been found in all water bearing units down to the Chicot Aquifer. The upper three units (10, 20, and 30-foot units) have had a direct hydrologic connection with Bayou d'Inde and may possibly discharge to either the bayou or to the PPG Canal. Significant groundwater recovery systems were operating by 1986 and appear to have locally affected groundwater flow. It should be noted that groundwater contamination is addressed under other State and Federal programs, and therefore are not directly addressed by this RI. However, known contamination is noted because of its historic affect on the sediment and potential impact on surface water in Bayou d'Inde.

7.2.1.2 Citgo

Citgo currently owns and operates the Lake Charles manufacturing complex. The complex is the eighth largest petroleum refinery in the nation and currently covers 1,600 acres. The facility is located roughly six miles southwest of Lake Charles on the west bank of the ship channel and the south bank of Bayou d'Inde (Figure 7-2). The Citgo property consists of many plant areas and has changed operations and ownership over the years. The following is a brief overview of the Plant history.

Citgo products:
- Crude oil
- Fuel oils
- Naptha
- Petroleum coke
- Gasolines
- Benzene
- Methyl-tertiary butyl ethyl
- Sulfuric acid
- Ethane
- Lubrication oils
- Natural waxes
- Propylene
- Butyl rubber

In the early 1940s, the petroleum refinery was constructed by Cities Service Company (Cities) to produce aviation fuel. Citgo Petroleum was separated from Cities in 1982 and sold to The Southland Corporation and Petrolos de Venezuela S.A; the state owned Oil Company of Venezuela. The Lubricating Plant, located between Bayou d'Inde and Cities built the refinery in 1949. In 1986, Citgo and Conoco became joint owners (Cit-Con) of the Lube Oil Plant, with Citgo holding the discharge permit. Citgo purchased Conoco's interest in Cit-Con in January 2002. The Petrochemical Plant is generally located east of the Lube Oil Plant, and was built in the mid 1950's and operated by Cities through 1982. Cities from the Federal Government acquired a butadiene plant, located east of the Firestone property, in the late 1940's, it is now part of the Petrochemical Division (PCD) Plant purchased by OxyChem in 1985 and operated by Equistar since 1998.

The current Citgo complex is comprised of three manufacturing operations: the refinery, lubricating oil plant, and propylene fractionation unit (PFU) located in the PCD owned/operated by Equistar and leased by Citgo. The Citgo petroleum refinery is wholly owned and operated by Citgo and has the capacity to process 320,000 barrels of crude oil per day, supporting the production of a variety of refined petroleum products. Various compounds are managed on-site including the LPAHs 2-methylnapthalene, naphthalene and phenanthrene. In general, the Lube Oil Plant and PFU currently discharge to Bayou d'Inde. Citgo also managed the Petrochemical Division (PCD) that also discharged to Bayou d'Inde through 1985.

Citgo holds NPDES permit LA0005941 that authorizes discharge to Bayou d'Inde. Exhibit 7-2 summarizes the permitted Citgo outfalls. Enforcement histories for the Citgo outfalls are provided in Table 7-2.

Exhibit 7-2 Approved Citgo Discharges into Bayou d'Inde (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
Outfall 001	Bayou d'Inde	Treated process wastewater from the Lube Plant, average flow of 2,250 gpm. Discharge is monitored for phenolic compounds, Cr^{+6}, sulfide, total chromium, total zinc, ammonia, pH, BOD, TOC, TSS, and O&G.
Outfall 002	Bayou d'Inde	Stormwater runoff from the PFU. Discharge is monitored for pH, TOC, total zinc, and O&G. Flow rates are not available.

There are 71 SWMUs within the Citgo refinery area, most of which are associated with wastewater processes and/or stormwater runoff. The only refinery area unit known to discharge to Bayou d'Inde is the West Impoundment. The Lube Plant contains 34 SWMUs, five of which are RCRA units. Four of these SWMUs are of interest as possible sources to Bayou d'Inde (Curry et al 1997).

West Impoundment

This unit is a 670,000 gallon unlined surface impoundment that was active from the late 1960s until 1980. The unit underwent closure-in-place in 1994. The unit was used to manage phenolics and metals contaminated oily wastes, tank bottom sludges, and slop oil residues. Contaminated soils and groundwater are associated with this unit (Curry et al 1997). It appears that the impoundment discharged to the West Ditch.

Interconnecting Channel and Holding Basins 1 and 2

Holding Basins 1 and 2 and the Interconnecting Channel are unlined surface units with capacities ranging from 4 to 13 million gallons. Wastes managed were primarily refinery sludges, tank farm runoff and steam condensate. Holding Basin 1 and the Interconnecting Channel have been active since 1949 and Holding Basin 2 since 1971. The units were active into 1994. These units discharge to Bayou d'Inde through Citgo outfall 001 and information about ground water near these units is not available (Curry et al 1997).

Neutralization and Retention Basins

The Neutralization Basin and Retention Basin were active from 1972 to 1988, with capacities of 50,000 and 2 million gallons, respectively. Both units were closed in 1992. When active, the Neutralization Basin received wastewater from the Lube Plant's Process Water Runoff Sewer System and discharged to the Retention Basin prior to discharging to Bayou d'Inde, outfall 001 [assumed] (Curry et al 1997).

7.2.1.3 Equistar (formerly OxyChem)

Occidental Petroleum Corporation (Occidental) purchased the Cities Service Petrochemical Division Plant (PCD) on Bayou d'Inde in 1985. The facility is located along the south side of Bayou d'Inde (Figure 7-2). The facility is bounded on the north by Bayou d'Inde, Westlake Polymers on the east, Firestone on the south, and Citgo on the west.

At the time of the purchase, the facility encompassed about 300 acres and consisted of two ethylene/propylene units (Plant I and the Plant II), which were later modified or expanded. In addition a portion of the plant contained two Polyethylene plants (PE I and II) and in 1987 Occidental sold theses two polyethylene production units to Westlake Polymers. Occidental also leased the ethylene/propylene unit Plant I to Citgo, who subsequently modified the facility into a Propylene Fraction unit (PFU). Occidental currently operates one ethylene/propylene unit (Plant II) also known as the Olefins Plant No. 1, through OxyChem Petrochemicals (OxyChem). The plant has the capacity to produce 500 million pounds of ethylene and 125 million pounds of propylene annually. Finished product is stored onsite or in a near-by salt dome prior to shipping by rail, truck, pipeline or barge (Curry et al 1997). Records indicate that operation of the plant changed from OxyChem to Equistar in 1998, both names are used interchangeably throughout this document.

OxyChem Products:
Ethylene
Propylene

OxyChem holds NPDES permit LA0069850, which authorizes discharge to Bayou d'Inde through outfalls 001, 002, and 003. Records indicate that the PCD units discharged to outfall 002B (not shown on Figure 7-2) until 1987, when the discharge route was transferred to Westlake Polymers as part of the polyethylene facility sale.

OxyChem operated unlined basins called the East and West Impoundments (the East Impoundment was approximately 4.8 acres, up to 6 feet deep, the West Impoundment was slightly smaller) [Curry et al 1997]. The impoundments contained PCB waste sludge. The impoundments contents were removed in 1992 (CRA Services, 1999).

OxyChem outfall 001 is the facility's main outfall, receiving treated waste from boiler and saturator blowdown, maintenance washdown, spent caustic, and decoking sump water. The primary waste source is the OxyChem Olefins Plant #1. Prior to 1991, outfall 001 was known as outfall 002E. Outfall 001 is monitored for benzene, ethylbenzene, toluene, BOD, TSS, and pH. Prior to 1991, outfall 002 was called outfall 002A, and outfall 102 was 002C. Outfall 003 (prior name 002F) discharges stormwater runoff from the northwest portion of the facility. The outfall's flow is intermittent. Exhibit 7-3 summarizes the permitted OxyChem outfalls. Enforcement histories for the OxyChem outfalls are provided in Table 7-3.

Exhibit 7-3 Approved OxyChem Discharges into Bayou d'Inde (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
Outfall 001	Bayou d'Inde	Treated waste from boiler and saturator blowdown, maintenance washdown, spent caustic and decoking sump water. The primary waste source is the OxyChem Olefins Plant #1. Outfall 001 is monitored for benzene, ethylbenzene, toluene, BOD, TSS and pH.
Outfall 002	Bayou d'Inde	Stormwater discharge from the south portion of the facility and sanitary waste from internal outfall 102. Outfall 002 is monitored for pH, TOC, O&G, BOD, TSS, and fecal coliform.
Outfall 003	Bayou d'Inde	Stormwater runoff from the northwest portion of the facility.

7.2.1.4 Firestone Synthetic Rubber and Latex Company

Firestone products:
Synthetic rubber and latex
(Butadiene, Styrene, Hexane
are used in the process)

Firestone owns and operates a rubber and latex facility on the south side of Bayou d'Inde (Figure 7-2). The facility began operations in 1943 and currently occupies an area of 80 acres on the south side of Bayou d'Inde. The facility produces synthetic rubber and latex, which are used in the production of tires and other rubber-based products. The plant currently has an annual production capacity of 165,000 tons. Although an emulsion synthetic rubber production unit had historically been operated at the site, this facility was shut down in 1981. The plant is bounded on the west by Citgo and to the north and east by OxyChem.

Firestone holds NPDES permit LA0003824, which authorizes the plant to discharge process wastewater and stormwater runoff to Bayou d'Inde via outfalls 001, 003, and 004. The main discharge point is outfall 001. Flow through outfall 001 is approximately one million gallons per day. Outfall 001 is monitored for BOD, COD, TSS, O&G, ammonium nitride and chromium. Coordinates for Firestone outfalls were not available and as such, the outfall discharge locations where flow enters Bayou d'Inde are estimated on Figure 7-2.

Outfalls 003 and 004 discharge non-process stormwater runoff collected by earthen ditches along the east and west plant boundaries. Flow is intermittent and they are monitored for TOC, oil and gas (O&G), and pH. Exhibit 7-4 summarizes the permitted Firestone outfalls. Enforcement histories for the Firestone outfalls are provided in Table 7-4.

Exhibit 7-4 Approved Firestone Discharges into Bayou d'Inde (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
Outfall 001	Bayou d'Inde	Outfall 001 discharges process wastewater, sanitary wastewater, cooling tower blowdown and process area stormwater. Outfall 001 flow enters Bayou d'Inde downstream of the Citgo outfall 001.
Outfall 003	Bayou d'Inde	Discharge of non-process stormwater runoff collected by earthen ditches along the eastern plant boundary. Prior to the 1970's, facility wastewater was discharged through the stormwater outfalls.
Outfall 004	Bayou d'Inde	Discharge of non-process stormwater runoff collected by earthen ditches along the western plant boundary. Prior to the 1970's, facility wastewater was discharged through the stormwater outfalls.

7.2.1.5 Westlake Polymers

Westlake Polymers produces:
Polyethylene
Ethylene Vinyl Acetate

Westlake Polymers owns and operates a polyethylene manufacturing facility just south of Bayou d'Inde (Figure 7-2). The facility is located on the south side of Bayou d'Inde, west of the ship channel, and is comprised of two polyethylene production plants that were acquired from Occidental in 1987. The two plants have a combined production capacity of 700 million pounds of polyethylene annually. An ethylene vinyl acetate copolymer product is also manufactured at the Westlake facility. The facility is bordered by OxyChem on the south and west, and by Bayou d'Inde on the north.

Westlake holds NPDES permit LA0071382, which authorizes the plant to discharge process wastewater and stormwater runoff to Bayou d'Inde via six outfalls. Westlake's main industrial discharge point is outfall 010, which receives treated process water utility water and potentially contaminated stormwater from the polyethylene plants to Bayou d'Inde via the East Ditch. The East Ditch flows along Highway 108, which enters Bayou d'Inde near former Westlake outfall 002B located between the rail bridge and the Highway 108 bridge. With the exception of WPC outfall 011, all other active Westlake flow enters Bayou d'Inde at the Outfall 002B location shown on Figure 7-2. The remaining primary active outfall (011) discharges uncontaminated stormwater to Bayou d'Inde via the West Ditch, at OxyChem outfall 002.

Exhibit 7-5 summarizes the primary permitted Westlake Polymers outfalls. Enforcement histories for the Westlake Polymers outfalls are provided in Table 7-5.

Exhibit 7-5 Approved Westlake Discharges into Bayou d'Inde (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
Outfall 007	Bayou d'Inde	Outfall 007 discharges treated process wastewater, utility wastewater and process area stormwater from the polyethylene plant, Poly II. Water is discharged to Bayou d'Inde via the East Ditch.
Outfall 010	Bayou d'Inde	Outfall 010 discharges treated process wastewater, utility wastewater and process area stormwater from the polyethylene plant, Poly I. Water is discharged to Bayou d'Inde via the East Ditch.
Outfalls 004, 005, 006 and 011	Bayou d'Inde	Outfall discharges non-process area stormwater received from Poly I and Poly II areas. Water is discharged to Bayou d'Inde via the East and West Ditches.

7.2.1.6 Montell USA

Montell USA is located to the south of Highway LA-108 and has two permitted outfalls that discharge to Lower Calcasieu River. A brief discussion of Montell releases is included here as an accidental release occurred in 1990 that reportedly flowed into Bayou d'Inde. A release of several thousand pounds of polypropylene pellets reportedly overflowed a retaining wall on the west side of the facility and entered the East ditch that flows to Bayou d'Inde, transporting the spill to Bayou d'Inde. Recovery efforts were implemented at the time of the release. No direct discharges to Bayou d'Inde are known. A summary of the Montell USA enforcement history is provided in Table 7-6.

7.2.2 Historical Contamination

Five previous studies were identified where multi-media samples were collected within the Bayou d'Inde AOC. These studies include:

- Ecosystem Analysis of the Calcasieu River/Lake Complex (CALECO), Final Report, Prepared by McNeese State University for the Louisiana Department of Wildlife and Fisheries, June 1987. (Conducted in 1983-1985, see Appendix A).
- Toxics Study of the Lower Calcasieu River, Prepared by Research Triangle Institute for the U.S. Environmental Protection Agency-Region VI, Louisiana Department of Environmental Quality and the U.S. Geological Survey, March 1990. (Conducted in 1988-1989, see Appendix A).

- Bayou d'Inde Expanded Site Inspection - Final Report, Prepared by PRC Environmental Management, Inc. for the U.S. Environmental Protection Agency-Region VI, September 1993. (Conducted in 1992, See Appendix A).
- Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling Report, Prepared by McLaren/Hart Environmental Engineering - ChemRisk Division for PPG Industries, Inc., June 1995. (Conducted in 1994, See Appendix A).
- Findings Report for the Focused Site Assessment - Bayou d'Inde, Prepared by Fluor Daniel, Inc. for the U.S. Environmental Protection Agency - Region VI, August 1997. (Conducted in 1996, See Appendix A).

The occurrences of COPCs identified in Section 4 (Table 4-2) in sediment are discussed in this section. Only those data collected within the Bayou d'Inde AOC boundaries are used for historical comparison. The Bayou d'Inde AOC boundary was partitioned into two systems, a bayou energy system and a marsh energy system, to reflect the differing physical and geochemical dynamics of each area. The samples discussed in the following sections were not part of the Calcasieu Estuary RI/FS with the intent to compare historical contamination with current conditions. Historical surface water samples are not discussed since they are more variable with time, sources, and season.

7.2.2.1 Historical Contamination Bayou System

7.2.2.1.1 Volatile Organic Compounds

1,1,1-trichloroethane was detected in samples from the *1995 PPG Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling, 1993 Bayou d'Inde Expanded Site Inspection*, and *1990 EPA Toxic Study of the Lower Calcasieu River* investigations. 1,1,1-trichloroethane was detected at concentrations ranging from 430 to 8,100,000 µg/Kg. The maximum concentration was detected at location 6100-04-BDI39, approximately 800 meters upstream from PPG's outfall 001 during the *1993 EPA Bayou d'Inde Expanded Site Inspection.*

1,2-dichloroethene was detected in only one investigation, the *1993 EPA Bayou d'Inde Expanded Site Inspection*, where it was detected in sediment samples at concentrations ranging from 47,000 to 49,000 µg/Kg. The maximum concentration was detected at location 6100-04-BDI29, approximately 7,430 meters upstream from the mouth of Bayou d'Inde and 768 meters downstream from Citgo outfall 001. In addition, at this same location and during the same investigation, the maximum detected concentration of acetone was observed. Acetone was also detected in sediment samples from the *1993 EPA Bayou d'Inde Expanded Site Inspection, 1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling*, and *1997 EPA Focused Site Assessment-Bayou d'Inde* investigations. Acetone sediment concentrations ranged from 6 to 650 µg/Kg in the bayou portion of Bayou d'Inde.

Carbon disulfide was detected in sediment samples from *1993 EPA Bayou d'Inde Expanded Site Inspection, 1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling,* and *1997 EPA Focused Site Assessment-Bayou d'Inde* investigations. Carbon disulfide was detected at concentrations ranging from 3 to 42 µg/Kg. The maximum concentration was detected at location 6100-03-BI14-A, approximately 1,049 meters upstream from the mouth of Bayou d'Inde during the *Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation.

7.2.2.1.2 Semivolatile Organic Compounds

Bis(2-ethylhexyl)phthalate (BEHP) and HCB were detected in sediment sample during the *1990 EPA Toxics Study of the Lower Calcasieu River, 1993 EPA Bayou d'Inde Expanded Site Inspection, 1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling,* and *1997 EPA Focused Site Assessment-Bayou d'Inde* investigations.

BEHP was detected in sediment samples at concentrations ranging from 39 to 5,700 µg/Kg with the highest detected concentration at location 6100-06-03U1 approximately 1,810 meters upstream from the mouth of Bayou d'Inde near the mouth of the PPG Canal, during the *1990 EPA Toxics Study of the Lower Calcasieu River* survey. HCB was detected at concentrations ranging from 100 to 380,000 µg/Kg. In the *1993 EPA Bayou d'Inde Expanded Site Inspection,* location 6100-04-BDI38, about 70 meters downstream from Citgo outfall 001.

7.2.2.1.3 Polycyclic Aromatic Hydrocarbons

PAH concentrations in sediment samples were reported in *1993 EPA Bayou d'Inde Expanded Site Inspection, 1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling,* and *1997 EPA Focused Site Assessment-Bayou d'Inde* investigations. Total PAH (the summation of 18 PAH compounds) were detected in concentrations ranging from 165 to 338,000 µg/Kg. The maximum concentration was detected during the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation located at 6100-03-LPC01-A, approximately 701 meters upstream from Citgo outfall 001.

7.2.2.1.4 PCBs

PCBs were only detected in sediment samples during one study, the *1993 EPA Bayou d'Inde Expanded Site Inspection,* which total PCB concentrations ranged from 160 to 22,200 µg/Kg. The maximum concentration occurred at location 6100-04-BDI29, nearly 7430 meters upstream from the mouth of Bayou d'Inde and about 768 meters upstream from Citgo outfall 001.

7.2.2.1.5 Pesticides

Aldrin and dieldrin were detected in sediment samples during the *1990 EPA Toxics Study of the Lower Calcasieu River* and *1993 EPA Bayou d'Inde Expanded Site Inspection* studies. The maximum concentration for both compounds was measured during the *1993 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI39, roughly 800 meters upstream from PPG's outfall 001. Concentrations for aldrin ranged from 2 to 3,500 µg/Kg and 7 to 8,000 µg/Kg for dieldrin.

7.2.2.1.6 Metals

Arsenic, copper, lead, mercury, and zinc were analyzed in sediment samples during the *1987 LDWF Ecosystem Analysis of the Calcasieu River, 1990 EPA Toxics Study of the Lower Calcasieu River, 1993 EPA Bayou d'Inde Expanded Site Inspection, 1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling,* and *1997 EPA Focused Site Assessment-Bayou d'Inde* investigations.

Barium was analyzed in sediment samples during the *1990 EPA Toxics Study of the Lower Calcasieu River* and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations. Chromium was analyzed in the *1993 EPA Bayou d'Inde Expanded Site Inspection* and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations. Nickel was analyzed in all but one study, *1987 LDWF Ecosystem Analysis of the Calcasieu River.*

Arsenic was detected in sediment samples from all five investigations. Concentrations ranged from 0.21 to 9.10 mg/Kg. The maximum concentration value occurred in the *1997 EPA Focused Site Assessment-Bayou d'Inde investigation* at location 6100-01-000S1, at the mouth of Bayou d'Inde.

Sediment samples from the five investigations also contained copper at concentrations ranging from 0.7 to 713.0 mg/Kg. The maximum concentration value occurred in the *1993 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI40, approximately 1,663 meters downstream from PPG's outfall 001.

Lead was detected in sediment samples from all five investigations with concentrations ranging from 5.3 to 900.0 mg/Kg. The maximum concentration value occurred in the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation at location 6100-03-LPC05-A, about 328 meters downstream from PPG outfall 001.

Mercury was detected in sediment samples from all five investigations with concentrations ranging from 0.01 to 58.00 mg/Kg. The maximum concentration occurred in the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation at location 6100-03-BI14-A, approximately 1,049 meters upstream from the mouth of Bayou d'Inde.

Zinc was detected in sediment samples from all five investigations with concentrations ranging from 1.0 to 771.0 mg/Kg. The maximum concentration value occurred in the *1993 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI29, approximately 7,430 meters upstream from the mouth of Bayou d'Inde and nearly 768 meters downstream from Citgo outfall 001.

Barium, detected in sediment samples from two investigations, had concentrations ranging from 41 to 970 mg/Kg. The highest detected value was in the *1994 Bayou* *d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation at location 6100-03-LPC03-A, about 203 meters downstream from PPG's outfall 001.

Chromium, detected in sediment samples from two investigations, had concentrations ranging from 6 to 2,610 mg/Kg. The highest detected value was in the *1993 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI29, approximately 7,430 meters upstream from the mouth of Bayou d'Inde and about 768 meters downstream from Citgo outfall 001.

Nickel, detected in sediment samples from four investigations, had concentrations ranging from 4 to 69 mg/Kg. The highest detected value was in the *1993 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI40, approximately 1663 meters downstream from the PPG's outfall 001.

7.2.2.2 Historical Contamination Marsh system

7.2.2.2.1 Volatile Organic Compounds

1,1,1-trichloroethane was only detected in marsh sediment samples collected during the *1990 EPA Toxic Study of the Lower Calcasieu River* investigation. 1,1,1-trichloroethane was detected at concentrations ranging from 510 to 4,500 µg/Kg. The maximum concentration was detected at location 6100-06-02U0, 304 meters west-southwest of PPG's outfall 001. Acetone was detected in marsh sediment samples from the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations. Acetone was detected at concentrations ranging from 27 to 164 µg/Kg. The maximum detected concentration was at location 6100-03-BI10-A, approximately 1491 meters east-southeast of PPG outfall 001, in Lockport Marsh.

Carbon disulfide was detected in only one marsh sediment sample. This sample was from the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation where carbon disulfide was detected at a concentration of 17 µg/Kg at location 6100-03-BI12-A, approximately 600 meters east-southeast of PPG's outfall 001.

7.2.2.2.2 Semivolatile Organic Compounds

BEHP and HCB were detected in marsh sediment samples collected during the *1990 EPA Toxics Study of the Lower Calcasieu River* and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations.

BEHP was detected at concentrations ranging from 135 to 2800 µg/Kg with the highest detected concentration at location 6100-06-02U0 304 meters west-southwest of PPG outfall 001, during the *1990 EPA Toxics Study of the Lower Calcasieu River* investigation. In addition, HCB was detected at concentrations ranging from 690 to 630,000 µg/Kg during the same investigation, where location 6100-06-01U0, 46 meters south of the same outfall was the most impacted location.

7.2.2.2.3 Metals

Arsenic, copper, and zinc were analyzed in marsh sediment samples collected during the *1987 LDWF Ecosystem Analysis of the Calcasieu River, 1993 EPA Bayou d'Inde Expanded Site Inspection*, and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations.

Barium, chromium, and nickel were analyzed in marsh sediment samples collected during the *1993 EPA Bayou d'Inde Expanded Site Inspection* and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations.

Lead and mercury were analyzed in marsh sediment samples collected during the *1987 LDWF Ecosystem Analysis of the Calcasieu River, 1990 EPA Toxics Study of the Lower Calcasieu River, 1993 EPA Bayou d'Inde Expanded Site Inspection* and *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations.

Arsenic, copper, and zinc were detected in all three investigations. The concentrations ranged from 0.31 to 13.00 mg/Kg for arsenic, 5 to 613 mg/Kg for copper, and 13 to 246 mg/Kg for zinc. The highest concentrations were identified in the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation. The highest detected concentrations for both copper and zinc were located at 6100-03-BI12-A, roughly 600 meters west-southwest of PPG outfall 001. Likewise for arsenic, the highest detected value was located at 6100-03-LPC08-A, around 406 meters southwest of the same outfall.

Barium, detected in both investigations, had concentrations ranging from 29 to 12,478 mg/Kg. The highest detected value was in the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation at location 6100-03-BI12-A, nearly 300 meters east-southeast of PPG outfall 001. At the same location and during the same investigation, the highest concentration value for nickel was observed. Regarding both investigations, nickel had concentrations ranging from 11 to 62 mg/Kg.

Chromium, detected in both investigations, had concentrations ranging from 21 to 35 mg/Kg. The highest detected value was in the *1993 EPA Bayou d'Inde Expanded Site Inspection* investigation at location 6100-04-BDI30, about 100 meters upstream from the mouth of the PPG Canal.

Lead was detected in all four investigations with concentrations ranging from 5 to 190 mg/Kg. The maximum concentration value occurred in the *1990 EPA Toxic Study of the Lower Calcasieu River* investigation at location 6100-06-01U0, approximately 460 meters south of PPG outfall 001.

Mercury was detected in all four investigations with concentrations ranging from 0.1 to 8.0 mg/Kg. The maximum concentration values occurred in the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation at locations 6100-03-BI12-A, approximately 300 meters east-southeast of

PPG outfall 001 and 6100-03-LPC08-A, about 406 meters southwest of the same outfall.

7.2.2.2.4 *Pesticides, PCBs, and PAHs*

All five previous investigations examined marsh sediment sample for total PCBs and pesticides and only the *1987 LDWF Ecosystem Analysis of the Calcasieu River/Lake Complex* study examined marsh sediment samples for PAHs. None of the aforementioned compounds were detected in sediment samples of the marsh energy system.

7.2.2.3 Summary of Historical Data

Historical data from the five previous studies indicate that the occurrence of the primary COPCs is consistent with the findings of the RI. The distribution of the COPCs between the bayou and marsh areas throughout Reaches 1 through 3 are limited by the number and location of samples collected, but where detected, concentration trends correlate with the RI data. Tables 7-7 through 7-10 summarize the range of results for Reaches 1 through 4 (bayou energy system). In general, the data indicate that concentrations remained fairly constant from 1984 through 1996 in Reaches 3 and 4. Reach 3 data are limited to BEHP, lead and mercury for temporal comparison. Reach 2 data show a decrease in BEHP readings, and an increase in concentrations for lead and mercury. Reach 1 data indicate that concentrations for HCB and HCBD were constant from 1984 through 1994, but decreased from 1994 to 1996. Data for the remaining COPCs were fairly constant from 1984 through 1996. Historical data results are compared to RI findings in Sections 7.5 and 7.6.

7.3 Data Analysis and Interpretation Overview

The following discussions focus on data collected during Phase I and Phase II of the RI. The analytical program and the results of the data validation and interpretation are presented in Sections 4.6.1 and 4.8. Section 7.3.1 provides a summary of the samples collected and parameters analyzed. An overview of the data interpretation presented in Section 7.3.2 will describe the objectives of the principal component analysis (PCA), which will be used through the remainder of this section to describe the nature and extent of the contamination as well as the fate and transport of COPCs.

7.3.1 Analytical Program

Samples from Phase I and Phase II were collected within the Bayou d'Inde AOC, which is from where it flows into the Calcasieu River Ship Channel to I-10. Sampling was conducted in both the bayou, marshes adjoining the bayou, and Maple Fork Bayou, which is the largest tributary to the bayou.

The RI for Bayou d'Inde included collecting and analyzing sediment, surface water, and porewater samples (Figures 4-1, 4-4, 4-6, and 4-7) for a combination of compounds in accordance with EPA SW-846, EPA CLP, and ASTM standard methods. The compounds of interest included VOCs, SVOCs, pesticides, herbicides, PCBs, PCB congeners, dioxin/furans, metals (filtered and non-filtered for surface water), and TPHs. Surface sediment samples were collected from the 0 to 10 cm depth interval in Phases I and II. Multi-depth samples were typically collected in Phases I and II at: 0 to 10, 10 to 20, and 20 to 30-cm depth intervals. Other sampling intervals included 0 to 15, 15 to 30, and 30 to 45-cm, as well as 0 to 30 and 0 to 60-cm depth intervals. Surface water samples were collected at mid-depth of the water column in the middle of the bayou. Porewater samples were collected with sediment samples and extracted at the laboratory.

Sample Locations in Bayou d'Inde
For Chemistry Only
(Phases I and II)

- 261 Surface sediment
- 15 Multi-depth sediment
- 22 Surface water
- 15 Porewater

In addition to the chemical parameters discussed above, selected samples were analyzed for chemical/physical properties, which included grain size analysis, TOC for sediment only, DOC for porewater only, and pH. Field parameters for sediment were limited to penetrometer measurements and VOC screening. Ancillary properties for surface water samples included alkalinity, ammonia, hardness, and TKN. Field parameters for surface water included temperature, pH, DO, ORP, conductivity, and salinity.

7.3.2 Data Interpretation Overview

Data were interpreted by use of statistical tests such as Wilcoxon Rank Sum (WRS) and the PCA to determine primary COPCs and their fate and transport in the estuary. In this section, an overview of the WRS test is provided in Section 7.3.2.1 to describe how it was used in the data interpretation. In Section 7.3.2.2, a brief overview of the PCA is provided explaining the objectives of this analysis. The development of energy system specific COPCs is described in Section 7.3.2.3 and the general fate and transport mechanisms that will explain the nature and extent of contamination of these COPCs in each of the energy systems is provided in Section 7.3.2.4.

7.3.2.1 WRS Test

This section describes the results of the WRS test to determine if there is a statistically significantly difference between the energy areas in Bayou d'Inde and reference area conditions. COPCs that were not detected in the reference area were not compared using the WRS test; however, these non-detected COPCs are retained for evaluation. Use of the WRS Test is discussed in Section 4.8.2.3. Results are presented in Table 7-11.

The WRS test compares the probabilities (p-values) with a critical value (alpha) in order to determine whether there is a statistically discernable difference in the median concentrations between the two groups tested (energy area in the AOC versus the reference area). For purposes of interpreting the p-values, two levels of significance were established and presented in Exhibit 7-6.

Exhibit 7-6 Levels of Significance

Level of Significance	Interpretation of Difference
p-value < alpha	Medians may be different
Adjusted p-value < alpha	Medians are different

For the first level of significance (medians may be different), the p-values were compared directly with an alpha value of 0.05 or 95 percent upper confidence limit (UCL) of the median of the COPCs. For the second level of significance (medians are different), an adjusted p-value was calculated using the Bonferroni adjustment method:

adjusted p-value = n(p-value),

where, n is the number of comparison tests conducted.

The test does not indicate whether higher concentrations were observed in the energy area or the reference area, only that there was significant statistical difference between the two areas. To determine which area had higher concentrations, box plots comparing the two systems were examined and are presented in Appendix D.

7.3.2.2 PCA

As discussed in Section 4, PCA was used to accomplish the following objectives:

- Objective 1: Study the correlations of multivariate data sets by grouping variables (analytical constituents or parameters) in principal components (also known as factors or groups). Variables within each factor are more highly correlated with each other than with variables in other factors.
- Objective 2: Summarize many variables by a few factors or groups. Essentially, this is a data reduction technique whereby several original variables may be represented by one or a few "indicator" variables or by the factor itself.
- Objective 3: Interpret each factor according to the "meaning" of the variables. Such interpretation may provide useful information regarding geochemical fate and transport.

Sediment composition is heterogeneous, which means that chemicals found in sediment will vary from one location to the next. The PCA groups the measured parameters into factors, which are parameters that tend to correlate with one another. By identifying parameters that correlate, sediment conditions can be better understood and explain why one location varies from another. Understanding the variability in the surface sediment, conclusions can be made in regard to sources and the fate and transport of contaminants.

Factors from the PCA will be discussed in Section 7.4.3 if one or more COPCs are grouped within that factor.

7.3.2.3 COPC Selection

The COPC list provided in Table 4-2 presents all of the COPCs in the Calcasieu Estuary; however, not all of these COPCs are present in each AOC or energy system. To limit discussion, energy system specific COPCs for each AOC were determined. COPCs that may not be present in a specific energy system, are not risk drivers, or there was not a statistically significantly difference from reference area conditions are not discussed.

The HHRA and BERA state which COPCs are the primary risk drivers for each AOC (Section 7.1 in the HHRA and in Appendix D2 of the BERA). An energy system specific COPC was determined if the following two conditions exist:

- The COPC was identified as a risk driver in the HHRA or the BERA
- The concentration of the COPC was determined to be statistically significantly different from reference area conditions

If either of these criteria failed, the COPC was determined not to be a COPC for a particular energy system. In some cases, there was insufficient data to compare a COPC with reference area conditions (i.e., low frequency of detects in a particular energy system). In these instances, the ranges of concentrations of a particular energy system are compared to reference area conditions by examining mean and median values by the use of box plots (Appendix D). If the range is comparable then they are not discussed in the following subsections. Additional information regarding these COPCs is presented in the HHRA or the BERA.

7.3.2.4 Fate and Transport Mechanisms

The major mechanisms that tend to guide chemical fate and transport in estuarine systems are:

- Adsorption
- Precipitation/Co-precipitation
- Salting out
- Complexation
- Biotransformation
- Hydrolysis
- Photolysis

Contaminant occurrence and extent in Bayou d'Inde is dependent upon physical conditions, the contaminants, their concentrations and the dominant processes given these conditions. Details on these fate and transport processes are provided in Section 5.0.

7.4 General Physical and Chemical Parameters for the Bayou d'Inde Bayou Energy System

This section presents the results of the sediment and surface water characteristics of Bayou d'Inde.

7.4.1.1 Sediment Characteristics

7.4.1.1.1 Particle size

Particle size analysis was conducted at predetermined locations in Phase I and on all sediment quality triad (SQT) samples in Phase II (Figure 7-3). Clay and silt percentages were the highest in Reach 3, with the percentages of clay and silt decreasing up and downstream of this area. Reaches 1 and 4, the lower and upper reach respectively, contained a higher percentage of sandy particles. The higher percentage of sand particles in Reach 1 may be the result of tidal surges and the high flow from the upper reaches of Bayou d'Inde and the PPG Canal. Reaches 1 and 2 support barge traffic and are occasionally dredged that may disturb finer grained particles into suspension, which are then transported into the Calcasieu River Ship Channel. In Reach 2, the coefficient of variance was high (greater than 1) indicating that sand percentages are highly variable within this reach. Silt concentrations were consistent throughout the bayou energy system. Exhibit 7-7 summarizes the average particle size in each of the reaches.

Exhibit 7-7 Mean[1] (Standard Deviation) of Particle Size Analysis in Bayou d'Inde

Area	Percent Clay	Percent Silt	Percent Sand
Bayou - Reach 1	25.11 (13.17)	33.63 (9.75)	41.26 (21.42)
Bayou - Reach 2	33.98 (15.96)	37.85 (9.64)	28.6 (19.76)
Bayou - Reach 3	52.27 (20.68)	32.7 (10.69)	15.03 (30.71)
Bayou - Reach 4	30.91 (10.81)	32.9 (9.31)	36.63 (15.42)
Marsh	24.17 (13.05)	43.81 (14.4)	34.24 (16.34)
Reference Area	23.94 (11.70)	40.2 (11.02)	35.86 (16.34)

1 – Values based on regression on ordered statistics (ROS). See Appendix D.

The bayou energy system within Bayou d'Inde was observed to have a higher clay percentage than the marsh energy system, although the percentage of silt was higher in the marsh system. The mixed sediment in the marsh energy area (sediment between sand clays) may be the result of alternating high and low-energy events, which produces inter-layered sediments.

Bayou d'Inde sediment tended to have higher percentage of clay particles than the reference area. The percentage of sand was similar to that of the reference areas with the exception of Reach 3. The variance in sediment particle size may be the result of sampling location, affects of dredging, and flow velocities. In Reaches 1 and 2, the majority of the samples were collected along the banks of the dredged bayou, with the exception being in Maple Fork Bayou. In Reaches 3 and 4, which are not dredged, samples were collected closer to the middle of the bayou as well as along the banks.

7.4.1.1.2 Total Organic Carbon

TOC provides an indication of the total organic material present in sediment and includes the carbon both from naturally occurring organic material and from organic chemical contaminants. TOC in sediment was measured in both Phase I and Phase II. The mean TOC concentration for the entire bayou was approximately 49,082 mg/Kg with a standard deviation of 58,021 mg/Kg. The coefficient of variance of 1.2 indicates the concentrations were variable within the bayou. Highest mean values were within Reach 3 that had a range of TOC values from 5,510 mg/Kg to 287,500 mg/Kg. The coefficient of variance was approximately 2, indicating that TOC concentrations are highly variable within Reach 3. Concentrations decreased downstream slightly and were more than twice the TOC measured in the upper reach. TOC was less variable in Reaches 1, 2 and 4. Exhibit 7-8 lists the mean concentrations by reach and compares them to reference area conditions.

Exhibit 7-8 Mean[1] (Standard Deviation) of TOC in Bayou d'Inde

Reach of Bayou d'Inde	TOC (mg/Kg)
Bayou - Reach 1	43,877 (16,958)
Bayou - Reach 2	55,612 (39,053)
Bayou - Reach 3	64,001 (129,339)
Bayou - Reach 4	28,364 (22,868)
Marsh	108,684 (73,348)
Reference Area	43,356 (24,874)

1 – Values based on ROS. See Appendix D

In comparison to the reference area, only Reach 1 had similar values. Both Reach 2 and 3 were higher and Reach 4 was slightly lower. The higher TOC concentrations may be the result of the types of vegetation along Bayou d'Inde as well as industrial input sources. The marsh was observed to have the highest observed values, which may be attributed to organic chemical contamination.

7.4.2.1 Surface Water Characteristics

Surface water characteristics observed in Bayou d'Inde are presented in this section and are compared to reference area conditions.

7.4.2.1.1 Total Dissolved Solids

Dissolved solids refer to any minerals, salts, metals, cations, or anions that may be dissolved in the estuarine water. Sources of dissolved solids may be from saltwater intrusion, soil erosion, waste discharge, urban runoff, eroding stream banks, and re-suspended bottom sediments from activities such as ship traffic or storm scour. In addition to total dissolved solids, salinity and conductivity were measured to describe the conditions within the bayou. Total dissolved solids is proportional to salinity and conductivity.

Salinity is the measure of the amount of dissolved salts (solids) in the estuary. Salinity levels control to some degree the types of animals and plants that may live in a particular area of the estuary. Salinity measurement is also important in determining if dissolved organic carbons will precipitate out of solution or "salt out".

Conductivity estimates the amount of total dissolved ions (solids) in water. Conductivity is controlled by geology, size of the watershed, evaporation of water, and other sources of ions to the bayou or estuary such as saltwater intrusion, wastewater, and urban and agricultural runoff. An increase in conductivity from what is normally observed could signal the introduction of a wastewater or runoff source or saltwater influence.

Mean values for TDS (Exhibit 7-9) were similar for the bayou energy system and the reference area although the maximum concentration was higher in the reference area. In Phases I and II, TDS values decreased moving upstream with little variation in values in the bayou as a whole. Reach 3, however, had TDS values that decreased significantly in both phases (by 83% and 86% for Phases I and II, respectively) before increasing in concentration in Reach 4. TDS results and comparison is presented in Exhibit 7-9. TDS was measured in the reference area in Phase II only.

Exhibit 7-9 Total Dissolved Solids (mg/L) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou – Phase I	3,000	24,000	15,598	4,924
Bayou – Phase II	800	24,500	12,724	7,256
Marsh – Phase I	9,150	43,000	18,998	3,977
Marsh – Phase II	8,000	25,000	18,316	6,204
Reference Area Phase II	6,000	32,000	13,467	10,245

1 – Values based on ROS. See Appendix D.

Within the marsh energy system, TDS values were slightly higher in Phase I than in Phase II and overall conditions in both phases were higher than reference area conditions. The higher TDS values in the marsh area may be the result of re-suspension of the silt and clay particles in the shallow marsh area and/or the influence of saltwater.

Salinity values were recorded in both Phase I and Phase II of the RI. Exhibit 7-10 presents summary statistics of the salinity for Bayou d'Inde and the reference area. Salinity in the reference area was measured in Phase II only.

Exhibit 7-10 Salinity (ppt) Levels in Bayou d'Inde and Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou – Phase I	3	26	16	6
Bayou – Phase II	1	27	13	8
Marsh – Phase I	2	25	19.1	3.6
Marsh – Phase II	7	27	19	7.1
Reference Area Phase II	6	36	14	12

1 – Values based on ROS. See Appendix D.

Salinity values decreased in the bayou moving upstream from the Calcasieu River Ship Channel to Reach 4. Based upon the USFWS salinity classification system and mean salinity values, there are two types of salinity regimes in Bayou d'Inde. Reach 1 and 2 would be classified as polyhaline (18 to 30 ppt) and changing to mesohaline (5 to 18 ppt) in Reaches 3 and 4. Salinity was higher in the reference area most likely due to its closer proximity to the Gulf of Mexico and their lack of freshwater sources.

Within the marsh area, salinity values decreased moving into the marsh regions, with the exception of the interior of Lockport Marsh and adjacent to PPG Canal. Elevated roads in Lockport Marsh may limit saltwater intrusion from the bayou or from Calcasieu River Ship Channel. However, more saline water may enter Lockport Marsh from PPG Canal. Salinity values were slightly higher than what was observed in the reference area.

Exhibit 7-11 presents the conductivity levels for both the bayou and marsh energy system in Bayou d'Inde. Conductivity in the reference area was measured in Phase II only.

Exhibit 7-11 Conductivity (µs/cm) in Bayou d'Inde and the Reference Area

Parameter	*Minimum* Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou – Phase I	1,500	36,600	12,719	11,938
Bayou – Phase II	242	135,000	17,781	34,299
Marsh – Phase I	1,000	39,200	21,235	14,052
Marsh – Phase II	1,660	41,250	20,129	16,699
Reference Area Phase II	1,350	53,800	21,363	18,967

1 – Values based on ROS. See Appendix D.

Mean conductivity levels in both Phase I and Phase II were slightly lower in the bayou energy system than reference area conditions, however, in Phase II, the max detection in the bayou was significantly higher than what was observed in the bayou. Station BIR4018 in Reach 3 had a result of 135,000 µs/cm, which indicates a source of dissolved ions in the vicinity (Exhibit 7-11).

Conductivity levels were similar to reference area conditions in the marsh energy system.

7.4.2.1.2 *Hardness*

Hardness is the measure of multivalent cations and is proportionate or equivalent to the concentration of calcium and magnesium in the surface water. Generally, as hardness increases, toxicity decreases. Surface water in Bayou d'Inde is considered very hard based on U.S Department of Interior and Water Quality Association standards (> 180 mg/L). The average fresh water value for the area is 140 mg/L (USACE 1998). Within the bayou energy system, hardness values decreased from Reach 1 to Reach 4. Hardness values in the marsh were more than double than what was observed in the reference area. Hardness was measured in Phase I and presented in Exhibit 7-12.

Exhibit 7-12 Hardness (mg/L as $CaCO_3$) in Bayou d'Inde and Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	2,250	3,085	2,857	436
Marsh	3,080	3,480	-	-
Hardness in Reference Area	1,295	1,295	-	-

1 – Values based on ROS. See Appendix D.

Hardness is typically a function of the geology of the area and/or influenced by point sources such as industries that discharge dissolved cations in effluent waters (EPA 1986). In comparison, wastewater from chemical industries has max concentrations of 1,000 mg/L, as $CaCO_3$, and electric utilities have a max concentration of 5,000 mg/L, as $CaCO_3$ (EPA 1986).

7.4.2.1.3 *Alkalinity and pH*

Increases or decreases of pH may be an indication of anthropogenic affects such as wastewater discharge or contamination from urban or agricultural runoff. Measurement of pH may isolate a particular area that might be receiving discharges from these or other sources. Alkalinity is the measure of a solution's resistance to changes in pH. Typically, water with a high alkalinity will resist the adverse affects of acidic contamination. The higher the alkalinity, the less likely a natural or man-made contaminant will cause a significant change in pH.

Exhibits 7-13 and 7-14 summarize the pH and alkalinity conditions present in the bayou and marsh energy system in Bayou d'Inde and the reference area. The pH was measured in Phase II only.

Exhibit 7-13 pH (standard units) Levels in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Median[1]
Bayou – Phase I	6.58	9.42	7.95
Bayou – Phase II	6.56	7.83	7.19
Marsh – Phase I	6.59	9.25	7.75
Marsh – Phase II	6.35	8.13	7.59
Reference Area	6.67	8.135	7.27

1 – Values based on ROS. See Appendix D.

Estuarine waters typically have pH values ranging from 7 to 7.5 (EPA 1993). Values for pH are slightly higher than what was observed in the reference area with the exception of the marsh energy system in Phase II. The difference in values may be due to chemical constituents entering the surface water from runoff or point sources in Bayou d'Inde.

Exhibit 7-14 Total Alkalinity (mg/L as $CaCO_3$) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	95.9	109	103	6
Marsh	76.4	101	-	-
Reference Area	42.1	42.1	-	-

1 – Values based on ROS. See Appendix D.

Estuaries typically have alkalinity values ranging from 30 to 160 mg/L as $CaCO_3$ (EPA 1993). Conditions in the reference area and in Bayou d'Inde (Phase I only) are not out of this range. The higher values in Bayou d'Inde may be due to the different geologic conditions (rocks or soils) in the area and/or industrial wastewater discharges.

7.4.2.1.4 Nitrogen

Nitrogen was measured as nitrate-nitrite, TKN, and ammonia. Nitrate and nitrite are inorganic ions occurring naturally as part of the nitrogen cycle (Smith 1990). TKN is the organic form of nitrogen and includes both the dissolved and particulate form, whereas ammonia is the dissolved form of nitrogen. Ammonia, at low levels, is an important nutrient for estuarine organisms, whereas it becomes toxic at high concentrations. In contrast to freshwater systems where phosphorous is the limiting nutrient factor, nitrogen is the primary limiting nutrient in the seaward portions of most estuarine environments (Paerl 1993). If high levels of nitrogen are introduced into the estuary, a significant increase of algae or large aquatic plants may occur; NOAA/EPA (1988) suggests that nitrogen levels between 0.1 and 1 mg/L to avoid algae blooms. Exhibit 7-15 summarizes Nitrate/Nitrite measurements for Phase I.

American Water Works Association (AWWA) recommends that for maximum diversity in estuarine environments, the nitrate-nitrite should not exceed 0.1 mg/L for maximum diversity and 1.0 mg/L for moderate diversity (Exhibit 7-15). Based on

Phase I nitrate-nitrite levels, the reference areas would support a more diverse environment whereas Bayou d'Inde would only support a moderate diversity.

Exhibit 7-15 Nitrate-Nitrite (mg/L) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	0.083	0.37	0.23	0.13
Marsh	0.064	0.34	0.18	0.17
Reference Area	0.06	0.06	-	-

1 – Values based on ROS. See Appendix D.

Higher TKN and ammonia values were found in the bayou in comparison with reference area conditions (Exhibits 7-16 and 7-17).

Exhibit 7-16 TKN (mg/L) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	1.7	2.9	2.4	0.5
Marsh	1.2	3.9		
Reference Area	0.95	0.95	-	-

1 – Values based on ROS. See Appendix D.

Exhibit 7-17 Ammonia, as N, (mg/L) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	0.96	2.5	1.7	0.7
Marsh	1.3	3.8	-	-
Reference Area	0.0064	0.0064	-	-

1 – Values based on ROS. See Appendix D.

TKN is the summation of ammonia and organic nitrogen. For Bayou d'Inde, ammonia makes up more than 50 percent of TKN values, which is very different from the reference area. However, with the marsh energy system, TKN is mostly comprised of ammonia with very little organic nitrogen. Sources of TKN are typically the decay of organic material and urban and industrial sewage discharge. According to EPA (1989b), the criteria maximum concentrations (CMC) for total ammonia for pH, temperatures and salinity found in Bayou d'Inde range from 44 to 50 mg/L. The criteria continuous concentrations (CCC), according to EPA (1989b), range from 6.6 to 12 mg/L. Ammonia levels were below the CMC and CCC values for Bayou d'Inde.

7.4.2.1.5 Dissolved Oxygen

Dissolved oxygen is typically an indicator of high quality for aquatic life and helps determining the ability of aerobic organisms to survive. The concentration is dependent upon temperature, salinity, wind, water turbulence, atmospheric pressure, and presence of oxygen demanding compounds and organisms, and photosynthesis. The percent saturation is the measured dissolved oxygen level divided by the greatest amount of oxygen that the water can hold at that temperature and atmospheric conditions. Low dissolved oxygen levels typically indicate an excessive demand on the system from organic material deposited from pollution sources or from natural sources such as leaves and grass. Exhibit 7-18 presents dissolved oxygen data for Bayou d'Inde.

Exhibit 7-18 Dissolved Oxygen, in Percent Saturation, in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou – Phase I	5	19.5	11	3
Bayou – Phase II	3.02	11.75	6.84	2.60
Marsh – Phase I	3.29	19.9	9.9	3.4
Marsh – Phase II	6.07	12.05	9.06	2.05
Reference Area	*7.50*	*12.76*	*10.36*	1.55

1 – Values based on ROS. See Appendix D.

Typically, values over 80 percent represent water of high quality, which will support various flora and fauna, whereas values less than 80 percent indicate poor water quality conditions. If oxygen-requiring organisms perish, the remaining organisms will be air-breathing insects and anaerobic bacteria (Gower 1980).

7.4.2.1.6 Biochemical and Chemical Oxygen Demand

Biochemical oxygen demand (BOD_5) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions in five days. Chemical oxygen demand (COD), however, does not differentiate between biologically available and inert organic matter and is a better indicator of medium to long-term demand. COD is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values will always be greater than or equal to BOD_5 values and these data are typically measured when there are nearby industrial sources. High BOD_5 /COD values may deplete the water system of oxygen needed to support fish and other aquatic life. In an estuary, the rate of oxygen consumption is dependent upon temperature, presence of certain kind of microorganisms, and the type of organic and inorganic material in the water (EPA 1993). BOD_5 values between 1 and 2 mg/L represent clean water. BOD_5 values between 2 and 5 mg/L are considered moderately clean. BOD_5 values exceeding 5 mg/L indicate a nearby pollution source. The various sources of organic enrichment include urban and agricultural runoff, sanitary sewer overflows, landfills and septic systems.

Exhibit 7-19 presents the chemical oxygen demand and COD values observed in Phase I. BOD_5 and COD were not analyzed in the reference areas.

Exhibit 7-19 BOD_5 and COD (mg/L) in Bayou d'Inde

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
BOD_5 in Bayou	2.85	10.4	6.4	3.6
COD in Bayou	71	83.2	76	5.9
BOD_5 in Marsh	3.5	7.3	-	-
COD in Marsh	55.4	196	-	-

1 – Values based on ROS. See Appendix D.

BOD_5 levels increased from Reach 1 to Reach 4 with the maximum located at station BIR5004. The high BOD_5 values may be due to urban and agricultural runoff in the upper segments of the bayou. Within the marsh energy area, BOD_5 levels did not vary greatly. There is little variation in COD values throughout Bayou d'Inde indicating that industrial discharges do not significantly affect the oxygen demand in the system.

7.4.3.1 Porewater

Porewater is the water occupying space between sediment particles. DOC, salinity, conductivity, hardness, total alkalinity, ammonia as N, unionized ammonia, and pH were measured at ten sample locations in Bayou d'Inde. DOC and salinity are presented in this section whereas discussion of the other parameters is presented in the BERA.

7.4.3.1.1 Porewater Dissolved Organic Carbon

Porewater DOC is the organic fraction of carbon in water that is filterable. DOC plays a role in the fate and transport of trace elements in the subsurface as well as influences the bioavailability of hydrophobic compounds. In saline environments, dissolved organic matter is removed from the water to the sediment phase, which can effectively sorb hydrophobic chemicals (Chapman et al 2001). Porewater DOC was measured in Phase II only and presented in Exhibit 7-20.

Exhibit 7-20 Porewater DOC (mg/L) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	2.52	23.09	14.31	6.01
Marsh	8.43	16.6	11.1	2.7
Reference Area	2.29	13.52	4.78	3.41

1 – Values based on ROS. See Appendix D.

7.4.3.1.2 Porewater Salinity

As discussed previously, salinity is a measure of TDS in water. Porewater salinity was measured in Phase II only and is presented in Exhibit 7-21.

Exhibit 7-21 Porewater Salinity (ppt) in Bayou d'Inde and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	11	22	19.2	3.1
Marsh	15	23	20.6	2.2
Reference Area	12	24	17.1	3.8

1 – Values based on ROS. See Appendix D.
2 – Results from Phase II only

The difference between salinity measurements in surface water and porewater are most likely related to sediment type and duration of sediment exposure to surface water salinity conditions (Chapman et al 2001). Equilibrium between surface water and porewater is slow in sediments containing higher percentages of fine particles such as clay and silt (Chapman et al 2001).

7.5 Nature and Extent for the Bayou Energy System

The results and discussion section is organized into four sections: COPCs identified for the bayou energy system (Section 7.5.1), the results of the PCA (Section 7.5.2), and contaminants that showed little or no correlation to other contaminants or parameters (Section 7.5.3).

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix D provides details of the PCA and complete summary statistics for all compounds detected in the bayou energy system in Bayou d'Inde.

7.5.1 COPCs for the Bayou Energy System in Bayou d'Inde

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. These energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 7.5.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 7.5.1.2 presents the bayou energy system COPCs identified.

7.5.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 7-11. Contaminant concentrations that were determined to have a statistically significantly difference when compared to the reference area are:

- SVOCs (BEHP, HCB, and HCBD)
- PAHs (as pyrene)
- Total PCBs (as Aroclor 1254)

- Pesticides (aldrin and dieldrin)
- Dioxin/Furans (as 2,3,7,8 TCDD TEQ)
- Inorganics (arsenic, barium, chromium, copper, lead, mercury, and zinc)

7.5.1.2 COPCs Selection

Energy system specific COPCs for Bayou d'Inde were selected by determining if the COPC is a risk driver in the HHRA or the BERA and the concentration was determined to have a statistically significant difference when compared to the reference area conditions (Table 7-12). The following COPCs were selected for the bayou energy system in Bayou d'Inde:

- SVOCs (BEHP, HCB, HCBD)
- PAHs (as Low and High Molecular Weight)
- PCBs
- Pesticides (aldrin)
- Dioxin/Furans
- Inorganics (chromium, copper, lead, mercury, and zinc)

The nature and extent as well as the fate and transport of these COPCs will be discussed in Sections 7.5.2 (PCA) and 7.5.3 (Isolated Chemistry).

7.5.2 PCA

The PCA revealed four dominant factors that accounted for most of the variability (63%) in surface sediment within Bayou d'Inde. These factors are:

- Medium to high-level concentrations of major cations, metals and PAHs (Major Cations/Metal/PAH Factor) that accounts for 18 percent of the variability.
- Medium to high-level concentrations of furans/dioxins and metals (Furan/Dioxin/Metal Factor) that accounts for 18 percent of the variability.
- Medium to high-level concentrations of dioxins, PAHs, PCBs, and metals (Dioxin/PAH/PCB/Metal Factor) that accounts for 16 percent of the variability.
- Medium to high-level of concentrations of pesticides (Pesticide Factor) that accounts for 12 percent of the variability.

These factors present groups of parameters and/or contaminants that tend to correlate with each other and explain variability in the data set.

7.5.2.1 Major Cations/Metals/PAH Factor

This section presents the extent of the Major Cations/Metals/PAH Factor and discussion as to the fate and transport of contaminants in this factor.

7.5.2.1.1 Results

Various metals and cations as well as two PAHs and a pesticide were grouped in this factor. The metals grouped in the factor are at low level concentrations are similar to reference area conditions. However, the PAHs and the pesticide represent contamination to the bayou. The cations help to explain compound fate and transport in the system. In addition to major cations, clay and sand were grouped within this factor. Sand was negatively correlated to the contaminants, signifying that areas within the bayou with a low percentage of sand (or high percentage of clay) would be more likely to have higher concentrations of contaminants grouped within this factor. Summary statistics are presented in Exhibits 7-22 through 7-24.

Exhibit 7-22 Summary Statistics of Inorganics (mg/Kg) in Major Cations/Metals/PAH Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Beryllium	83/87	0.27	1.2	0.8	0.2	0.3
Iron	87/87	5,610	25,900	13,718	4,398	0.3
Magnesium	87/87	1,520	11,100	3,926	1,327	0.3
Potassium	87/87	886	4,150	2,183	688	0.3
Vanadium	87/87	9.3	59.2	24.1	9.1	0.4
Aluminum	87/87	4,390	28,100	13,399	5,003	0.4
Arsenic	87/87	1.3	8.4	4.0	1.3	0.3
Cobalt	87/87	2.6	16.1	6.0	1.9	0.3
Manganese	87/87	59.4	1,020	211	127	0.6
Sodium	87/87	3,380	21,100	9,389	3,903	0.4

1 – Values based on ROS. See Appendix D.

Exhibit 7-23 Summary Statistics of PAHs (µg/Kg) in Major Cations/Metals/PAH Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Benzo(a)anthracene	21/97	33.7	1,950	127.9	244	1.91
Benzo(b)fluoranthene	21/98	54.1	1,990	169	255	1.50

1 – Values based on ROS. See Appendix D.

Exhibit 7-24 Summary Statistics of Pesticides (µg/Kg) in Major Cations/Metals/PAH Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detect	Minimum *Detected* Value	Maximum *Detected* Value	*Mean*[1]	Standard Deviation	Coefficient *of* variance
Endrin Aldehyde	25/99	0.86	77	5.32	11.92	2.24

1 – Values based on ROS. See Appendix D.

Benzo(a)anthracene was used as the indicator variable for this factor.

Surface Sediment

Elevated concentrations of contaminants grouped within this factor were located in 4 areas within the bayou energy system (Figure 7-4). The first area is located in Reach 4 approximately 120 to 250-m downstream of I-10. This area showed lower concentrations in comparison with the other areas in Bayou d'Inde and concentrations were consistent among Reach 4 sample locations.

The second area is located 52 m upstream to 250 m downstream of LA-108. Elevated concentrations were primarily between LA-108 and the railroad crossing. Concentrations of HPAHs are the highest in Bayou d'Inde at this location (BIR4015) measured at 23,000 µg/Kg. Concentrations decreased downstream. In Reach 1 the second highest concentration was recorded at 5,820 µg/Kg.

In Maple Fork Bayou at station BIR3024, an area from about 250 to 650-m from the *mouth of Maple Fork Bayou reported elevated concentrations* at 4,000 µg/Kg. Contaminant concentrations are more varied within Maple Fork Bayou with high detections located at both ends of this segment.

The Reach 1 HPAH impacted area encompasses the region approximately 1,125 to 375-m from where Bayou d'Inde flows into the Calcasieu River Ship Channel. Concentrations are varied within this area as well.

Subsurface Sediment

Benzo(b)fluoranthene and benzo(b)anthracene concentrations in subsurface sediment decrease with depth, similar to HPAHs in the bayou energy system (Figure 7-4). Within Reach 1, HPAH concentrations increase at station BIR1003 (near the confluence of PPG Canal and Bayou d'Inde) from 220 to 2,420 µg/Kg whereas stations BIR1010 and 1012 (within the lower one-third of Bayou d'Inde Reach 1) decrease with depth. BIR1014 (near the mouth of Bayou d'Inde) increases from 260 µg/Kg in surface sediment to 900 µg/Kg in the 10 to 20-cm interval before decreasing in the 20 to 30-cm interval (280 µg/Kg).

In Reach 2, at station BIR3024, HPAH concentrations decrease with depth from 619 to 195 µg/Kg. Station BIR4015, in Reach 3, concentrations increase sharply from 398 to 1,430 µg/Kg in the 10 to 20-cm interval. HPAHs were not detected in the 20 to 30-cm interval at station BIR4015.

Surface Water

PAHs were not detected in surface water samples within the bayou energy system in Bayou d'Inde.

7.5.2.1.2 Discussion

Distribution of the compounds detected in the Major Cations/Metals/PAHs factor for the bayou energy system are found at concentrations of potential concern in Reaches 1 and 3, and in Maple Fork Bayou. The primary COPCs in this correlated group of detections are HPAHs. The HPAHs correlate with a broad group of major cations and associated metals. This group of cations and metals appear to represent clay local mineralogy and the association with sediment sodium may indicate sediment deposition under saline conditions.

The maximum HPAH concentrations were found in Reach 3, at 23,000 µg/Kg. The lateral extent in Reach 3 is limited, it appears that the release was localized, possibly entering Bayou d'Inde near BIR4015 (near Citgo Outfall 001) and that the PAHs salted-out of solution, binding with sediments and have remained in the immediate local area. The core data suggests that this release has been relatively recent as the concentrations of HPAHs in BIR4015 decrease in the 10 to 20-cm and 20 to 30-cm samples. The concentrations in these lower horizons are 1,400 µg/Kg and non-detect, respectively. Conversely, historic data from 1992 studies found that HPAH concentrations ranged from 239 to 24,900 µg/Kg throughout Reach 3. Compared to core data from BIR 4015, this would indicate that surface material has moved within Reach 3. Current conditions are similar to those of 1992 and it appears that the potential for sediment mobility in Reach 3 exists currently.

The second highest occurrence of HPAHs is in Reach 1 of Bayou d'Inde. The surface sediment concentrations range from 260 to 5,820 µg/Kg. The distribution is not linear, but scattered from the confluence of the PPG Canal to the mouth of Bayou d'Inde. The surface sediment distribution may be attributed to two things, the generally lower percentage of clay in the Reach 1 sediments lead to the more isolated concentrations of HPAHs, and sediment mobility, or localized sources related to oil and gas production activities. The subsurface data from Reach 1 indicates a similar variability in the lateral distribution and concentration gradients. An example of the total HPAH concentration variability in Reach 1 is the variability noted in the following vertical profiles:

Reach 1

- BIR1003: 290 µg/Kg, 1,000 µg/Kg, 2,420 µg/Kg (maximum is in the 20 to 30-cm interval)
- BIR1010: 3,010 µg/Kg, 1,880 µg/Kg, 2,200 µg/Kg (maximum is in the 0 to 10-cm interval)
- BIR1012: 5,820 µg/Kg, 24 µg/Kg, 413 µg/Kg (maximum is in the 0 to -10-cm interval)
- BIR1014: 260 µg/Kg, 900 µg/Kg, 280 µg/Kg (maximum is in the 10 to 20-cm interval)

Previous studies found that HPAH concentrations were higher in surface sediments than detected in the RI. The data from 1992 ranged from 7,920 to 17,870 µg/Kg, which was also higher than that observed in any of the cores collected during the RI. This suggests that surface sediment may have been removed from the area. The variability in the RI core data supports this interpretation.

The third area of elevated HPAHs is in Maple Fork Bayou. The elevated concentrations are detected in the middle portion of the bayou. No known sources are present in this area. Potential sources are pipeline and railroad crossings located within 150 m of the detected maximum as well as runoff from I-10 approximately 300 to 500 m to the upstream. The vertical distribution of contaminant concentrations in BIR 3024 in Maple Fork Bayou shows a marked decrease with depth (4,200 µg/Kg, 630 µg/Kg, and 195 µg/Kg [0 to 10, 10 to 20, and 20 to 30-cm, respectively]). Elevated surface concentrations are noted in several of the adjacent sample locations in Maple Fork Bayou. Maple Fork Bayou was not sampled in previous studies, therefore no temporal evaluation beyond the subsurface core data is available.

7.5.2.2 Furan/Dioxin/Metal Factor

This section presents the extent of the Furan/Dioxin/Metal Factor and discussion of the fate and transport of contaminants in this factor.

7.5.2.2.1 Results

The Furan/Dioxin/Metal Factor is comprised of five furan congener groups and one dioxin congener group. In addition, the beta-BHC, hexachloro-1,3-butadiene, phenol, copper, lead mercury, and nickel are grouped in this factor. Controlling 18% of the variance, the Furan/Dioxin/Metal Factor is the result of contamination introduction to the bayou. Summary statistics for the parameters that group within this factor are presented in Exhibits 7-25 through 7-27.

Exhibit 7-25 Summary Statistics of Furans and Dioxins (pg/g) in Furan/Dioxin/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Total HxCDF	27/27	21	36,000	2,354	8,639	3.67
OCDF	27/27	39	290,000	17,547	69,755	3.98
Total TCDF	27/27	12	11,000	806	2,609	3.24
Total PeCDF	26/27	12	25,000	1,576	6,019	3.82
Total HpCDF	27/27	46	54,000	3,637	12,892	3.54
Total TCDD	25/27	1.29	120	17.6	27.7	1.57

1 – Values based on ROS. See Appendix D.

Exhibit 7-26 Summary Statistics of Organic Parameters (µg/Kg) in Furan/Dioxin/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Beta-BHC	28/98	5.2	300	28.0	69.6	2.48

Hexachloro-1,3-butadiene	8/98	100	1,600	(-)	(-)	(-)
Phenol	9/98	49	400	(-)	(-)	(-)

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 7-27 Summary Statistics of Inorganic Parameters (mg/Kg) in Furan/Dioxin/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Mercury	73/99	0.0698	3	0.65	0.76	1.17
Copper	98/99	8.27	280	60.2	46.6	0.77
Nickel	99/99	4.64	53.8	19.5	9.4	0.48
Lead	94/99	7.45	218	38.1	25.4	0.67

1 – Values based on ROS. See Appendix D.

Nickel was used as the indicator variable to discuss the contamination present in the bayou energy system of Bayou d'Inde.

A brief discussion of the nature and extent of the COPCs grouped in this factor is presented below.

Surface Sediment

As shown in Figure 7-5, elevated concentrations are located in Reach 3 and downstream of Maple Fork Bayou to the Calcasieu River Ship Channel. Reach 3 had variable concentrations throughout the area with elevated concentrations observed at the following: the entry of Little Bayou d'Inde into Bayou d'Inde; 525 m downstream of Little Bayou d'Inde; 215 m downstream of Citgo outfall 001 approximately where a Firestone outfall empties into Bayou d'Inde; and near the railroad crossing at LA-108 outfall area of Westlake Polymers and OxyChem.

The *concentrations in* Maple Fork Bayou *are elevated with concentrations increasing* from I-10 the confluence of Maple Fork Bayou and Bayou d'Inde (approximately 275 m upstream of the confluence in Maple Fork Bayou). Once in Bayou d'Inde, *concentrations remain constant until* Reach 1 *where they increase.* Reach 1 was observed to have the highest detects, specifically from 190 m upstream of the mouth of PPG Canal to 1,000 m downstream of PPG Canal in Bayou d'Inde.

Subsurface Sediment

At stations BIR1003 and BIR1010, HCBD concentrations increased in the subsurface (Figure 7-5). At station BIR1012, HCBD was detected in the surface sediment sample and at the 20 to 30-cm interval, but was not detected in the middle interval. At station BIR1014, HCBD was not detected in the surface sediment (most likely due to high detection limits), but it was detected in the subsurface at decreasing concentrations.

Mercury concentrations tended to decrease with depth in Reach 1 (Stations BIR1003, BIR1010, and BIR1012) with the exception of station BIR1014 (Figure 7-5). At station BIR1014, mercury concentrations decreased in the 10 to 20-cm layer and increasing in the 20 to 30-cm layer. In the upper reaches at station BIR3024 and BIR4015, mercury concentrations were higher in the 10 to 20-cm interval. BIR3024 exhibited the highest concentration of mercury of all subsurface samples with a result of 4.8 mg/Kg in the 20 to 30-cm layer. Mercury was not detected in the subsurface at station BIR4017.

With the exception of stations BIR1010 and BIR1012 (Reach 1), copper concentrations decreased with depth (Figure 7-5). At station BIR1010, concentrations decreased from the surface sample to the 10 to 20-cm interval sample. Concentrations in the 20 to 30-cm interval, however, had the highest concentration for copper for subsurface samples with an observed value of 195 mg/Kg. Copper behaved similarly at station BIR1012.

In Reach 1, lead concentrations increased in the 20 to 30-cm interval at station BIR1003 and BIR1014 and decreased in the 20 to 30-cm interval (Figure 7-5). Highest concentration for lead in the subsurface for lead was observed at station BIR1014 with a value of 83 mg/Kg. In Reaches 2 and 3, lead concentrations decreased in the subsurface.

Dioxin/furans in the subsurface will be discussed as a whole as 2,3,7,8-TCDD TEQ in Section 7.5.3.5.

Surface Water

Copper, lead, mercury, and nickel were detected in surface water samples collected in the bayou energy system in Bayou d'Inde. Exhibit 7-28 presents the total and dissolved (if detected) concentrations of these contaminants and compares them to EPA Ambient Water Quality Regulations (AWQC; as reported in the Federal Register 1995) criteria continuous concentration (CCC; chronic) and criteria maximum concentration (CMC; acute) values and/or LDEQ Water Quality Regulation (LDEQ 2000) for both freshwater and marine environments. For systems with salinity between 1 and 10 ppt, the more stringent of either fresh or marine values should be used to compare with mean dissolved concentrations. In cases where the dissolved phase was not detected, the surface water criteria for that contaminant were converted to an unfiltered criterion using a conversion factor provided in LDEQ 2000.

Exhibit 7-28 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Furan/Dioxin/Metal Factor in Surface Water, Bayou Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Copper	0.0082 (0.0032)	0.0082 (0.0071)	0.035[3]	0.022[3]	**0.00363**	**0.00363**
Lead	0.0022 (0.0005)	0.00195 (0.0002)	0.138[3]	0.00531[3]	0.209	0.00808
Mercury	0.0001 (0.00005)	0.0001[2]	0.0017[3]	0.00001[3]	0.0017	**0.000021**
Nickel	0.0112 (0.0123)	0.0103 (0.0118)	2.49[3]	0.279[3]	0.074	**0.0082**

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected in one sample.
3 – LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.

Dissolved copper concentrations exceed both the acute and chronic criterion for marine surface water. The highest dissolved concentration of copper observed was at station BIR4004 in Reach 3 with a value of 0.0231 mg/L. This maximum concentration also exceeds the chronic criteria for freshwater. Dissolved mercury and nickel concentrations exceeded the chronic criteria for marine surface water. Dissolved mercury was only detected at one location, ECOBI014. The highest concentration of dissolved nickel was observed at BIR1004 with a concentration of 0.0348 mg/L.

7.5.2.2.2 *Discussion*

The Furan/Dioxin/Metal Factor is comprised of five furan congener groups and the COPCs HCBD, copper, mercury, lead, and nickel. As noted above, the extent of the dioxin/furans and metals compounds is represented by the distribution of nickel. Elevated concentrations of this group of compounds are noted from 650 m upstream of the Maple Fork Bayou confluence with Bayou d'Inde through to the ship channel. Concentrations are greatest around the PPG Canal and Citgo outfall 001.

Mercury is found to occur in the middle reaches of Maple Fork Bayou at elevated levels, albeit lower than those in Reach 1. It appears that mercury is entering Bayou d'Inde from various sources. Potential sources in Lockport Marsh include oil field (gas metering) equipment. Available data do not indicate known discharge to Maple Fork Bayou. Mercury is managed on-site at a number of facilities throughout Bayou d'Inde (OxyChem, Firestone and PPG) and each has had reported releases or NPDES exceedances. Comparison of some metals total versus dissolved concentrations in surface water illustrates the degree of suspended or colloidal phase material in Bayou d'Inde. An example is dissolved phase copper. Dissolved copper was less than total copper, indicating adsorption to suspended phase material. This finding is significant as suspended phase transport may be a major process for some PAHs, PCBs, metals, and dioxins.

Copper tends to have similar distribution, with the exception that elevated concentrations of copper are noted in two places: downstream of Maple Fork Bayou in Bayou d'Inde and downstream of Citgo outfall 001. Copper tends to become more soluble in saline waters due to chlorine complexing and this may account for the greater downstream extent of copper.

The occurrence of lead is fairly consistent throughout Bayou d'Inde. Levels are generally greater than the reference areas and less than values measured in previous studies. The distribution of elevated lead noted during the RI is primarily in and at the confluence of Maple Fork Bayou, upstream of LA-108 and in Reach 1. This distribution is consistent with previous studies.

Historical concentrations of lead were generally higher than those observed in the RI. Concentrations as high as 900 mg/Kg in Reach 2 downstream of Maple Fork Bayou were noted. Concentrations, however, remained near 200 mg/Kg throughout middle Reach 2, decreasing to less than 100 mg/Kg in lower Reach 2. Concentrations increase at PPG Canal and remain elevated (200-400 mg/Kg levels) into the ship channel.

Sources of the dioxin/furan/metal compounds in this factor appear to be Citgo, OxyChem and Westlake Polymers outfall areas and PPG Canal. Lead compounds, formed in the environment due to precipitation processes, are generally stable in the environment, with the exception of chloride complexes, which tend to form more soluble lead and copper compounds. However, the data suggests that the metals observed in sediment are not expected to become mobile or soluble in Bayou d'Inde. Transport of the precipitated compounds adsorbed to sediments, however, is possible and is apparent where sediments are disturbed. The condition is apparent from historical data in lower Reach 1 where sediments with elevated lead concentrations are noted in both Reach 1 and the confluence of Bayou d'Inde and the ship channel. Increased concentrations in Reach 1 may be due to water velocity drops and sediment accumulation.

HCBD distribution is an exception to the group, its occurrence is isolated to Reach 1 below the PPG Canal; however, and no discernable concentration gradients are noted. The primary source of HCBD is the PPG Canal; however, compound distribution is controlled by the mobility of the sediments to which the compound binds.

7.5.2.3 Dioxin/PAH/PCB/Metal Factor

This section presents the extent of the Dioxin/PAH/PCB/Metal Factor and discussion as to the fate and transport of contaminants in this factor.

7.5.2.3.1 Results

This factor groups various dioxins, PAHs, PCBs, and metals as well as TOC, which may explain the mobility of these contaminants within the bayou energy system. Summary statistics for these contaminants are presented in Exhibits 7-29 through 7-33.

Exhibit 7-29 Summary Statistics of Dioxins (pg/g) in Dioxin/PAH/PCB/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Total HxCDD	27/27	25.5	1,200	199	259	1.30
Total HpCDD	27/27	92.4	4,700	820	1,001	1.22
OCDD	27/27	593	23,000	5,406	4,732	0.88

1 – Values based on ROS. See Appendix D.

Exhibit 7-30 Summary Statistics of PAH (µg/Kg) in Dioxin/PAH/PCB/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Fluoranthene	28/98	76	3,560	236	453	1.92
Pyrene	38/98	85	2,550	248	346	1.40

1 – Values based on ROS. See Appendix D.

Exhibit 7-31 Summary Statistics of SVOCs (µg/Kg) in Dioxin/PAH/PCB/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Benzaldehyde	6/97	41	290	-	-	-

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 7-32 Summary Statistics of PCBs (µg/Kg) in Dioxin/PAH/PCB/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Aroclor 1260	4/98	59	190	-	-	-

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 7-33 Summary Statistics of Inorganics (mg/Kg) in Dioxin/PAH/PCB/Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Chromium	87/87	7.1	231	46.5	33.9	0.73
Silver	39/99	3,380	21,100	9,389	3,903	0.42

1 – Values based on ROS. See Appendix D.

Pyrene was used as the indicator variable to describe the distribution of contaminants grouped in this factor. Dioxin/furans distribution and fate and transport are discussed as a whole as 2,3,7,8-TCDD TEQ. The detail is provided in Section 7.5.3.5.

Surface Sediment

Contamination from this factor is present in all four reaches of the bayou energy system (Figure 7-6). With the exception of metals, the dioxins, PAHs, and PCBs are variable in the bayou with three areas of elevated concentration noted.

In Reach 3, elevated concentrations were observed from the area downstream of the CitCon outfall to approximately 200 m downstream of LA-108. Highest concentrations were observed near the Citgo outfall 001 and where the railroad crosses the bayou at LA-108.

Maple Fork Bayou was also observed to have elevated concentrations of dioxins, PAHs, and metals from approximately 260 m to 675 m downstream of I-10. Aroclor 1260 was not detected in the Maple Fork Bayou.

In Reach 1, station BIR1010 was reported to having high concentrations. Concentrations decreased both upstream and downstream from this location.

Subsurface Sediment

Pyrene and fluoranthene decreased in concentration in the subsurface or concentrations remained similar (Figure 7-6). Station BIR1003 did exhibit increasing concentrations from surface to the deeper interval with values increasing from 220 to 2,420 µg/Kg. See discussion in Section 7.5.2.1.1.

Chromium had similar concentrations with depth for samples in Reach 1 (Figure 7-6). Stations BIR3024, BIR4015, and BIR4017 had increasing chromium concentrations from the surface sediment layer to the 10 to 20-cm interval and then decreasing in the 20 to 30-cm interval. Station BIR3024 exhibited the highest chromium concentration at the middle depth interval (20 to 30 cm) with a measured value of 357 mg/Kg. Aroclor 1260 was not detected in the subsurface sediments.

Dioxin/furans in the subsurface will be discussed in Section 7.5.3.5.

Surface Water

Neither PAHs nor PCBs were detected in surface water in the bayou energy system in Bayou d'Inde.

Mean total and dissolved chromium (total) concentrations are presented in Exhibit 7-34 and compared to fresh and marine acute/chronic criterion.

Exhibit 7-34 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Dioxin/Furan/Metal Factor in Surface Water, Bayou Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Chromium (total)	0.0057 (0.0163)	0.0034 (0.0047)	NA	NA	NA	NA

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
NA – Not available. LDEQ provides criteria for Cr^{3+} and Cr^{6+}.

7.5.2.3.2 *Discussion*

Reach 1 tends to have the highest concentrations of HPAHs, although the HPAH compounds are found throughout Bayou d'Inde. The occurrence of these compounds is concentrated in three areas: near the Citgo outfall 001; near the highway LA-108 bridge downstream of the Westlake Polymers dock and outfall 002B; and below the PPG Canal. Slightly elevated concentrations of the PAH Factor compounds are noted in the lower to middle portions of Maple Fork Bayou. No documented discharge to Maple Fork Bayou was found, however unidentified sources in the area near the PAH detections may be present.

Sources of PAHs to Bayou d'Inde appear to be Citgo outfall 001, Westlake Polymers outfall 002B and the PPG Canal. PAHs are hydrophobic, with strong tendencies to bind to suspended or dissolved organics. The presence of suspended organic material and detritus which is elevated in Reach 1 and Lockport Marsh combined with velocity drops due to bayou geometry appear to make Reach 1 a contaminant sink.

The extent of elevated chromium in Bayou d'Inde is primarily in Reach 2 and Reach 3. The bayou energy system concentrations are highest in Maple Fork Bayou and in Bayou d'Inde downstream of the confluence with Maple Fork Bayou. The concentrations are higher than the reference area, both for mean and maximum values. The distribution of sediment concentrations indicates decreasing concentrations downstream of apparent sources. Concentrations noted in the RI are generally lower than those observed during previous studies.

Historically, the highest concentrations of chromium were found in Reach 3, near the Citgo outfall 001 (2,610 mg/Kg). Concentrations were also elevated downstream of the Westlake Polymers outfall 002B area near Reach 2.

Potential sources are numerous, as many of the facilities handle chromium and many of them have had releases to Bayou d'Inde. However, it appears that the Citgo outfall 001 and Westlake Polymers outfall 002B area are primary contributors in Reach 3, as is the PPG Canal in Reach 1.

Chromium will generally precipitate out in the environment as chromium hydroxide. The hydroxide compound consists of trivalent chromium, which is generally stable in the environment. Chromium is not expected to become more soluble under the conditions present in Bayou d'Inde. Particle transport of the adsorbed chromium, however, is possible.

As noted earlier, the correlation of several different dioxin/furans in more than one PCA factor resulted in a standalone discussion of 2,3,7,8 TCDD TEQ occurrence. This is considered the most comprehensive approach to presenting dioxin/furan data. The grouping of hepta-, hexa- and octa-dioxins with the dioxin/PAH/PCB/Metal factor here appears to be related to the spatial distribution. The common thread may be the distribution noted in Reaches 2 and 3, possibly associated with the railroad line.

7.5.2.4 Pesticides Factor

This section presents the extent of the Pesticides Factor and discussion as to the fate and transport of contaminants in this factor.

7.5.2.4.1 Results

The Pesticide Factor is comprised of several pesticides. Summary statistics for the parameters that group within this factor are presented in Exhibits 7-35.

Exhibit 7-35 Summary Statistics of Pesticides (µg/Kg) in Pesticide Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Aldrin	20/99	0.65	370	9.67	48.2	4.98
Gamma-BHC	9/98	1.9	23	-	-	-
4,4'-DDE	26/99	0.63	120	4.85	15.2	3.14
Endosulfan Sulfate	32/99	0.93	110	6.19	15.7	2.53
Heptachlor	5/98	50	240	-	-	-
Hexachlorobenzene	11/98	630	24,000	-	-	-

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Hexachlorobenzene (HCB) was used as the indicator variable for this factor.

Surface Sediment

Elevated pesticide and HCB concentrations are located in Reach 1, from PPG Canal to where Bayou d'Inde flows into the Calcasieu River Ship Channel (Figure 7-7). Concentrations decrease from PPG Canal to approximately 780 m downstream (BIR1008), where they become elevated again. Pesticide concentrations become variable from BIR1008 to the ship channel.

Subsurface Sediment

Aldrin was the only pesticide COPC detected in the subsurface. At station BIR1010, the aldrin concentration decreased from 370 µg/Kg in the surface sediment to 300 µg/Kg in the 10 to 20-cm interval. It was not detected in the 20 to 30-cm interval.

HCB at stations BIR1003 and BIR1010 exhibited higher concentrations in the 20 to 30-cm interval than in the upper layers of the sediment (Figure 7-7). Concentrations decreased from the surface to the 10 to 20-cm interval before increasing significantly in the 20 to 30-cm interval. At station BIR1014, HCB concentrations were higher in the middle depths (10 to 20-m interval), with similar concentrations in the surface and 20 to 30-cm interval.

Surface Water

Contaminants within the Pesticide Factor were not detected in surface water in the bayou energy system in Bayou d'Inde.

7.5.2.4.2 Discussion

A significant portion of Bayou d'Inde data variability is explained by the data referred to as the Pesticide Factor. The factor is comprised of several pesticides including aldrin and HCB. These two compounds are COPCs in terms potential human risk and/or ecological risk. They are the focus of the following fate and transport discussion.

Pesticides were not detected extensively throughout Bayou d'Inde; they are limited to Reach 1. Further, they were each detected in less than 20% of the samples collected in Bayou d'Inde. Sources of pesticides are likely anthropogenic.

The historic occurrence of pesticides tends to correlate with the RI findings. The highest concentration measured in previous studies was at location 6100-04-BDI39 in the PPG Canal. This location had levels of 3,500 and 8,800 μg/Kg aldrin and dieldrin, respectively. Elevated PAHs and BEHP values were also reported at this location.

The behavior of pesticides in Reach 1 appears to be affected by suspended particulate material. The compounds are hydrophobic with generally high log K_{ow} values leading to sorption to organics. However, Reach 1 of the bayou system generally contains less TOC than Reaches 2 or 3. Pesticides have an affinity for organic-rich, fine-grained materials; however the Reach 1 matrix is 55% silts and clay, and 45% sand, which has a lower silt and clay content than either Reaches 2 or 3 (Figure 7-3). One explanation may be the mobilization and re-suspension of pesticide-sorbed colloidal phase material and collection/deposition in Reach 1. Anthropogenic use of detected pesticides is common throughout the region to control a variety of pests. The accumulation of these compounds in the Reach 1 sediments appears not to be an issue of release or source, but one of deposition.

Dissolved organics and TSS content are locally higher due to input from PPG Canal and Lockport Marsh and this may control the deposition or coagulation of these fine-grained particles in Reach 1. Reach 1 appears to act as a sediment trap for Bayou d'Inde. It is the broad, deep and an intermediate step to the ship channel, and it is the largest overall geometry in Bayou d'Inde. Significant velocity decreases appear to occur just upstream of the PPG Canal confluence with Reach 1. The organic rich waters of Lockport Marsh and Reach 1 appear to provide a source of algal drift that helps create organic flocculants that bind and precipitate many contaminants (PCBs, PAHs, dioxins, pesticides and metals).

7.5.3 Isolated Chemistry

Several COPCs that were detected in 5 percent or greater of the samples did not group with the major PCA factor groups previously discussed. These include:

- SVOCs (bis[2-ethylhexyl]phthalate)
- LPAHs
- PCBs (Aroclor 1254)
- Inorganics (zinc)
- 2,3,7,8-TCDD TEQ

These COPCs did not group with the other major factors for one or more of the following reasons:

- The frequency of detection was typically low.
- The distribution of contamination was different than observed for the compounds for the four major factors.

Each of these COPCs is discussed in the following sections. In addition, the nature and extent of dioxin/furans presented as 2,3,7,8-TCDD TEQ is discussed.

7.5.3.1 Bis(2-ethylhexyl)phthalate

This section presents the nature and extent of bis(2-ethylhexyl)phthalate (BEHP) in the bayou energy system in Bayou d'Inde and describes its fate and transport in the environment.

7.5.3.1.1 Results

Surface Sediment

Bis(2-ethylhexyl)phthalate is located throughout the bayou energy system in Bayou d'Inde (Figure 7-8). Concentrations are highly variable as evident by the high correlation coefficient (Exhibit 7-36).

Exhibit 7-36 Summary Statistics of BEHP (µg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
BEHP	64/98	66	80,000	1,573	10,314	6.6

1 – Values based on ROS. See Appendix D.

Station BIR1003 had the highest concentration at 80,000 µg/Kg, which is located near the mouth of the PPG Canal in Reach 1. Highest mean concentrations are in Reach 1 and Reach 3 at 6,447 (±22,747) µg/Kg and 560 (±1,414) µg/Kg, respectively. Reach 4 had comparable mean concentrations 458 (±376) µg/Kg as Reach 3, but had a lower coefficient of variance. This indicates that sediment concentrations are more consistent.

Subsurface Sediment

BEHP values in the subsurface varied, some locations were found to decrease with depth while others were found to increase. There was not a consistent depositional pattern (Figure 7-8). This may indicate fine-particle deposition and re-mobilization, indicating lower sediment stability.

Surface Water

BEHP was not detected in surface water in the bayou energy system in Bayou d'Inde.

7.5.3.1.2 Discussion

BEHP is present throughout Bayou d'Inde and its range of concentrations is variable. The highest individual and mean concentration is located near the mouth of PPG Canal in Reach 1. However the second highest mean concentration is found in Reach 3, due primarily to elevated levels near Reach 3 industrial outfalls. It appears that BEHP is binding to the suspended particle material and being transported by tidal activity and storm surge throughout the bayou.

Historically, BEHP has been found throughout Bayou d'Inde, and the maximum of 5,700 μg/Kg was detected in lower Reach 1 during the EPA Toxics study in June of 1988. However, levels one-half of that maximum were detected throughout Reaches 2 and 3. BEHP was detected at several locations above 1,000 μg/Kg in Reach 4, hundreds of meters upstream of Little Bayou d'Inde.

Potential sources of BEHP to Bayou d'Inde appear to be the areas near Citgo outfall 001, Westlake Polymers outfall 002B, and PPG Canal. The distribution of BEHP through Bayou d'Inde appears to be the result of significant small particle or colloidal size particle mobilization/transport. The upstream extent of BEHP supports this interpretation, e.g., the increasing TOC levels in Reaches 3 and 4 provide sorption sites for BEHP released into the system near LA-108. Results from the marshes in Reach 2 further support this interpretation. The increase in sediment concentration in Reach 1 downstream of PPG Canal, however, may indicate the addition of BEHP to the system.

7.5.3.2 LPAHs

This section presents the nature and extent of LPAHs in the bayou energy system in Bayou d'Inde and describes its fate and transport in the environment. LPAHs were calculated by summing the corresponding low molecular weight PAHs that were detected. Non-detects were not included in the summation due to elevated detection limits.

7.5.3.2.1 Results

LPAH contamination was located at 24 stations and was highly variable throughout the energy system (Exhibit 7-37).

Surface Sediment

LPAHs tend to concentrate in four areas in the bayou energy system: downstream of PPG Canal in Reach 1; in Maple Fork Bayou; downstream of LA-108; and downstream of I-10 (Figure 7-9).

Exhibit 7-37 Summary Statistics of LPAHs (µg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detect	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
LPAHs	24/98	5	3,737.8	427.7	901.3	2.1

1 – Values based on ROS. See Appendix D.

The highest LPAH concentration was observed at station BIST008 in Maple Fork Bayou.

Subsurface Sediments

LPAH concentrations varied in the subsurface with stations exhibiting different profiles (Figure 7-9). At stations BIR1003 and BIR1010 concentrations decrease from the surface sediment layer to the 10 to 20-cm layer and then increase in the 20 to 30-cm layer. The deeper interval had the highest observed concentrations ranging from 770 to 1,130 µg/Kg. BIR1012 and BIR3024 had similar gradients showing decreasing concentrations with depth. LPAH concentrations at station BIR1014 and BIR4015 increase in the 10 to 20-cm interval and then decrease in the 20 to 30-cm interval. At station BIR4015, LPAHs were not detected in the surface sediment.

Surface Water

LPAHs were not detected in the surface water in the bayou energy system of Bayou d'Inde.

7.5.3.2.2 Discussion

LPAHs in the bayou energy system of Bayou d'Inde were detected at 24 locations. Analytical results were highly variable, however, the LPAHs tend to concentrate in four areas: downstream of the PPG Canal in Reach 1, in Maple Fork Bayou, downstream of highway LA-108 and downstream of I-10. The highest concentration of LPAHs was in Maple Fork Bayou.

LPAHs in Reach 1 were found to have the highest concentrations at depth, generally the 20 to 30-cm horizon. In Reach 3 the concentrations tend to decrease with depth. One exception was sample location BIR4015, which did not contain LPAHs in the surface sediment (0-10 cm) interval, only at depth (in the 10 to 20-cm and 20 to 30-cm intervals) (Figure 7-9).

LPAH sources appear to be the Citgo outfall 001 area, Westlake Polymers outfall 001, area and the PPG Canal. LPAHs tend to be more soluble than many other PAHs and the relatively broad distribution, particularly notable in upper Reach 3 and lower Reach 4, may be an indicator of LPAH adsorption to suspended or particulate matter.

7.5.3.3 PCBs

This section presents the nature and extent of Aroclor 1254 and PCB congeners in the bayou energy system in Bayou d'Inde and describes its fate and transport in the environment.

7.5.3.3.1 Results

Surface Sediment

Aroclor 1254 did not correlate with other PCBs or contaminants in the bayou energy system in Bayou d'Inde. Exhibit 7-38 presents the summary statistics for Total PCBs. Appendix D includes the statistics for individual Aroclors.

Exhibit 7-38 Summary Statistics of Total PCBs (µg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detect	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Aroclor 1254	52/99	33	590	80.0	91.9	1.15

1 – Values based on ROS. See Appendix D.

Aroclor was frequently detected in Reach 3. Concentrations in this area range from 37 to 550 µg/Kg and had a higher mean concentration in comparison with the other reaches.

In Maple Fork Bayou, elevated concentrations were detected at station BIR3024 (Reach 2) and generally decreased in concentration moving downstream toward Bayou d'Inde. Concentrations range from 55 to 310 µg/Kg.

Aroclor 1254 was detected at high concentrations in Reach 1 downstream of PPG Canal to the Calcasieu River Ship Channel. Concentrations range from 33 to 260 µg/Kg.

Two dominant PCB congeners were observed in the bayou energy system in Bayou d'Inde. PCB-118, which tends to have elevated concentrations upstream of Reach 1, and PCB-15, which is more dominant in Reach 1. Figure 7-11 presents the PCB congener data for Bayou d'Inde.

Subsurface Sediment

Aroclor 1254 was detected in the subsurface at BIR3024 in Maple Fork Bayou. Concentrations range from 310 µg/Kg at the 0 to 10-cm, increases to 1,700 µg/Kg and then decreases to 460 µg/Kg.

In addition, at station BIR4015, Aroclor 1254 was detected in all three horizons. It was measured in the three intervals at 52, 4 and 280 µg/Kg, respectively. The maximum was noted in the 20 to 30-cm interval.

At station BIR1003, PCB-15 is the dominant congener in the surface layer and decreases with depth (Figure 7-11). At station BIR1010, PCB-118, PCB-15, PCB-61/70 and PCB-66 are the dominant congeners in the surface sediment. Values tended to decrease slightly in the 10 to 20-cm layer. In the 20 to 30-cm interval, some PCB congeners increase slightly with PCB-15 the dominant PCB congener at that interval (Figure 7-11).

The dominant congeners at station BIR1014 were the same as BIR1010 and decreased slightly in the 10 to 20-cm interval. However, the observed concentrations in the 20 to 30-cm interval were greater than found in BIR1010 at the same interval (Figure 7-11).

Dominant congeners at station BIR3024 include PCB-105, PCB-118, PCB-162, PCB-61/70 and PCB-66. The congeners are similar to that of Reach 1 with one exception; in BIR3024 PCB-15 was not a dominant congener. In addition, PCB congener concentrations increased in the 10 to 20-cm interval and decreased in the deeper layer.

Surface Water

Aroclor 1254 was not detected in the surface water in the bayou energy system in Bayou d'Inde. PCB congeners were not analyzed in surface water.

7.5.3.3.2 Discussion

Aroclor 1254 was detected in sediment downstream of Little Bayou d'Inde. Reach 3 had the greatest number of locations where it was detected, however, Reach 1 exhibited the highest concentration.

Occurrence with depth was variable at station BIR4015, with concentrations decreasing in the middle horizon and then increasing in the deeper interval. This may indicate scouring or movement of material due to flow entering Bayou d'Inde.

PCB congener profiles vary by reach in Bayou d'Inde. In Reach 1, the dominant congeners in surface sediment are PCB-15, PCB-61/70, PCB-66 and PCB-118. At depth in Reach 1, the dominant congener is PCB-15. Upstream at station BIR3024 the dominant congeners differ; where PCB-118 in surface sediment and PCB-105 in subsurface sediment were present and PCB-15 concentrations were insignificant. It appears that deposition of PCBs is ongoing, particularly in Reach 1, and the result of two different sources. The primary potential source of PCBs in Reach 3 appears to be the East and West Impoundments operated by OxyChem. The impoundments operated for several years and were closed in 1999 (CRA Services, 1999). The source of PCBs in Reach 1 may be the result of air deposition and/or storm runoff/surface water transport from the PPG TSCA incinerator.

Aroclor 1254 is not likely to desorb from sediments; the high sorption capability leads Aroclor 1254 to bind strongly to sediments. Aroclors are typically transported only through physical transport of the sediments to which they adsorb.

Historical Total PCB data indicates that concentrations have ranged from 160 to 22,200 µg/Kg. The maximum detection was in Reach 3 downgradient of the Citgo outfall 001 area, however positive detections were found throughout Reaches 1 through 3. Elevated concentrations tended to be most consistent in the PPG Canal. Aroclor or congener data is not available for historic data.

7.5.3.4 Zinc

This section presents the nature and extent of zinc in the bayou energy system in Bayou d'Inde and describes its fate and transport in the environment.

7.5.3.4.1 Results

Surface Sediment

Elevated zinc concentrations are located primarily in and downstream of Maple Fork Bayou and in Reach 3, upstream of LA-108 (Figure 7-12). Exhibit 7-39 presents the summary statistics and shows that concentrations are fairly consistent with a coefficient of variance of 0.6.

Exhibit 7-39 Summary Statistics of Zinc (mg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Zinc	87/99	39.7	700	177	107	0.6

1 – Values based on ROS. See Appendix D.

Reach 2 had the highest mean concentration (221 ±164 mg/Kg) and had the highest variability in concentration. Two areas that have the highest concentrations are in Maple Fork Bayou and an area 854 to 1,400 m downstream of the confluence of Maple Fork and Bayou d'Inde.

Subsurface Sediment

Zinc was detected at all the multi-depth locations with the exception of station BIR1014 (Figure 7-12). Zinc concentrations decreased in the subsurface with the highest concentration observed (209 mg/Kg) at station BIR3024 in the 20 to 30-cm interval.

Surface Water

Zinc was detected in surface waters samples in the bayou energy system in Bayou d'Inde. Exhibit 7-40 presents the mean total and dissolved concentrations and compares the values to LDEQ acute and chronic criterion.

Exhibit 7-40 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Metal Factor in Surface Water, Bayou Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Zinc	0.009 (0.003)	0.0134 (0.003)	0.205[2]	0.187[2]	0.090	0.081

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – *LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.*

Mean zinc concentrations did not exceed LDEQ criterion.

7.5.3.4.2 Discussion

Distribution of zinc in Bayou d'Inde is consistent with the occurrence of lead. Zinc is found at the confluence of Maple Fork Bayou, and upstream of LA-108. Mean and maximum concentrations for zinc are greater in comparison to concentration data from the reference area.

Zinc was found in previous studies in the same general areas as the RI. Historically, the highest concentration (771 mg/kg) was detected approximately 700 m downstream of Citgo outfall 001. Moderate concentrations (200 to 400 mg/Kg) were noted in Reach 2 downstream of the Maple Fork Bayou confluence and throughout Reach 1.

Sources appear to be the Citgo and Westlake Polymers outfall areas and PPG Canal. Zinc precipitates as hydroxides or carbonates and adsorbs to suspended and colloidal phase organic materials and transport via suspended bed load is common. The low coefficient of variability for zinc and its widespread distribution in Bayou d'Inde indicates that this may be occurring. Transport of these smaller particles increases where sediments are disturbed, as is common in Bayou d'Inde due to barge traffic.

7.5.3.5 2,3,7,8-TCDD TEQ

This section presents the nature and extent of 2,3,7,8-TCDD TEQ in the bayou energy system in Bayou d'Inde and describes its fate and transport in the environment. Dioxin/furans were evaluated as 2,3,7,8-TCDD TEQ solely, since various dioxins/furans are grouped with different factors.

7.5.3.5.1 Results

Surface Sediment

Elevated concentrations of 2,3,7,8-TCDD were located primarily in the lower reaches of Bayou d'Inde. The distribution of contamination is presented in Figure 7-13 with elevated concentrations found at BIR1004 (2,314 ρg/g) and BIR1010 (969 ρg/g); summary statistics are presented in Exhibit 7-41.

Exhibit 7-41 Summary Statistics of 2,3,7,8-TCDD TEQ (pg/g) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
2,3,7,8-TCDD TEQ	25/25	1.78	2,314	184	568	3.1

1 – Values based on ROS. See Appendix D.

Mean concentrations decrease from Reach 1 (651 ±1,014 pg/g) to Reach 4 (19 ±27 pg/g). Coefficient of variance ranges from between 1 and 1.5 for each of the reaches indicating there is limited variability in concentration in the reaches.

Subsurface Sediment

Concentrations of dioxin/furans expressed as 2,3,7,8-TCDD TEQ were typically lower in the subsurface samples (Figure 7-13). Station BIR1012 had concentrations that increased slightly from the 10 to 20-cm interval to the 20 to 30-cm interval. The next highest TEQ concentration was observed in BIR1012 just downstream of BIR1010 with a detection of 251 pg/g. At station BIR3024, concentrations increased from the surface to the 10 to 20-cm interval and then decreased. Highest observed subsurface concentration was at the 10 to 20-cm interval at station BIR3024 with a result of 119 pg/g.

Surface Water

Dioxin/furans were not analyzed in surface water.

7.5.3.5.2 Discussion

Dioxin/furans expressed as 2,3,7,8-TCDD TEQ provide a unified picture of the area that may exhibit elevated concentrations in comparison to background values observed in the reference area.

Elevated concentrations were noted in the lower reaches of Bayou d'Inde (from 969 to 2,314 pg/g), however dioxin/furan TEQ were also noted in Reach 3. Distribution indicates that the most elevated concentrations are located in Reach 1. Concentrations decreased with depth in Reach 1. Concentrations were highest in Reach 3 in the 10 to 20-cm interval (119 pg/g).

Dioxin/Furans were not analyzed in previous studies, limiting temporal variability discussions. As noted previously, dioxin/furans bind to sediments and are transported only through physical transport of the sediments to which they adsorb.

7.6 Nature and Extent of the Marsh Energy System

The results and discussion section is organized into four sections: COPCs identified for the marsh energy system (Section 7.6.1), the results of the PCA (Section 7.6.2), and isolated contaminants that showed little or no correlation to other contaminants or parameters (Section 7.6.3).

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix D provides details of the PCA and complete summary statistics for all compounds detected in the marsh energy system in Bayou d'Inde.

7.6.1 COPCs for the Marsh Energy System in Bayou d'Inde

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. These energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 7.6.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 7.6.1.2 presents the marsh energy system COPCs identified.

7.6.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 7-11. Contaminant concentrations that were determined to have a statistically significant difference when compared to reference area concentrations are:

- SVOCs (BEHP, HCB, and HCBD)
- PAHs (as pyrene)
- PCBs (as Aroclor 1254)
- Pesticides (aldrin and dieldrin)
- Dioxin/Furans (as 2,3,7,8 TCDD TEQ)
- Inorganics (arsenic, barium, chromium, copper, lead, mercury and zinc)

7.6.1.2 COPCs Selection

Energy system specific COPCs for Bayou d'Inde were selected by determining if the COPC is a risk driver in the HHRA or the BERA and the concentration was determined to have a statistically significantly difference when compared to reference area conditions (Table 7-13). The follow COPCs were selected for the marsh energy system in Bayou d'Inde:

- SVOCs (BEHP, HCB, HCBD)
- PAHs (as LPAH and HPAHs)
- Pesticides (aldrin and dieldrin)
- PCBs

- Dioxin/Furans
- Inorganics (arsenic, chromium, copper, lead, mercury, and zinc)

The nature and extent as well as the fate and transport of these COPCs will be discussed in Sections 7.6.2 (PCA) and 7.6.3 (Isolated Chemistry).

7.6.2 PCA

The PCA revealed two dominant factors that accounted for most of the variability (59%) in marsh area surface sediment within Bayou d'Inde. These factors are:

- Medium to high-level concentrations of furans, dioxins and metals (Furan/Dioxin/Pesticide/Metal Factor) that accounts for 25 percent of the variability.
- Medium to high-level concentrations of metals and dioxins (Metal/Dioxin Factor) that accounts for 21 percent of the variability.
- Background physical or major cations (Background Factor) that accounted for 13percent of the variability, but does not group any COPCs.

The Furan/Dioxin/Metal and Pesticide Factors are discussed below. The Background Factor is not be discussed since they do not describe the nature or extent of COPCs in the marsh energy system.

7.6.2.1 Furan/Dioxin/Metal Factor

This section presents the extent of the Furan/Dioxin/Metal factor and discussion as to the fate and transport of contaminants in this factor.

7.6.2.1.1 Results and Extent

The Furan/Dioxin/Metal Factor is comprised of several dioxin/furans, metals, and a SVOC. This represents medium to high concentrations and controls 25 percent of the variance in the marsh energy system in Bayou d'Inde. Summary statistics for the parameters that group within this factor are presented in Exhibits 7-42 through 7-45.

Exhibit 7-42 Summary Statistics of Dioxin/Furans (pg/g) in Furan/Dioxin/Pesticide/Metal Factor in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Total PeCDF	23/23	40	14,100	1,487	3,513	2.36
Total HxCDF	23/23	34	18,600	2,089	4,606	2.20
Total TCDF	23/23	77	8,150	1,372	1,931	1.41
Total HpCDF	23/23	98	14,900	2,518	4,121	1.64
Total TCDD	22/23	4	163	34.5	45.3	1.31
OCDF	22/23	310	41,700	7,362	12,293	1.67

1 – Values based on ROS. See Appendix D.

Exhibit 7-43 Summary Statistics of Pesticides (µg/Kg) in Furan/Dioxin/Pesticide/Metal Factor Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Endosulfan Sulfate	45/110	0.86	150	5.04	18.8	3.72
Aldrin	25/109	0.35	320	5.8	41.0	7.07
Beta-BHC	40/109	1.5	480	13.7	58.0	4.23
4,4'-DDE	26/110	0.67	120	3.5	15.9	4.6
Gamma-BHC	4/109	8	30	-	-	-
4,4'-DDD	22/109	0.61	120	4.8	14.5	3.0

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 7-44 Summary Statistics of Metals (mg/Kg) in Furan/Dioxin/Pesticide/Metal Factor Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Copper	161/162	7.1	943	126	155	1.23
Nickel	150/162	5.1	110	22	16	0.74

1 – Values based on ROS. See Appendix D.

Exhibit 7-45 Summary Statistics of PAHs (µg/Kg) in Furan/Dioxin/Pesticide/Metal Factor Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
1,2-benzphenanthracene	28/160	110	10,400	-	-	-

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Nickel was used as the indicator variable for the constituents in this factor.

Surface Sediment

Contamination by dioxins, furans, pesticides, metals and the PAH, 1,2-benzphenanthracene (1,2-BPA) was observed at sampling locations in the marsh areas of Bayou d'Inde (Figure 7-4). Areas with the highest concentrations include the surrounding area near the mouth of PPG Canal and the interior portions of Lockport Marsh. Elevated concentrations tend to be located near PPG Canal and decrease moving towards the Calcasieu River Ship Channel within Lockport Marsh. Maximum concentrations are typically located at BIST011, which is located in Lockport Marsh near the mouth of PPG Canal. The western half of Lockport Marsh (across Bayou d'Inde) was observed to have elevated concentrations in the northwest corner and decreases toward Bayou d'Inde and the Calcasieu River Ship Channel.

The fringe marshes along the bayou have variable concentrations, but in general tend to decrease upstream from PPG Canal.

Subsurface Sediment

Copper concentrations decreased in the subsurface with the exception of station BIR3046. Concentrations increased from the 10 to 20-cm to the 20 to 30-cm interval. Highest observed subsurface copper concentration was at the 20 to 30-cm interval at station BIR3046 with a result of 692 mg/Kg (Figure 7-5).

Dioxin/furans in the subsurface are discussed as 2,3,7,8-TCDD TEQ in Section 7.5.4.8.

Surface Water

Copper and nickel were detected in both the total and dissolved phase in the marsh energy system. Exhibit 7-46 Presents the mean and standard deviation and compares the concentrations to LDEQ's acute and chronic criterion.

Exhibit 7-46 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Furan/Dioxin/Pesticide/Metal Factor in Surface Water, Marsh Energy System

Analyte	Mean Total^{1}	Mean Dissolved^{1}	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Copper	0.0159 (0.0138)	0.0056 (0.0013)	0.035^{2}	0.022^{2}	**0.00363**	**0.00363**
Nickel	0.0074 (0.0011)	0.0064 (0.0011)	2.49^{2}	0.279^{2}	0.074	0.0082

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.

Dissolved copper concentrations exceeded both the marine acute and chronic criteria in the marsh energy system. The maximum concentration of copper detected was 0.0079 mg/L at station BIR2068.

Dioxin/furans were not analyzed and pesticides/PAHs were not detected in surface water within the marsh energy system in Bayou d'Inde.

7.6.2.1.2 Discussion

Primary occurrence of dioxin/furans in Bayou d'Inde marshes is in Lockport Marsh, however, dioxin/furan were detected in marshes adjacent to Maple Fork Bayou. The highest concentrations were noted at the confluence of PPG Canal, Bayou d'Inde and Lockport Marsh and included total HpCDF, total HxCDF, total PeCDF, total TCDD, OCDF, and nickel. The marsh adjacent to Maple Fork Bayou (station BIR3018) contained the second highest concentrations. The remaining marsh areas were generally an order of magnitude less in concentration.

Copper and nickel concentrations correlated with the dioxin/furans, highest detections were in Lockport Marsh and the Maple Fork Bayou Marsh, as well. Nickel and copper values were higher in the marshes than those measured in the bayou (maximum of 943 mg/Kg in the marsh versus 280 mg/Kg measured in the in the bayou). Dioxin/furans were not sampled at depth in the marshes.

Metals tend to decrease with depth in the Bayou d'Inde marshes. There was one exception, the marsh in middle Reach 2 at BIR3046, located between Maple Fork

Bayou and PPG Canal. The highest copper concentration noted was in the 20 to 30-cm interval in this Reach 2 marsh.

Various pesticides correlated with dioxins and metals and their distribution is generally slightly higher in the marshes than the bayou. Vertical distribution of pesticides was not observed.

Dioxin/furans were not analyzed in previous studies. Maximum copper concentrations have been comparable to that observed in the RI (613 compared to 692 mg/Kg in the RI), whereas nickel was higher in concentration in comparison to previous studies (a maximum of 62 mg/Kg in previous studies compared to 110 mg/Kg in the RI).

Overall, the copper and nickel concentrations appear to be highest in the vicinity of BIR3046 (Reach 2) marsh and Lockport Marsh. This would indicate that these two marshes are contaminant sinks for Reach 3 and Reach 1 dioxin/furan, copper and nickel releases.

Concentrations of 1,2-BPA, which were measured at a maximum of 10,400 µg/Kg in Lockport Marsh and at 4,600 µg/Kg in Reach 1 of Bayou d'Inde indicate that Lockport Marsh is a sink for 1,2-BPA. It is noteworthy that the compound is also largely absent from the remaining marshes, although it is present in Reaches 1 through 3. Lockport Marsh tends to have the highest concentration of TOC and detritus, which may be influential in adsorbing HPAHs.

1,2-BPA is not expected to desorb from the organic rich sediments in Lockport Marsh. It appears to be most concentrated in the 10 to 20-cm interval, and it is expected, along with the majority of PAHs, to remain at these concentrations. Major storm surge may be capable of disturbing and mobilizing the upper 10 cm of sediment in Lockport Marsh, given its proximity to the ship channel and limited seclusion in the lower portion of the area.

7.6.2.2 Metal/Dioxin Factor

This section presents the extent of the Metal/Dioxin Factor and discussion as to the fate and transport of contaminants in this factor. Dioxin/furans in the subsurface are discussed as 2,3,7,8-TCDD TEQ in Section 7.6.4.7.

7.6.2.2.1 Results

The Metal/Dioxin Factor is comprised primarily of metals and includes total HpCDD and total HxCDD. This factor represents 21 percent of the variability in the marsh energy system. Summary statistics for the parameters that group within this factor are presented in Exhibit 7-47 through 7-48.

Exhibit 7-47 Summary Statistics of Metals (mg/Kg) in Metal/Dioxin Factor in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Iron	148/149	772	28,300	11,626	4,960	0.43
Beryllium	126/149	0.24	2.4	0.76	0.27	0.35
Cobalt	123/149	1.6	10.2	5.5	1.8	0.33
Zinc	151/162	9.9	468	148	99	0.67
Aluminum	149/149	956	25,200	11,159	4,900	0.44
Vanadium	149/149	1.8	34.1	18.1	5.9	0.33
Potassium	142/149	818	3,680	2,201	612	0.28
Cadmium	23/162	0.074	3.8	-	-	-
Chromium	149/149	2.8	774	102	129	1.26

1 – Values based on ROS. See Appendix D.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 7-48 Summary Statistics of Dioxins (pg/g) in Metal/Dioxin Factor in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Total HpCDD	23/23	110	2,700	850	725	0.85
Total HxCDD	23/23	17	1,500	306	357	1.17

1 – Values based on ROS. See Appendix D.

Zinc was used as the indicator variable for this factor.

Surface Sediment

Elevated concentrations of contaminants grouped within the Metal/Dioxin Factor were observed in both Lockport Marsh and the fringe marshes located along the bayou (Figure 7-14). Three areas that exhibited high concentrations include the Lockport Marsh area surrounding the mouth of PPG Canal, the interior of Lockport Marsh, and the fringe marshes located adjacent to and across from Maple Fork Bayou.

Highest concentrations were observed in the fringe marshes near Maple Fork Bayou although elevated concentrations were observed in all fringe marshes. Within Lockport Marsh, concentrations decrease sharply moving towards the Calcasieu River Ship Channel.

Subsurface Sediment

Zinc concentrations decreased in the subsurface in the marshes of Bayou d'Inde as shown in Figure 7-14. Zinc at station BIR3018 did increase in concentration from the 10 to 20-cm to the 20 to 30-cm interval (from 64 to 92 mg/Kg). The highest zinc concentration observed in the subsurface was at BIR3046 with a result of 145 mg/Kg.

Chromium concentrations tend to decrease in the subsurface in the marsh energy system in Bayou d'Inde. At station BIR3018, however, concentrations increase from the 10 to 20-cm interval to the 20 to 30-cm interval. Concentration for this interval at station BIR3018 was 290 mg/Kg.

Surface Water

Zinc and chromium were detected in the surface water in the marsh energy system in Bayou d'Inde. Exhibit 7-49 provides the mean concentrations for total and dissolved chromium (total) and zinc.

Exhibit 7-49 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Metal/Dioxin Factor in Surface Water, Marsh Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Chromium (total)	0.0036 (0.0114)	ND	NA	NA	NA	NA
Zinc	ND	0.01[2]	0.205[3]	0.187[3]	0.090	0.081

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected at one location.
3 – LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.
NA – Not available. LDEQ provides criteria for Cr^{3+} and Cr^{6+}.

Chromium (total) and zinc did not exceed criteria listed in LDEQ 2000.

7.6.2.2.2 Discussion

As noted earlier, dioxin/furans are discussed as a group for the marsh area as 2,3,7,8-TCDD TEQ concentrations. The following discussion will focus on chromium and zinc.

The distribution of metals (specifically chromium and zinc) is fairly widespread throughout the marshes. Chromium is found to be highest in the fringe marshes near Maple Fork Bayou. Chromium concentrations tend to decrease with depth, being highest in the surface sediments. Zinc concentrations tend to be lower overall than chromium, however the number of positive detections of zinc is slightly higher.

7.6.3 Isolated Chemistry

Several COPCs were detected in 5 percent or greater of the samples did not group with the three major PCA factor groups previously discussed. These include:

- SVOCs (bis[2-ethylhexyl]phthalate, hexachlorobenzene)
- HPAHs and LPAHs
- PCBs
- Inorganics (lead and mercury)

These COPCs did not group with the other major factors for one or more of the following reasons:

- The frequency of detection is typically low
- The distribution of contamination was different than observed for the compounds for the four major factors

Each of these COPCs is discussed in the following sections. In addition, the nature and extent of dioxin/furans presented as 2,3,7,8-TCDD TEQ is discussed.

7.6.3.1 Bis(2-ethylhexyl)phthalate

This section presents the results of BEHP in the marsh energy system of Bayou d'Inde and discusses the fate and transport of this compound.

7.6.3.1.1 Results

BEHP summary statistics for surface sediment are provided in Exhibit 7-50.

Exhibit 7-50 Summary Statistics of BEHP (µg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
BEHP	83/162	58	8,000	393	865	2.20

1 – Values based on ROS. See Appendix D.

Highest concentration was observed at station BIR2042, which is located in Lockport Marsh (Figure 7-8). Elevated concentrations are also located in the marsh areas between PPG Canal and Maple Fork Bayou.

Subsurface Sediment

BEHP was only detected in the subsurface at only one location, station BIR2072. Concentrations decreased from the surface to the 10 to 20-cm interval (1,100 µg/Kg to non-detect). However, concentrations increased dramatically to 150,000 µg/Kg in the 20 to 30-cm interval.

Surface Water

BEHP was not detected in the surface water in the marsh energy system of Bayou d'Inde.

7.6.3.1.2 Discussion

BEHP was detected in the marsh at a maximum of 8,000 µg/Kg. The maximum was located in Lockport Marsh. The distribution in Lockport Marsh is scattered, no significant trends are apparent. Remaining detections appear to show a trend, the southern most Reach 2 marsh containing stations BIR3054 through BIR3062 contained the greatest number of detections and the second highest concentration. The marsh across Bayou d'Inde (locations BIR3045 through BIR3050) contained the third highest marsh concentration in Bayou d'Inde. This meander in Reach 2 is the main collection point of BEHP that originates upstream. It should be noted however, that the concentrations within the bayou energy system were an order of magnitude higher than those measured in the marshes (80,000 in the bayou, Reach 1 near the mouth of PPG Canal and 8,000 µg/Kg measured in the center of Lockport Marsh, versus 3,900 µg/Kg measured in Reach 2 Marsh).

Limited historic data was collected specifically in the marsh areas. The two available marsh samples collected from the Reach 2 southern marsh area both were non-detect with elevated (1,800U and 2,000U µg/Kg) detection limits.

Potential sources appear to be the Citgo outfall 001 area, and PPG Canal. The concentrations within the bayou portion of d'Inde with the exception of Reach 1 were less than that measured in the Reach 2 marshes. The distribution of BEHP in Lockport Marsh and Reach 1 appear unrelated. The BEHP appears to be adsorbing to bayou sediments versus settling out into Lockport Marsh. This indicates that sufficient quantity of organic material is present within Reach 1 of the bayou to bind available BEHP. Surface water data indicates that the sorption capacity is sufficient to bind BEHP to sediment.

7.6.3.2 Hexachlorobenzene

This section presents the results of hexachlorobenzene (HCB) in the marsh energy system of Bayou d'Inde and discusses the fate and transport of this compound.

7.6.3.2.1 Results

HCB summary statistics for surface sediment are provided in Exhibit 7-51.

Exhibit 7-51 Summary Statistics of HCB (µg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
HCB	10/162	130	790	-	-	-

1 – Values based on ROS. See Appendix D.
(-) – Mean value is not calculated for less than 20% detected due to estimation of distribution becomes less accurate.

HCB was observed at isolated in Lockport Marsh and the marsh area to the north of PPG Canal. However, there is uncertainty in the extent of HCB in the marsh areas resulting from elevated analytical detection limits (Figure 7-15). Elevated detection limits and non-detectable concentrations in many locations exceed maximum detected concentrations. Highest concentration observed was at station BIR2088, which is located in the northwest corner of Lockport Marsh.

Subsurface Sediment

HCB was not detected in subsurface samples in the marsh energy system in Bayou d'Inde.

Surface Water

HCB was not detected in surface water in the marsh energy system in Bayou d'Inde.

7.6.3.2.2 Discussion

The occurrence of HCB in marsh sediment is limited to Lockport Marsh. The range of concentrations of 130 to 790 μg/Kg is an order of magnitude less than the bayou energy system, indicating that Lockport Marsh may receive flow from Reach 1 but is not a sediment sink for HCB. The distribution within Lockport Marsh indicates that there may be two sources of HCB to Lockport Marsh. It appears that the maximum may be influenced by flow from Bayou d'Inde, communication between the marsh and bayou is apparent in this area. The remaining low level detections (130 to 240 μg/Kg) are more isolated from the bayou and may have been sourced by overflow of PPG Canal, as they are in the northeastern portion of the marsh, isolated from Reach 1.

The sediments in the isolated portions of Lockport Marsh are less likely to be disturbed by minor storm surge or high spring tides than are the sediments adjacent to the bayou. The HCB sorbs readily to sediment, as was noted by the lack of HCB in marsh surface water, however, disturbance of those sediments could result in mobilization of the HCB.

Historically, HCB was found to be in the same areas of Reach 1 and Lockport Marsh, however the concentrations were higher from 1984 through 1994. Surface sediment concentrations were found to decrease in 1996 and those concentrations are comparable to measurements from the RI.

7.6.3.3 PAHs

This section presents the results of PAHs in the marsh energy system of Bayou d'Inde and discusses the fate and transport of this compound. PAHs were calculated by summing the corresponding low or high molecular weight PAHs that were detected. Non-detects were not included in the summation due to elevated detection limits.

7.6.3.3.1 Results

HPAHs and LPAHs were summed for the marsh energy system in Bayou d'Inde as described in Section 4. PAHs summary statistics for surface sediment are provided in Exhibit 7-52.

Exhibit 7-52 Summary Statistics of PAHs (μg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum *Detected* Value	Maximum *Detected* Value	*Mean*[1]	Standard Deviation	Coefficient *of* variance
HPAH	50/160	61	66,884	2,917.7	12,089.7	4.1
LPAH	21/160	26	73,800	6,511.3	2,0106.5	3.1
TPAH	53/160	26	73,800	5332.5	15,699.9	2.9

1 – Values based on ROS. See Appendix D.

Elevated HPAH concentrations were located throughout the marsh areas in Bayou d'Inde (Figure 7-16). Highest HPAH concentration was observed at station BIR2020 in the northern portion of Lockport Marsh.

Similar to HPAH, highest LPAH concentration was observed at station BIR2020 (Figure 7-17). Elevated concentrations were not as widespread as HPAHs, but were at greater concentrations and were less variable.

Subsurface Sediment

HPAHs were detected in the subsurface at stations BIR3018 and BIR3046 (Figure 7-16). At station BIR3018, concentrations were similar ranging from 53 to 82 µg/Kg. At station BIR3046, HPAHs were not detected in the surface layer, but were detected at the 10 to 20-cm interval with a concentration of 1,180 µg/Kg.

Surface Water

PAHs were not detected in the surface water in the marsh energy system of Bayou d'Inde.

7.6.3.3.2 Discussion

PAH distribution in the Bayou d'Inde marshes consists primarily of HPAH compounds, as noted in the bayou. The primary PAH compound in the marshes is pyrene. The concentrations are most notable in the Maple Fork Bayou and downstream Reach 2 marshes (stations BIR3018, BIR3036 and BIR3067). Marsh concentrations of TPAHs are higher in the marshes than those measured in the bayou portion Bayou d'Inde (73,800 µg/Kg marsh maximum versus 3,737 µg/Kg maximum in the bayou). Concentrations tend to be highest within the interior of Lockport Marsh, indicating possible flow from the PPG Canal. This is noted for LPAH and HPAH groups. Concentrations within the Maple Fork Bayou and downstream Reach 2 marshes are elevated, however, lower than measurements in Lockport Marsh. Potential sources of low and high molecular weight PAHs to Bayou d'Inde include Citgo (LPAHs), Equistar (LPAHs), and Westlake Polymers (LPAHs and HPAHs). Further, oil and gas production activities in Lockport Marsh may be localized sources of PAHs.

Historically, the distribution and contaminant suites were similar, although concentrations were generally higher. Vertically, PAH distribution varies from the marsh at Maple Fork Bayou to the marsh at station BIR3046 in Reach 2. At Maple Fork Bayou the concentrations are generally consistent with depth, however downgradient at station BIR3046 the concentration increase from non-detect at the surface to a maximum of 1,180 µg/Kg in the 10 to 20-cm interval. This may indicate that there are more sources that are recent closer to this upstream location. Vertical extent was not sampled in Lockport Marsh.

Potential sources of PAHs to Bayou d'Inde marshes appear to be the Citgo outfall 001 area, Westlake Polymers outfall 001 area and the PPG Canal.

7.6.3.4 PCBs

This section presents the results of PCBs in the marsh energy system of Bayou d'Inde and discusses the fate and transport of this compound.

7.6.3.4.1 Results

Surface Sediment

Aroclor 1254 and Aroclor 1260 were detected in the marsh energy system in Bayou d'Inde. Aroclor 1260, however, was only detected at two locations with concentrations ranging from 120 to 140 µg/Kg. Aroclor 1254 had a higher detection frequency and the summary statistics are presented in Exhibit 7-53.

Exhibit 7-53 Summary Statistics of Aroclor 1254 (µg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Aroclor 1254	49/111	4.9	1,300	116	235	2.04

1 – Values based on ROS. See Appendix D.

Elevated concentrations of Aroclor 1254 were predominantly located in the fringe marshes in Reach 2 (Figure 7-10). Concentrations tend to decrease in the marshes moving downstream towards the Calcasieu River Ship Channel and into Lockport Marsh. Aroclor 1254 was only detected at 13 locations within Lockport Marsh with concentrations less than what was observed in the upper reaches of Bayou d'Inde. Station BIR3018 was observed to have the maximum concentration and is located in a fringe marsh adjacent to Maple Fork Bayou. Stations BIR3007 and BIR3041 were observed to have similar concentrations.

PCB-105, 118, 15, 61/70, and 66 accounted for more than 70 percent of total PCB concentration at stations in the marsh energy area where congeners were measured (Figure 7-11). PCB-118 and PCB-15 tended to be the more dominant congeners. Distribution in the surface sediment tends to show a prevalence of either PCB-118 or PCB-15. In the upper marshes (e.g., BIR3018) PCB-118 accounts for 37% of the PCBs detected. At location BIST011, PCB-15 accounted for 35%. This trend tends to reverse near BIR3046.

Subsurface Sediment

Aroclor 1254 was measured in the subsurface at stations BIR3018 and BIR3046 (Figure 7-10). At station BIR3018, concentrations decreased with depth from 1,300 µg/Kg in surface sediment to 910 µg/Kg in the 10-20 cm interval and finally to 650 µg/Kg in the 20 to30-cm interval. At station BIR3046, concentrations decreased from 810 µg/Kg in surface sediment to 620 in the 10 to -20-cm interval and finally to 310 in the 20 to 30-cm interval.

Elevated PCB congener concentrations were observed at stations BIR3018 and BIR3046 (Figure 7-11). The dominant congeners were PCB-105, PCB-118, PCB-61/70, and PCB-66 at both locations. PCB-15 was also a dominant congener at station BIR3046, but detected at low concentrations at station BIR3018.

At station BIR3018, PCB congener concentrations increased from the surface sediment interval to the 10 to 20-cm interval. Concentrations then decreased to near surface sediment levels. PCB-118 was the dominant congener in all three depths with a maximum concentration of 125,000 ng/Kg at the 10 to 20-cm interval.

At station BIR3046, PCB congener concentrations tended to decrease with depth for the dominant congeners. The dominant congener in surface sediment was PCB-15 with a concentration of 69,100 ng/Kg.

Surface Water

Aroclor 1254 was detected at station BIR3013, which is located in the Maple Fork Bayou marsh, upstream of Maple Fork Bayou. Surface water concentrations are compared to established criteria in Exhibit 7-54.

Exhibit 7-54 Aroclor 1254 in Surface Water, Marsh Energy System

Analyte	Mean[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Aroclor 1254	0.21[2]	2.00	**0.0140**	10.0	**0.03**

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected at one location.
3 – Criteria for Total PCBs

The reported result exceeded the fresh and marine chronic criterion established by LDEQ.

7.6.3.4.2 Discussion

Aroclor 1254 detected within the fringe marshes of Bayou d'Inde was widespread. The highest concentration noted was found upstream of Maple Fork Bayou and continued to downstream marshes in Reach 2 (primarily on the south side of Bayou d'Inde). The concentrations decreased downstream. The concentrations are higher than what was measured in the bayou energy system. This may indicate that material is moved from the bayou to the marshes by surge or storm events and that there are not considerable ongoing releases adding PCBs to the system in Reach 2. This is consistent with release history information. The concentrations vary in Lockport Marsh and there appears to be downstream movement in Reach 1 of the bayou.

Historically, the distribution of total PCBs was similar to previous sampling events. Aroclor 1254 decreased with depth at both core locations in the fringe marshes. Core locations were not collected in Lockport Marsh. Congener analysis indicates that near Maple Fork bayou the dominant congener is PCB-118 (maximum value of 125,000 ng/g), whereas at station BIR3046 downstream, the dominant congener is PCB-15 (maximum value of 69,100 ng/g). This may indicate that the PCB-118 source was nearer to station BIR3018 and material has moved downstream, collecting in the Reach 2 marshes. Cores were not sampled in Lockport Marsh.

Aroclor 1254 was detected at 0.21 µg/L at station BIR3013, at the Maple Fork Bayou marsh. It is unlikely, due to the nature of Aroclor 1254 that this aqueous detection is the result of desorption from impacted sediments and may be the result of an unknown localized release.

The former OxyChem impoundments Reach 3 industrial area and the PPG Canal may be potential sources of PCBs in Bayou d'Inde.

7.6.3.5 Lead

This section presents the nature and extent of lead in the marsh energy system in Bayou d'Inde and describes its fate and transport in the environment.

7.6.3.5.1 Results

Surface Sediment

Lead, although present throughout the marshes, was found in the highest concentrations in Lockport Marsh (Figure 7-18). Summary statistics for lead is presented in Exhibit 7-55.

Exhibit 7-55 Summary Statistics of Lead (mg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Lead	153/162	4.6	902	87	117	1.3

1 – Values based on ROS. See Appendix D.

Within Lockport Marsh, elevated lead concentrations were typically found near the mouth of PPG Canal and near the center of the marsh. The highest concentration was located at station BIR2044, which is located between the roads in the marsh and the Calcasieu River Ship Channel.

Subsurface Sediment

In the subsurface, lead tended to decrease with depth (Figure 7-18). Station BIR3046 exhibited the highest subsurface concentration (64.5 mg/Kg) in the 10 to 20-cm interval.

Surface Water

Total lead was detected at 7 of 8 locations whereas dissolved lead was detected at 3 of 8 locations. Exhibit 7-56 presents the mean concentrations for total and dissolved lead and compare to LDEQ criterion.

Exhibit 7-56 Mean & Standard Deviation of Total and Dissolved Concentrations Lead (mg/L) in Surface Water, Marsh Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Lead	0.0030 (0.0011)	0.0015 (0.0011)	0.138[3]	0.00531[3]	0.209	0.00808

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected in one sample.
3 – LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.

Dissolved concentrations of lead in surface water did not exceed criterion established by LDEQ.

7.6.3.5.2 Discussion

Lead distribution tends to be highest in Lockport Marsh followed by the middle Reach 2 marshes (station BIR3060). Lockport Marsh detections tend to be concentrated near the mouth of PPG Canal or in the center of the marsh. The maximum location within Lockport Marsh is isolated somewhat away from the PPG Canal and the bayou. The location likely receives flow from the Calcasieu River Ship Channel. Concentrations tend to exceed the reference area lead results.

Lead concentrations decrease with depth in all multi-depth samples. Surface water samples do not exceed CCC or CMC adjusted limits.

7.6.3.6 Mercury

This section presents the nature and extent of mercury in the marsh energy system in Bayou d'Inde and describes its fate and transport in the environment.

7.6.3.6.1 Results

Elevated mercury concentrations were primarily in Lockport Marsh (Figure 7-20). The high variability of mercury in sediment may be possibly due to the maximum detected value (Exhibit 7-57).

Exhibit 7-57 Summary Statistics of Mercury (mg/Kg) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
Mercury	145/162	0.11	93.9	2.7	9.3	3.5

1 – Values based on ROS. See Appendix D.

Station BIR2013 in Lockport Marsh had a detected value of 94 mg/Kg. This station is located near the mouth of PPG Canal where it enters into Bayou d'Inde. The next highest concentration of mercury is at station BIR2023 with a detected value of 13 mg/Kg.

Subsurface Sediment

Mercury concentrations decreased with depth as shown in Figure 7-20. Station BIR3046 had the highest detected concentration (1.4 mg/Kg) in the 10 to 20-cm interval.

Surface Water

Total mercury was detected at 8 of 8 locations within the marsh energy system whereas dissolved mercury was only detected at one location. Mean concentrations are presented in Exhibit 7-58.

Exhibit 7-58 Mean & Standard Deviation of Total and Dissolved Concentrations (mg/L) in Metal Factor in Surface Water, Marsh Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Mercury	*0.00017 (0.0009)*	*0.000078*[2]	*0.0017*[3]	*0.00001*[3]	*0.0017*	***0.000021***

1 – Based on ROS. See Appendix D. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected in one sample.
3 – LDEQ Water Quality Regulations (LDEQ 2000) based on 200 mg/L hardness for dissolved concentrations.

Dissolved concentrations of mercury did not exceed LDEQ established criterion.

7.6.3.6.2 *Discussion*

Mercury concentrations within the marshes are elevated in Lockport Marsh and Maple Fork Marsh. The most significant detection was noted near the mouth of PPG Canal and measured 93 mg/Kg. The remaining values were not significantly elevated. The second highest marsh detection was noted in Maple Fork Bayou at 12 mg/Kg. The remaining values were fairly consistent, with concentrations ranging from 1 to 3 mg/Kg. Historical results are similar, including a maximum of 58 mg/Kg. The maximum measured concentrations at station BIR2013 and the isolated nature of the area in Lockport Marsh suggest a source other than the PPG Canal or Bayou. Local oil field operations (i.e., gas well monometers) may have contributed to localized elevated mercury detections.

Mercury tends to accumulate in the marsh areas; in general the concentrations are higher in the marshes than those noted for the bayou energy system. Also, elevated concentrations are typically surficial occurrences.

7.6.3.7 2,3,7,8-TCDD TEQ

This section presents the nature and extent of 2,3,7,8-TCDD TEQ in the marsh energy system in Bayou d'Inde and describes its fate and transport in the environment. Dioxin/furans were evaluated as 2,3,7,8-TCDD TEQ since various dioxins/furans are grouped with different factors. In addition, some dioxin/furans may be at background concentrations and this will provide an overall picture of areas that may exhibit elevated concentrations of dioxin/furans.

7.6.3.7.1 Results

Surface Sediment

The concentrations of 2,3,7,8-TCDD TEQ are variable in the marsh areas of Bayou d'Inde (Exhibit 7-59). Elevated concentrations were found in the marshes adjoining the bayou and in Lockport Marsh (Figure 7-14). The maximum concentration was detected at station BIST011, which is at the mouth of PPG Canal prior to it entering into Bayou d'Inde.

Exhibit 7-59 Summary Statistics of 2,3,7,8-TCDD TEQ (ρg/g) in Surface Sediment, Marsh Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of variance
2,3,7,8-TCDD TEQ	24/25	1.16	1,645.65	201.85	397.17	1.97

1 – Values based on ROS. See Appendix D.

Subsurface Sediment

Dioxin/furans as expressed as 2,3,7,8-TCDD TEQ typically decreased with depth with the exception of station BIR3018 (Figure 7-14). At station BIR3018, concentrations slightly increased with depth from 33 to 57 ρg/g. Station BIR3046 had the highest subsurface detection at the 10 to 20-cm interval with a value of 201 ρg/g.

Surface Water

Dioxin/furans were not analyzed in surface water.

7.6.3.7.2 Discussion

2,3,7,8-TCDD TEQ values are variable in Bayou d'Inde, however, they tend to be highest at the mouth of PPG Canal. Concentrations in core samples tend to decrease with depth. One exception is Maple Fork Bayou where concentrations increased slightly. Concentrations at depth generally approximate the surface sample mean. Concentrations are slightly higher in the marshes than values measured for the bayou. Dioxin concentrations in general are elevated in Lockport Marsh and may be attributed to the local operation of industrial incinerators. Localized surface deposition of air emissions impacting surface run-off into the PPG Canal and subsequently Lockport Marsh.

Historically, dioxin/furans data was not collected. No temporal comparison is available for 2,3,7,8-TCDD TEQ.

7.7 Summary and Conclusions

This section summarizes the COPCs found in Bayou d'Inde and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability and chemical fate and transport.

7.7.1 Summary

Potential Sources to Bayou d'Inde:

Citgo, Equistar, Firestone, Westlake Polymers, Montell USA, and PPG

Bayou d'Inde is divided into five geographic areas; four reaches in the bayou energy system and the marsh areas. Marshes are present in Reaches 1 and 2. The reaches are defined in Section 7.1.2 and Figure 7-1. Lower Bayou d'Inde below highway LA-108 can be characterized as a moderately-saline to saline, broad channelized ship channel with significant industrial development. The upper reach of Bayou d'Inde (Reach 4) is a less saline, steep-sided, narrow and vegetated low-flow system. The drainage area for the upper reach (Reach 4) is generally rural residential. The majority of Bayou d'Inde from Reaches 1 through 3 receives surface runoff and wastewater discharge from several industrial facilities (PPG, Westlake Polymers, Firestone, Citgo and Equistar [formerly OxyChem]), (Figure 7-2). Point and non-point sources are present in Reaches 1 through 3. Introduction of contaminants to the system appears to occur due to industrial release primarily between Little Bayou d'Inde and Highway LA-108 and near the LA-108 Bridge; through unidentified release to Maple Fork Bayou; and from industrial release to the PPG Canal.

Contaminants of Potential Concern in Bayou d'Inde:

Dioxin/Furans, PCBs, Mercury, HPAHs, LPAHs, BEHP, HCB, and HCBD

Contaminants of primary interest in Bayou d'Inde are those contaminants that increase human health or ecological risk. The occurrence of COPCs varies across Bayou d'Inde; the following is an overview of the condition of each of the four reaches and associated marshes, within Bayou d'Inde.

The largest set of contaminants and generally the greatest concentrations are found in Reach 1 of Bayou d'Inde and Lockport Marsh. PPG operates three major process areas in the immediate vicinity: the Chlor-Alkali plant; the Derivatives plant and the Chlor-Alkali/Silicas area. All process areas drain to the PPG Canal. Further three offsite facilities, CetainTeed Products, Jupiter Chemicals and Big Three Industries also discharge to the PPG Canal. The non-PPG permitted design flows account for 1 MGPD of a 233 MGPD design flow capacity for the PPG Canal.

Dioxin/furans are predominant in Reaches 1 through 3, Lockport Marsh and Maple Fork Bayou Marsh (the location of sample BIR3018). Dioxin/furan concentrations are comparable where bayou and marsh locations are present. Dioxin/furan contamination is widespread throughout Bayou d'Inde. Primary impacted areas are lower Reach 3 and Reach 1. The highest 2,3,7,8-TCDD TEQ (or most toxic) concentrations are found in Reach 1 and in Lockport Marsh (see Figure 7-13). No documented sources of dioxin/furans were noted in the regulatory record, however, it is noted that incomplete or uncontrolled combustion of PCBs may result in the production of dioxin or furan compounds and industrial incinerators in the area used to burn chlorinated wastes.

PCBs tend to occur in two areas in two primary groupings, those grouped with PCB-118 and those with PCB-15. The PCB-118 group appears to originate in lower Reach 3 and extends through to the middle Reach 2 marsh area (BIR3046). The apparent source of this is the former OxyChem impoundments. The PCB-15 impacted areas begin at PPG Canal and are prevalent up to BIR3046 in middle Reach 2 marsh and extend downstream through Reach 1 to the ship channel. Lockport Marsh contains the highest detection of PCBs at location BIR2018, near the mouth of PPG Canal. The occurrence of PCBs in Lockport Marsh is within the bermed area. No documented PCB releases were noted in the regulatory record, however PCBs are handled and disposed of through incineration at PPG and localized air deposition is likely. Surface transport of impacted soils to the estuary may be occurring.

Mercury tends to be found from Maple Fork Bayou through Reach 1 to the ship channel. The concentrations, however lower, extend into upper Reach 2. Mercury concentration is highest in the marshes. Potential sources to Lockport Marsh include the former PPG mercury-cell settling pond that was operated in the late 1960's. The pond was an unlined impoundment within the PPG Canal drainage area. In addition, enforcement history data indicates numerous NPDES exceedances. It should be noted that elevated, localized detections within Lockport Marsh may be due to the use of mercury manometers by the oil and gas industry. These manometers contain elemental mercury and are sometimes damaged or broken on-site, causing localized mercury release.

HPAHs are found in the highest concentration in Reach 1, Lockport Marsh, Maple Fork Bayou marsh (BIR3018) and the eastern Reach 2 marsh (BIR3036). PPG Canal, Maple Fork Bayou, lower Reach 3 and LA-108 appear to be the sources of these PAHs. Elevated concentrations are noted in the marshes upstream of PPG Canal and may indicate overflow conditions to this area. HPAHs tend to be slightly higher in concentration in the marshes than in the bayou sediments, overall. No known sources exist on Maple Fork Bayou, although numerous industrial pipelines, a highway and a railroad spur cross Maple Fork near the highest detections, release from these operations are unknown. Urban runoff from the nearby highways may be a source of PAHs, as well.

LPAH distribution is not as widespread in Bayou d'Inde as HPAHs. The LPAHs tend to be found in Lockport Marsh and concentrations are generally higher than HPAHs. The second highest concentration of LPAHs is in Maple Fork Bayou, in lower Reach 3 and near LA-108 in Reach 2. In general, LPAHs tend to increase with depth. Potential LPAH sources include PPG, Citgo, Westlake Polymers and Equistar.

BEHP is found throughout Bayou d'Inde and in Reaches 2 and 3. Potential sources of BEHP include Westlake Polymers, and Equistar. BEHP appears to accumulate in the Reach 2 marshes (predominantly the Middle and Lower Reach 2 marshes, areas identified by BIR3054 and BIR3062, respectively) in this area. However, in Reach 1 where significant levels of BEHP as found, the bayou contains the majority of the contaminant, not the marsh. The concentrations in the bayou are greater than the

Lockport Marsh by an order of magnitude in Reach 1. The overall distribution of BEHP suggests that the compound is greatly influenced by the presence of suspended or colloidal phase material in the water column. The distribution of BEHP indicates the greatest degree of transport of any COPC in Bayou d'Inde and suggests that its concentration in sediment is an indicator of low surface water flow velocity (high settling rate) and high organic or detritus material, either particulate or suspended. Flow appears to control BEHP distribution, as noted in Reach 1 where the configuration of the channel has been modified creating a broader, slower flow regime.

7.7.2 Conclusions

The general distribution of COPCs in Bayou d'Inde is complex, given the multiple sources and flow dynamics. Industrial releases to Reaches 1 and 3 are a significant component of surface water flow volume in Bayou d'Inde. Permitted and unpermitted discharges mix with surface water in the bayou that migrate up and downstream via, natural pathways, wind and tidal fluctuation. Large storms may push water and sediment upstream in Bayou d'Inde perhaps explaining the isolated occurrences of COPCs in Reach 4.

In the upstream region, Reach 4, the level of contamination is minimal; the primary contaminants noted are LPAHs, mercury, copper, BEHP, and PCBs. The detections were noted downstream of I-10 and in the lower portion of Reach 4 near Little Bayou d'Inde.

Reach 3 contained a number of COPCs and concentrations in the area tend to be the second highest observed in all of Bayou d'Inde. Two areas of possible sources were noted, the area near Citgo outfall 001 and upstream of the LA-108 bridge near the Equistar and Westlake Polymers outfalls. Primary COPCs in Reach 3 are dioxin/furans, PCBs, BEHP, HPAHs, LPAHs, and mercury.

Reach 2 COPCs are essentially the same as Reach 3, however, PCBs mercury, HPAHs, and BEHP tend to dominate. Reach 2 marshes tend to show the highest concentrations for metals, dioxin/furans and most HPAHs. Concentrations tend to be about the same in the marshes and the bayou for PCBs and tend to be lower in the marshes in Reach 2 for LPAHs. Reach 1 was the area with the greatest number of compounds detected and the highest COPC concentrations. Reach 1 COPCs are dioxin/furans, PCBs, BEHP, mercury, HPAHs, LPAHs, HCB, and HCBD.

Overall, contaminants appear to be highest in Reach 3, Maple Fork Bayou, Reach 1, and Lockport Marsh. The contaminant suite in each of these areas is similar, and may represent some source and transported sediment overlap. The data suggests that fine or suspended particle transport is active in Bayou d'Inde. Flocculation and suspended particle binding may be prevalent for some compounds (LPAHs, BEHP, and some metals). Distribution and concentration gradients of many of the COPCs indicate sediment movement into the marshes, however this is not the case for all compounds. Overall, sediment stability tends to be moderate to poor. Open areas of

Lockport Marsh are susceptible to sediment mobilization. Reaches 2 and 3 tend to be net sediment exporters. Sediment stability within the fringe marshes in Reach 2 is typically good. Potential for mobilization from the marshes immediately upstream of PPG Canal is moderate given the increased flow potential in Reach 1. It appears that re-suspension of fine grained material (organic or inorganic) facilitates physical transport throughout Bayou d'Inde.

Arsenic	89/91	0.86	18.7	3.9	2.6	0.66

1 – Values based on ROS. See Appendix E.

8.5.2.2.2 Discussion

These metals typically represent background conditions.

8.5.2.3 Pesticide/VOC

The Pesticide/VOC factor was the third factor to account for the variability in surface sediment. The results and discussion of contaminants in this factor in Bayou Verdine are presented in this section.

8.5.2.3.1 Results

This factor groups pesticides, 1,2-dichloroethane (EDC), and thallium within this factor. Exhibit 8-25 through 8-27 presents the summary statistics for these contaminants.

Exhibit 8-25 Summary Statistics of Pesticides (µg/Kg) in Pesticide/VOC Factor in Surface Sediment

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Aldrin	5/70	2.6	3.1	-	-	-
Beta-BHC	3/70	3.4	57	-	-	-
4,4'-DDT	4/70	4.8	48	-	-	-
Delta-BHC	6/70	4.6	55	-	-	-

1 – Values based on ROS. See Appendix E.
(-) – Mean value is not calculated for less than 20% detected due to estimation of distribution becomes less accurate.

Exhibit 8-26 Summary Statistics of Organics (µg/Kg) in Pesticide/VOC Factor in Surface Sediment

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
EDC	17/105	15	19,000,000	-	-	-
Bis(2-chloroethyl)ether	3/101	630	49,000	-	-	-

1 – Values based on ROS. See Appendix E.
(-) – Mean value is not calculated for less than 20% detected due to estimation of distribution becomes less accurate.

Exhibit 8-27 Summary Statistics of Metals (mg/Kg) in Pesticide/VOC Factor in Surface Sediment

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Thallium	7/91	0.54	1.9	-	-	-

1 – Values based on ROS. See Appendix E.
(-) – Mean value is not calculated for less than 20% detected due to estimation of distribution becomes less accurate.

EDC was used as an indicator variable for this factor.

Surface Sediment

Elevated concentration of contaminants grouped in this factor was primarily located in the middle reaches of Bayou Verdine (Figure 8-6). Highest concentrations were located within close proximity of Vista West Ditch in Reaches 2 and 3. For EDC, in particular, approximately 120 m of bayou are highly contaminated (80 m upstream and 40 m downstream of Vista West Ditch).

Within the other areas of Bayou Verdine, pesticides, EDC, or thallium were detected at low concentrations or not at all.

Subsurface Sediment

EDC was detected in the subsurface at station BVR3007. In the 15 to 30-cm interval, BVR3007 was reported to have a concentration of 20 µg/Kg.

Surface Water

Contaminants grouped within this factor were not detected in the surface water.

8.5.2.3.2 Discussion

Various VOCs indicative of chlorinated process byproducts are present in the sediments from the middle of Reach 3 to approximately 100 m downstream of Vista West Ditch in Reach 2 (Figure 8-6). Compounds with the greatest Frequency of Detects and/or concentration include EDC, tetrachloroethene (PCE), TCE, 1,2-DCE, chlorobenzene, 4-bromofluorobenzene, dibromofluromethane, and dichloromethane. Each of these VOCs is readily volatilized and degraded. The presence of PCE, TCE, and 1,2-DCE at, or downstream of, BVR2C3SS indicates ongoing biodegradation (anaerobic reductive dechlorination). The lack of large areal extent is to be expected given the volatile nature of the contaminants. The presence of the contaminants in the sediments at the elevated concentrations noted (location BVR2C3SS: PCE 38,000 µg/Kg; TCE 50,000; total 1,2-DCE 46,000) indicates deposition of material entrained in finer grained sediments and organic matter, limiting direct contact with the overlying waters and subsequent dissolution and volatilization.

EDC is present in the sediments at significant concentrations. The current findings may be related to EDC releases from former CONDEA Vista operations. Several historic releases may have flowed into the Vista West Ditch or impacted subsurface soil layers that intersect Bayou Verdine. The downstream extent is 27 µg/Kg at R2EDC10SS; the upstream extent is defined as non-detect (66U µg/Kg) at BVR3007 (Figure 8-5). Chemical degradation of halogenated alkanes is controlled by hydroxyl radicals. The presence of EDC in the anoxic sediments appears to be limiting exposure to hydroxyl radicals, preventing significant degradation. Subsequently, EDC undergoes anaerobic dechlorination to chloroethane (biologically remediated). The volatility of chloroethane limits its use as a definitive marker of this process; however, the significant concentrations of EDC observed indicate that it is not having substantial impact on this contaminated sediment.

Section 10
Lower Calcasieu - Nature and Extent

This section describes the nature and extent investigation of the portion of Calcasieu Estuary called the Lower Calcasieu AOC. Section 10.1 reviews the reaches and energy areas within Lower Calcasieu. Historical activities, including industrial development, permitted discharges, accidental spills, and releases are discussed in Section 10.2. An overview of the analytical program is provided in Section 10.3. Presentation of the data from the RI is provided in Section 10.4, including the results of the PCA as well as the summary statistics of the COPCs in Lower Calcasieu. Section 10.5 describes the fate and transport of COPCs, and Section 10.6 presents the summary and conclusions for Lower Calcasieu.

10.1 Introduction

The Lower Calcasieu study area comprises the portion of Calcasieu Estuary from the I-210 Bridge (just south of Coon Island Loop) to the outlet of Moss Lake a distance of approximately 11 km (Figure 10-1). Lower Calcasieu is comprised of the ship channel interconnected to shallow lakes, small lagoons, and a bayou. A description of the physical setting and energy systems follows.

10.1.1 Physical Setting

Lower Calcasieu is comprised of the ship channel and interconnected shallow lakes and lagoons (Figure 10-1). The ship channel is 125 m wide and 15 m deep and is routinely dredged (USACE 1976). Prien Lake is located on the east side of the ship channel, and the mouth of the lake is located across the ship channel from Lockport Marsh. The lake runs parallel to the ship channel, with openings across from Lockport Marsh and north of Indian Marais. Prien Lake lies within the old channel of the Calcasieu River. Prien Lake is approximately 4.8 km in length.

Historic or Current Permitted Dischargers to Lower Calcasieu:

Citgo, Montell USA, L.A. Pigments, Westlake Group and W.R. Grace

Indian Marais lagoon has a 230,000-kiloliter capacity and is partially contained within an earthen embankment built-up along the west side of the ship channel on Citgo property mid-way between Prien Lake and Moss Lake. Indian Marais flows west to east through the Citgo refinery and discharges into the Calcasieu River Ship Channel to the south of Indian Marais Lagoon. The lagoon is about 3 m deep with a 300-m long pier parallel to the ship channel. The lagoon is partially bermed (2 to 3-m) and may still occasionally receive stormwater runoff as process use and outfall discharges were terminated in 1992. . In 1992 sheet piling was installed adjacent to the ship channel to reduce communication of the Indian Marais Lagoon with the Calcasieu River. Although the sheet piling reduced communication the sheet piling did not eliminate sediment scouring that may occur during times of high tide. Moss Lake flows into the ship channel from the west and is fed by Bayou Olsen. Bayou Olsen drains the area south and west of Bayou d'Inde. The Bayou Olsen and Moss Lake segment is approximately 5 km in length.

Relief in the lower portion of the Calcasieu Estuary ranges from 1.6 to 4.6-m above MSL. The area surrounding Lower Calcasieu is located within the 100-year floodplain of the Calcasieu River Basin (Figure 2-6).

Much of the adjacent land in the Lower Calcasieu study area is undeveloped, but several industrial facilities have outfalls to the ship channel between Prien Lake and Moss Lake (Figure 10-2). The industries with potential to discharge to the estuary include:

- Bridgestone Firestone
- CitCon
- Citgo
- Conoco
- Entergy
- Himont
- LA Pigment
- Lake Charles Harbor
- Lyondell
- Montell
- OxyChem/Equistar
- PPG
- W.R. Grace

The ship channel is used extensively throughout Lower Calcasieu, providing transport for over 40 million tons of product annually. The channel is dredged to 125 m wide and 15 m deep (USACE 1976). Dredging of the ship channel is routine and occurs on average about every 2 to 4 years. The USACE maintains the design geometry of the channel to accommodate large, deep draft vessel passage. Design of the ship channel in Lower Calcasieu has remained constant since the channel was enlarged to its current size in the 1960s.

10.1.2 Lower Calcasieu Energy Systems

The Lower Calcasieu area contains four energy systems: shallow lakes (Prien and Moss Lakes and the areas to the south of Prien Lake and east of the ship channel), low-flow bayou (Bayou Olsen and Bayou Guy), the ship channel, and Indian Marais lagoon. Indian Marais lagoon is considered a potential sediment source and is susceptible to sediment scouring and breaching, thereby acting as a sediment source.

The ship channel is a high-flow, tidally influenced, saline to brackish environment. The channel is routinely dredged (generally every 2 to 4 years) to clear accumulated sediment and debris. Increased water salinity and vegetation losses have weakened soils, leading to increased sloughing.

Prien Lake is located on the east side of the ship channel; the mouth of the lake is located across from Lockport Marsh. Rhodamine dye tests indicate that Prien Lake receives flow from the mouth of Bayou d'Inde (Curwick 1988). Flow through Prien Lake may exit through two openings to the ship channel; however, flow rates through the shallow lake are low and the geometry is such that circulation throughout is limited. The Prien Lake segment is approximately 4.8 km in length.

Indian Marais lagoon is partially contained by a pier approximately 300-m long (a partial earthen embankment) built-up along the side of the ship channel. The former lagoon is bermed with an embankment (2 to 3-m high) that separates Indian Marais Lagoon from the surrounding land area. The Indian Marais passes to the west of the lagoon and drains areas to the west.

Bayou Guy is located at the southern most boundary of the Lower Calcasieu AOC. It is a low-flow bayou that drains predominately rural residential and undeveloped land east of the ship channel. At the mouth, water mixes with the Calcasieu River Ship Channel.

Moss Lake flows into the ship channel from the west and is fed by Bayou Olsen. Bayou Olsen drains the area south and west of Bayou d'Inde. Moss Lake is generally a moderate flow surface water body with uniform circulation and significant tidal influence. The Bayou Olsen and Moss Lake segment is approximately 9.6 km in length. The bayou is generally a vegetated low-flow system. The bayou is subject to tidal surge, and salinity is brackish in both Bayou Olsen and Moss Lake.

Overall, Lower Calcasieu is tidally influenced with 6 to 12-inches of daily fluctuation (USACE 1976). Salinity stratification tends to be density driven and seasonal. Observations during the RI indicated a mixed salinity regime; however, during warmer months, a salt-wedge regime has been reported (Duke 1985). Density-driven flood tide (upstream) currents have been noted along the bottom of the ship channel, generally 6 m below the surface (Duke 1985; DeRouen and Stevenson 1987). Salinity of the Lower Calcasieu area surface water ranges from brackish to saline.

These systems are interconnected, yielding a network of sediment sources, exporters, and sinks. The nature of Lower Calcasieu makes this portion of the estuary a net sediment exporter.

10.2 Industrial Setting and Historical Contamination

This section describes the industrial setting along Lower Calcasieu, including facilities descriptions for those industries that historically or currently discharged to the system. In addition, results from previous investigations conducted in Lower Calcasieu are discussed to identify if contaminant suites or concentrations have varied over time. This temporal information will be used to support the chemical fate and transport discussions.

10.2.1 Industrial Setting

Land use within the drainage basin of Lower Calcasieu Estuary is generally mixed. It consists of rural, agricultural, industrial, and urban land use. Industrial facilities are the most concentrated sources of discharge; however, significant non-point discharge (urban and agricultural runoff) is also possible (Figure 10-2).

10.2.1.1 Citgo

Citgo currently owns and operates the Lake Charles manufacturing complex. The complex is the eighth largest petroleum refinery in the nation and currently covers 600 acres. The facility is located roughly 6 miles southwest of Lake Charles on the west bank of the ship channel and the south bank of Bayou d'Inde (Figure 10-2). The Citgo complex consists of a petroleum refinery and a lube oil facility. Citgo is currently a wholly owned subsidiary of Petrolos de Venezuela S.A.; the state owned Oil Company of Venezuela.

Citgo products:

Fuel oils
Naptha
Petroleum coke
Gasolines
Benzene
Methyl-tertiary butyl ethyl
Sulfuric acid
Ethane
Propylene
Butyl rubber
Isobutylene
Isoprene

The Citgo refinery is wholly owned and operated by Citgo and has the capacity to process 320,000 barrels of crude oil per day, supporting the production of a variety of refined petroleum products. The petrochemical plant produces a variety of products. Both process areas discharge to the Lower Calcasieu ship channel.

Citgo has Outfall 003 as the primary outfall for process wastewater. Citgo has used the Indian Marais Lagoon to manage process wastewater discharge from outfall 003. In June of 1992, Outfall 003 flow was re-routed to discharge directly to the Calcasieu River Ship Channel. Indian Marais Lagoon in-flow was reportedly re-routed. It appears that flow enters the lagoon during heavy rains, primarily from surface runoff.

Citgo holds NPDES permit LA0005941 that authorizes discharge to Calcasieu River. Exhibit 10-1 summarizes the permitted Citgo outfalls. Enforcement histories for the Citgo outfalls are provided in Table 7-2.

Exhibit 10-1 Approved Citgo Discharges into Lower Calcasieu (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
003	Calcasieu River	Treated process wastewater from the Refinery. Discharge includes process wastewater, ballast water and stormwater runoff. Outfall 003 receives treated oxidation pond discharge (Outfall 013) associated with a package sanitary unit. Outfall 003 discharged to Indian Marais until 1992 when it was re-routed to discharge directly to the Calcasieu River. The outfall is monitored for phenolic compounds, Cr^{6+}, sulfide, total chromium, total zinc, ammonia, pH, BOD, TOC, TSS, and oil and gas.
004	Calcasieu River	Non-contact cooling water, regeneration wastewater and rinse water from the power plant. As of 1991, average flow through 004 was 64 MGPD.
006	Calcasieu River	Stormwater from the northeast side of the refinery and treated sanitary wastewater from the Butyl Rubber Plant.
008	Indian Marais	Stormwater runoff from the refinery Spent Catalyst Disposal Area. The outfall discharges to Indian Marais, flow is intermittent.
009	Calcasieu River	Stormwater runoff from the Lube Plant Tank Farm and Citgo's dock facility on the Calcasieu River. Flow through the outfall is intermittent.
010	Calcasieu River	Stormwater runoff from the West Tank Farm of the refinery, area of approximately 300 acres. Drainage area may also include the South Tank Farm and Land Farm. Citgo has the option to redirect discharge to the wastewater treatment plant and subsequent discharge through Outfall 003, and to the Calcasieu river.
011	Calcasieu River	Stormwater runoff from the South Tank Farm.
013	Calcasieu River	Established in March 1995. Surface runoff and conveyance of vacuumed sanitary waste from a package sanitary unit to the oxidation pond for treatment. Unit serves the Citgo Contractor Compound. Treated wastewater is discharged to Calcasieu River through Outfall 003.

There are 71 SWMUs within the Citgo refinery area, most of which are associated with wastewater processes and/or stormwater runoff. The two largest process units with potential environmental concerns are described below.

West Impoundment

This unit is a 670,000 gallon unlined surface impoundment that was active from the late 1960s until 1980. The unit reportedly underwent closure in 1994. The unit was used to manage phenolics and metal contaminated oily wastes, tank bottom sludges and slop oil residues. Contaminated soils and groundwater are associated with this unit (Curry et al 1997).

Surge Pond

The Surge Pond is an unlined surface impoundment, contained within and embankment in the original Indian Marais channel (Curry et al 1997). The unit had a capacity of 60 million gallons and was active from the early 1940s until 1994. The unit received F037 sludges, runoff from the land treatment unit, process water and ship ballast. Prior to 1970 the unit discharged directly to the Calcasieu River, after 1970 it discharged to the Equalization Basin and then through Outfall 003 to Calcasieu River. Groundwater has been impacted on the eastern side of the Surge Pond, possibly due to up-gradient Citgo sites (the Tail Gas #2 Unit and the Sulphur Recover Unit). Contaminants potentially discharging to Lower Calcasieu from this area include PAHs, and various VOCs (Curry et al 1997).

10.2.1.2 W. R. Grace

W.R. Grace has owned and operated a manufacturing facility in Carlyss, Louisiana since 1953. The facility covers 58 acres and is located approximately 2,500 feet west of the Calcasieu River, south of Citgo Petroleum Corporation. The facility's sole product is a silica-alumina petroleum cracking catalyst. Manufacturing processes at the facility do not use any organic chemicals. The types of waste byproducts generated from the manufacturing of the catalyst include silicone dioxide, alumina, sodium sulfate anhydrous, and ammonia sulfate. Surface drainage from the plant flows south to Young's Bayou and then to Bayou Olsen.

W.R. Grace holds NPDES permit LA0001333, which authorizes discharge from outfalls 001 and 002 to the Calcasieu River via Young's Bayou. Internal flow collected by outfall 101 is also authorized to discharge to outfall 001. Exhibit 10-2 summarizes permitted discharge to these outfalls.

Exhibit 10-2 Approved W.R. Grace Discharges into Calcasieu River (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
001	Calcasieu River via Young's Bayou	Treated process wastewater, sanitary wastewater and stormwater. Estimated average flow is 2.8 MGPD.
002	Calcasieu River via Young's Bayou	Non-process area stormwater collected from a roadside ditch.

Minor insoluble metals have been noted in the effluents. W.R. Grace discharge is not considered a significant impact to Lower Calcasieu.

10.2.1.3 Montell USA

Montell USA Incorporated is located on 200 acres in Westlake, Louisiana. In March 1995, Montell assumed ownership of Himont Chemical. Himont had assumed ownership of Hercules Inc. in November 1983. Montell is surrounded by Louisiana Highway 1134 to the north, the Calcasieu River to the east, Citgo Petroleum Corporation to the south, and Louisiana Highway 108 to the west. Montell produces polypropylene and high molecular weight polyethylene. The bulk of the product is sold as produced and the remainder is extruded as pellets and then sold. Waste byproducts generated at the facility include olefin polymer and cation and anion resin. Montell discharges to the ship channel under NPDES permit LA0003689 through outfalls 001 and 002. In addition, a series of wastewater ponds are used in the wastewater treatment process. Exhibit 10-3 summarizes permitted discharge to these outfalls. Table 7-6 presents the enforcement history for Montell.

Exhibit 10-3 Approved Montell Discharges into Calcasieu River (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
001	Calcasieu River	Process wastewater and sanitary wastewater.
002	Calcasieu River	Stormwater drainage and once-through non-contact cooling water.

10.2.1.4 Westlake Group

Westlake Group operates four facilities in Lower Calcasieu, Westlake Petrochemicals Ethylene Production Facility and Polyethylene Production Facility, Westlake Styrene Production Facility and the Marine Terminal Facility. Westlake Group has four permitted outfalls, each of which discharge to Lower Calcasieu.

The Complex is located on 320 acres formerly owned and developed by Citgo Petroleum Corporation, purchased from Citgo in 1989. Ethylene production began at the first production unit, Petro I, in 1991. A second production unit, Petro II, was put into operation in 1997. Outfall 001 discharges combined flow from this facility, Poly III and the Styrene facility, including treated process wastewater and process area stormwater. Non-process stormwater and utility water discharge to Calcasieu River via Indian Marais and Ethylene Unit outfalls 002, 003, and 004.

The Polyethylene Production Facility consists of one unit, Poly III. Operation began in 1997. The Styrene Plant manufactures styrene monomer. The unit began operation in 1992. The Marine Terminal Facility is used for the loading and unloading of styrene, benzene and toluene. Westlake operations at the Terminal began in 1992.

Westlake Group facilities discharge to the Calcasieu River under the following LPDES permits: Ethylene Production Facility (LA0082511); Polyethylene Production Facility (LA0103004); Westlake Styrene (LA0087157); and Marine Terminal Facility (LA0089362). Exhibit 10-4 summarizes permitted outfalls and discharge areas.

Combined flow to the Calcasieu River is approximately 1.91 MGD. Table 10-1 presents the enforcement history for the Westlake Group facilities.

Exhibit 10-4 Westlake Group Discharges into Lower Calcasieu AOC (Curry et al 1997)

Outfall	Discharge Area	Approved Discharges
001	Calcasieu River	Process area wastewater and stormwater from the Petro I and II units within the Ethylene Facility; the Poly III process area, Stryene Facility and the Marine Terminal Facility stormwater.
002, 003, and 004	Calcasieu River	Stormwater from non-process areas of the Ethylene Facility, Poly III process area, the Stryene Facility and the Marine Terminal Facility.

10.2.1.5 LA Pigment

LA Pigment produces a titanium dioxide, which is a white pigment used as a whitener and opacifer in paints, plastics, paper, ceramics, and other consumer products. Operations began in 1992 under the ownership of Kronos Louisiana, Inc. and transferred operations to LA Pigment in October of 1993.

The initial phase of the production generates metal chlorides, unreacted coke, and process inerts that are transferred to a neutralization tank and treated with quick lime to convert the metal chlorides to non-soluble metal hydroxides. This stream is sent to a series of filter presses where the removed water is discharged via outfall 001 and the filter cakes are sent to an on-site landfill.

The finishing process generates wash water that is clarified and discharged via outfall 002. In addition, LA Pigment has two on-site boilers to generate steam and a desulphurization unit to increase sulphur recovery. This results in continuous blowdown of a waste stream that contains 93 percent water, iron, sodium salts, and sodium thiosulfate at three to five gallons per minute.

LA Pigment operates a non-hazardous waste landfill, which began in September of 1993 and includes a surface impoundment. The landfill is excavated to 20 feet deep and is double lined. A leachate detection and collection system is installed at the landfill. Collected leachate is pumped into the settling pond for treatment prior to being discharged under and LAPDES permit.

Exhibit 10-5 summarizes the approved discharges for LA Pigment into Lower Calcasieu. Enforcement history for the outfalls is presented in Table 10-2.

Exhibit 10-5 LA Pigment Petrochemical Discharges into Lower Calcasieu AOC (LDEQ 1995)

Outfall	Discharge Area	Approved Discharges
001	Lower Calcasieu	Treated process wastewater from the chlorination plant, laboratory drains, boiler blowdown, once through non-contact cooling water, filter backwash, and from the CPI separator
002	Lower Calcasieu	Finishing process water discharge
003	Lower Calcasieu	Stormwater discharge
004	Lower Calcasieu	Landfill leachate and settling pond discharge
005	Lower Calcasieu	Uncontaminated stormwater runoff from the solid waste landfill site

10.2.2 Historical Contamination

Multi-media samples were collected during four previous studies from the Lower Calcasieu AOC. These studies include:

- Toxics Study of the Lower Calcasieu River, Prepared by Research Triangle Institute for the U.S. Environmental Protection Agency-Region VI, Louisiana Department of Environmental Quality and U.S. Geological Survey, March 1990. (Conducted in 1988-1989, see Appendix A).
- Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling Report, Prepared by McLaren/Hart Environmental Engineering - ChemRisk Division for PPG Industries, Inc., June 1995. (Conducted in 1994, See Appendix A).
- Bayou d'Inde Expanded Site Inspection - Final Report, Prepared by PRC Environmental Management, Inc. for the U.S. Environmental Protection Agency-Region VI, September 1993. (Conducted in 1992, See Appendix A).

The occurrences of COPCs identified in Section 4 (Table 4-2) in sediments are discussed in this section. None of the sample location or data is presented graphically. Only those data collected within the Lower Calcasieu AOC boundary were partitioned into four energy systems, bayou, marsh, ship channel, and shallow lake, to reflect the differing physical and geochemical dynamics of each area. Incidentally, no sediment samples were collected in the marsh or bayou energy systems during any of the previous investigations. The samples discussed in the following sections were not part of the Calcasieu Estuary RI/FS; the intent was to compare historical contamination with current conditions. Historical surface water samples are not discussed since their concentrations are more variable with time, sources, and season.

10.2.2.1 Historical Contamination - Shallow Lake System

10.2.2.1.1 Volatile Organic Compounds

Acetone was detected only during one investigation, *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation and likewise, carbon disulfide was detected only during one investigation, the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Of the sediment samples collected from the Lower Calcasieu shallow lake energy system area and analyzed for VOCs, four were collected and analyzed for acetone and three were collected and analyzed for carbon disulfide.

Acetone was found in one sediment sample at a concentration of 27 µg/Kg. This sediment sample was detected at location 6100-03-CSC13, positioned in the upper reach of Prien Lake, just over 67 m southeast of the junction of the Calcasieu Ship Channel, with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde.

Carbon disulfide was detected in two sediment samples at concentrations of 2 and 12 µg/Kg. The higher concentration was detected at location 6100-04-BDI03, which is found along the southwest corner of the upper reach of Prien Lake, bordering on the eastern end of the passage between the upper and lower reaches of Prien Lake, and approximately 777 m south of the second inlet to Prien Lake.

10.2.2.1.2 Semivolatile Organic Compounds

Bis(2-ethylhexyl)phthalate was detected in both the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation and the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Four sediment samples were collected from the Lower Calcasieu shallow lake energy system area and analyzed for SVOCs.

Bis(2-ethylhexyl)phthalate was detected in two sediment samples at concentrations of 110 and 1100 µg/Kg. The higher sediment concentration occurred at sample location 6100-06-14U0, situated in the upper reach of Prien Lake, about 104 m southeast of the junction of the Calcasieu Ship Channel with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde.

10.2.2.1.3 Polycyclic Aromatic Hydrocarbons

PAH concentrations in two sediment samples were reported in only one study, the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Total PAH (the summation of 18 PAH compounds) was found in the two sediment samples with concentrations of 225 and 795 µg/Kg. The maximum concentration was detected at sample location 6100-04-BDI01, situated in the upper reach of Prien Lake, nearly 84 m southeast of the junction of the Calcasieu Ship Channel with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde.

10.2.2.1.4 Pesticides and Polychlorinated Biphenyls

Only one of the four previous investigations examined shallow lake sediment samples for pesticides and total PCBs. During the *1992 EPA Bayou d'Inde Expanded Site*

Inspection, three sediment samples were collected and analyzed for pesticides and total PCBs.

Endrin aldehyde was detected in one sample with a concentration of 0.8 µg/Kg at sample location 6100-04-BDI01, situated in the upper reach of Prien Lake, nearly 84 meters southeast of the junction of the Calcasieu Ship Channel with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde. No PCBs were detected in any of the sediment samples.

10.2.2.1.5 *Metals*

Arsenic, barium, copper, lead, mercury, nickel, and zinc were analyzed in three sediment samples collected during the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Barium, chromium, copper, lead, and zinc were analyzed in one sediment sample during the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* Investigation. Chromium, lead, and mercury were analyzed in three sediment samples during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* Investigation.

Arsenic was detected in two of the three sediment samples during the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Sediment concentrations values were 1.6 and 2.0 mg/Kg. The higher concentration value occurred at sample location 6100-04-BDI03. The highest detected concentration value for nickel was also found during the *1992 EPA Bayou d'Inde Expanded Site Inspection*. The range of values for nickel was 6.0 to 16.8 mg/Kg, with the elevated concentration value at sample location 6100-04-BDI03. This sample location was found along the southwest corner of the upper reach of Prien Lake, bordering on the eastern end of the passage between the upper and lower reaches of Prien Lake, and approximately 777 m south of the second inlet to Prien Lake.

Copper, detected during the *1992 EPA Bayou d'Inde Expanded Site Inspection* and the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation, was identified in all four sediment samples, with concentrations ranging from 4.3 to 16.4 mg/Kg. The highest concentration value occurred during the *1992 EPA Bayou d'Inde Expanded Site Inspection* at sample location 6100-04-BDI03, the same location that the maximum concentration was observed for arsenic and nickel.

Zinc, also detected in all four sediment samples from the *1992 EPA Bayou d'Inde Expanded Site Inspection* and the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation, was detected at the highest concentration value during the *1992 EPA Bayou d'Inde Expanded Site Inspection*. The concentrations for zinc ranged from 9.4 to 37.4 mg/Kg, with the maximum value located at 6100-04-BDI03, the same location that the maximum concentration was observed for arsenic, nickel, and copper.

Barium, detected in all four sediment samples from the *1992 EPA Bayou d'Inde Expanded Site Inspection* and the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigation, had concentrations ranging from 80.5 to 366.0 mg/Kg. The highest detected value was in the *1992 EPA Bayou d'Inde Expanded Site Inspection* at location 6100-04-BDI01, situated in the upper reach of Prien Lake, nearly 84 m southeast of the junction of the Calcasieu Ship Channel with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde.

Lead, detected in sediment samples from all three previous investigations, was observed at concentrations ranging from 8.1 to 50.0 mg/Kg. Peak concentration values occurred during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation at sample locations 6100-06-14U0 and 6100-06-16U0. Sample location 6100-06-14U0 was situated in the upper reach of Prien Lake, about 104 m southeast of the junction of Calcasieu Ship Channel with the second inlet to Prien Lake directly across from the mouth of Bayou d'Inde. Sample location 6100-06-16U0 was positioned along the southwest corner of the upper reach of Prien Lake, bordering on the eastern end of the passage between the upper and lower reaches of Prien Lake approximately 789 m south of the second inlet to the lake.

Mercury was observed in three of the five sediment samples at concentrations ranging from 0.12 to 0.28 mg/Kg during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation and the 1992 EPA Bayou d'Inde Expanded Site Inspection. The maximum concentration value occurred at sample location 6100-06-16U0, which was positioned along the southwest corner of the upper reach of Prien Lake bordering on the eastern end of the passage between the upper and lower reaches of Prien Lake approximately 789 m south of the second inlet to the lake.

Chromium, detected in all four sediment samples from the *1988-89 EPA Toxics Study of the Lower Calcasieu River* and the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling* investigations, had concentrations ranging from 8.0 to 30.0 mg/Kg. The highest detected concentration value was established during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation. The sediment value was located at 6100-06-16U0, which is found along the southwest corner of the upper reach of Prien Lake, bordering on the eastern end of the passage between the upper and lower reaches of Prien Lake, and approximately 789 m south of the second inlet to Prien Lake.

10.2.2.2 Historical Contamination - Ship Channel System

10.2.2.2.1 Volatile Organic Compounds

Acetone and carbon disulfide were detected in two previous investigations, the *1992 EPA Bayou d'Inde Expanded Site Inspection* and the *1994 PPG Bayou d'Inde/PPG Canal* investigation. Sediment samples were collected from the Lower Calcasieu ship channel energy system area and analyzed for VOCs.

Acetone was detected in 11 of the 13 sediment samples at concentrations ranging from 11 to 167 µg/Kg. The maximum concentration was detected at sample location 6100-

03-CSC08, located along the Lower Calcasieu Ship Channel, nearly 120 m south of the I-210 Bridge. This sample was collected during the *1994 PPG Bayou d'Inde/PPG Canal* investigation. Detected in seven out of nine sediment samples, carbon disulfide generated a maximum concentration value during the same investigation at sample location 6100-03-CSC07, located along the Lower Calcasieu Ship Channel, about 124 m south of the I-210 Bridge.

10.2.2.2.2 Semivolatile Organic Compounds

Hexachlorobutadiene was detected in only one investigation, the *1992 EPA Bayou d'Inde Expanded Site.* Three sediment samples were collected from the Lower Calcasieu ship channel energy system area during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* and the *1992 EPA Bayou d'Inde Expanded Site Inspection* and analyzed for SVOCs.

Hexachlorobutadiene was found in one sediment samples at a concentration of 9800 µg/Kg, occurring at sample location 6100-06-12U0, located along the Lower Calcasieu ship channel, approximately 256 m south of the I-210 Bridge, at the junction of Bayou d'Inde with the second inlet to Prien Lake.

10.2.2.2.3 Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls

Sediment samples collected during all of the previous investigations conducted on the Lower Calcasieu ship channel energy system areas were not analyzed for PAHs. Only two sediment samples were collected for PCB analysis; none were detected.

10.2.2.2.4 Pesticides

Aldrin and hexachlorobenzene were detected during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation and the *1992 EPA Bayou d'Inde Expanded Site Inspection*. Four sediment samples were collected for pesticides analysis from the Lower Calcasieu - Ship Channel energy system area.

Aldrin was detected in only one sediment sample, with a concentration of 190 µg/Kg and hexachlorobenzene was detected in two sediment samples, with concentrations of 6000 and 27,000 µg/Kg. Both compounds revealed maximum concentrations at sample location 6100-06-12U0, which is located along the Lower Calcasieu ship channel, approximately 256 m south of the I-210 Bridge near the junction of Bayou d'Inde with the second inlet to Prien Lake.

10.2.2.2.5 Metals

Arsenic, barium, copper, lead, mercury, nickel, and zinc were detected in sediment samples collected during all three of the previous investigations that were conducted on the Lower Calcasieu ship channel energy area. Chromium was analyzed and detected in two of the previous investigations, the *1988-89 Toxics - Lower Calcasieu River* and the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling investigations.*

Maximum concentration values for barium, nickel, and zinc were witnessed during the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment*

Sampling investigation at sample location 6100-03-CSC15, which is found along the Lower Calcasieu ship channel, approximately 372 m south of the I-210 Bridge. Barium was detected in all 17 sediment samples, with concentrations ranging from 5 to 983 mg/Kg. Nickel was detected in all eight sediment samples, with concentrations ranging from 6 to 24 mg/Kg. Zinc was detected in all 17 sediment samples, with concentrations ranging from 5 to 120 mg/Kg.

Copper, detected in all 15 sediment samples from all three previous investigations, had concentrations ranging from 5 to 50 mg/Kg. The highest detected value was observed during the *1988-89 EPA Toxics Study of the Lower Calcasieu River* investigation at sample location 6100-06-12U0, located along the Lower Calcasieu ship channel, approximately 256 m south of the I-210 Bridge, at the junction of Bayou d'Inde with the second inlet to Prien Lake. The highest detected concentration value for chromium in all 16 sediment samples was also found during the same investigation. The range of values for chromium was 3 to 50 mg/Kg, with the elevated concentration value at sample location 6100-06-13U0, located along the Lower Calcasieu ship channel, approximately 258 m south of the I-210 Bridge, at the junction of Bayou d'Inde with the second inlet to Prien Lake. Likewise, in six of the eight sediment samples collected during the same investigation, the highest detected concentration value for mercury was discerned at sample location 6100-06-12U0, the same location that the maximum concentration was observed for copper. Mercury concentrations ranged from 0.3 to 2.1 mg/Kg in the Lower Calcasieu ship channel.

The maximum concentrations values for both arsenic and lead that were observed occurred during the same investigation, the *1994 Bayou d'Inde, Lower PPG Canal, Calcasieu River Ship Channel Water and Sediment Sampling*. Both compounds were detected in sediment samples collected during all three investigations. Arsenic, detected in all 14 sediment samples, had concentrations ranging from 0.85 to 7.00 mg/Kg. The highest detected value was attained at sample location 6100-03-CSC11, which was located along the ship channel, approximately 265 m south of the I-210 Bridge, near the junction of Bayou d'Inde with the second inlet to Prien Lake. Lead, detected in all 19 sediment samples, had concentrations ranging from 8 to 57 mg/Kg. The highest detected value was attained at sample location 6100-03-CSC05, which was found along the Lower Calcasieu ship channel, just over 28 m north of the I-210 Bridge.

10.2.2.3 Summary of Historical Data

Historical data from the three previous studies indicate that the occurrences of the primary COPCs are consistent with the finding of the RI. The distribution of the COPCs between the energy system areas throughout the Lower Calcasieu AOC were limited by the number and location of sediment samples collected, but when COPCs in samples were detected, the concentration trends tended to correlate to the concentrations established in the RI. Tables 10-3 and 10-4 summarize the range of results for shallow lake and ship channel energy areas.

In general, the data indicates that about 50 percent of the highest detected sediment concentrations occurred at the confluence of the second inlet to Prien Lake, the mouth of Bayou d'Inde, and the Calcasieu Ship Channel. Approximately 30 percent of the highest detected sediment concentrations were revealed to be within 150 m of that confluence. Historical data results are compared to RI findings in Sections 10.5 and 10.6.

10.3 Data Analysis and Interpretation Overview

The following discussions focus on data collected during Phase I and Phase II of the RI. The analytical program and the results of the data validation and interpretation are presented in Sections 4.6.1 and 4.8. Section 10.3.1 provides a summary of the samples collected and parameters analyzed. An overview of the data interpretation presented in Section 10.3.2 will describe the objectives of the PCA, which will be used through the remainder of this section to describe the extent of the contamination as well as the fate and transport of COPCs.

10.3.1 Analytical Program

Samples from Phase I and Phase II were collected within the Lower Calcaseiu AOC, which is from the I-210 Bridge to Moss Lake (Figure 10-1). Sampling was conducted throughout the AOC, which included a bayou, Indian Marais Lagoon (other energy system), shallow lake, and ship channel energy system.

The RI for the Lower Calcasieu AOC included collecting and analyzing sediment, surface water, and porewater samples (Figures 4-3, 4-4, 4-6, and 4-9) for a combination of compounds in accordance with EPA SW-846, EPA CLP, and ASTM standard methods. The compounds of interest included VOCs, SVOCs, pesticides, herbicides, PCBs, PCB congeners, dioxins/furans, metals (filtered and non-filtered for surface water), and TPHs. Surface sediment samples were collected from the 0 to 10-cm depth interval in Phases I and II. Multi-depth samples were typically collected in Phases I and II at: 0 to 10-cm, 10 to 20-cm, and 20 to 30-cm depth intervals. Surface water samples were collected at mid-depth of the water column because of the lack of a salinity gradient at the time of sampling. Porewater samples were collected with sediment samples and extracted at the laboratory.

Sample Locations in Lower Calcasieu For Chemistry Only (Phases I and II)

- 153 surface sediment
- 1 multi-depth sediment
- 23 surface water
- 8 porewater

In addition to the chemical parameters discussed above, samples were analyzed for chemical/physical properties, which may have included particle size analysis, TOC for sediment only, DOC for porewater only, and pH. Field parameters for sediment were limited to penetrometer measurements and VOC screening. Ancillary properties for surface water samples included alkalinity, ammonia, hardness, and

TKN. Field parameters for surface water included temperature, pH, DO, ORP, conductivity, and salinity.

10.3.2 Data Interpretation Overview

Data were interpreted by use of statistical tests such as WRS and the PCA to determine primary COPCs and their fate and transport in the estuary. In this section, an overview of the WRS test is provided in Section 10.3.2.1 to describe how it was used in the data interpretation. In Section 10.3.2.2, a brief overview of the PCA is provided, explaining the objectives of this analysis. The development of energy system specific COPCs is described in Section 10.3.2.3, and the general fate and transport mechanisms that will explain the extent of contamination of these COPCs in each of the energy systems is provided in Section 10.3.2.4.

10.3.2.1 WRS Test

This section describes the results of the WRS test to determine if there is a statistically significant difference between the energy areas in Lower Calcasieu and reference area conditions. COPCs that were not detected in the reference area were not compared using the WRS test; however, these non-detected COPCs are retained for evaluation. Use of the WRS test is discussed in Section 4.8.2.3. Results are presented in Table 10-5.

The WRS test compares the probabilities (p-values) with a critical value (alpha) in order to determine whether there is a statistically discernible difference in the median concentrations between the two groups tested (energy area in the AOC versus the reference area). For purposes of interpreting the p-values, two levels of significance were established and are presented in Exhibit 10-6.

Exhibit 10-6 Levels of Significance

Level of Significance	Interpretation of Difference
p-value < alpha	Medians may be different
Adjusted p-value < alpha	Medians are different

For the first level of significance (medians may be different), the p-values were compared directly with an alpha value of 0.05 or 95 percent UCL of the median of the COPCs. For the second level of significance (medians are different), an adjusted p-value was calculated using the Bonferroni adjustment method:

adjusted p-value = n(p-value),

where, n is the number of comparison tests conducted.

The test does not indicate whether higher concentrations were observed in the energy area or the reference area. A review of box-plots of contaminants by energy area (Appendix G) indicates which area had higher observed concentrations.

10.3.2.2 PCA

As discussed in Section 4, PCA was used to accomplish the following objectives:

- Objective 1: Study the correlations of multivariate data sets by grouping variables (analytical constituents or parameters) in principal components (also known as factors or groups). Variables within each factor are more highly correlated with each other than with variables in other factors.

- Objective 2: Summarize many variables by a few factors or groups. Essentially, this is a data reduction technique whereby several original variables may be represented by one or a few "indicator" variables or by the factor itself.

- Objective 3: Interpret each factor according to the "meaning" of the variables. Such interpretation may provide useful information regarding geochemical fate and transport.

Sediment composition is heterogeneous, which means that chemicals found in sediment will vary from one location to the next. The PCA groups the measured parameters into factors, which are parameters that tend to correlate with one another. By identifying parameters that correlate, sediment conditions can be better understood and explain why one location varies from another. Understanding the variability in the surface sediment, conclusions can be made in regard to sources and the fate and transport of contaminants.

Factors from the PCA will be discussed in Section 10.5 if one or more COPCs are grouped within that factor.

10.3.2.3 COPC Selection

The COPC list provided in Table 4-2 presents all of the COPCs in the Calcasieu Estuary; however, not all of these COPCs are present in each AOC or energy system. To limit discussion, energy system specific COPCs for each AOC were determined. COPCs that may not be present in a specific energy system, are not risk drivers, or were not statistically significantly different than reference area conditions are not discussed.

The HHRA and BERA state which COPCs are the primary risk drivers for each AOC (Section 7.1 in the HHRA and in Appendix G2 of the BERA). An energy system specific COPC was determined if the following two conditions exist:

- The COPC is identified as a risk driver in the HHRA or the BERA.

- The COPC was determined to be statistically significant different and at a greater concentration from reference area conditions.

If either of these criteria failed, the COPC was determined not to be a COPC for a particular energy system. In some cases, there were insufficient data to compare a COPC with reference area conditions (i.e., low frequency of detects in a particular energy system). In these instances, the ranges of concentrations of a particular energy system are compared to reference area conditions by examining mean and median values by the use of box plots (Appendix G). If the range is comparable, then they are not discussed in the following subsections. Additional information regarding these COPCs is presented in the HHRA or the BERA.

10.3.2.4 Fate and Transport Mechanisms

The major mechanisms that tend to guide chemical fate and transport in estuarine systems are:

- Adsorption
- Precipitation/Co-precipitation
- Salting out
- Complexation
- Biotransformation
- Hydrolysis
- Photolysis

Contaminant occurrence and extent in the Lower Calcasieu AOC is dependent upon physical conditions, the contaminants, their concentrations, and the dominant processes given these conditions. Details on these fate and transport processes are provided in Section 5.0. Sections 10.4 through 10.8 will discuss the general physical and chemical parameters, the extent of contamination, and the processes controlling COPC behavior in Lower Calcasieu.

10.4 General Physical and Chemical Parameters for the Lower Calcasieu AOC

This section presents the results of the sediment and surface water characteristics of the four energy systems in Lower Calcasieu.

10.4.1 Sediment Characteristics

10.4.1.1 Particle size

Particle size analysis was conducted at predetermined locations in Phase I and on all SQT samples in Phase II (Figure 10-3). The percentage of fine particles, such as clay and silt, were higher in the shallow lake and ship channel energy systems (Exhibit 10-7). The high percentage in the shallow lake is due to the shallow nature of these areas and the low velocity attributed to these areas, allowing smaller particles to settle. Within the ship channel, samples were collected near the shoreline, which may not be extensively affected by flow in the channel.

Indian Marais Lagoon sediments contain a high percentage of sand. This appears to be due to sediment scouring. This is based upon the composition of sediments from surrounding low-flow areas. The ship channel inlet area upstream of the lagoon

(LCR1019) and the shallow lake areas in Lower Calcasieu each have a greater percentage of fine-grained sediments than those in the lagoon. The operation history of the lagoon would imply that sediments within the unit were typically fine grained (the lagoon was used as a settling basin), and available records indicate that sediments were left in place once in-flow was re-routed directly to the ship channel.

The bayou energy system (Bayou Olsen and Bayou Guy) typically has higher sand percentages due to velocities in the bayous that are able to transport finer particles out of the system.

Exhibit 10-7 Mean[1] (Standard Deviation) Particle Size Analysis within Lower Calcasieu

Energy System	Percent Clay	Percent Silt	Percent Sand
Bayou	18.74 (5.53)	31.75 (5.46)	49.51 (10.16)
Other	20.82 (11.08)	16.99 (0.43)	65.06 (18.29)
Shallow Lake	31.91 (19.20)	42.65 (11.61)	25.30 (20.98)
Ship Channel	36.86 (18.15)	36.73 (15.52)	26.41 (30.09)
Reference Area	23.94 (11.70)	40.2 (11.02)	35.86 (16.34)

1 – Values based on regression on ordered statistics (ROS). See Appendix G.

The ship channel and shallow lake exhibited higher clay percentages, whereas Indian Marais Lagoon had a significantly lower percentage of silt and a higher percentage of sand. The reference area is considered a bayou energy system but more closely resembles the particle size distribution of the shallow lake energy area probably because of the low-flow characteristics. The Lower Calcasieu bayous may also be higher than average in sand because of surface rocks.

10.4.1.2 Total Organic Carbon

TOC provides an indication of the total organic material present in sediment and includes the carbon both from naturally occurring organic material and from organic chemical contaminants. TOC in sediment was measured in both Phase I and Phase II. TOC concentrations were highest in the bayou possibly due to vegetation and low energy of the system, allowing organic material to settle. Exhibit 10-8 lists the mean concentrations by reach and compares them to reference area conditions.

Exhibit 10-8 Mean[1] (Standard Deviation) of TOC in Bayou Energy System

Energy System	TOC (mg/Kg)
Bayou	86,418 (50,520)
Other	36,354 (8,832)
Shallow Lake	65,389 (67,564)
Ship Channel	37,088 (59,010)
Reference Area	43,356 (24,874)

1 – Values based on ROS. See Appendix G.

The bayou and shallow lake energy system were observed to have higher TOC concentrations than reference area conditions. This may be due to flow differences and vegetation in the reference areas.

10.4.2 Surface Water Characteristics

Surface water characteristics are presented in this section and are compared to reference area conditions.

10.4.2.1 Total Dissolved Solids

Dissolved solids refer to any minerals, salts, metals, cations, or anions that may be dissolved in the estuarine waters. Sources of dissolved solids may be from soil erosion, saltwater influence, waste discharge, urban runoff, eroding stream banks, and stirred-up bottom sediments from activities such as ship traffic or dredging. In addition to measuring total dissolved solids, salinity and conductivity were measured to describe the conditions within the bayou. Salinity and conductivity are related and essentially equivalent through conversion factors.

Salinity is the measure of the amount of dissolved salts (solids) in the estuary. Salinity levels control to some degree the types of animals and plants that may live in a particular area of the estuary. Salinity measurements are also important in determining if dissolved organic carbon will precipitate out of solution or "salt out".

Conductivity estimates the amount of total dissolved ions (solids) in water. Conductivity is controlled by salinity of a system, geology, size of the watershed, evaporation of water, and other sources of ions to the bayou or estuary such as wastewater, urban, or agricultural runoff. An increase in conductivity could signal the introduction of wastewater or saltwater influence.

Mean total dissolved solids were higher in Phase I than what was observed in Phase II (Exhibit 10-9). The higher concentration may be due to the higher salinity levels found during the Phase I field effort. The highest mean total dissolved solid concentration was found in the bayou energy system (Bayou Olsen and Bayou Guy), which are located along the southernmost extent of the AOC and are affected by saltwater influence.

Exhibit 10-9 Total Dissolved Solids (mg/L) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value (Phase I/II)	Maximum Detected Value (Phase I/II)	Mean[1] (Phase I/II)	Standard Deviation (Phase I/II)
Bayou	18,000/5,500	26,000/20,000	23,833/8,920	2,357/8,043
Other	20,000/13,000	21,000/18,000	-/15,333	-/2,836
Shallow Lake	17,000/2,920	26,000/30,000	21,760/11,481	2,846/9,884
Ship Channel	17,000/ -	26,000/ -	21,233/ -	1,990/ -
Reference Area[2]	6,000	32,000	13,467	10,245

1 – Values based on ROS. See Appendix G.
2 – *Phase II only.*
(-) – Not measured or not calculated due to limited data.

Salinity concentrations were highest in the bayou and ship channel energy system (Exhibit 10-10). The ship channel is a conduit for saltwater movement up into the estuary. The bayou has a high salinity concentration due to its closer proximity to the gulf and saltwater influence.

Exhibit 10-10 Salinity Levels (ppt) in Lower Calcasieu and Reference Area

Energy System	Minimum Detected Value (Phase I/II)	Maximum Detected Value (Phase I/II)	Mean[1] (Phase I/II)	Standard Deviation (Phase I/II)
Bayou	19/5	27/20	25/8.4	2.4/8.6
Other	20/15	22/18	20.8/ -	1.0/ -
Shallow Lake	12.3/2	24.5/32	19.6/11.3	2.2/10.8
Ship Channel	17/ -	27/ -	22/ -	2.4/ -
Reference Area[2]	6	36	14	12

1 – Values based on ROS. See Appendix G.
2 – Phase II Only.
(-) – Not measured or not calculated due to limited data.

In Phase I, Lower Calcasieu would be classified as polyhaline (18 to 30 ppt) based upon the USFWS salinity classification system. In Phase II, the bayou and shallow lake energy systems shifted to a mesohaline (5 to 18 ppt) salinity system. However, a limited number of locations were measured in Phase II and they may not accurately describe conditions as well as in Phase I. In comparing Phase II conditions, the Lower Calcasieu AOC had lower mean concentrations to that of the reference areas.

Mean conductivity levels were comparable for each of the energy systems and the reference area, with the exception of the Indian Marais Lagoon (other energy system; Exhibit 10 -11).

Exhibit 10-11 Conductivity (µs/cm) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value (Phase I/II)	Maximum Detected Value (Phase I/II)	Mean[1] (Phase I/II)	Standard Deviation (Phase I/II)
Bayou	3,500/869	42,100/12,750	19,550/3,734	19,498/6,469
Other	3,200/2,400	3,400/2,830	3,275/2,550	103/323
Shallow Lake	3,167/456	42,200/49,400	20,572/5,296	15,422/18,367
Ship Channel	3,200/ -	41,800/ -	21,611/ -	15,563/ -
Reference Area[2]	1,350	53,800	21,363	18,967

1 – Values based on ROS. See Appendix G.
2 – Phase II only.
(-) – Not measured or not calculated due to limited data.

Conductivity typically correlates to salinity and other dissolved ions in the water. Since salinity concentrations are typical of what was observed in Lower Calcasieu, Indian Marais Lagoon has significantly lower concentration of dissolved ions. Conductivity is comparable to the reference area for all areas except Indian Marais Lagoon. Conductivity is an order of magnitude less even though salinity and TDS were comparable to the reference areas. Lower Calcasieu measurements for Phase II suggest potentially sizeable ranges of general water chemistry parameters.

10.4.2.2 Hardness

Hardness is the measure of multivalent cations and is proportionate or equivalent to the concentration of calcium and magnesium in the surface water. Generally, as hardness increases, toxicity decreases. Surface water in Lower Calcasieu is considered very hard based on U.S Department of Interior and Water Quality Association standards (> 180 mg/L, Exhibit 10-12). The average fresh water value for the area is 140 mg/L (USACE 2002).

Exhibit 10-12 Hardness (mg/L as $CaCO_3$) in Lower Calcasieu and Reference Area

Energy Area	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake[2]	3,580	4,400	3,927	500
Ship Channel[2]	3,850	3,850	-	-
Reference Area	1,295	1,295	-	-

1 – Values based on ROS. See Appendix G.
2 – Results from Phase I only.
(-) – Not measured or not calculated due to limited data.

Hardness is typically a function of the geology of the area and/or influenced by point sources such as industries that discharge dissolved cations in effluent waters (EPA 1986). The higher values in Lower Calcasieu in comparison with reference area conditions may be due to geologic conditions (high calcium carbonate content of sediments). In comparison, wastewater from chemical industries has maximum concentrations of 1,000 mg/L, as $CaCO_3$, and electric utilities have a maximum concentration of 5,000 mg/L, as $CaCO_3$ (EPA 1986).

10.4.2.3 Alkalinity and pH

Increases or decreases of pH may be an indication of anthropogenic effects such as wastewater discharge or contamination from urban or agricultural runoff. Measurement of pH may isolate a particular area that might be receiving discharges from these or other sources. Alkalinity is the measure of a solution's resistance to changes in pH. Typically, water with a high alkalinity will resist the adverse affects of acidic contamination. The higher the alkalinity, the less likely a natural or manmade contaminant will cause a significant change in pH.

Exhibits 10-13 and 10-14 summarize the pH and alkalinity conditions present in the bayou energy system in Lower Calcasieu and the reference area. Alkalinity was only measured in Phase I.

Exhibit 10-13 pH Levels in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Median[1]
Bayou	7/7.03	8.61/7.82	7.83/7.63
Other	6.98/7.02	7.98/7.66	7.63/7.19
Shallow Lake	6.87/6.23	8.61/7.96	8.16/6.45
Ship Channel	5.29/ -	8.57/ -	8.1/ -
Reference Area	6.67	8.135	7.27

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

Estuarine waters typically have pH values ranging from 7 to 7.5 (EPA 1993). During Phase I, pH was higher than average conditions in the Lower Calcasieu; however, pH values were more typical in Phase II.

Exhibit 10-14 Total Alkalinity (mg/L as $CaCO_3$) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake[2]	1.2	1.4	1.3	0.11
Ship Channel[2]	84.7	84.7	-	-
Reference Area	42.1	42.1	-	-

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

Estuaries typically have alkalinity values ranging from 30 to 160 mg/L as $CaCO_3$ (EPA 1993). Conditions in the reference area and in Lower Calcasieu are not out of this range. The higher values in Lower Calcasieu in comparison with reference area conditions may be due to the different geologic conditions (rocks or soils) in the area.

10.4.2.4 Nitrogen

Nitrogen was measured as nitrate-nitrite, TKN, and ammonia. Nitrate and nitrite are inorganic ions occurring naturally as part of the nitrogen cycle (Smith 1990). TKN is the organic form of nitrogen and includes both the dissolved and particulate form, whereas ammonia is the dissolved form of nitrogen. Ammonia, at low levels, is an important nutrient for estuarine organisms, whereas it becomes toxic at high concentrations. In contrast to freshwater systems where phosphorous is the limiting nutrient factor, nitrogen is the primary limiting nutrient in the seaward portions of most estuarine environments (Paerl 1993). If high levels of nitrogen are introduced into the estuary, a significant increase of algae or large aquatic plants may occur NOAA/EPA (1988) suggests that nitrogen levels to avoid algae blooms to between 0.1 and 1 mg/L.

AWWA recommends that for maximum diversity in estuarine environments, the nitrate-nitrite should not exceed 0.1 mg/L for maximum diversity and 1.0 mg/L for moderate diversity (Exhibit 10-15). Based on nitrate-nitrite levels, the reference areas would support a more diverse environment, whereas Lower Calcasieu would only support a moderate diversity, based upon Phase I values.

Exhibit 10-15 Nitrate-Nitrite (mg/L) in Lower Calcasieu and the Reference Area

Parameter	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake	0.04	0.15	0.1	0.06
Ship Channel	0.15	0.15	-	-
Reference Area	0.06	0.06	-	-

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

TKN, the summation of ammonia and organic nitrogen, was similar in the shallow lake and ship channel energy system to what was observed in the reference areas. Exhibit 10-16 summarizes TKN results, which were measured in Phase I.

Exhibit 10-16 TKN (mg/L) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake	1.2	1.4	1.3	0.11
Ship Channel	1.2	1.2	-	-
Reference Area	0.95	0.95	-	-

1 – Values based on ROS. See Appendix G.
2 – Results from Phase I only
(-) – Not measured or not calculated due to limited data.

Ammonia concentrations were slightly higher, based upon Phase I values, than what was observed in the reference areas (Exhibit 10-17). According to EPA (1989b), the CMC for total ammonia for pH, temperatures, and salinity found in Lower Calcasieu range from 44 to 50 mg/L. The CCC, according to EPA (1989b), ranges from 6.6 to 12 mg/L. Ammonia levels were below the CMC and CCC values for Lower Calcasieu.

Exhibit 10-17 Ammonia, as N, (mg/L) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake	0.32	0.42	0.37	0.06
Ship Channel	0.44	0.44	-	-
Reference Area	0.0064	0.0064	-	-

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

10.4.2.5 Dissolved Oxygen

DO is typically an indicator of high quality water for aquatic life and helps determine the ability of aerobic organisms to survive. The concentration is dependent upon temperature, salinity, wind, water turbulence, atmospheric pressure, and presence of oxygen demanding compounds and organisms, and photosynthesis. The percent saturation is the measured dissolved oxygen level divided by the greatest amount of oxygen that the water can hold at that temperature and atmospheric conditions. Low dissolved oxygen levels typically indicate an excessive demand on the system from organic material deposited from pollution sources or from natural sources such as leaves and grass. Exhibit 10-18 summarizes DO measurements from Phase I.

Exhibit 10-18 Dissolved Oxygen, in Percent Saturation, in Lower Calcasieu and the Reference Area

Parameter	Minimum Detected Value (Phase I/II)	Maximum Detected Value (Phase I/II)	Mean[1] (Phase I/II)	Standard Deviation (Phase I/II)
Bayou	6.29/7.89	11.52/12.0	8.7/10.2	1.7/1.7
Other	4.4/8.59	10.1/10.92	8.1/9.7	3.1/1.3
Shallow Lake	5.4/6.42	12.9/9.47	9.0/8.3	1.5/0.8
Ship Channel	7.0/ -	11.8/ -	8.9/ -	1.2/ -
Reference Area (Phase II)	7.50	12.76	10.36	1.55

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

Typically, values over 80 percent represent water that is of high quality, which will support various flora and fauna, whereas values less than 80 percent indicate poor water quality conditions.

10.4.2.6 Biochemical and Chemical Oxygen Demand

BOD_5 is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions in five days. COD, however, does not differentiate between biologically available and inert organic matter and is a better indicator of medium- to long-term demand. COD is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values will always be greater than or equal to BOD_5 values, and these data are typically measured when there are nearby industrial sources. High BOD_5 /COD values may deplete the water system of oxygen needed to support fish and other aquatic life. In an estuary, the rate of oxygen consumption is dependent upon temperature, presence of certain kinds of microorganisms and the type of organic and inorganic material in the water (EPA 1993). BOD_5 values between 1 and 2 mg/L represent clean water. BOD_5 values between 2 and 5 mg/L are considered moderately clean. BOD_5 values exceeding 5 mg/L indicate a nearby pollution source. The various sources of organic enrichment include urban and agricultural runoff, sanitary sewer overflows, landfills, and septic systems.

Exhibit 10-19 presents the chemical oxygen demand and COD values observed in Phase I. BOD_5 and COD were not analyzed in the reference areas.

Exhibit 10-19 BOD_5 and COD (mg/L) in Lower Calcasieu

Energy System	Minimum Detected Value (BOD_5/COD)	Maximum Detected Value (BOD_5/COD)	Mean[1] (BOD_5/COD)	Standard Deviation (BOD_5/COD)
Bayou	-	-	-	-
Other	-	-	-	-
Shallow Lake	1.1/26.6	3/163	2.2/107.5	1.2/86.4
Ship Channel	2.9/136	2.9/136	-	-

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

BOD_5 and COD concentrations were not abnormal for Lower Calcasieu.

10.4.3 Porewater

Porewater is the water occupying space between sediment particles. DOC, salinity, conductivity, hardness, total alkalinity, ammonia as N, unionized ammonia, and pH were measured at 10 sample locations in Lower Calcasieu during Phase II. DOC and salinity are presented in this section, whereas discussion of the other parameters is presented in the BERA.

10.4.3.1 Porewater Dissolved Organic Carbon

DOC is the organic fraction of carbon in water that is filterable. DOC plays a role in the fate and transport of trace elements in the subsurface as well as influences the bioavailability of hydrophobic compounds. In saline environments, dissolved organic matter is removed from the water to the sediment phase, which can effectively sorb hydrophobic chemicals (Chapman et al 2001). Exhibit 10-20 presents the summary statistics for DOC in porewater.

Exhibit 10-20 Porewater DOC (mg/L) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	3.49	11.88	6.32	3.85
Other	3.37	5.15	4.45	1.16
Shallow Lake	3.05	25.04	7.04	10.76
Ship Channel	-	-	-	-
Reference Area	2.29	13.52	4.78	3.41

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

The higher DOC values found in the Lower Calcasieu energy systems in comparison with reference area conditions may be due to vegetation or the presence of organic contamination.

10.4.3.2 Porewater Salinity

As discussed previously, salinity and conductivity are measures of TDS in water. Salinity and conductivity values are presented in Exhibit 10-21.

Exhibit 10-21 Porewater Salinity (ppt) in Lower Calcasieu and the Reference Area

Energy System	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation
Bayou	13	20	16.4	2.8
Other	19	19	19	-
Shallow Lake	16	24	20.6	3.4
Ship Channel	-	-	-	-
Reference Area	12	24	17.1	3.7

1 – Values based on ROS. See Appendix G.
(-) – Not measured or not calculated due to limited data.

Porewater salinity did not vary greatly from reference area conditions. Salinity is slightly higher in porewater than in surface water (comparing with Phase II conditions) and is most likely related to sediment type and duration of sediment exposure to surface water salinity conditions (Chapman et al 2001). Equilibrium between surface water and porewater is slow in sediments containing high amounts of fine particles such as clay and silt (Chapman et al 2001).

10.5 Nature and Extent for the Bayou Energy System

The results and discussion section is organized into three sections: COPCs identified for the bayou energy system (Section 10.5.1), the results of the PCA (Section 10.5.2), and contaminants that showed little or no correlation to other contaminants or parameters (Section 10.5.3). Bayou Olsen and Bayou Guy are the two energy systems that were classified as a bayou in Lower Calcasieu.

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix G provides details of the PCA and complete summary statistics for all compounds detected in the bayou energy system in Lower Calcasieu.

10.5.1 COPCs for the Bayou Energy System in Lower Calcasieu

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. The energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 10.5.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 10.5.1.2 presents the bayou energy system COPCs identified.

10.5.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 10-5. Contaminant concentrations that were determined to be statistically significantly different than the reference area are:

- SVOCs (bis[2-ethylhexyl]phthalate)
- PCBs
- Inorganics (zinc)

10.5.1.2 COPCs Selection

Energy system specific COPCs for Lower Calcasieu were selected by determining if the COPC is a risk driver in the HHRA or the BERA and were determined to be statistically significant different than reference area conditions (Table 10-6). In addition, contaminants are only discussed if they are observed in at least two locations or if more than 5 percent of the samples for the energy system were detected. The following COPCs were selected for the bayou energy system in Lower Calcasieu:

- Bis(2-ethylhexyl)phthalate
- PAHs (as low and high molecular weight PAHs)

The extent as well as the fate and transport of these COPCs will be discussed in Sections 10.5.2 (PCA) and 10.5.3 (Isolated Chemistry).

10.5.2 PCA

The PCA revealed three dominant factors that accounted for most of the variability (55 percent) in surface sediment within Lower Calcasieu in the bayou energy system. These factors are:

- A Background Metal Factor that accounts for 27 percent of the variability
- A Background and Major Cation Factor that accounts for 28 percent of the variability

These factors present groups of parameters and/or contaminants that tend to correlate with each other and explain variability in the data set.

Zinc and nickel were part of individual factors and combined they controlled approximately 37 percent of the variability in sediment. However, these contaminants are not considered a primary COPC for this energy system and will not be discussed in this section. PCA and statistical results are presented in Appendix G.

10.5.2.1 Background Metals Factor

This section presents the nature of the Background Metals Factor.

10.5.2.1.1 Results and Extent

The factor represents constituents with concentrations similar to what was observed in the reference areas. It contains compounds such as lead, chromium, copper, mercury, nickel, and zinc but at low-level concentrations (Exhibit 10-22).

Exhibit 10-22 Summary Statistics of Metals (mg/Kg) in Background Metal Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Lead	17/17	9	41.8	21.85	9.15	0.42
Chromium	12/12	8	35.3	15.88	9.40	0.56
Copper	17/17	8.7	51.6	19.25	12.53	0.65
Mercury	7/17	0.12	0.28	0.14	0.11	0.82
Beryllium	12/12	0.76	1.5	1.11	0.21	0.19
Iron	12/12	3,470	17,500	9,578	4,662	0.49
Nickel	17/17	6.4	20.8	12.9	4.9	0.38
Zinc	8/17	29.1	84.2	43.3	20.7	0.48

1 – Values based on ROS. See Appendix G.

Although these metals explain some of the variability in sediment, they are at concentrations similar to or lower than reference area conditions. Therefore, the extent of these compounds will not be discussed further.

Subsurface Sediment

Subsurface samples were not collected in the bayou energy system for Lower Calcasieu.

Surface Water

Surface water samples were not collected in the bayou energy system in Lower Calcasieu.

10.5.2.1.2 Discussion

As noted previously, the metals contained in this factor are not statistically significant different than reference area conditions. Therefore, these metals are assumed to be at background concentrations and are not further discussed.

10.5.2.2 Background Major Cation Factor

This section presents the summary statistics for the major cations found in the bayou energy system in Lower Calcasieu.

10.5.2.2.1 Results

This factor represents major cations and metals found in the bayou energy system. Summary statistics are presented in Exhibit 10-23.

Exhibit 10-23 Summary Statistics of Cations/Metals (mg/Kg) in Major Cation Factor in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Sodium	12/12	11,000	28,500	18,325	5,420	0.30
Magnesium	12/12	3,360	7,220	5,408	1,093	0.20
Calcium	12/12	1,820	4,770	3,138	930	0.30
Manganese	12/12	67.9	659	184.8	190	1.03
Carbon disulfide	5/12	3	7	4.84	1.39	0.29
Barium	12/12	26.5	88.5	51.4	20.6	0.40
Potassium	12/12	1,690	3,110	2,443	418	0.17

1 – Values based on ROS. See Appendix G.

These major cations do not represent any COPCs for the bayou energy system in Lower Calcasieu; their extent in surface sediment will not be discussed further.

Subsurface Sediment

Subsurface samples were not collected in the bayou energy system.

Surface Water

Surface water samples were not collected in the bayou energy system.

10.5.2.2.2 Discussion

As noted previously, the metals contained in this factor are not statistically significantly different than reference area conditions. Therefore, these metals are assumed to be at background concentrations and are not further discussed.

10.5.3 Isolated Chemistry

Several COPCs that were detected in 5 percent or greater of the samples did not group with the two major PCA factor groups previously discussed. These include:

- BEHP
- PAHs

These COPCs did not group with the other major factors for one or more of the following reasons:

- The frequency of detection is typically low.
- The distribution of contamination was different than observed for the compounds for the four major factors.

Each of these COPCs is discussed in the following sections.

10.5.3.1 Bis(2-ethylhexyl)phthalate

This section presents the extent of BEHP in the bayou energy system in Lower Calcasieu and describes its fate and transport in the environment.

10.5.3.1.1 Results

Surface Sediment

BEHP was detected at 10 locations within Bayou Olsen and Bayou Guy (Figure 10-4). The summary statistics for the bayou energy system are presented in Exhibit 10-24.

Exhibit 10-24 Summary Statistics of BEHP (µg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
BEHP	10/17	68	1,400	277	373	1.35

1 – Values based on ROS. See Appendix G.

Elevated concentrations of BEHP were primarily in Bayou Olsen, with the maximum detected concentration located at LCR2078, which is approximately 1,500 m upstream from the mouth of the bayou as it enters Moss Lake. Samples collected in the immediate vicinity of this location were observed to have low concentrations. Further downstream, station LCR2077 was observed to have elevated concentrations and decreased moving downstream to the mouth of the bayou.

Bayou Guy had three locations where BEHP was observed in the surface sediment. Concentrations were in the 70 to 350 µg/Kg range.

Subsurface Sediment

Subsurface samples were not collected in the bayou energy system in Lower Calcasieu.

Surface Water

Surface water samples were not collected in the bayou energy system in Lower Calcasieu.

10.5.3.1.2 Discussion

The occurrence of BEHP in Lower Calcasieu is limited. The maximum of 1,400 µg/Kg was noted in Bayou Olsen midway up the bayou from Moss Lake. The next highest detection was one-half the maximum concentration (771 µg/Kg). The extent is limited to the bayou. Low levels are detected in Bayou Guy but at lower concentrations. Historically, BEHP was detected in the shallow lakes at comparable concentrations; Bayou Olsen and Bayou Guy were not sampled. Overall, BEHP distribution in Lower Calcasieu indicates a consistent low-level source.

10.5.3.2 PAHs

This section describes the extent of PAHs observed in the bayou energy system in Lower Calcasieu.

10.5.3.2.1 Results

Sediment

Both HPAHs and LPAHs were detected in the bayou energy system in Lower Calcasieu (Figure 10-5). HPAHs are the more dominant PAHs found and were located only in Bayou Olsen. Summary statistics are provided in Exhibit 10-25.

Exhibit 10-25 Summary Statistics of PAHs (µg/Kg) in Surface Sediment, Bayou Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
HPAH	3/18	73	1,364	545.7	917.4	1.68
LPAH	2/18	141.8	245	-	-	-

1 – Values based on ROS. See Appendix G.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Station LCST009 was observed to have the maximum concentration for both HPAHs and LPAHs. This station is located approximately 170 m upstream from the mouth of Bayou Olsen. Houses and boat docks are located from the mouth of Bayou Olsen to approximately 600 m upstream. The sample is located in a shallow area sheltered by outgoing flow from Bayou Olsen by three small islands.

Concentrations decrease moving upstream from LCST009 to LCST025 where PAHs were also observed. This location is an adjacent shallow area of Bayou Olsen to the east of an inactive and abandoned hazardous waste site under LDEQ jurisdiction.

Subsurface Sediment

Subsurface samples were not collected in the bayou energy system in Lower Calcasieu.

Surface Water

Surface water samples were not collected in the bayou energy system in Lower Calcasieu.

10.5.3.2.2 Discussion

Distribution of PAHs in the bayous of Lower Calcasieu is limited and highly variable. Potential sources include anthropogenic residential boating and industrial site activity. Local industrial use of PAHs along Bayou Olsen (both high and low molecular weight compounds) is documented; however, history of release is minimal. Current extent does not appear to be a concern for Lower Calcasieu.

10.6 Nature and Extent for the Other Energy System

The results and discussion section is organized into two sections: COPCs identified for the other energy system (Section 10.6.1) and the results of the PCA (Section 10.6.2). This energy system describes the other energy system (Indian Marais Lagoon) as well as a sample located in the Indian Marais.

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix G provides details of the PCA and complete summary statistics for all compounds detected in the marsh in Lower Calcasieu.

10.6.1 COPCs for the Other Energy System in Lower Calcasieu

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. These energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 10.6.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 10.6.1.2 presents the other energy system COPCs identified.

10.6.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 10-5. Contaminant concentrations that were determined to be statistically significantly different than the reference area or did not have sufficient data to compare are:

- SVOCs (bis[2-ethylhexyl]phthalate)
- PCBs (as Aroclor 1254)
- Dioxins/Furans (as 2,3,7,8-TCDD TEQs)
- PAHs (as pyrene)
- Inorganics (arsenic, barium, chromium, copper, lead, mercury, and zinc)

10.6.1.2 COPCs Selection

Energy system specific COPCs for Lower Calcasieu were selected by determining if the COPC is a risk driver in the HHRA or the BERA and were determined to be statistically significantly different than reference area conditions (Table 10-7). In addition, contaminants are only discussed if they are observed in at least two locations or if more than 5 percent of the samples for the energy system were detected. The following COPCs were selected for the other energy system in Lower Calcasieu:

- Bis(2-ethylhexyl)phthalate
- PAHs
- PCBs
- Dioxins/Furans
- Inorganics (barium, chromium, copper, lead, mercury, and zinc)

The extent as well as the fate and transport of these COPCs will be discussed in Sections 10.6.2 through 10.6.3.

10.6.2 PCA

The PCA revealed two dominant factors that accounted for most of the variability (87 percent) in surface sediment within the other energy system in Lower Calcasieu. These factors are:

- A medium- to high-level contamination Metal and Major Cation Factor that accounts for 42 percent of the variability. Factor included the COPCs arsenic, copper, chromium, lead, mercury, and zinc.
- A PAH Factor that accounts for 45 percent of the variability in sediment.

These factors present groups of parameters and/or contaminants that tend to correlate with each other and explain variability in the data set.

10.6.2.1 Metal/PCB/PAH Factor

This section presents the extent of the metal/PCB/PAH factor and discussion as to the fate and transport of contaminants in this factor.

10.6.2.1.1 Results

This factor contains five of the six inorganic COPCs as well as Aroclor 1254 and PAHs. Summary statistics for these contaminants are presented in Exhibits 10-26 and 10-27.

Exhibit 10-26 Summary Statistics of Inorganics (mg/Kg) in Metal/PCB/PAH Factor in Surface Sediment, Other Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Magnesium	7/7	1,760	5,630	2,981	1,512	0.51
Cadmium	4/7	0.092	0.29	0.18	0.09	0.47
Arsenic	7/7	1.96	5.2	3.30	1.2	0.36
Aluminum	7/7	5,370	18,500	9,181	5,672	0.62
Potassium	7/7	950	2,720	1,598	788	0.49
Cobalt	6/7	2.3	7.1	3.9	1.8	0.47
Selenium	5/7	1	3.5	1.5	0.8	0.75
Calcium	7/7	929	5,490	2,090	1,876	0.90
Iron	7/7	5,170	13,900	8,244	3,298	0.40
Nickel	4/7	9.1	30.3	14.1	9.1	0.65
Copper	7/7	22.4	285	104	102	0.99
Sodium	6/7	4,370	22,400	8,128	8,134	1.00
Silver	4/7	0.1	0.3	0.16	0.08	0.51
Chromium	7/7	19.1	205	84.3	67	0.79
Lead	7/7	51.1	793	330	298	0.9
Zinc	7/7	41.5	322	149	107	0.72
Manganese	7/7	47	105	68.3	22.9	0.34
Mercury	7/7	0.14	2.5	0.94	0.87	0.92

1 – Values based on ROS. See Appendix G.

Exhibit 10-27 Summary Statistics of Organics (µg/Kg) in Metal/PCB/PAH Factor in Surface Sediment, Other Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Aroclor 1254	3/6	140	860	214	409	1.91
Napthalene	3/7	110	1,500	425	978	2.30
Indeno(1,2,3-cd)pyrene	4/7	345	2,780	871	1,099	1.26

1 – Values based on ROS. See Appendix G.

Lead, based on its ranking and frequency of detection, is the indicator variable for this factor.

Surface Sediment

Elevated concentrations are primarily located on the north end of the Indian Marais Lagoon and decrease moving toward the ship channel (Figure 10-6). Maximum concentrations were typically observed at LCR1031, which is along the shoreline on the north side.

Subsurface Sediment

Subsurface samples were collected at station LCR1031. Metal concentrations were typically higher at the surface and decreased to the 10 to 20-cm interval (Exhibit 10-28). Metal concentrations increased from the 10 to 20-cm to the 20 to 30-cm interval. Copper concentrations were higher at the 20 to 30-cm than at the surface.

Exhibit 10-28 Subsurface Results for Inorganics (mg/Kg) at Station LCR1031

Parameter	0 to 10-cm	10 to 20-cm	20 to 30-cm
Arsenic	4.4	1.1	2.2
Barium	137	26.5	64.1
Chromium	205	11.1	19.1
Copper	285	97.1	434
Lead	793	48.8	132
Mercury	2.5	0.34	0.99
Zinc	322	45.2	152

Aroclor 1254 was not detected in the subsurface.

Surface Water

Surface water samples were not collected in this energy system.

10.6.2.1.2 Discussion

The distribution of metals in surface sediment in the northern end (closed end of the lagoon) indicates that the surface layer (0 to 10-cm) has been subjected to moderate scouring and re-working, moving the upper 10 cm toward the shoreline. The vertical profile (decrease in concentration at 10 to 20-cm and subsequent increase at the 20 to 30-cm interval) infers changes in source during deposition of the middle layer. The history of Indian Marais Lagoon indicates that flow to the lagoon was re-routed in 1992. This active (pre-1992) period appears to correlate to the 20 to 30-cm interval. The decrease correlates with the 10 to 20-cm interval, and the higher concentration in the surface sediments indicates the addition of material. The difference in upper and middle interval concentrations indicates that material from the 10 to 20-cm layer has been exported away from the sample locations.

The presence of Aroclor 1254 is indicative of recent deposition. The number of detections and range of concentrations possibly indicate a nearby terrestrial source versus air deposition.

10.6.2.2 PAH Factor

This section presents the extent of the PAH Factor and discussion as to the fate and transport of contaminants in this factor.

10.6.2.2.1 Results

This factor is comprised of both high and low molecular weight PAHs. Exhibit 10-29 presents the summary statistics for this factor.

Exhibit 10-29 Summary Statistics for the PAH Factor (µg/Kg) in Surface Sediment, Other Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Phenanthrene	4/7	1,360	140,000	23,566	69,113	2.93
Pyrene	7/7	360	149,000	27,600	71,253	2.58
1,2-benzphenanthracene	7/7	350	83,100	16,871	38,061	2.26
Benzo(a)anthracene	7/7	110	42,400	8,522	19,357	2.27
Benzo(b)fluoranthene	7/7	190	21,200	4,746	9,272	1.95
Benzo(g,h,l)perylene	5/7	561	16,800	3,752	7,352	1.96
Fluoranthene	7/7	100	22,200	4,835	9,709	2.01
Acenaphthene	3/7	252	15,900	3,262	7,253	2.22
Benzo(k)fluoranthene	6/7	76.8	6,630	1,571	2,791	1.78
Benzo(a)pyrene	7/7	170	23,600	5,949	9,749	1.64
Fluorene	3/7	279	13,300	3,031	6,459	2.13
Dibenzo(a,h)anthracene	4/7	376	10,400	2,071	4,963	2.40
Anthracene	6/7	120	21,700	5,288	9,293	1.76
2-Methylnapthalene	6/7	53	15,400	3,813	6,662	1.75
Acenaphthylene	4/7	53	8,740	1,341	4,682	3.49

1 - Values based on ROS. See Appendix G.

Pyrene is an HPAH and is used as the indicator variable for this factor. An HPAH was selected, as the HPAHs tend to have slightly lower coefficient of variation values than the LPAHs.

Surface Sediment

PAHs, similar to the metals factor, are primarily located on the northern half of Indian Marais Lagoon (Figure 10-7). LCR1031 tends to be the location with the highest detected values, with stations decreasing in concentrations toward the confluence of the lagoon and the Calcasieu River Ship Channel.

Subsurface Sediment

PAHs were analyzed in subsurface sediment at station LCR1031. HPAHs and LPAHs were summed to examine whether a specific category increases or decreases with depth. At this station, HPAHs decreased from surface sediment concentration of 85,130 to 22,840 µg/Kg and then slightly increased to 31,100 µg/Kg in the 20 to 30-cm interval. LPAHs, however, increase with depth from 56,300 in surface sediment to 89,000 µg/Kg at 10 to 20-cm and 207,700 µg/Kg in the 20 to 30-cm depth interval.

Surface Water

Surface water samples were not collected in this energy system.

10.6.2.2.2 Discussion

The occurrence and distribution of both HPAHs and LPAHs in surface sediment indicates, recent deposition at these locations. The vertical profile at location LCR1031 shows a general increase in both total HPAH and total LPAH concentrations with depth. The highest concentrations are found in the 20 to 30-cm interval and likely represent the pre-1992 operating period concentrations. The concentrations decreased by approximately one-half from the 20 to 30-cm interval to the 10 to 20-cm and 0 to 10-cm (surface) intervals. The 0 to 10-cm and 10 to 20-cm interval concentrations are fairly consistent in comparison to the deep sample.

Historically, Indian Marais Lagoon was not sampled. No additional temporal evaluation can be provided.

10.6.3 Isolated Chemistry

A few COPCs that were detected in 5 percent or greater of the samples did not group with the two major PCA factor groups previously discussed. These include:

- BEHP
- Dioxins/Furans

These COPCs did not group with the other major factors for one or more of the following reasons:

- The frequency of detection is typically low.
- The distribution of contamination was different than observed for the compounds for the four major factors.

Each of these COPCs is discussed in the following sections.

10.6.3.1 BEHP

This section describes the extent of BEHP observed in the Indian Marais Lagoon in Lower Calcasieu.

10.6.3.1.1 Results

Surface Sediment

BEHP was detected at three locations in Indian Marais Lagoon. Summary statistics are provided in Exhibit 10-30.

Exhibit 10-30 Summary Statistics of BEHP (µg/Kg) in Surface Sediment, Other Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
BEHP	3/7	66	670	196	280	1.4

1 – Values based on ROS. See Appendix G.

The maximum concentration was observed at station LCR1030. Concentrations decreased toward where the lagoon empties into the ship channel. A concentration of 160 µg/Kg was reported in Indian Marais Lagoon.

Subsurface Sediment

BEHP was not detected in the subsurface.

Surface Water

Surface water samples were not collected within this energy system.

10.6.3.1.2 Discussion

BEHP detections are low-level concentrations in less than one-half of the samples detected. The distribution is comparable to the metals, PAHs, and dioxins/furans in that impacted material is found in the back of the lagoon, away from the mouth where it appears that material is removed by tidal surge action.

The significance of the distribution of BEHP is not in the impact BEHP might have on the estuary; the concentrations are not elevated but in the line of evidence provided in describing sediment stability from within Indian Marais Lagoon. The BEHP distribution is a marker for the extent of sediment scouring that is observed at the lagoon.

10.6.3.2 Dioxins/Furans

This section describes the extent of dioxins/furans (presented as 2,3,7,8-TCDD TEQs) observed in the other energy system in Lower Calcasieu.

10.6.3.2.1 Results

Surface Sediment

Dioxins/furans were only measured at station LCR1031 that had a 2,3,7,8-TCDD TEQ concentration of 39.09 pg/g.

Subsurface Sediment

Within the subsurface, the 10 to 20-cm interval reported a concentration of 5.35 pg/g, and the 20 to 30-cm interval reported a concentration of 17.64 pg/g.

Surface Water

Surface water samples were not collected within this energy system.

10.6.3.2.2 Discussion

Dioxins/Furans (presented as 2,3,7,8 TCDD TEQ) were sampled for in two locations within Indian Marais Lagoon surface sediments. Subsurface samples were taken from one of the locations, LCR1031. The results indicate that the highest concentration in the lagoon is in the surface sediment. The concentration in the subsurface (10 to 20-cm and 20 to 30-cm, respectively) is one-half the concentration noted in the surface sample. The lateral distribution, as defined by these two samples, extends throughout the length of the Indian Marais Lagoon. The highest location is in the back of the lagoon as noted with BEHP. However, the dioxins/furans show evidence of a concentration gradient from the back of the lagoon toward the mouth. This trace is to be expected based upon the nature of the dioxins/furan compounds compared to BEHP. The BEHP tends to have a greater affinity to adsorb to smaller particulates and/or suspended sediment than dioxins/furans. The stability of the smaller particulates would be less than larger grain-size material under sediment scouring conditions, as noted by the dioxins/furan concentration gradients.

Historically, sediments from the Indian Marais Lagoon were not analyzed for dioxins/furans. No additional temporal evaluation is available.

10.7 Nature and Extent of Shallow Lake Energy System

The results and discussion section is organized into three sections: COPCs identified for the shallow lake energy system (Section 10.7.1), the results of the PCA (Section 10.7.2), and contaminants that showed little or no correlation to other contaminants or parameters (Section 10.7.3).

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix G provides details of the PCA and complete summary statistics for all compounds detected in the shallow lake energy system in Lower Calcasieu.

10.7.1 COPCs for the Shallow Lake Energy System in Lower Calcasieu

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. These energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 10.7.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 10.7.1.2 presents the shallow lake energy system COPCs identified.

10.7.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 10-5. Contaminants that were determined to be statistically significantly different than the reference area or did not have sufficient data to compare are:

- SVOCs (bis[2-ethylhexyl]phthalate)
- PAHs (as pyrene)
- Dioxins/Furans (as 2,3,7,8-TCDD TEQ)
- Inorganics (arsenic, barium, copper, and nickel)

10.7.1.2 COPCs Selection

Energy system specific COPCs for Lower Calcasieu shallow lake energy system were selected by determining if the COPC is a risk driver in the HHRA or the BERA and was determined to be statistically significantly different than reference area conditions (Table 10-8). In addition, contaminants are only discussed if they are observed in at least two locations or if more than 5 percent of the samples collected for the energy system were positive detections. The following COPCs were selected for the shallow lake energy system in Lower Calcasieu:

- BEHP
- PAHs
- Dioxins/Furans
- Inorganics (copper)

The extent as well as the fate and transport of these COPCs will be discussed in Sections 10.7.2 (PCA) and 10.7.3 (Isolated Chemistry).

10.7.2 PCA

The PCA revealed three dominant factors that accounted for most of the variability (72 percent) in surface sediment within the shallow lake energy system in Lower Calcasieu. These factors are:

- A background/low-level contamination Metal Factor that accounts for 31 percent of the variability in surface sediment
- A total TCDD/TCDF TCDD/TCDF Factor that accounts for 20 percent of the variability in surface sediment.
- A Dioxin/Furan Factor that accounts for 21 percent of the variability in surface sediment.

These factors present groups of parameters and/or contaminants that tend to correlate with each other and explain variability in the data set.

10.7.2.1 Metal Factor

This section presents the extent of the Metal Factor and discussion as to the fate and transport of contaminants in this factor.

10.7.2.1.1 Results

This factor groups inorganics that are low-level concentrations and similar to reference area conditions with the exception of copper. In addition, this factor includes important physical parameters such as sand and clay, which may explain the contaminant's mobility in the system. Exhibit 10-31 presents the summary statistics for this factor.

Exhibit 10-31 Summary Statistics of Inorganics (mg/Kg) in Metal Factor in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Nickel	71/76	1.3	32.9	11.5	6.3	0.55
Vanadium	69/69	10.6	126	51.6	32.4	0.63
Beryllium	45/69	0.27	1.5	0.69	0.34	0.49
Chromium	68/69	2.1	47.6	17.6	10.7	0.61
Zinc	54/76	10.6	126	51.6	32.4	0.63
Iron	69/69	1,360	24,300	10,983	6,651	0.61
Cobalt	61/69	1.4	13.4	5.61	2.80	0.50
Potassium	68/69	296	5,610	2,510	1,177	0.47
Lead	76/76	3.4	60.4	23.3	14.2	0.61
Mercury	27/76	0.0532	0.68	0.13	0.14	1.08
Copper	62/69	3.7	93.6	23.6	18.4	0.78
Manganese	69/69	12.9	895	213	198	0.93
Magnesium	69/69	417	10,800	4,704	2,550	0.54
Arsenic	69/69	0.59	17.6	4.51	2.84	0.63

1 – Values based on ROS. See Appendix G.

Copper, although it does not rank as high as iron or lead in the analysis (PCA), was used as the indicator variable as it was statistically significant different than the reference areas.

Surface Sediment

Elevated concentrations of copper are present in several areas within the shallow lake energy system (Figure 10-8) although primarily in Prien Lake and Moss Lake. Maximum concentration was located at station LCR2039, which is located south of the old ship channel and in an area that is predominantly clay and silt (approximately 60 percent combined clay and silt).

In Prien Lake, copper concentrations are highly variable, ranging from 3.7 mg/Kg at station LCR2015 to 78.1 mg/Kg at station LCR2018, with no spatial trend. Higher concentrations in Prien Lake are correlated with clay and inversely correlated with sand. At station LCR2018, sediment is comprised of approximately 57 percent clay.

In Moss Lake, elevated concentrations are primarily in the center of the lake. Concentrations decrease toward the north and the ship channel. Copper concentrations range from 6.8 mg/Kg at station LCR2072 to 44.3 mg/Kg at station LCR2064.

Subsurface Sediment

Subsurface sediment samples were not collected in the shallow lake energy system.

Surface Water

Copper, lead, mercury, nickel, and zinc were detected in surface water samples collected in the shallow lake energy system in Lower Calcasieu. Exhibit 10-32 presents the total and dissolved (if detected) concentrations of these contaminants and compares them to EPA AWQC (as reported in the Federal Register 1995) CCC (chronic) and CMC (acute) values and/or LDEQ Water Quality Regulation (LDEQ 2000) for both freshwater and marine environments. For systems with salinity between 1 and 10 ppt, the more stringent of either fresh or marine values should be used to compare with mean dissolved concentrations. In cases where the dissolved phase was not detected, the surface water criteria for that contaminant was converted to unfiltered criteria using a conversion factor provided in LDEQ 2000.

Exhibit 10-32 Mean and Standard Deviation of Total and Dissolved Concentrations (mg/L) in Metal Factor in Surface Water, Shallow Lake Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Copper	0.008 (0.003)	0.009 (0.020)	0.035[4]	0.022[4]	**0.00363**	**0.00363**
Lead	0.001 (0.001)	0.001 (0.001)	0.138[4]	0.00531[4]	0.209	0.00808
Mercury	0.000061[2]	ND	0.0017[3,4]	**0.00001[3,4]**	0.0017[3]	**0.000021[3]**
Nickel	0.0057 (0.0015)	0.0044 (0.0008)	2.49[4]	0.279[4]	0.074	0.0082
Zinc	0.0095 (0.0143)	0.0098 (0.0259)	0.205[4]	0.187[4]	0.09	0.081

1 – Based on ROS. See Appendix G. If only two samples, an average was calculated. ND: Not Detected
2 – Only detected in one sample.
3 – Converted to filtered basis using the conversion factors (Hg: 0.85)
4 – LDEQ Water Quality Regulations based on 200-mg/L hardness for dissolved concentrations.

Copper concentrations exceed both the marine acute and chronic criteria at all locations in the shallow lake energy system. The maximum copper concentration detected was at station LCR2018, with a concentration of 0.0643 mg/L. This station coincides with the maximum copper concentration found in surface sediment in Prien Lake. In addition, mercury exceeded both the fresh and marine surface water chronic criteria. Mercury was only detected as total mercury at station LCR2058, which is located on the north side of Moss Lake (Figure 10-8).

No other contaminants exceeded criteria.

10.7.2.1.2 Discussion

The metals factor consists of generally low-level concentrations of metals. With the exception of copper, the group does not significantly (i.e., statistically) differ from the reference areas. Copper concentrations are statistically higher than the reference areas. Distribution of copper is widespread throughout Prien and Moss lakes. The highest concentrations are found in sediments with a composition of greater than 50 percent silt and clay. No spatial trend is noted in the distribution of copper in Prien Lake; copper is scattered throughout. However, in Moss Lake, the highest concentrations tend to be along the middle of the lake. This area is where the boat access channel exists in an east-west orientation. Concentrations tend to decrease southward toward the ship channel.

10.7.2.2 TCDD/TCDF Factor

This section presents the extent of the TCDD/TCDF Factor and discussion as to the fate and transport of contaminants in this factor.

10.7.2.2.1 Results

This factor groups total TCDD and TCDF as well as physical parameters such as calcium, sodium, TOC, CEC, and pH that may explain the fate and transport in the energy system. Exhibits 10-33 and 10-34 present the summary statistics for this factor.

Exhibit 10-33 Summary Statistics of Organics in TCDD/TCDF Factor in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Total TCDF (pg/g)	16/16	5.6	490	123	141	1.14
Total TCDD (pg/g)	16/16	2.1	32	17.0	8.6	0.50
Dichloromethane (µg/kg)	7/69	2	290	33.1	70.2	2.12

1 – Values based on ROS. See Appendix G.

Exhibit 10-34 Summary Statistics of Inorganics (mg/Kg) in TCDD/TCDF Factor in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Sodium	64/69	1,640	48,600	13,458	10,935	0.81
Calcium	67/69	244	8,020	2,726	1,843	0.68

1 – Values based on ROS. See Appendix G.

Total TCDD is used as the indicator variable for this factor.

Surface Sediment

Total TCDD was elevated in multiple locations in the shallow lake energy system in Lower Calcasieu (Figure 10-9). The maximum concentration was observed at LCR2058, which is located along the north edge of Moss Lake. Elevated concentrations were observed at all three locations in Moss Lake.

Within Prien Lake, stations LCR2018 and LCST001 reported elevated concentrations, which are located on the west side of the lake. South of Prien Lake and the old ship channel, station LCR2039 was also observed to have elevated concentrations of total TCDD and TCDF.

When normalized to TOC, elevated concentrations are primarily in Prien Lake although the maximum normalized concentration was observed in Moss Lake at station LCR2066. This station is located on the eastern edge of Moss Lake adjacent to the ship channel.

Subsurface Sediment

Subsurface samples were not collected in the shallow lake energy system in Lower Calcasieu.

Surface Water

Total TCDD and Total TCDF were not analyzed in the surface water in the shallow lake energy system in Lower Calcasieu.

10.7.2.2.2 Discussion

The distribution of tetra - dioxins/furans (TCDD/TCDF) and the high correlation with calcium, sodium, and TOC are evidence of chemical precipitation guided deposition in Lower Calcasieu. Evaluation of the TOC normalized total TCDD/total TCDF data indicates that the most impacted area (overall concentration and greater spatial distribution) is Prien Lake. The maximum total TCDD and TCDF concentration was found in eastern Moss Lake near the confluence with the ship channel. This area tends to be the contact zone for waters of the ship channel and Moss Lake. The geometry dictates a decrease in surface water velocity and an increase in TOC due to greater algae in the warmer shallow waters of the lake. This shallow lake also tends to have higher salinities than the upper layer (upper 2 m) of the water in the ship channel. The difference in salinity may be the primary reason for increased TCDD/TCDF in location LCR2066. This is noted in the resulting sediment chemistry.

10.7.2.3 Dioxin/Furan/SVOCs Factor

This section presents the extent of the dioxin/furan/SVOCs Factor and discussion as to the fate and transport of contaminants in the shallow lake energy system.

10.7.2.3.1 Results

The dioxin/furan factor groups the hexa-, hepta-, and octa- dioxins/furans and penta-furans as well as acetone, BEHP, and cyanide. BEHP, however, is negatively correlated to the other constituents grouped in this factor (high concentrations are at locations where low concentrations of dioxins/furans were observed). Exhibits 10-35 and 10-36 present the summary statistics for this factor.

Exhibit 10-35 Summary Statistics of Organics in Dioxin/Furan/SVOCs Factor in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value (pg/g)	Maximum Detected Value (pg/g)	Mean[1] (pg/g)	Standard Deviation	Coefficient of Variation
Total HpCDF	13/16	15	500	144	164	1.14
Total HxCDF	10/16	13.3	240	74.3	83.8	1.13
OCDF	14/16	11	2,000	451	597	1.32
Total HpCDD	15/16	210	880	457	231	0.51
OCDD	16/16	1,100	8,100	4,148	2,205	0.53
Total PeCDF	10/16	6	120	33.4	38.1	1.14
Total HxCDD	16/16	39	250	108.5	56.4	0.52

1 – Values based on ROS. See Appendix G.

Exhibit 10-36 *Summary Statistics of SVOCs/Metals in Dioxin/Furan/SVOCs Factor in* Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Acetone (µg/Kg)	38/69	7	290	35.5	50.5	1.42
BEHP (µg/Kg)	24/76	36	120,000	1,968	19,487	9.90
Cyanide (mg/Kg)	24/69	0.08	3.3	0.17	0.50	2.93

1 – Values based on ROS. See Appendix G.

Since both dioxins/furans and BEHP are COPCs, both will be discussed in this factor. Total HpCDD is used as the indicator variable for dioxins/furans.

Surface Sediment

An elevated concentration of dioxins/furans was located in the southern half of Prien Lake (Figure 10-10). Elevated BEHP concentrations were also primarily located in southern Prien Lake at stations LCR2021, LCR2023, and LCR2031. The maximum concentration was observed at station LCR2021. Moss Lake was observed to have elevated concentrations along the eastern edge, adjacent to the ship channel with concentrations ranging from 66 to 3,000 µg/Kg. The remaining locations in the shallow lake energy system were less than 570 µg/Kg.

Subsurface Sediment

Subsurface sediment samples were not collected in the shallow lake energy system in Lower Calcasieu.

Surface Water

Contaminants grouped in this factor were not detected in the shallow lake energy system in Lower Calcasieu. Dioxins/furans were not analyzed in the surface water in the shallow lake energy system in Lower Calcasieu.

10.7.2.3.2 Discussion

Distribution of the heavier hexa, hepta, octa, and penta-dioxins/furans in Lower Calcasieu are present at 60 percent or more of the locations sampled. The concentrations of OCDD are highest, ranging from 1,100 to 8,100 pg/g, with a mean concentration of 4,148 pg/g. This grouping of dioxins/furans is typically associated from atmospheric deposition from municipal waste incineration (Brzuzy 1996).

As noted in the results section, BEHP is negatively correlated to dioxin/furan detections. The BEHP tendency to adsorb to suspended material may help explain this relationship. BEHP is found at moderate to high concentrations just as the dioxins/furans; however, they are not found in the same locations. Upon examining the distribution of both compounds, it appears that the dioxins/furans and BEHP are depositing along a primary circulation pattern in Prien Lake. Rhodamine dye tests and a series of aerial photos both illustrate a dominant circulation pattern in Prien Lake. Flow enters the lake at the north end and circulates along the east side of the lake, around the southern end, and exits through either the confluence with the ship channel or out through the old river meander. The direction exiting flow takes is likely dependent upon tidal stage (flood or ebb tide) and tidal strength.

The difference in distribution may be due to the size of the particle to which the dioxin/furan or BEHP binds. BEHP tends to bind to suspended particles and so would be transported further along the circulation path, as is noted.

Historically, dioxins/furans were not analyzed. No temporal analysis of dioxins/furans is available for the Lower Calcasieu shallow lakes.

10.7.3 Isolated Chemistry

Several COPCs that were detected in 5 percent or greater of the samples did not group with the two major PCA factor groups previously discussed. These include:

- HPAHs and LPAHs
- 2,3,7,8-TCDD TEQs (was not included in the PCA)

COPCs that did not group with the other major factors for one or more of the following reasons:

- The frequency of detection is typically low.
- The distribution of contamination was different than observed for the compounds for the four major factors.

Each of these COPCs is discussed in the following sections.

10.7.3.1 PAHs

This section presents the extent of PAHs in the shallow lake energy system in Lower Calcasieu and describes its fate and transport in the environment.

10.7.3.1.1 Results

Surface Sediment

HPAH concentrations were detected at a slightly greater frequency and varied more than LPAHs in the shallow lake energy system (Exhibit 10-37). Detected locations are shown in Figure 10-11.

Exhibit 10-37 Summary Statistics of PAHs (µg/Kg) in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
HPAH	26/79	21	5,220	470	1,259	2.68
LPAH	7/79	20.1	1,368	314	590	1.88

1 – Values based on ROS. See Appendix G.

Elevated concentrations of HPAHs were observed in Prien Lake, with the maximum concentration located at station LCR2017 (Figure 10-11). This station is located on the eastern edge of Prien Lake along the shoreline. The area along the shore is a residential development with several boat docks around the sampling location. Elevated LPAHs were also detected at this location; however, the maximum concentration was observed at station LCR2043.

Subsurface Sediment

Subsurface sediment samples were not collected in the shallow lake energy system in Lower Calcasieu.

Surface Water

PAHs were not detected in surface water samples.

10.7.3.1.2 Discussion

HPAHs and LPAHs were detected throughout Prien and Moss Lakes. The HPAHs were detected at slightly greater frequency and with greater variation in concentrations than the LPAHs. The distribution of both LPAH and HPAHs appears to be in line with flow from the mouth of Prien Lake across from Bayou d'Inde and Coon Island Loop. These areas are adjacent to or in line with recreational boat traffic from the residential area and may represent anthropogenic release from boating activities.

Historically, samples were collected from the shallow lakes and analyzed for PAHs in the 1992 expanded site inspection. Two samples were analyzed for PAHs from the lakes. The concentrations of total HPAHs were an order of magnitude greater than that measured for the LPAHs. The limited number of samples collected hinders evaluation of the historic distribution of PAHs.

10.7.3.2 2,3,7,8-TCDD TEQ

This section describes the distribution of dioxins/furans presented as 2,3,7,8-TCDD TEQs for the shallow lake energy system in Lower Calcasieu.

10.7.3.2.1 Results

Summary statistics are provided in Exhibit 10-38 for 2,3,7,8-TCDD TEQ. Elevated concentrations were observed in Prien Lake, with it having the maximum concentration at station LCR2018 (Figure 10-12).

Exhibit 10-38 Summary Statistics of 2,3,7,8-TCDD TEQ (pg/g) in Surface Sediment, Shallow Lake Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
2,3,7,8-TCDD TEQ	16/16	2.04	30.6	10.4	8.7	0.83

1 – Values based on ROS. See Appendix G.

Concentrations decrease away from this location. Stations LCR2010 and LCR2020 were also observed to have slightly elevated concentrations and are located toward the middle of the lake.

Stations LCR2047 and LCR2053 were observed to have elevated concentrations. LCR2047 is located in the old ship channel, and LCR2053 is located north of where Bayou Guy enters into the ship channel. The distribution of 2,3,7,8-TCDD is similar to what was observed for the Dioxins/Furan Factor in Section 10.7.2.3.

Subsurface Sediment

Subsurface samples were not collected in the shallow lake energy system in Lower Calcasieu.

Surface Water

Dioxins/furans were not analyzed in the surface water in the shallow lake energy system in Lower Calcasieu.

10.7.3.2.2 Discussion

2,3,7,8-TCDD TEQ distributions in the shallow lakes of Lower Calcasieu were found to be highest in LCR2018 near the southern end of Prien Lake. Slightly lower concentrations were found north of this location, near the mouth of Prien Lake, across from Bayou d'Inde. Limited TEQ detections are noted below Prien Lake within the old river meander near Bayou Guy. The concentrations are moderately elevated; however, distribution in this area is also limited. The overall distribution of the various dioxin/furan compounds is similar; frequency of detections and concentrations vary and are the primary differences in these discussions for the shallow lakes areas.

10.8 Nature and Extent for the Ship Channel Energy System

The results and discussion section is organized into three sections: COPCs identified for the ship channel energy system (Section 10.8.1), the results of the PCA (Section 10.8.2), and contaminants that showed little or no correlation to other contaminants or parameters (Section 10.8.3).

Graphical presentation will illustrate the concentrations of an indicator variable that will be representative of the other parameters or constituents in that factor. Key contaminants that were not presented in a factor will be presented in individual figures.

Appendix G provides details of the PCA and complete summary statistics for all compounds detected in the ship channel energy system in Lower Calcasieu.

10.8.1 COPCs for the Ship Channel Energy System in Lower Calcasieu

To focus on the COPCs that are the primary risk drivers, energy system specific COPCs were selected for discussion. These energy system specific COPCs were identified by comparing the primary risk drivers from the HHRA and the BERA and comparing those COPCs to reference area conditions. Section 10.8.1.1 presents the results of the statistical comparison of these COPCs between energy system and reference area. Section 10.8.1.2 presents the ship channel energy system COPCs identified.

10.8.1.1 Comparison to Reference Areas

Results of the WRS test are presented in Table 10-5. Contaminants that were determined to be statistically significantly different than the reference area or did not have sufficient data to compare are:

- SVOCs (bis[2-ethylhexyl]phthalate)

- PAHs (as pyrene)

10.8.1.2 COPCs Selection

Energy system specific COPCs for Lower Calcasieu were selected by determining if the COPC is a risk driver in the HHRA or the BERA and were determined to be statistically significantly different than reference area conditions (Table 10-9). In addition, contaminants are only discussed if they are observed in at least two locations or if more than 5 percent of the samples for the energy system had positive detections. The following COPCs were selected for the ship channel energy system in Lower Calcasieu:

- SVOCs (bis[2-ethylhexyl]phthalate)
- HPAHs and LPAHs

The extent as well as the fate and transport of these COPCs will be discussed in Sections 10.8.2 (PCA) and 10.8.3 (Isolated Chemistry).

10.8.2 PCA

The PCA revealed three dominant factors that accounted for most of the variability (63 percent) in surface sediment within the ship channel energy system in Lower Calcasieu. These factors are:

- A Background Metals Factor that accounts for 23 percent of the variability in surface sediment.
- A medium- to high-level contamination Dioxin/Furan/Metals Factor that accounts for 23 percent of the variability in surface sediment.
- A medium- to high-level contamination PAH/Dioxin Factor that accounts for 17 percent of the variability in surface sediment.

These factors present groups of parameters and/or contaminants that tend to correlate with each other and explain variability in the data set.

10.8.2.1 Background Metal Factor

This section describes the extent of the dioxins/furans and metals grouped within this factor.

10.8.2.1.1 Results

The Background Metal Factor metals that have concentrations similar to what was observed in the reference areas. Exhibit 10-39 presents the summary statistics for the constituents grouped within this factor.

Exhibit 10-39 Summary Statistics for Metals (mg/Kg) in the Background Factor for the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Nickel	37/52	0.78	29.3	8.40	5.83	0.69
Iron	52/52	453	28,000	7,600	6,124	0.81
Beryllium	28/52	0.07	1.2	0.50	0.37	0.74
Potassium	51/52	111	4,740	1,928	1,180	0.61
Cobalt	44/52	0.69	20.6	18.6	17.9	0.96
Zinc	37/52	8.2	104	31.3	22.7	0.73
Aluminum	52/52	318	20,300	8,486	5,359	0.63
Chromium	50/52	1.2	58.9	13.1	10.8	0.82
Vanadium	51/52	0.54	71	17.6	12.4	0.71
Arsenic	52/52	0.18	29.6	3.62	4.79	1.32
Manganese	52/52	3.5	1,770	188	309	1.64
Copper	42/52	3.3	80.8	18.6	17.9	0.96

1 – Values based on ROS. See Appendix G.

Since this factor presents metals similar to background concentrations, their extent in the ship channel energy system in Lower Calcasieu will not be discussed further.

10.8.2.2 Dioxin/Furan/Metal Factor

This section describes the extent of contaminants grouped in this factor within the ship channel energy system in Lower Calcasieu.

10.8.2.2.1 Results

This factor groups hexa- and octa- dioxin and furans as well as total (penta) PeCDFs and total (hepta) HpCDDs. Other contaminants include: barium, cyanide, mercury and diesel and include pH. Exhibits 10-40 and 10-41 present the summary statistics for contaminants in this factor.

Exhibit 10-40 Summary Statistics for Dioxins/Furans (pg/g) in the Dioxin/Furan/Metal Factor for the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Total PeCDF	4/10	8.5	150	19.0	53.2	3.32
OCDF	6/10	13	1,300	181	515	2.84
Total HxCDF	5/10	11	230	30.3	96.1	3.17
Total HxCDD	10/10	7.1	180	80.9	51.6	0.64
Total HpCDD	10/10	56	780	326	248	0.76
OCDD	10/10	430	4,000	1,913	1,215	0.64

1 – Values based on ROS. See Appendix G.

Exhibit 10-41 Summary Statistics for Other Contaminants in the Dioxin/Furan/Metal Factor for the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Diesel (µg/Kg)	4/10	67,000	280,000	73,174	105,903	1.44
Barium (mg/Kg)	52/52	16	1,430	158	248	1.57
Cyanide (mg/Kg)	26/52	0.07	1.4	0.18	0.29	1.60
Mercury (mg/Kg)	10/52	0.08	1.7	-	-	-

1 – Values based on ROS. See Appendix G.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Total HxCDD was used as the indicator variable for this factor.

Surface Sediment

Contaminants grouped in this factor were observed to have elevated concentrations along the shoreline of the Citgo facility, directly across the channel from the Citgo facility, and across the channel from LC Harbor/Terminal (Figure 10-13). Highest concentration of dioxins/furans was observed at station LCR1027, which is located where Indian Marais lagoon enters into the ship channel. LCR1027 also had a diesel concentration of 240,000 (µg/Kg). Directly south and across the ship channel, station LCR1036 was also observed to have elevated concentrations of dioxins/furans and was the location where the maximum concentration of diesel was observed. Station LCR1020 is located on the northern edge of the Citgo facility on the western shore of the ship channel, and was also observed to have elevated concentrations. This area is slightly off the channel in a shallow area that may be less affected by other locations along the channel.

Subsurface Sediment

Multi-depth sediment samples were not collected in the ship channel in Lower Calcasieu.

Surface Water

Barium and mercury were detected in surface water samples collected in the ship channel energy system in Lower Calcasieu. Exhibit 10-42 presents the total and dissolved (if detected) concentrations of these contaminants and compares them to EPA AWQC (as reported in the Federal Register 1995) CCC (chronic) and CMC (acute) values and/or LDEQ Water Quality Regulation (LDEQ 2000) for both freshwater and marine environments. For systems with salinity between 1 and 10 ppt, the more stringent of either fresh or marine values should be used to compare with mean dissolved concentrations. In cases where the dissolved phase was not detected, the surface water criteria for that contaminant was converted to an unfiltered criterion using a conversion factor provided in LDEQ 2000.

Exhibit 10-42 Mean and Standard Deviation of Total and Dissolved Concentrations (mg/L) in Metal Factor in Surface Water, Shallow Lake Energy System

Analyte	Mean Total[1]	Mean Dissolved[1]	Fresh Acute	Fresh Chronic	Marine Acute	Marine Chronic
Barium	0.1035 (0.007)	0.0071 (0.081)	-	-	-	-
Mercury	0.000049[2]	0.000058[2]	0.002[3]	**0.000012[3]**	0.002[3]	**0.000025[3]**

1 – Based on ROS. See Appendix G. If only two samples, an average was calculated. ND: Not detected
2 – Only detected in one sample.
3 – LDEQ Water Quality Regulations based on 200-mg/L hardness for dissolved concentrations.
(-) – No criteria established by LDEQ.

Mercury was detected at station LCR1024, which is located directly across the ship channel from the Citgo facility. Mercury concentrations exceed both the fresh and marine chronic criteria established by LDEQ.

10.8.2.2.2 Discussion

The highest dioxin/furan detection was found across from the mouth of Indian Marais Lagoon. The occurrence tends to correlate with elevated diesel detections as well. Distribution tends to be limited to the area near the Citgo facility; concentrations decrease upstream and downstream of this area.

Mercury is present in 10 of 52 sediment samples collected from the Lower Calcasieu AOC ship channel energy system. The concentrations range from 0.08 to 1.7 mg/Kg. Historically, samples analyzed for mercury (1989 EPA Toxics study) had positive detections in six of eight samples at similar concentrations. Mercury was detected in the surface water in the RI and indicates recent release to the ship channel.

10.8.2.3 PAH/Dioxin Factor

This section describes the extent of contaminants grouped in the PAH/Dioxin Factor in the ship channel energy system in Lower Calcasieu.

10.8.2.3.1 Results

This factor groups PAHs, dioxins, and acetone as well as silt, which is important in determining fate and transport of these contaminants. The PAHs, however, are negatively correlated with the dioxins, acetone, and silt. These PAHs tend to be elevated in areas where there is a low silt percentage as well as low concentrations of dioxins and acetone. Summary statistics are provided in Exhibits 10-43 and 10-44.

Exhibit 10-43 Summary Statistics for PAHs in the PAH/Dioxin Factor for the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Pyrene	12/52	53	7,400	395	1,273	3.23
Fluoranthene	10/52	47	7,600	-	-	-

1 – Values based on ROS. See Appendix G.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Exhibit 10-44 Summary Statistics for Other Constituents in the PAH/Dioxin Factor for the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Total PeCDD	6/10	7.1	28	15.4	11.3	0.74
Total TCDD	9/10	0.66	31	15.3	13.1	0.86
Acetone	30/52	3	170	22.9	33.5	1.47

1 – Values based on ROS. See Appendix G.

Pyrene was used as the indicator variable for this factor and is indicative of both LPAHs and HPAHs

Surface Sediment

Contaminants grouped within this factor are primarily along the Citgo facility shoreline and across the ship channel from the facility (Figure 10-14). Maximum concentrations were observed at station LCR1055, which is located between Citgo outfalls 4 and 6. A loading/unloading dock is also located at this location.

Concentrations decrease upstream and downstream as well as across the channel from this location. There are select samples where elevated concentrations of PAHs were observed. Station LCR1041, which is located between Conoco and Citgo in Lower Calcasieu and station LCR1046, which is located along the shoreline of the Westlake facility.

Dioxins, which are negatively correlated to PAHs according to the PCA, were also observed to have elevated concentrations adjacent to the Citgo facility but detected at different sample locations. The difference may be due to the lack of samples collected for dioxin/furan analysis. Since silt correlated with dioxins, PAHs may be more correlated with smaller grain size particles.

Subsurface Sediment

Multi-depth subsurface samples were not collected in the ship channel energy system in Lower Calcasieu

Surface Water

Dioxin was not analyzed in surface water. PAHs and acetone were not detected in surface water samples.

10.8.2.3.2 Discussion

The PAHs tend to be elevated in areas adjacent to Citgo. The dioxins tend to be associated with elevated silt concentrations. These areas are not necessarily the same. Distribution of dioxins in the ship channel is elevated primarily at and downgradient of the Citgo facility with low levels clustered below Citgo near LCR1033 on the eastern bank of the ship channel below the Citgo facility. The PAH (HPAHs, specifically pyrene) distribution correlates with the (overall lower concentration) distribution of LPAHs. The area at LCR1033 is a major bend in the ship channel and likely represents a surface water velocity drop along the shallow shelf where these samples were collected. The maximums noted at Citgo are located near the shipping dock and below NPDES outfalls 004 and 006.

10.8.3 Isolated Chemistry

Several COPCs that were detected in 5 percent or greater of the samples did not group with the two major PCA factor groups previously discussed. These include:

- BEHP
- PCBs

This COPC did not group with the other major factors for one or more of the following reasons:

- The frequency of detection is typically low.
- The distribution of contamination was different than observed for the compounds for the four major factors.

Each of these COPCs is discussed in the following sections.

10.8.3.1 BEHP

This section presents the extent of BEHP in the ship channel energy system in Lower Calcasieu and describes its fate and transport in the environment.

10.8.3.1.1 Results

Surface Sediment

BEHP was highly variable in the ship channel based on its coefficient of variation (Exhibit 10-45). However, there are three areas where elevated concentrations of BEHP were observed: along the western edge of the ship channel adjacent to Lockport Marsh, adjacent to the Citgo facility, and adjacent and south of the Westlake facility (Figure 10-15)

Exhibit 10-45 Summary Statistics for BEHP (µg/Kg) in the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
BEHP	22/52	42	30,000	768	5,995	7.81

1 – Values based on ROS. See Appendix G.

The maximum concentration of BEHP was observed at LCR1019, which is located at the north corner of the Citgo facility along the west edge of the ship channel. This area is somewhat set back from the channel and shallow in depth. Concentration of

BEHP along the Citgo facility ranges from 87 to 510 µg/Kg and with a variable spatial distribution.

Near the Westlake facility, BEHP concentration ranges from 280 to 1,400 µg/Kg, with concentrations decreasing downstream of station LCR1051. Along Lockport Marsh, BEHP ranges from 42 to 300 µg/Kg and is concentrated in an area approximately 500 m in diameter and encompasses a station across the channel.

Subsurface Sediment

Multi-depth subsurface sediment samples were not collected in the ship channel energy system in Lower Calcasieu.

Surface Water

BEHP was detected at three locations, with concentrations that range from 2 to 5 µg/L. The locations were widely distributed and did not exceed AWQC.

10.8.3.1.2 Discussion

The distribution of BEHP in the Lower Calcasieu ship channel energy system tends to be highest in the shallow inlet near the Westlake facility, upstream of Citgo. The limited number of detections and the distribution of BEHP are in the backwater, quiet locations, which align with previous findings, indicating association with fine grained or suspended material. Occurrence of BEHP within the ship channel is limited.

10.8.3.2 PCBs

This section presents the extent of total PCBs in the ship channel energy system in Lower Calcasieu and describes its fate and transport in the environment.

10.8.3.2.1 Results

Both Aroclor 1254 and Aroclor 1260 were detected in the ship channel energy system in Lower Calcasieu (Figure 10-16). Aroclor 1254 was the most frequently detected PCB in the energy system (Exhibit 10-45).

Exhibit 10-45 Summary Statistics for PCBs (µg/Kg) in the Ship Channel Energy System

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
Aroclor 1254	6/52	13	590	-	-	-
Aroclor 1260	1/52	60	60	-	-	-

1 – Values based on ROS. See Appendix G.
(-) – Mean value not calculated due to estimation of distribution becomes less accurate for less than 20% detected.

Aroclor 1254 was primarily detected from the Citgo facility downstream to Moss Lake. The maximum concentration observed for Aroclor 1254 was at station LCR1026 and decreased upstream and downstream of this location.

Aroclor 1260 was only detected at one location, LCR1036. This location is directly south and across the ship channel from where Indian Marais joins the Calcasieu River Ship Channel.

Subsurface Sediment

PCBs were not analyzed in the subsurface in the ship channel energy system.

Surface Water

PCBs were not detected in the surface water in the ship channel energy system.

10.8.3.2.2 Discussion

PCB detections were limited. Distribution was clustered around the Citgo facility, specifically near Indian Marais Lagoon. Aroclor 1260 was detected only once, at the bend on the eastern side of the ship channel below Indian Marais Lagoon at station LCR1036. The areas with detected concentrations are areas with either possible nearby sources (Indian Marais Lagoon) or protected shallow water where velocity decreases, allowing settling and accumulation of contaminants with fine-grained materials.

10.9 Summary and Conclusions

This section summarizes the COPCs found in Lower Calcasieu and presents an overview of their relation to historic data, reference areas results, spatial distribution, sediment stability, and chemical fate and transport.

10.9.1 Summary

Lower Calcasieu is divided into four energy systems: bayou, shallow lake, other (Indian Marais Lagoon), and ship channel. The energy systems are defined in Section 10.1.2 and Figure 10-1.

Potential Sources to Lower Calcasieu:

Citgo, Montell USA,
LA Pigments, and
W.R. Grace

Bayous Olsen and Guy represent the bayou system in Lower Calcasieu. Both bayous are saline, low-flow systems. Bayou Guy receives runoff from predominantly rural residential areas. Bayou Olsen receives industrial discharge from W. R. Grace Inc. and rural residential runoff. Both systems are net sediment exporters, and receiving bodies are Moss Lake for Bayou Olsen and the Old Calcasieu River channel below Prien Lake to Bayou Guy.

The shallow lake areas include Prien Lake and Moss Lake; they are semi-confined shallow low-flow systems with limited circulation. Moss Lake tends to have the larger opening to the ship channel. The ship channel system includes the main ship channel from the I-210 Bridge south the southern end of Moss Lake.

Contaminants of Potential Concern in Lower Calcasieu:

Dioxins/Furans, HPAHs, LPAHs, BEHP and Various metals

The areas that define Lower Calcasieu represent a mixture of land uses and point and non-point contaminant sources. Additional input to the Lower Calcasieu system includes flow from Upper Calcasieu, Bayou Verdine, and Bayou d'Inde sources. The most significant introduction of contaminants to the system appears to occur near the Citgo facility. Contaminants of primary interest in Lower Calcasieu are those contaminants that increase human health or ecological risk. The layout of Lower Calcasieu tends to lead to somewhat isolated occurrence of COPCs; the following is an overview of contaminant distribution within Lower Calcasieu.

Overall, the most impacted area within Lower Calcasieu is the Indian Marais Lagoon. The largest set of contaminants and highest concentrations are found in the lagoon. Former discharge has impacted lagoon sediments. Primary COPCs are PAHs and various metals, primarily lead, copper, chromium, and zinc.

The shallow lake areas, specifically Prien Lake, tend to have broad distribution of moderate-, to low-level concentrations of dioxins/furans, PAHs and some metals. Copper, lead, mercury, nickel, and zinc were present in Prien Lake in the surface water. Copper exceeded the ambient water quality criteria set for acute and chronic marine exposure and chronic freshwater exposure limits. Mercury exceeded the chronic ambient water quality criteria for freshwater systems.

Data from the ship channel portion of Lower Calcasieu had limited detections of dioxins/furans, PAHs, BEHP, and mercury. The distribution is primarily associated with the Citgo facility and the Indian Marais Lagoon. Distribution appears to represent some degree of sediment transport downstream of the potential sources, e.g., the Citgo outfalls 004 and 006 or the Indian Marais Lagoon, to a shallow shelf on the eastern side of the ship channel where velocities appear to decrease and settling occurs.

10.9.2 Conclusions

The distribution of COPCs in Lower Calcasieu is mostly concentrated in the Indian Marais Lagoon and is present in generally disperse, low-level concentrations in the ship channel and Prien Lake. Minor distribution of PAHs and various metals are present in Moss Lake.

Evidence of flow-driven transport is noted in the ship channel, with select COPC distribution noted between LCR1055 to LCR1036 (from Citgo facility to the ship channel bend south of the Citgo facility) and in Prien Lake. Distribution of dioxins/furans and BEHP in Prien Lake appear to be the result of sediment accumulation in the southern end of the lake. The specific origin of the dioxins/furans and BEHP is unknown, but based upon observed surface water circulation patterns associated with Prien Lake; it is likely that the contaminants have originated outside of the lake. The presence of COPCs in the remainder of Lower Calcasieu, e.g., the Bayou Guy, Bayou Olsen, and Moss Lake, are minimal.

COPCs of interest in Lower Calcasieu are PAHs (HPAH and LPAH), dioxins/furans, and various metals. The highest concentrations are found in the Indian Marais Lagoon, and lower levels of a sub-set of COPCs are noted in Prien Lake. It should be noted that minor sediment transport and deposition appears to be occurring downgradient of the Citgo facility and within Prien Lake. Limited historic data is available for use in evaluating sediment stability over time. Vertical core data show the highest concentrations in the 0 to 10-cm interval in Indian Marais Lagoon. Likewise, cores indicate the sediment scouring has occurred in Indian Marais Lagoon. PAH data in the subsurface indicates material is present in the shallow surface sediments but that concentration levels are lower than in the past. Subsurface data is limited to the Indian Marais Lagoon in Lower Calcasieu.

In general, PAH and dioxin/furan distribution in Lower Calcasieu sediment tends to be concentrated in the Indian Marais Lagoon. Minor miscellaneous detections are also noted in the shallow lakes, primarily Prien Lake. Minor PAH distribution extends a short distance to the area downstream of the Citgo facility within the ship channel. This distribution appears to be due to physical transport of fine-grained material and subsequent settling due to velocity drops in downstream bends of the ship channel. Concentrations indicate that the ship channel effectively exports much of the sediment that enters.

The leading potential source of contaminants appears to be the Citgo outfalls within the area. Overall, contaminants appear to be highest in the Indian Marais Lagoon. The data suggests that moderate fine or suspended particle transport is occurring, with limited deposition occurring within the ship channel near station LCR1033. Overall, sediment stability appears to be dynamic. Current conditions have led to accumulation; however, the site is susceptible to storm surge scouring. It appears that material moves out of the lagoon into the ship channel during periods of high flow and that once material enters the ship channel the compounds are carried out of the system. The data indicate that in Lower Calcasieu deposition along the shoulder of the ship channel is minor; the ship channel is an effective sediment exporter.

upper reaches. The upper portions of Lockport Marsh appear to receive contaminant input from PPG Canal and sediment stability in these areas is moderate. Protection by the levees however, would be compromised by high storm surges or flooding. Release to Lockport Marsh appears to be primarily from waste storage or discharge activities and/or impacted groundwater in-flow.

Bayou d'Inde Reach 1

Reach 1 was the Bayou d'Inde area with the greatest number of detections and the highest COPC concentrations. Reach 1 contaminants that exceed the 95 percent UCL include dioxin/furans, PCBs, BEHP, mercury, lead, and zinc. The HPAHs, LPAHs, HCB, and HCBD concentrations are also elevated, however, they are not shown on Figure 15-1. The contaminant concentrations and distribution in this reach warrant further evaluation. The BERA (CDM 2002c) identified areas throughout Reach 1 as high-risk to benthic invertebrate and fish.

The major potential source of contaminants within Reach 1 is PPG. Reach 1 also appears to receive minor amounts of impacted sediment (primarily BEHP and possibly Aroclor-1254) from upper reaches. Reach 1 may, under specific flow conditions, act as a sink for contaminated sediments exported by upper reaches. The primary contaminant source to Reach 1 is the PPG Canal. Sediment stability in Reach 1 is generally considered low and storm surges or wind forcing would likely mobilize sediments.

Bayou d'Inde Reach 2 Bayou and Marshes

The Reach 2 COPCs that exceed the 95 percent UCL include metals, PCBs, and dioxin/furans. The contaminant concentrations of metals are highest for copper, chromium, mercury, lead, and zinc. Reach 2 marshes tend to exhibit the highest concentrations for metals, dioxin/furans, and most HPAHs. Lead and zinc do not exceed the 95 percent UCL for the marshes; however, they are present in Reach 2 of the bayou at elevated concentrations.

Similarly, the HPAH compound 1,2-BPA is absent from Reach 2 marshes even though 1,2-BPA is present in the bayou, possibly indicating rapid chemical precipitation when it was released. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrate and fish.

Potential sources of contaminants within Reach 2 include Citgo, Westlake Polymers, Equistar, and PPG. Reach 2 appears to receive impacted sediment from Reach 3 industrial releases. Reach 2 bayou is a net sediment exporter and its marshes act as sinks for contaminated sediments exported by Reaches 2 and 3. Evidence of flow both up and down stream is noted for Reach 2, specifically from contaminant gradient and compound presence. Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution. Sediments may be mobilized by storm surges or wind forcing throughout lower Reach 2.

Bayou d'Inde Reach 3

Reach 3 contained a limited number of COPCs that exceed the 95 percent UCL, specifically PCBs, copper, zinc, and lead. However, concentrations of PAHs, BEHP, mercury, and dioxin/furans in Reach 3 tend to be the second highest of all detections observed in Bayou d'Inde. Two areas of possible contaminant sources are observed; the area between the uppermost Cit-Con Outfall and the Firestone outfall, and the area between OxyChem outfall 001 and Westlake outfall 002B near the LA-108 Bridge. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish.

Reach 3 is a net sediment exporter. Reach 2 marshes appear to receive contaminated sediments exported by Reach 3. Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution, and is likely mobilized by barge traffic near the docks at LA-108. Further, it appears likely that the shallow depth of Reach 3 makes the area susceptible to turbulence driven mixing due to strong winds or tidal forces.

Maple Fork Bayou

Contaminants that exceed the 95 percent UCL in Maple Fork Bayou include Aroclor-1254, chromium, and zinc. Mercury and dioxin/furans are also present at elevated levels. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish.

No major contaminant sources are known to exist for Maple Fork Bayou. Anthropogenic releases from the railroad and industrial pipelines that cross Maple Fork Bayou appear to be a possible contaminant source. Contaminant concentrations indicate local release within the bayou.

Maple Fork Bayou appears to be a net sediment exporter. Sediment stability in Maple Fork Bayou is moderate given the limited temporal data available to evaluate the contaminant entry into Maple Fork Bayou. Storm surge or wind forcing may mobilize sediments.

Indian Marais Lagoon

The primary contaminants in Indian Marais Lagoon that exceed the 95 percent UCL include PAHs (HPAH and LPAH), PCBs, lead and zinc. Vertical core data indicate that sediment scouring has occurred in Indian Marais Lagoon.

The leading potential source of contaminants appears to be the former waste handling activities in the Indian Marais Lagoon with some addition from outfalls within the area (e.g., Citgo) or upstream industrial releases to Upper Calcasieu, Bayou Verdine or Bayou d'Inde. The BERA (CDM 2002c) has indicated that Indian Marais is a high risk for benthic invertebrate and fish. Overall, sediment stability appears to be low. Current conditions have led to sediment accumulation, however, historically the site has been susceptible to storm scouring. It appears that material moves out of the lagoon into the ship channel during periods of high flow.

Table 2-1
Summary of Discharge Data And Permit Limits

Facility	Chemical	Mean Load (pounds/day)	Maxium Load (pounds/day)	Average Permitted Load (pounds/day)	Maximum Permitted Load (pounds/day)
Lyondell NPDES # LA0005347	1,2-dichloroethane	ND	ND	2.24	7.1
	Ammonia	263	514	1,820	4,732
	Anthracene	ND	ND	0.14	0.37
	Benzo(a)anthracene	ND	ND	0.14	0.37
	Benzo(a)pyrene	ND	ND	0.14	0.38
	Chrysene	ND	ND	0.14	0.37
	Copper	2.839	5.489	monitor	monitor
	Flow (mgd)	2.86	3.33	NA	NA
	Nickel	2.12	3.08	9.85	23.1
	Zinc	4.01	9.54	88	176
Citgo Petroleum NPDES # LA0005941	Ammonia	263	656	1,695	3,701
	BOD	874	1,611	NA	NA
	Cadmium	0.0835	0.0835	NA	NA
	Chromium	4.13	5.29	NA	NA
	Chromium VI	0.93	1.17	NA	NA
	Flow (mgd)	11.3	15	NA	NA
	Oil and Grease	422	793	NA	NA
	Phenolics	2.1	4.76	19.6	57
	Sulfide	5.28	11.5	NA	NA
	Total Organic Carbon	3,342	5,132	NA	NA
	Total Suspendid Solids	1,198	2,237	NA	NA
	Zinc	3.63	5.51	13	25.9
Conoco Refinery NPDES # LA0003026	1,2-dichloroethane	0.384	1.24	none	none
	Ammonia	45.5	109	1,152	2,516
	Flow (mgd)	3.86	5.76	NA	NA
	Phenolics	0.307	1.04	13.3	43
	Zinc	14.4	14.8	monitor	monitor
Condea Vista NPDES # LA0003336	1,2-dichloroethane	0.932	4.05	3.18	4.14
	Ammonia	5.42	13.4	41	88
	Flow (mgd)	1.96	2.72	NA	NA
	Zinc	15.9	22.4	79.6	177
PPG Industries NPDES # LA0000761	1,2-dichloroethane	0.98	3.03	monitor	monitor
	Bromoform	8.95	30.9	41	81
	Copper	5.78	14.8	28	73.2
	Flow (mgd)	16.2	18.9	NA	NA
	Hexachlorobenzene	0.00155	0.0162	0.0001	0.00034
	Hexachlorobutadiene	0.0351	0.487	0.0675	0.203
	Mercury	0.0153	0.0492	0.13	0.3
	Nickel	6.25	16.4	17.6	46.1

NA - Not Analyzed (not a pollutant of concern)

ND - No data or not detected and reported as 0

Table 2-1
Summary of Discharge Data And Permit Limits

Facility	Chemical	Mean Load (pounds/day)	Maxium Load (pounds/day)	Average Permitted Load (pounds/day)	Maximum Permitted Load (pounds/day)
OxyChem *NPDES #* LA0069850	*Flow (mgd)*	*0.95*	*1.19*	NA	NA
Firestone NPDES # LA0003824	Ammonia	12.6	31.3	92.5	185
	Flow (mgd)	1.27	1.87	NA	NA
Westlake Polymers NPDES # LA0071382	1,2-dichloroethane	ND	ND	0.49	1.57
	Anthracene	ND	ND	0.05	0.13
	Benzo(a)anthracene	ND	ND	0.05	0.13
	Benzo(a)pyrene	ND	ND	0.05	0.13
	Chrysene	ND	ND	0.05	0.13
	Flow (mgd)	0.93	1.24	NA	NA
	Fluoranthene	ND	ND	0.06	0.15
	Hexachlorobenzene	ND	ND	0.00013	0.0003
	Hexachlorobutadiene	ND	ND	0.019	0.043
	Phenanthrene	ND	ND	0.05	0.13
	Phenol	ND	ND	0.05	0.13
	Pyrene	ND	ND	0.05	0.13
	Zinc	0.434	0.571	none	none
Westlake Petrochemicals NPDES # LA0082511	1,2-dichloroethane	ND	ND	0.32	1.01
	Anthracene	ND	ND	0.1	0.28
	Benzo(a)anthracene	ND	ND	0.1	0.28
	Benzo(a)pyrene	ND	ND	0.11	0.29
	Chrysene	ND	ND	0.1	0.28
	Flow (mgd)	0.94	1.23	NA	NA
	Fluoranthene	ND	ND	0.12	0.32
	Fluorene	0.0143	0.136	0.1	0.28
	Hexachlorobenzene	ND	ND	0.005	0.01
	Hexachlorobutadiene	ND	ND	0.1	0.23
	Phenanthrene	0.0325	0.205	0.1	0.28
	Phenol	ND	ND	0.07	0.12
	Zinc	ND	ND	0.12	0.32
Louisiana Pigment NPDES # 0080829	1,2-dichloroethane	0.000109528	ND	monitor	monitor
	Copper	0.0586	0.324	none	6
	Flow (mgd)	1.13	1.48	NA	NA
	Lead	0.154	0.224	none	1.8
	Mercury	0.00145	0.0143	none	0.06
	Nickel	0.495	1.13	none	6
	Zinc	ND	0.838	none	11.9

NA - Not Analyzed (not a pollutant of concern)

ND - No data or not detected and reported as 0

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Benzene	4/21/1990	A spill of 45 gallons occurred at the plant dock facility into the ship channel.	NOI
Benzene	2/18/1991	Inspection reported presence of 15.7 ppb in sampling.	NA
Chlorobenzene	2/18/1991	Inspection reported presence of 775.9 ppb in sampling.	NA
Chlorobenzene	10/21/1991	Inspection reported presence of 306 ppb in sampling.	NA
Chlorobenzene	4/22/1987	A spill of 4-5 bbls occurred.	NA
Chromium	12/9/1985	A spill of 300-400 gallons of water with 3 mg/l of chromium occurred from the rainwater discharge into the Calcasieu River.	006
Chromium	5/13/1986	Approximately .0076 lbs leaked into a sewer at the Citgo Refinery and into the Calcasieu River.	NA
Chromium, Total	11/19/1981	Permittee was authorized to discharge "after Sabine river water" an average of 38 lbs/day and a maximum of 64 lbs/day.	003
Chromium, Total	11/19/1981	Discharge from outfalls 002 = 3.5 ave., 6.0 max; 002A = 2.7 ave., 4.4 max.; 002B = 0.8 ave., 2.4 max	002
Cresol	12/11/1985	Wastewater was received by three impoundments.	NA
Dichlorobenzene,1,3-	2/18/1991	Inspection reported presence of 24.9 ppb in sampling.	NA
Dichlorobenzene,1,4-	2/18/1991	Inspection reported presence of 120.7 ppb in sampling.	NA
Methyl Ethyl Ketone	12/11/1985	Wastewater was received by three impoundments.	NA
Mysidopsis Bahia	04/00/1997	Failed bioassay test (August 10-15, 1997). Three additional samples passed with no lethality at the low flow 42%.	TX1S
Naphthalene	06/00/1987	Naphthalene was detected in wells 32 and 51.	NA
Naphthalene	10/00/1987	Naphthalene was detected in well 36.	NA
Naphthalene	10/00/1989	Sampling of Surge Pond wells detected naphthalene.	NA
Phenol	4/16/1981	Reported value of 691 lbs/day was in violation of the permit value of 650 lbs/day.	003
Phenol	4/26/1981	Reported value of 10.3 lbs/day was in violation of the permit maximum of 7.0 lbs/day.	001
Phenol	6/23/1981	Reported value of 1,048 lbs/day was in violation of the permit maximum of 650 lbs/day.	003
Phenol	8/4/1981	Recorded value was 345 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	8/4/1981	Reported value of 345 lbs/day was in violation of the permit maximum of 32 lbs/day.	003
Phenol	8/6/1981	Reported value of 419 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	8/11/1981	Reported value of 331 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	8/13/1981	Reported value of 743 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	8/18/1981	Recorded value was 470 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	8/18/1981	Reported value of 470 lbs/day was in violation of the permit maximum of 32 lbs/day.	003
Phenol	8/20/1981	Recorded value was 2,239 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	8/25/1981	Recorded value was 665 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	8/27/1981	Recorded value was 237 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/1/1981	Recorded value was 325 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/3/1981	Recorded value was 199 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/8/1981	Recorded value was 147 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/10/1981	Recorded value was 139 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/15/1981	Reported value of 37 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	9/22/1981	Recorded value was 174 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/24/1981	Recorded value was 131 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	9/29/1981	Recorded value was 37 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	10/1/1981	Reported value of 94 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/6/1981	Reported value of 93 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/8/1981	Reported value of 80 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/13/1981	Reported value of 120 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/15/1981	Reported value of 112 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/20/1981	Reported value of 289 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	10/22/1981	Reported value of 699 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	11/5/1981	Reported value of 52.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	11/10/1981	Reported value of 90.8 lbs/day was in violation of the permit limit of 32 lbs/day.	003
Phenol	11/12/1981	Reported value of 61.4 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	11/17/1981	Reported value of 104.0 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	11/24/1981	Reported value of 163.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	11/26/1981	Reported value of 372.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/1/1981	Reported value of 350 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/2/1981	Reported value of 45.7 lbs/day was in violation of the permit value of 32 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	12/5/1981	Reported value of 46.4 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/6/1981	Reported value of 41.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/7/1981	Reported value of 119.0 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/8/1981	Reported value of 128.6 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/10/1981	Reported value of 52.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/11/1981	Reported value of 108 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/12/1981	Reported value of 60.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/13/1981	Reported value of 626 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/14/1981	Reported value of 2,189 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/15/1981	Reported value of 2,637 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/16/1981	Reported value of 2,533 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/17/1981	Reported value of 2,467 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/18/1981	Reported value of 2,286 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/19/1981	Reported value of 2,110 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/20/1981	Reported value of 2,538 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/21/1981	Reported value of 1,356 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/22/1981	Reported value of 453 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/23/1981	Reported value of 311 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/24/1981	Reported value of 205 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/25/1981	Reported value of 166 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/26/1981	Reported value of 136 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/27/1981	Reported value of 120 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/28/1981	Reported value of 106.8 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/29/1981	Reported value of 78.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	12/30/1981	Reported value of 95 lbs/day was in violation of the permit value of 32 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	12/31/1981	Reported value of 464 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/1/1982	Reported value of 68 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/2/1982	Reported value of 48 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/3/1982	Reported value of 84.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/4/1982	Reported value of 69.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/5/1982	Reported value of 47.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/6/1982	Reported value of 46.1 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/7/1982	Reported value of 50 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/8/1982	Reported value of 42.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/9/1982	Reported value of 65.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/11/1982	Reported value of 46.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/12/1982	Reported value of 182.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/13/1982	Reported value of 102.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/14/1982	Reported value of 93.1 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/15/1982	Reported value of 76.1 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/16/1982	Reported value of 76.6 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	1/17/1982	Reported value of 64.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/9/1982	Reported value of 45.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/12/1982	Reported value of 47.6 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/13/1982	Reported value of 64.8 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/14/1982	Reported value of 127.8 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/15/1982	Reported value of 159.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/16/1982	Reported value of 139.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/17/1982	Reported value of 83.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/18/1982	Reported value of 39.5 lbs/day was in violation of the permit value of 32 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	2/19/1982	Reported value of 46.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/20/1982	Reported value of 47.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/21/1982	Reported value of 41.1 lbs/day was in violation of the permit value e of 32 lbs/day.	003
Phenol	2/22/1982	Reported value of 46.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/23/1982	Reported value of 64.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/24/1982	Reported value of 74.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/25/1982	Reported value of 87.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/26/1982	Reported value of 72.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/27/1982	Reported value of 67.4 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	2/28/1982	Reported value of 57.4 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol	9/19/1983	Recorded value was 551.6 lbs/day. Permit values were a daily maximum of 230 lbs/day, and a daily average of 115 lbs/day.	003
Phenol	9/21/1983	Recorded value was 427.9 lbs/day. Permit values were a daily maximum of 230 lbs/day, and a daily average of 115 lbs/day.	003
Phenol	12/29/1983	A value of 66 was recorded at Plywood Dam, near Gate No. 25. Permit limits were not provided.	NA
Phenol	12/29/1983	A value of 0.11 was recorded at Final Culvert Before Bayou D'Inde. Permit limits were not provided.	NA
Phenol	1/5/1984	A value of 0.05 was recorded at Plywood Dam Near Gate No. 25. Permit limits were not provided.	NA
Phenol	1/5/1984	A value of 0.07 was recorded at Bayou D'Inde Bridge. Permit limits were not provided.	NA
Phenol	5/10/1984	Recorded value was 216.7 lbs/day. Permit values were a daily maximum of 7.0 lbs/day and a daily average of 3.0 lbs/day.	001
Phenol	5/11/1984	Recorded value was 1,156.0 lbs/day. Permit values were a daily maximum of 7.0 lbs/day and a daily average of 3.0 lbs/day.	001
Phenol	5/12/1984	Recorded value was 372.9 lbs/day. Permit values were a daily maximum of 7.0 lbs/day and a daily average of 3.0 lbs/day.	001
Phenol	5/13/1984	Recorded value was 293.4 lbs/day. Permit values were a daily maximum of 7.0 lbs/day and a daily average of 3.0 lbs/day.	001
Phenol	5/14/1984	Recorded value was 8.1 lbs/day. Permit values were a daily maximum of 7.0 lbs/day and a daily average of 3.0 lbs/day.	001

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	9/16/1985	Recorded value was 45.9 lbs/day. Permit values were a daily maximum of 32 lbs/day, and a daily average of 15 lbs/day.	003
Phenol	10/27/1985	Recorded value was 1,317.3 lbs/day. Permit values were a daily maximum of 32.0 lbs/day, and a daily average of 15.0 lbs/day.	003
Phenol	10/28/1985	Recorded value was 3,947 lbs/day. Permit values were a daily maximum of 32 lbs/day, and a daily average of 15 lbs/day.	003
Phenol	10/29/1985	Reported value of 1,794.1 was in violation of the limit of 32.	003
Phenol	10/30/1985	Recorded value was 1,022.6 lbs/day. Permit values were a daily maximum of 32 lbs/day, and a daily average of 15 lbs/day.	003
Phenol	10/31/1985	Recorded value was 371.6 lbs/day. Permit values were a daily maximum of 32.0 lbs/day, and a daily average of 15.0 lbs/day.	003
Phenol	5/20/1986	Approximately 16,400 gallons of untreated refinery effluent spilled into the Indian Marais. Analysis of the effluent spill indicated that 1.9 lbs of Phenol at a concentration of 14 ppm were discharged. The NPDES permit limit for this contaminant was 32 lbs/day. Concentration did not exceed permit limits.	003
Phenol	6/8/1986	Permittee discharged 210 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenol	6/11/1986	Reported value of 172 lbs/day was in violation of the permitted daily maximum of 32 lbs/day.	003
Phenol	11/24/1986	Permittee discharged 228 lbs/day. Permit values were a daily maximum of 15.6 lbs/day, and a daily average of 60.1 lbs/day.	003
Phenol	6/28/1989	Recorded value was 83.8 lbs/day. Permit values were a daily average of 15.6 lbs/day and a daily maximum of 60.1 lbs/day.	003
Phenol	6/29/1989	Recorded value was 0.002 mg/l. Closure permit testing value was 0.002 mg/l.	NA
Phenol	6/29/1989	Permittee discharged 1,364 lbs/day in violation of the daily maximum permit limit of 60.1 lbs/day from a sum of outfalls 003A and 003B.	003
Phenol	6/30/1989	Recorded value was 92 lbs/day. Permit values were a daily average of 15.6 lbs/day and a daily maximum of 60.1 lbs/day.	003
Phenol	7/1/1989	Recorded value for outfalls 003a and 003b was 129 lbs/day. Permit value was 60.1 lbs/day.	SUM
Phenol	11/23/1989	Total phenol compounds discharged was 18,530 pounds. The discharge triggered a series of events which resulted in 9 daily exceedances and 2 monthly exceedances. The fish kill was estimated at 400 pounds, and dead crabs were nearby the outfall.	001
Phenol	12/28/1989	Recorded value was 249 lbs/day. Permit values were a daily average of 15.6 lbs/day, and a daily maximum of 60.1 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol	01/00/1981	Reported value of 230 lbs/day was in violation of the permit value of 130 lbs/day.	003
Phenol	03/00/1981	Reported value of 170 lbs/day was in violation of the permit average of 130 lbs/day.	003
Phenol	04/00/1981	Reported value of 215 lbs/day was in violation of the permit average of 130 lbs/day.	003
Phenol	06/00/1981	Reported value of 357 lbs/day was in violation of the permit average of 130 lbs/day.	003
Phenol	08/00/1981	Reported value of 681 lbs/day was in violation of the permit average of 15 lbs/day.	003
Phenol	09/00/1981	Reported average of 135 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol	09/00/1981	Reported value of 135 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol	10/00/1981	Reported average of 166 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol	11/00/1981	Reported average of 112 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol	11/00/1985	Permittee discharged an average of 6.1 lbs/day. Daily average permit value was 3.0 lbs/day.	001
Phenol	11/00/1985	Permittee discharged 47.3 lbs/day. Daily maximum permit value was 7.0 lbs/day.	001
Phenol	12/00/1981	Reported average of 705 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol, Avg	01/00/1982	Reported value of 66 lbs/day was in violation of the permit value of 15 lbs/day.	003
Phenol, Avg	02/00/1981	Reported value of 3.2 lbs/day was in violation of the permit average of 3.0 lbs/day.	BAC1
Phenol, Avg	05/00/1984	Permittee discharged 137 lbs/day. Permit value was 3 lbs/day.	001
Phenol, Max	1/18/1982	Reported value of 83.6 lbs/day was in violation of permit limit of 32 lbs/day.	003
Phenol, Max	1/19/1982	Reported value of 89 lbs/day was in violation of permit limit of 32 lbs/day.	003
Phenol, Max	1/21/1982	Reported value of 100 lbs/day was in violation of permit limit of 32 lbs/day.	003
Phenol, Max	1/22/1982	Reported value of 69.2 lbs/day was in violation of permit limit of 32 lbs/day.	003
Phenol, Max	1/23/1982	Reported value of 66.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	1/24/1982	Reported value of 58 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	1/26/1982	Reported value of 44.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	1/27/1982	Reported value of 38.8 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	1/28/1982	Reported value of 72.7 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	1/29/1982	Reported value of 73.8 lbs/day was in violation of the permit value of 32 lbs/day.	003

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenol, Max	1/30/1982	Reported value of 90.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	2/1/1982	Reported value of 64.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	2/2/1982	Reported value of 49.9 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	2/3/1982	Reported value of 72.5 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	2/4/1982	Reported value of 56.3 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenol, Max	2/6/1982	Reported value of 50.2 lbs/day was in violation of the permit value of 32 lbs/day.	003
Phenolics	6/11/1981	Reported value of 1,857 lbs/day was in violation of the permit maximum of 7.0 lbs/day.	001
Phenolics	6/16/1981	Recorded value was 49 lbs/day. Permit value was a daily maximum of 7.0 lbs/day.	001
Phenolics	6/18/1981	Reported value of 16 lbs/day was in violation of the permit maximum of 7.0 lbs/day.	001
Phenolics	6/25/1981	Recorded value was 1,905 lbs/day. Permit value was a daily maximum of 650 lbs/day.	003
Phenolics	8/13/1981	Recorded value was 743 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenolics	9/14/1984	Permittee discharged 175.1 lbs/day. Permit value was 32 lbs/day.	003
Phenolics	9/15/1985	Permittee discharged 114 lbs/day. Permit value was 32 lbs/day.	003
Phenolics	9/16/1985	Permittee discharged 45.9 lbs/day. Permit value was 32 lbs/day.	NOI
Phenolics	12/11/1985	Wastewater was received by clay impoundments.	NA
Phenolics	12/3/1989	Reported that from 11/28 to 12/3 they had recovered approximately 300-400 lbs. of dead fish and crabs from an area approximately one-half mile upstream and to one mile downstream from the outfall.	001
Phenolics	12/21/1989	Recorded value was 300 lbs/day. Permit value was a daily maximum of 60.1 lbs/day.	003
Phenolics	12/26/1989	Recorded value was 358 lbs/day. Permit values were a daily average of 15.6 lbs/day and a daily maximum of 60.1 lbs/day.	003
Phenolics	12/27/1989	Recorded value was 325 lbs/day. Permit values were a daily average of 15.6 lbs/day and a daily maximum of 60.1 lbs/day.	003
Phenolics	12/28/1989	Recorded value was 249 lbs/day. Permit values were a daily average of 15.6 lbs/day, and a daily mazimum of 60.1 lbs/day.	003
Phenolics	9/13/1997	A spilled of one drum occurred to the ground.	NOI
Phenolics	11/29/1997	A discharge of 2,871 lbs/day occurred.	NOI
Phenolics	02/00/1981	Reported value of 141 lbs/day was in violation of the permit average of 130 lbs/day.	003
Phenolics	05/00/1989	Recorded value was 1,243 lbs/day. Permit value was a daily maximum of 60.1 lbs/day.	003A

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Phenolics	06/00/1981	Reported value of 214 lbs/day was in violation of the permit average of 3.0 lbs/day.	001
Phenolics	06/00/1986	Recorded value was 15 lbs/day. Permit value was a daily minimum of 16 lbs/day.	003
Phenolics	06/00/1986	Recorded value was 211 lbs/day. Permit value was a daily maximum of 32 lbs/day.	003
Phenolics	06/00/1986	Reported value of 16 lbs/day was in violation of the daily minimum permit limit of 15 lbs/day. Three exceedances occurred.	003
Phenolics	06/00/1989	Recorded value was 136.5 lbs/day. Permit value was a daily maximum of 60.1 lbs/day.	003A
Phenolics	07/00/1989	Recorded value was 131.3 lbs/day. Permit value was a daily maximum of 60.1 lbs/day.	003A
Phenolics	09/00/1985	Permittee discharged a monthly average of 16 lbs/day. Permit value was 15 lbs/day.	003
Phenolics	10/00/1985	Reported monthly average of 275 was in violation of the limit of 15.	NOI
Phenolics	10/00/1985	Permittee discharged an average of 275 lbs/day. Permit value was an average of 15 lbs/day.	NOI
Phenolics	11/00/1986	Recorded value was 228.2 lbs/day. Permit value was a daily maximum of 60.1 lbs/day.	003A
Phenolics	11/00/1989	Recorded value was 5,124 lbs/day. Permit value was a daily maximum of 10.6 lbs/day.	001
Phenolics	9/13/1997	A spill of one drum occurred to the ground.	NA
Phenols, Average	08/00/1981	Recorded value was 681 lbs/day. Permit value was a daily average of 15 lbs/day.	003
Phenols, Maximum	4/26/1981	Recorded value was 10.3 lbs/day. Permit value was a daily maximum of 7.0 lbs/day.	BAC1
Phenols, Maximum	05/00/1989	Reported value of 1243 lbs/day was in violation of the daily maximum permit limit of 60.1 lbs/day. Two exceedances occurred.	003A
Phenols, Maximum	06/00/1986	Reported value of 211 lbs/day was in violation of the daily maximum permit limit of 32 lbs/day.	003
Phenols, Maximum	06/00/1986	Reported value was 211 lbs/day. Permit value was 32 lbs/day.	003
Solvent	11/00/1989	The source document stated "...by discharging pollutants in excess of the permit effluent limitations during November and December 1989. This noncompliance was precipitated by a large volume of solvent being discharged into the wastewater treatment and subsequently to Bayou D'Inde. This discharge exceed [sic] the effluent limitations for phenolics, TOC, BOD, and TSS and precipitated a fishkill in Bayou D'Inde."	001
Toluene	11/25/1989	A discharge over reportable quantities occurred (no measurements of the discharge or permit values were provided).	001
Toluene	11/26/1989	Permit value was 1,163 lbs/day. Permit value was a daily maximum of 1,000 lbs/day.	001
Zinc	11/16/1993	Permittee discharged 4.20 lbs/day. Permit limit was 3.00 lbs/day.	001

Table 7-2
Citgo Petroleum Corporation - Lake Charles Operations
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Zinc	7/14/1981	Reported values:Outfall 002 = 28.8 ave., 65.5 ave; 002A = 11.4 AVE., 37.2 MAX.; 002B = 17.4 AVE., 56.9 MAX	002
Zinc	11/19/1981	Discharge values: Outfall 002 = 10.1 ave., 17.3 max; 002A = 6.9 ave., 14.2 max; 002B = 3.1 ave, 6.0 max	002
Zinc	12/3/1981	Reported values:Outfall 002 = 17.0 ave., 81.6 max.; 002A = 7.1 ave., 27.1 max.; 002B = 14.8 ave., 75.9 max	002B
Zinc	3/2/1995	Daily maximum discharge of 28.8 pounds/day was in violation of the permit limit of 24 pounds/day.	003
Zinc	12/18/1995	Reported value of 0.28 mg/l was in violation of the daily maximum permit limit of 0.10 mg/l.	008
Zinc	6/18/1996	Reported value of 303.42 lbs/day was in violation of the daily maximum permit limit of 1.92 lbs/day.	002A
Zinc	6/18/1996	Reported value of 151.99 lbs/day was in violation of the daily average permit limit of .96 lbs/day.	002A
Zinc	00/00/0000	Reported value of 0.3 mg/l was in violation of the daily maximum of 0.1 mg/l.	NOI
Zinc	02/00/1981	Reported values: Outfall 002 = 30.9 ave., 57.4 max.; 002A = 7.2 ave., 16.3 max.; 002B = 23.7 ave., 41.2 max.	002
Zinc	03/00/1995	March daily average of 12.6 pounds/day was in violation of the permit limit of 12 pounds/day.	003
Zinc	05/00/1981	Reported values: Outfall 002 = 27.7 ave., 139.8 max.; 002A = 3.7 ave., 6.4 max.; 002B = 24 ave., 136.9 max.	002
Zinc	11/00/1983	A violation of an unreported amount occurred.	002B
Zinc, Average	02/00/1981	Recorded value from outfalls 002A and 002B was 23.7 lbs/day. Permit value was a daily average of 22.0 lbs/day.	002A
Zinc, Daily Avg	06/00/1996	Reported value of 151.99 lbs/dy was in violation of permit limit of .96 lbs/dy.	002A
Zinc, Daily Max	12/00/1995	Reported value of 0.3 mg/l was in violation of permit limit of 0.1 mg/l.	008A
Zirconium	3/24/1989	Approximately 50 gals. were discharged at the Lake Charles Port - Calcasieu River.	NA
Zirconium	6/25/1990	Approximately two gallons spilled at the "A" dock to the Calcasieu River.	NA

NOI - No Outfall Identified
Information obtained from permit files.

Table 10-2
LA Pigment
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Mercury	6/3/1994	Recorded value was in violation of the permit limit of 0.004 mg/l.	004
Ore Dust (PM10)	5/23/1997	A release of 1.1 pounds of an ore dust occurred over a duration of 29 minutes.	NS
Total Organic Carbon	8/4/1996	The release of 53.57 ppm of total organic carbon exceeded permit level of 50 ppm.	101
Titanium Dioxide	2/20/1995	Louisiana Pigment Company released four pounds of titanium dioxide into the atmosphere. This exceeded the permit limit of 0.88 lb/hr.	NS
Titanium Dioxide	5/9/1995	Louisiana Pigment Company released 0.2 pounds of titanium dioxide into the atmosphere. This was less than the PM-10 permit limit of 0.88 lb/hr.	NS
Titanium Dioxide	5/10/1995	A release of 0.2 pounds of titanium dioxide occurred over a duration of three minutes. This was less than the PM-10 permit limit of 0.88 lbs/hr.	NS
Titanium Dioxide	5/16/1995	A release of 0.15 lbs occurred over a duration of 10 minutes.	NS
Titanium Dioxide	6/21/1995	A release of 0.43 pounds of titanium dioxide occurred over a duration of four minutes. The PM-10 permit limit is 0.88 lbs/hr.	NS
Titanium Dioxide	6/24/1995	A release of an estimated half-pound of titanium dioxide occurred over a duration of 30 minutes. The permit limit of PM-10 is 0.4 lbs/hr.	NS
Titanium Dioxide	6/26/1995	A release of two pounds of titanium dioxide occurred over a duration of five minutes. The permitted emission limit for PM-10 is 0.898 lbs/hr.	NS
Titanium Dioxide	6/26/1995	A release of one pound of titanium dioxide occurred over a duration of five minutes. The permitted emission limit for PM-10 is 0.4 lbs/hr.	NS
Titanium Dioxide	6/26/1995	A release of an estimated 0.5 pound of titanium dioxide occurred over a duration of five minutes. The permitted emission limit for PM-10 is 0.88 lbs/hr.	NS
Titanium Dioxide	6/27/1995	A release of an estimated two pounds of titanium dioxide occurred over a duration of five minutes. The PM-10 permit limit is 3.898 lbs/hr.	NS
Titanium Dioxide	7/3/1995	A release of an estimated half-pound of titanium dioxide occurred over a duration of three minutes. The permit limit for PM-10 is 0.19 lbs/hr.	NS
Titanium Dioxide	7/8/1995	A release of 1.5 pounds of titanium dioxide occurred over a duration of five minutes. This emission point has a permit limit of 3.898 lbs/hr of PM-10.	NS
Titanium Dioxide	7/16/1995	A release of less than one pound of titanium dioxide occurred over a duration of ten minutes.	NS
Titanium Dioxide	7/21/1995	A release of 0.5 pounds of titanium dioxide occurred over a duration of 30 minutes. The PM-10 permit limit is 0.4 lb/hr	NS
Titanium Dioxide	7/22/1995	A release of 0.5 lbs of titanium dioxide occurred over a duration of 30 minutes.	NS
Titanium Dioxide	8/5/1995	A release of an estimated quarter pound of titanium dioxide occurred over a duration of five minutes. This emission point has a permit limit of 0.4 lbs/hr of PM-10.	NS
Titanium Dioxide	8/17/1995	Louisiana Pigment Company release two pounds of titanium dioxide into the atmosphere. The permitted emission limit of PM-10 is 0.4 lb/hr.	NS
Titanium Dioxide	8/31/1995	Louisiana Pigment Company released approximately one pound of titanium dioxide into the atmosphere. The PM-10 permit limit is 0.88 lb/hr.	NS

Table 10-2
LA Pigment
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Mercury	6/3/1994	Recorded value was in violation of the permit limit of 0.004 mg/l.	004
Ore Dust (PM10)	5/23/1997	A release of 1.1 pounds of an ore dust occurred over a duration of 29 minutes.	NS
Total Organic Carbon	8/4/1996	The release of 53.57 ppm of total organic carbon exceeded permit level of 50 ppm.	101
		Louisiana Pigment Company released four pounds of titanium	
Titanium Dioxide	10/3/1995	Facility discharged into the air from16:15 hours to 16:21 hours an estimated 0.3 lbs of titanium dioxide.	NS
Titanium Dioxide	10/6/1995	Facility discharged into the air from11:42 hours to 11:45 hours an estimated 0.25 lbs of titanium dioxide.	NS
Titanium Dioxide	10/12/1995	Louisiana Pigment Company released approximately 2 pounds of titanium dioxide into the atmosphere.	NS
Titanium Dioxide	10/8/1995	A release of one-tenth of a pound of titanium dioxide occurred over a duration of five minutes. The permit limit for PM-10 is 0.88 lb/hr.	NS
Titanium Dioxide	11/8/1995	A release of a minor amount of titanium dioxide occurred over a duration of five minutes. The release is estimated to be approximately equivalent to the permit limit of 0.11 lb/hr.	NS
Titanium Dioxide	11/14/1995	Louisiana Pigment Company released 0.8 pounds of titanium dioxide into the atmosphere. The permit limit for PM-10 is 0.11 lb/hr.	NS
Titanium Dioxide	12/26/1995	A release of approximately two pounds of titanium dioxide occurred over a duration of five minutes. The permit limit for this emission point is 0.4 lb/hr of PM-10.	NS
Titanium Dioxide	12/28/1995	A release of approximately three pounds of titanium dioxide occurred over a duration of 15 minutes. The permit limit for this emission point is 0.88 lbs/hr of PM-10.	NS
Titanium Dioxide	2/10/1996	A release into the atmosphere of an estimated 0.10 pounds of titanium dioxide which did not exceed the permit limit of 0.88 lb/hr between 08:00 hours and 08:05 hours.	NS
Titanium Dioxide	3/7/1996	A release into the atmosphere of 2.24 pounds of titanium dioxide in excess of the permit limit of 0.88 lbs/hr occurred between 12:45 hours of March 7, 1996 and 01:02 hours of March 8, 1996.	NS
Titanium Dioxide	4/13/1996	Louisiana Pigment Company released an unmeasurable amount of titanium dioxide into the atmosphere.	NS
Titanium Dioxide	12/5/1996	A release of approximately 1.2 pounds of titanium dioxide occurred over a duration of 10 minutes. This exceeded the permit limit of 0.88 pounds/hr.	NS
Titanium Dioxide	12/9/1996	A release of 1.9 pounds of titanium dioxide occurred over a duration of 15 minutes. This exceeded the permit level of 0.88 lb/hr.	NS
Titanium Dioxide	8/6/1997	A release of approximately 1.54 pound of titanium dioxide occurred over a duration of 35 minutes. This exceeded the permit limit of 0.88 lbs/hr.	NS
Coke & Ore Dust (PM10)	8/25/1997	An estimated 1.7 pounds of ore was released.	NS
Titanium Dioxide	9/29/1997	A release of approximately 1.2 pounds of titanium dioxide occurred over a duration of 30 minutes. This exceeded the permit limit of PM-10 of 0.88 lb/hr.	NS

Table 10-2
LA Pigment
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Mercury	6/3/1994	Recorded value was in violation of the permit limit of 0.004 mg/l.	004
Ore Dust (PM10)	5/23/1997	A release of 1.1 pounds of an ore dust occurred over a duration of 29 minutes.	NS
Total Organic Carbon	8/4/1996	The release of 53.57 ppm of total organic carbon exceeded permit level of 50 ppm.	101
Titanium Tetrachloride	3/28/1994	Louisiana Pigment Company released four pounds of titanium A release of 65 lbs occurred over a duration of 3 minutes.	NS
Titanium Tetrachloride	4/26/1994	As a result of two separate plumes, a total release of 6.08 lbs occurred over a duration of 37 minutes.	NS
Titanium Tetrachloride	6/30/1994	A release of 45.3 pounds occurred over a duration of four minutes.	NS
Titanium Tetrachloride	7/28/1994	A release of 412 pounds occurred over a duration of four minutes.	NS
Titanium Tetrachloride	9/1/1994	A release of 7.55 pounds occurred over a duration of six minutes.	NS
Titanium Tetrachloride	9/6/1994	A release of 3.6 pounds occurred over a duration of six minutes.	NS
Titanium Tetrachloride	2/20/1995	Louisiana Pigment released 4.05 pounds of titanium tetrachloride into the atmosphere. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	3/9/1995	Louisiana Pigment Company released 10.2 pounds of titanium tetrachloride into the atmosphere. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	4/11/1995	Louisiana Pigment Company released 5.39 pounds of titanium tetrachloride into the atmosphere. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	4/24/1995	A release of an unknown amount occurred over an estimated one minute.	NS
Titanium Tetrachloride	4/25/1995	A release of 0.5 pounds of titanium tetrachloride occurred. This did not exceed the reportable quantity for titanium tetrachloride of one pound. This was not a violation.	NS
Titanium Tetrachloride	5/10/1995	Louisiana Pigment Company released a total of 1.57 pounds of titanium tetrachloride into the atmosphere. The release was from two separate events of approximately 0.7 pounds and 0.9 pounds that occurred over a duration of seven minutes.	NS
Titanium Tetrachloride	5/13/1995	Louisiana Pigment Company released 22 pounds of titanium tetrachloride into the atmosphere. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	5/27/1995	Louisiana Pigment Company released 3.58 pounds of titanium tetrachloride into the atmosphere. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	6/7/1995	A release of 7.2 pounds of titanium tetrachloride occurred over a duration of 15 minutes. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	6/10/1995	A release of 14.3 pounds of titanium tetrachloride occurred over a duration of four minutes. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	6/27/1995	A release of 3.61 pounds of titanium tetrachloride occurred over a duration of five minutes. This exceeded the reportable quantity of one pound.	NS
Titanium Tetrachloride	9/14/1995	Facility released an unknown quantity of titanium tetrachloride into the atmosphere at 11:05 hours. It is not believed that the amount exceeded the reportable quantity.	NS
Titanium Tetrachloride	9/16/1995	Louisiana Pigment Company released 148.6 pounds of titanium tetrachloride into the atmosphere.	NS
Titanium Tetrachloride	9/29/1995	Facility discharged into the air from 7:26 hours to 7:45 hours an unmeasurable quantity of titanium tetrachloride.	NS

Table 10-2
LA Pigment
Enforcement History by Contaminant

CHEMICAL	DATE	VIOLATION	OUTFALL
Mercury	6/3/1994	Recorded value was in violation of the permit limit of 0.004 mg/l.	004
Ore Dust (PM10)	5/23/1997	A release of 1.1 pounds of an ore dust occurred over a duration of 29 minutes.	NS
Total Organic Carbon	8/4/1996	The release of 53.57 ppm of total organic carbon exceeded permit level of 50 ppm.	101
Titanium Tetrachloride	1/30/1996	Louisiana Pigment Company released four pounds of titanium A release from a gasket in the CP-1 Process Unit of titanium tetrachloride in the estimated amount of 0.9 pounds whish is below the reportable quantity of 1000 pounds occurred from approximately 6:50 pm until 7:35 pm.	NS
Titanium Tetrachloride	2/16/1996	A release of chlorine and titanium tetrachloride occurred at 16:17 hours when these elements backed up from the process into the aluminum feed piping, burning a hole in the feed line. The release did not leave the plant nor was there any off-site impact.	NS
Titanium Tetrachloride	12/15/1996	Louisiana Pigment Company released approximately 13.3 pounds of titanium tetrachloride into the atmosphere over a 57 minute period of time.	NS
Titanium Tetrachloride	8/22/1997	A release of approximately 1.8 pounds of titanium tetrachloride occurred over a duration of 20 minutes. The reportable quantity for titanium tetrachloride is 1000 pounds.	NS
Titanium Tetrachloride	3/25/1998	Recorded value of 29.4 pounds which did not exceed the reportable quantity.	NS
Titanium Tetrachloride	3/27/1998	Louisiana Pigment released 349.4 pounds of titanium tetrachloride. DID NOT EXCEED THE REPORTABLE QUANTITY.	NS
Titanium Tetrachloride	3/29/1998	Louisiana Pigment released 144.28 pounds of titanium tetrachloride. DID NOT EXCEED THE REPORTABLE QUANTITY.	NS
Total Vanadium, D. Max	07/00/94	The recorded value of 3.6 lbs/day was in violation of the permit limit of 2.8 lbs/day. One excursion reported.	001A
Total Vanadium, D. Max	7/26/1994	The recorded value of 0.899 mg/l was in violation of the permit limit of 0.400 mg/l. One excursion reported.	001A
Total Zirconium, D. Max	11/7/1993	The recorded value of 0.3037 mg/l was in violation of the permit limit of 0.100 mg/l. One excursion reported.	004A
Copper	2/9/1996	The recorded value of 0.0716 mg/l was in violation of the permit limit of 0.071 mg/l.	004
Zinc	2/10/1996	The recorded value of 8.554 mg/l was in violation of the permit limit of 0.868 mg/l.	004

Reference Sheet

REF+158414

Printed: 09/26/2003 6:46 am

Reference Sheet

REF+158415

Printed: 09/26/2003 6:46 am

EPA REGION 6 TRANSMITTAL

☐ fax
☐ fax w/ hard copy to follow
☒ hard copy only

fax # ____________
# of pages (inc. cover) ________

Remediation Services Division
Manager: [illegible]
Team Leader: Wilson
AI #: 7443
TEMPO Task #:
☐ Desk Copy File Room: IAS

TO:

Duane Wilson
Office of Environmental Assessment
Remediation Services Division
602 N. Fifth Street
Baton Rouge, LA 70802

FROM:

John Meyer
1445 Ross Ave (6SF-LP)
Dallas, TX 75202
214-665-6742
fax 214-665-6660

DATE: **September 5, 2003**

RECEIVED
SEP 08 2003
LA DEPT. OF ENV. QUALITY
REMEDIATION SERVICES
LOG #: 42004-1335

TRANSMITTED

ITEM	DESCRIPTION
1	Changed pages for Calcasieu Final RI report
2	CD copy of .pdf files for Final Calcasieu RI

REMARK:

AI# 7443