FINAL
DAMAGE ASSESSMENT AND RESTORATION PLAN/ ENVIRONMENTAL ASSESSMENT FOR GREENS BAYOU, HARRIS COUNTY, HOUSTON TEXAS

December 14, 2008

Prepared by the:

National Oceanic and Atmospheric Administration

Texas Commission on Environmental Quality

Texas Parks and Wildlife Department

and

United States Fish and Wildlife Service

acting on behalf of the

United States Department of the Interior

EXECUTIVE SUMMARY

This Final Damage Assessment and Restoration Plan/Environmental Assessment (DARP/EA) has been developed by the Texas Commission on Environmental Quality, the Texas Parks and Wildlife Department, the National Oceanic and Atmospheric Administration of the U. S. Department of Commerce, and the United States Fish and Wildlife Service acting on behalf of the U.S. Department of the Interior, (collectively, 'the Trustees') to address natural resources (including ecological services) injured, lost or destroyed within Greens Bayou and a portion of the surrounding properties in Harris County, Houston, Texas. The natural resource injuries and loss are due to releases of hazardous substances and subsequent response actions to address the release.

The Greens Bayou Site (the 'Site') consists of two industrial facilities owned and operated by GB Biosciences Corporation and ISK Magnetics, Inc., surrounding industrial and undeveloped properties, the Harris County Flood Control District (HCFCD) ditch, and Greens Bayou. Historically the Site (or portions of the Site) was owned and operated by Occidental Chemical Corporation. Haden Road roughly divides the Site into two parcels consisting of the operating facilities (approximately 134 acres) and a largely undeveloped tract of land (approximately 83 acres). Surface water from the Site is conducted in the HCFCD ditch, a partially-lined culvert, where it flows through the facilities from north to south, then turns southwest near Haden Road and terminates at Greens Bayou. The HCFCD ditch was tidally influenced in the southern sections until a sediment retention dam was constructed at the mouth of the ditch in 2002. Greens Bayou flows east through an industrialized area before turning southwest prior to entering the Houston Ship Channel approximately 20 miles northeast of its confluence into Galveston Bay. Historical operations at these two facilities have resulted in releases of hazardous substances, such as dichlorodiphenyltrichloroethane (DDT) and its metabolites, to the Greens Bayou Site. This Final DARP/EA addresses only injuries to natural resources at the Site that are or may be attributable to releases from these two facilities and subsequent remedial actions. It does not address natural resource injuries at the Site due to releases of hazardous substances by any other party.

The Trustees determined that two categories of injury resulted at the Greens Bayou Site, injury to bayou sediments and injury to terrestrial forested wetlands/grasslands. Approximately 6.9 acres of benthic habitat in Greens Bayou were impacted by hazardous substances historically released from the Site. This area and approximately 12.4 acres of additional benthic habitat will likely be impacted by the remedial actions at the Site. The creation of the Confined Dredge Disposal

Facility to manage sediments dredged as part of the remedial activities will result in the destruction of approximately 34.6 acres of prairie, forested wetlands, and woodlands habitats.

Under this Final DARP/EA, assessed resource injuries will be compensated for by the construction of approximately 10.9 acres of vegetated intertidal wetlands as well as the preservation in perpetuity of 100.0 acres of forested wetlands. These actions will result in the replacement of benthic resources lost and/or injured due to exposure to hazardous substances as well as response activities associated with the removal of contaminated sediments from Greens Bayou. These restoration actions will also result in the replacement of terrestrial resources lost and/or injured due to response activities associated with the Site. The selected restoration alternatives will be located in the general vicinity of the Site, in upper Galveston Bay, Buffalo Bayou or San Jacinto River watersheds. The wetlands will be constructed within the Baytown Nature Center, a model of ecological restoration in which a former residential subdivision has been converted back into intertidal and freshwater habitat enjoyed by humans and wildlife alike. The forested wetlands will be preserved in conjunction with the Spring Creek Preserve initiative spearheaded by local government and the Legacy Land Trust. These actions will be implemented by the potentially responsible parties, with Trustee oversight, pursuant to the terms of a settlement of natural resource damage claims for the Site embodied in a formal Consent Decree.

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LIST OF ACRONYMS AND ABBREVIATIONS

AR	Administrative Record
BBP	Buffalo Bayou Partnership
CDF	Confined Dredge Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIE	Conservative Injury Evaluation
COC	Contaminant of Concern
CWA	Federal Water Pollution Control Act or Clean Water Act
CZMA	Coastal Zone Management Act
DARP/EA	Damage Assessment and Restoration Plan/Environmental Assessment
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DDTr	Total DDT, DDD, and DDE
DOC	Department of Commerce
DOI	Department of Interior
DMMU	Dredge Material Management Unit
DSAY	Discounted Service Acre Year
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EqDSAY	Equivalent Discounted Service Acre Year
ERA	Ecological Risk Assessment
ERL	Effects Range Low
ERM	Effects Range Medium
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
GBB	Greens Bayou Biosciences
GBF	Galveston Bay Foundation
GDDA	Greens Bayou Dredge Disposal Area
GIS	Geographic Information System
HCB	Hexachlorobenzene
HCFCD	Harris County Flood Control District
HCH	Benzene Hexachloride
HEA	Habitat Equivalency Analysis
HSC	Houston Ship Channel
ISKM	ISK Magnetics
LOAEL	Lowest Observable Adverse Effect Level
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observable Adverse Effect Level
NRDA	Natural Resource Damage Assessment

OCC	Occidental Chemical Corporation
PCB	Polychlorinated Biphenyl
PCL	Protective Concentration Level
PHA	Port of Houston Authority
ppb	Part per billion
ppt	Part per thousand
PRP	Potentially Responsible Party
RAP	Remedial Action Plan
RWDA	Retired Waste Disposal Area
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TRRP	Texas Risk Reduction Program
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

1 INTRODUCTION

This Final Damage Assessment and Restoration Plan/Environmental Assessment (DARP/EA) has been developed by the Texas Commission on Environmental Quality (TCEQ), the Texas Parks and Wildlife Department (TPWD), the National Oceanic and Atmospheric Administration (NOAA) of the U. S. Department of Commerce (DOC), and the United States Fish and Wildlife Service (USFWS) acting on behalf of the U.S. Department of the Interior (DOI), (collectively, 'the Trustees') to address natural resources (including ecological services[1]) injured, lost or destroyed within Greens Bayou and a portion of the surrounding properties in Harris County, Houston, Texas. The natural resource injuries and loss are due to releases of hazardous substances and subsequent response actions to address the releases.

The Greens Bayou Site (the 'Site') consists of two industrial facilities owned and operated by GB Biosciences Corporation (GBB) and ISK Magnetics, Inc. (ISKM), respectively, surrounding industrial and undeveloped properties, the Harris County Flood Control District (HCFCD) ditch, and Greens Bayou. Historically the Site (or portions of the Site) was owned and operated by Occidental Chemical Corporation (OCC). The GBB and ISKM facilities are located at 2237 and 2239 Haden Road in Houston, TX approximately 0.2 miles south of Interstate Highway 10 and 1.2 miles west of Beltway 8. Haden Road roughly divides the Site into two parcels consisting of the operating facilities (approximately 134 acres) and a largely undeveloped tract of land (approximately 83 acres). Surface water from the Site is conducted in the HCFCD ditch, a culvert (lined in portions with concrete), where it flows through the facilities from north to south, then turns southwest near Haden Road and terminates at Greens Bayou. The HCFCD ditch was tidally influenced in the southern sections until a sediment retention dam was constructed at the mouth of the ditch in 2002. Greens Bayou flows east through an industrialized area before turning southwest prior to entering the Houston Ship Channel approximately 20 miles northeast of its confluence into Galveston Bay. Historical operations at these two facilities have resulted in releases of hazardous substances, such as dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyldichloroethane (DDD), and other hazardous compounds, to the Greens Bayou Site. This Final DARP/EA addresses only injuries to natural resources at the Site that are or may be attributable to releases from these two facilities

1 *Ecological services* is defined in 43 C.F.R. § 11.14(nn) as the "physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource."

and subsequent remedial actions. It does not address natural resource injuries at the Site due to releases of hazardous substances by any other party.

This Final DARP/EA describes the Trustees' proposed assessment of the natural resource injuries attributable to hazardous substances released from the GBB and ISKM facilities into the Site. Further, it presents the restoration alternatives considered and identifies the selected restoration alternatives to compensate for injuries to natural resources at the Site. The injury assessment and restoration actions proposed herein were developed by the Trustees working in cooperation with GBB, OCC, and ISKM, the potentially responsible parties (PRPs) for the Site. The Trustees and PRPs elected to use an integrated approach to remediation and natural resource damage assessment (NRDA) planning. Such cooperation resulted in the identification of selected restoration alternatives that both the Trustees and the PRPs consider appropriate to compensate for the nature and scale of natural resource injuries attributable to the PRPs' operations and settle the public's natural resource damage claims.

The selected actions will result in the replacement of benthic resources lost and/or injured due to exposure to hazardous substances as well as response activities associated with the removal of contaminated sediments from Greens Bayou. The selected actions will also result in the replacement of terrestrial resources lost and/or injured due to response activities associated with the Site. The selected restoration actions will be located in the general vicinity of the Site, in the upper Galveston Bay, Buffalo Bayou or San Jacinto River watersheds. These actions would be implemented by the PRPs, with Trustee oversight, pursuant to the terms of a settlement of natural resource damage claims for the Site embodied in a formal Consent Decree.

1.1 AUTHORITY

This Final DARP/EA was prepared jointly by the Trustees pursuant to their respective authorities and responsibilities as natural resource trustees under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9601 *et seq.*; the Federal Water Pollution Control Act, 33 U.S.C. § 1251, *et seq*. (also known as the Clean Water Act or CWA), and other applicable federal or state laws, including Subpart G of the National Oil and Hazardous Substances Contingency Plan (NCP), at 40 C.F.R. §§ 300.600 through 300.615, and DOI's CERCLA natural resource damage assessment regulations at 43 C.F.R. Part 11 (NRDA regulations), which provide guidance for the natural resource damage assessment and restoration planning process under CERCLA.

CERCLA applies to Sites contaminated with hazardous substances and to releases of such substances. In addition to addressing the cleanup of contaminated Sites, CERCLA establishes

liability for the injury to, destruction of, or loss of natural resources caused by releases of hazardous substances. Damages recovered for these losses must be used to restore, replace, rehabilitate or acquire equivalent natural resources or services, in accordance with a restoration plan developed by designated natural resource trustees.

CERCLA is the primary statute under which the Trustees are acting in releasing this Final DARP/EA**.** It identifies the specific projects selected for use to restore and compensate for natural resource injuries and losses attributable to hazardous substances released at the Greens Bayou Site. Issuance of this Final DARP/EA is part of the restoration planning process under CERCLA, and is consistent with all applicable provisions pertaining to natural resource damages.

The Federal Water Pollution Control Act, also known as the CWA, is the principal law governing pollution control and water quality of the nation's waterways. Section 404 of the Act establishes a permit program, administered by the U. S. Army Corps of Engineers, to regulate dredge and fill activities in navigable waters. Section 401 of the CWA also requires that such projects be certified as compliant with state water quality standards.

Habitat restoration projects that move significant amounts of material into or out of waters or wetlands, such as the restoration project proposed herein, must be permitted under CWA Section 404 and certified as compliant with state water quality standards under CWA Section 401. All necessary 404 permits and 401 certifications will be obtained for the selected project prior to implementation.

1.2 NEPA COMPLIANCE

Actions undertaken by the Trustees to restore natural resources or services under CERCLA and other federal laws are subject to the National Environmental Policy Act (NEPA), 42 U.S.C. § 4321 *et seq.*, and the regulations guiding its implementation at 40 C.F.R. Parts 1500 through 1508. NEPA and its implementing regulations outline the responsibilities of federal agencies when preparing environmental documentation for proposed projects. In general, federal agencies contemplating implementation of a major federal action must produce an environmental impact statement (EIS) if the action is expected to have significant impacts on the quality of the human environment. When it is uncertain whether the proposed action is likely to have significant impacts, federal agencies prepare an environmental assessment (EA) to evaluate the need for an EIS. If the EA demonstrates that the proposed action will not significantly impact the quality of the human environment, the agency issues a Finding of No Significant Impact (FONSI), which satisfies the requirements of NEPA, and no EIS is required. For a proposed restoration plan, if a

FONSI determination is made, the Trustees then issue a final restoration plan describing the selected restoration action(s).

In accordance with NEPA and its implementing regulations, this Final DARP/EA summarizes the current environmental setting; assesses the injury to or loss of natural resources or ecological services associated with the Site; describes the purpose and need for restoration actions; identifies alternative actions; assesses their applicability and potential impact on the quality of the physical, biological and cultural environment; and summarizes the opportunity the Trustees provided for public participation in the decision-making process. This information has been used to make a threshold determination as to whether preparation of an EIS is required prior to selection of the final restoration action. Based on the EA integrated into this document, the federal Trustees – NOAA and USFWS – do not believe that the selected restoration action meets the threshold requiring an EIS, and since no comments were received from the public on this Final DARP/EA, propose to issue a Finding of No Significant Impact as described in Section 7.

1.3 PUBLIC PARTICIPATION

The Trustees have prepared this Final DARP/EA to provide the public with information on the natural resource injuries and service losses assessed in connection with the Site, the resource restoration objectives that guided the Trustees in developing this plan, the restoration alternatives that were considered, the process used by the Trustees to identify both the selected restoration alternative and the rationale for its selection. Public review of the Draft DARP/EA is the means by which the Trustees seek comment on the analyses used to define and quantify the resource injuries and losses as well as on the restoration action proposed for use to compensate for those injuries and losses. As such, public review is an integral and important part of the NRDA process and is consistent with all applicable state and federal laws and regulations, including NEPA and its implementing regulations, and the regulations guiding assessment and restoration planning under CERCLA at 43 C.F.R. Part 11.

The draft of this Final DARP/EA was made available for review and comment by the public for a period of 30 days. Notice of this public review period which ran from October 17, 2008 to November 17, 2008 was published in the Texas Register (33 TexReg 8664). No comments were received during the review period and the Trustees finalized this DARP/EA without any substantive changes.

1.4 ADMINISTRATIVE RECORD

The Trustees have maintained records documenting the information considered and actions taken by the Trustees during this assessment and restoration planning process, and these records collectively comprise the Trustees' administrative record (AR) supporting this Final DARP/EA. The AR records are available for review by interested members of the public. Interested persons can access or view these records at the office of Jessica White, at the following address:

NOAA c/o US EPA
Suite 1200, MC 6SF-T
1445 Ross Avenue
Dallas, Texas 75202
(214) 665-2217

Arrangements must be made in advance to review or obtain copies of these records by contacting the person listed above. Access to and copying of these records is subject to all applicable laws and policies including, but not limited to, laws and policies relating to copying fees and the reproduction or use of any material that is copyrighted.

2 PURPOSE AND NEED FOR RESTORATION

The purpose of the identified restoration actions is to compensate the public for natural resources injured, lost or destroyed within Greens Bayou and a portion of the surrounding properties in Harris County, Houston, Texas, due to releases of hazardous substances and subsequent response actions to address the releases. The need to pursue such actions is based upon the implementing regulations of CERCLA. CERCLA establishes liability for the injury to, destruction of, or loss of natural resources caused by releases of hazardous substances. Damages recovered for these losses must be used to restore, replace, rehabilitate or acquire equivalent natural resources or services, in accordance with a restoration plan developed by designated natural resource trustees.

This section generally describes the area of the Site affected by releases of hazardous substances by the PRPs (GBB, ISKM, and OCC); summarizes the response actions that have been, will be, or are expected to be undertaken to address that contamination; summarizes the Trustees' assessment of natural resource injuries and losses attributable to that contamination, including area; and the associated compensation requirements.

2.1 OVERVIEW OF THE SITE [2]

The Site is located in southeast Houston, TX approximately 0.2 miles south of Interstate Highway 10 and 1.2 miles west of Beltway 8 (Figure 2-1). Haden Road bisects the Site into north and south parcels. The area north of Haden Road consists of approximately 134 acres of mostly developed land housing the GBB and ISKM facilities, but is bordered with undeveloped land. The HCFCD ditch passes through this area before draining into Greens Bayou. The ditch runs from north to south through the east of the GBB and ISKM facilities; turns southwest near Haden Road, and then forms the southeast boundary of the southern parcel where it reaches Greens Bayou. The eastern boundary of the northern parcel is formed by a property known as the Wah Chang tract. It is owned by the Port of Houston Authority (PHA) and is an undeveloped forested wetland. South of the Wah Chang tract is the Greens Bayou Dredge Disposal Area (GDDA), which historically received sediments removed from the bayou by the PHA. The southern parcel is relatively undeveloped, with approximately 83 acres including forested wetlands, uplands, and a pond. This parcel includes a 66 acre tract known as the ISK Recreational Area, made up of open fields, shrub/wooded areas, and a large freshwater pond which, in the past, was used for fishing. The bayou forms the southern boundary of the south

2 Much of the information provided in this section was obtained from the Conceptual Site Model – Greens Bayou and Surrounding Areas, Groundwater Services, Inc. 2004.

parcel, and flows to the east then to the southwest before entering the Houston Ship Channel nearly 20 miles to the north of Galveston Bay. Greens Bayou and the Houston Ship Channel (also known as Buffalo Bayou) are tidally influenced brackish waterways which receive commercial and industrial traffic. However, Greens Bayou also has areas which have not been greatly impacted and offer refuge for aquatic life and wildlife.

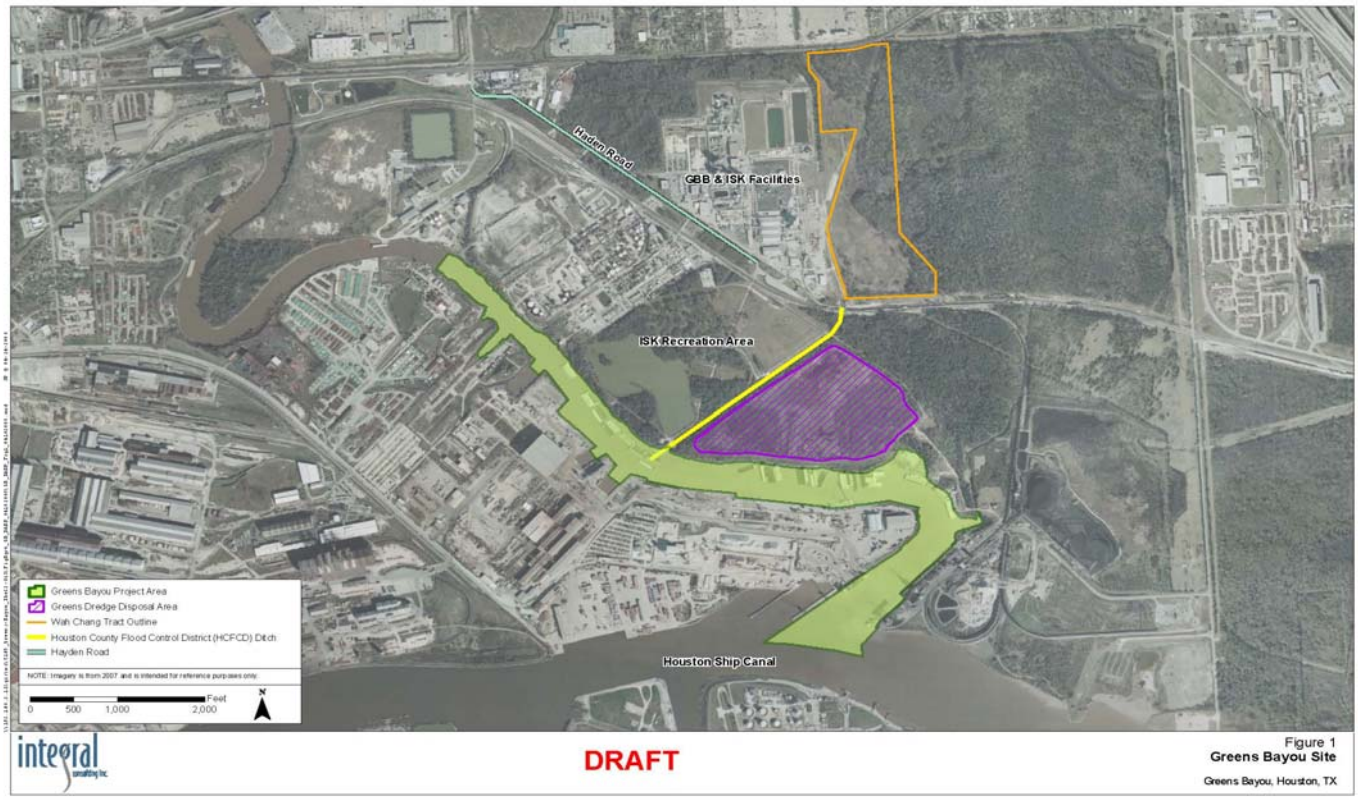

Figure 2-1 – Greens Bayou Location Map.

Two industrial facilities are currently operating at the Greens Bayou Site, GBB and ISKM. Both of these facilities are located on industrial property formerly owned and operated by OCC, a successor of Diamond Shamrock Corporation.

2.2 OPERATIONAL HISTORY OF THE SITE[3]

Diamond Alkali Company purchased property along Greens Bayou in 1946 to build the Greens Bayou Plant, which went into operation in 1951. From 1951 to 1983, Diamond owned and operated the facility under various names, such as Diamond Alkali Company, Diamond Shamrock Corporation, and Diamond Alkali Organic Chemicals Division, Inc. In 1987, Occidental Chemical Corporation assumed (and is the direct successor to) all of Diamond Alkali and Diamond Shamrock liability from 1946-1983. Diamond Shamrock and Showa Denko created SDS Biotech Corporation in 1983. SDS Biotech Corporation purchased the Greens Bayou facility in 1983, which it operated until 1986. At that time, ownership and operations were transferred to its subsidiary, GB Biosciences (then known as Fermenta Plant Protection Company). In 1995, ISK Magnetics leased a portion of the GBB facility to begin operations at the Site. ISKM purchased the property (approximately 85 acres) from GBB in 1998 since by that time it was operating as a separate entity from GBB. Currently, GBB still owns and operates chemical processing/manufacturing facilities on the Site, however, ISKM closed its manufacturing facilities in 2001.

The primary products GBB and its predecessors used and produced at the Site are agricultural chemicals, including pesticides. ISKM manufactured magnetic iron oxide that was used in video cassettes. During the early years of operations at the Site, various chemical products were manufactured and produced, including DDT and Lindane (production of Lindane ceased in or around 1966 and DDT was discontinued in or around 1970). Other products historically manufactured at the Site include chloral, chloral hydrate, dimethyl tetrachloroterephthalate (Dacthal), monosodium methyl arsenate, disodium methyl arsenate, and magnetic iron oxide. In addition to the hazardous substances produced at the Site, additional hazardous substances were utilized, stored, generated, created, or disposed of on Site, including arsenic, cyanide, and polychlorinated biphenyls (PCBs). Currently only three products are made at the Site; chlorothalonil (trade names Bravo™ and Daconil™), isophthalonitrile, and hydrochloric acid.

Historically, hazardous substances were improperly disposed of and released into the environment – both on Site and in surrounding areas. Studies have revealed the presence of DDT and other hazardous substances in groundwater, soil, and sediment in the HCFCD ditch, in the Wah Chang tract, in the GDDA, and in Greens Bayou. A significant source of this contamination was the HCFCD ditch, which likely received untreated process water, storm water, and ground water containing hazardous substances from the facility. The HCFCD ditch receives and conducts water from the Site before entering into Greens Bayou. In an effort to

3 Much of the information provided in this section was obtained from the Conceptual Site Model – Greens Bayou and Surrounding Areas, Groundwater Services, Inc. 2004.

mitigate further impacts from contamination in the HCFCD ditch, a sediment retention dam was installed at the confluence of the ditch and Greens Bayou in 2002.

2.3 SUMMARY OF RESPONSE ACTIONS

Over the years, the Greens Bayou Site has been the subject of a number of investigations. Contaminant migration has been the primary area of study, and the results facilitated a lawsuit brought against the PRPs by the PHA. This suit (Port of Houston Authority v. GB Biosciences Corporation *et al*.) culminated in the decision that the PRPs were responsible for the contamination of the PHA property and, as such, were required to perform necessary response actions to reduce risk and prevent future impacts to human health and the environment. The response actions identified in the suit include groundwater monitoring and recovery, soil removal, property acquisition, and sediment removal.

The goals of the settlement agreement between the PHA and PRPs were to resolve litigation, ensure continued navigational use of the bayou, prevent future impacts to the bayou from the PRP properties, and to protect human health and the environment. A combination of response actions was selected to meet these goals, at an estimated cost of $45 million:

- removal of approximately 7,500 cubic yards of soil along Haden Road and across the Site;
- installation of 20 new extraction well systems across the Site;
- purchase, by the PRPs, of approximately 114 acres belonging to the PHA that had been impacted, or would be impacted by the response actions;
- remediation of the HCFCD ditch through the removal of 13,000 cubic yards of soil and placement of 38,000 cubic yards of clean fill followed by a concrete liner;
- removal of nearly 553,000 cubic yards of sediment from six Dredge Material Management Units (DMMUs) and the Federal Navigation Channel within the bayou; and
- construction of a Confined dredge Disposal Facility (CDF) to manage the sediments from the bayou, which will comply with water quality requirements until the sediments have de-watered and the CDF is capped and closed.

In addition to the investigations undertaken for the lawsuit, a remedial investigation was conducted under the oversight of the TCEQ via the Texas Risk Reduction Program (TRRP). TRRP is a process whereby facilities are systematically evaluated to determine the potential for adverse risk to human health and the environment and screen remedial alternatives. The response actions identified in the settlement agreement between the PRPs and PHA are expected to fully comply with TRRP requirements. The TRRP evaluation included the identification of

contaminants of concern (COCs), the delineation of contamination (nature and extent), as well as human health and ecological risk assessments. The major ecological risk driver at the Site was found to be contaminated sediments (DDT and metabolites were the primary COCs), which directly impact benthic fish and invertebrates. Per TRRP guidance, a Protective Concentration Level (PCL) was developed for DDTr (2, 4- and 4, 4- DDT, DDD, DDE) by a consensus based method that involved a review of the Biological Effects Database for Sediments and the selection of an appropriate effects level that closely approximated the mean of the midpoints between the No Observable Adverse Effect Level (NOAEL) and Lowest Observable Adverse Effect Level (LOAEL) [4] for total DDT in marine and freshwater sediments. The resulting PCL for DDTr was 157 parts per billion (ppb).

The sediment management plan developed for the settlement agreement was based upon a goal of achieving 100 ppb DDE equivalents in bayou sediments in order to achieve a mass removal of DDT hot spots (areas with elevated levels of contamination). This goal was not based on risk to human health or the environment, but was based upon the distribution of DDT concentrations in sediment and breaks within that data set. It was expected that by decreasing the overall concentration of DDT equivalents to 100 ppb, a significant mass reduction of DDT related compounds would result. Because this plan was intended to remove contaminated sediments to facilitate dredging for navigation and development of the bayou, some areas were targeted for response actions even though the human health and ecological risk assessments did not support the actions. For example, some areas with contaminants at depth are covered by clean sediments at the surface but will be dredged to clear the way for future dredging events. Other areas may be excluded from response because they are isolated or otherwise did not fall in the dredge prism although they have sediments with contaminants above the PCL. Finally, the potential for unimpacted areas to become contaminated through re-suspension and distribution of dredged sediments could affect the outcome of the management plan for the bayou.

In order to address the discrepancies between the results of the ecological risk assessment under TRRP and the sediment management plan developed in the settlement agreement, the PRPs and Trustees agreed to an adaptive approach. The sediment management plan would be implemented as the response; however, the PRPs had to evaluate the impacts from the response and any residual ecological risk and provide compensation for any adverse ecological impacts. The Trustees considered the PCL developed under TRRP as a threshold for such impacts.

[4] The default calculation of a PCL is derived from the mean of the primary and secondary benchmarks (or NOAEL and LOAEL). It is meant to establish the level at which contaminant concentrations may be considered safe for exposure to receptors, and thereby is often the threshold for remediation.

Following the conclusion of the risk assessment process, a management decision was made to conduct an Ecological Services Analysis to manage the risk and resolve impacts associated with the response actions. Under TRRP, an Ecological Services Analysis allows the evaluation of remedial alternatives through comparison of the net impact to ecological service flows resulting from each response action. The Ecological Services Analysis also allows the option of compensatory ecological restoration to counter negative service flows (in cases where the response action results in a net loss of ecological services). Because an Ecological Services Analysis frequently involves the same methods as used in NRDA, it facilitates the coordination between the two processes. The Ecological Services Analysis will be conducted after the submittal of the Response Action Plan (RAP) as an appendix to the plan. The RAP describes in detail the areas of Greens Bayou to be dredged, the construction and maintenance of the CDF, and the remediation of the HCFCD ditch.

The response actions described or outlined above, if appropriately planned and implemented, should be sufficient to protect natural resources from future harm due to hazardous substances releases from this Site, and to allow natural resources affected by those releases the opportunity to return to baseline conditions within a reasonable period of time. The Trustees will continue to work with the TCEQ as well as the PRPs to ensure response decisions and plans are protective of natural resources. Response actions, however, do not compensate the public for the resource injuries or losses caused by these hazardous substances, including any losses of resources or resource services pending recovery or due to response actions undertaken (e.g., the removal of sediments within the bayou). The investigations of contaminants at the Greens Bayou Site revealed the presence of hazardous substances at levels sufficient to cause harm to natural resources within these areas.

2.4 STRATEGY FOR ASSESSING RESOURCE INJURIES AND COMPENSATION REQUIREMENTS

The Trustees' goal in this NRDA process is to reliably identify the nature and extent of natural resource injuries attributable to historical releases of hazardous substances to the Greens Bayou Site from the PRPs' facilities, to identify injuries from response actions planned or undertaken, to quantify the resulting resource and ecological service losses, and to provide the technical basis for determining the need for, type of, and amount of restoration appropriate to compensate the public for those losses. The remainder of this section provides an overview of the Trustees' assessment strategy for this Site, including the approaches used to evaluate potential injuries to specific resources and quantify associated losses.

As noted in Subsection 1.1, the assessment process is guided by the NRDA regulations issued under CERCLA and found at 43 C.F.R. Part 11. For the Site, the Trustees and PRPs identified

an assessment approach that could be performed in conjunction with the remedial investigations undertaken and the response planning pertinent to the Greens Bayou Site. This "integrated" approach permits data sharing, since much of the data needed to support remedial planning can be useful in evaluating and estimating natural resources injuries (Gouguet, 2005). Additionally, such integration typically results in time and cost savings, and promotes efficiency in the overall process. Further, NRDAs undertaken with the cooperation of PRPs avoid costly litigation and expedite restoration of the environment.

The Trustees sought to directly link injury assessment and restoration planning, so these processes would occur simultaneously and allow restoration-based compensation to be defined more directly and quickly. In a restoration-based assessment, injuries to and/or losses of natural resources and ecological services are quantified in ways that facilitate the identification of restoration projects that serve to compensate the public with the same level, type and quality of resources, or resource services, as were lost. The restoration-based assessment approach is consistent with the CERCLA NRDA regulations at 43 C.F.R. § 11.31. They allow restoration planning to be included as part of the Assessment Plan Phase where available data are sufficient to support their concurrent development.

The injury assessment process has two stages: 1) resource injury evaluation and 2) resource and service loss quantification. A number of factors are considered in identifying and quantifying resource injuries, including, but not limited to:

- the hazardous substances of concern (COCs)
- the specific natural resources and ecological services of concern;
- the evidence indicating exposure, pathway and injury;
- the mechanism(s) by which injury to natural resources of concern would occur;
- the type, degree, spatial and temporal extent of injury; and
- the type(s) of restoration that would be appropriate and feasible for use as compensation.

To evaluate injury to resources for the Site, the Trustees reviewed existing information, including remedial investigation data, ecological risk assessments, and scientific literature, and applied their collective knowledge and understanding of the function of the terrestrial and aquatic ecosystems at and near the Site. Identifying and understanding the COCs for the Site, as well as their pathways to and potential effects on ecological receptors, is key to the Trustees' approach to injury assessment. DDT and its metabolites were identified as the primary COCs for natural resource damage assessment purposes for the Site.

The Trustees determined that two categories of injury resulted at the Greens Bayou Site, injury to bayou sediments and injury to terrestrial forested wetlands and prairie. Sediments in Greens Bayou were impacted by hazardous substances historically released from the Site. In addition, the creation of the CDF to manage those sediments would result in the destruction of the existing habitat (a mixture of grassy uplands, wetlands, and woodlands) at the CDF location. Two different injury assessments were conducted to address these impacts.

2.4.1 Injury Assessment and Loss Quantification

Data from site-specific studies as well as results of studies reported in the scientific literature were used to identify and estimate resource injuries in Greens Bayou sediments, as part of a Habitat Equivalency Analysis (HEA) (NOAA, 2000). The HEA is recognized as a valid and reliable procedure for quantifying ecological losses and for scaling or evaluating their restoration equivalent. The data generated by the previous studies of the Site were used to create a spatial representation of the distribution of COCs across Greens Bayou in relation to the locations of the different habitat areas (shallow or deep sediment) by plotting the data on aerial photographs using software combining database and geographic information system (GIS) packages (ArcMap 9.2). With the concentrations of COCs in each habitat area plotted, the amount of potentially affected acreage was determined for each habitat type.

The Trustees and PRPs agreed that the benthic habitat and the associated benthic macroinvertebrate community are the habitat and resource of concern in Greens Bayou. Benthic habitat (as defined in the risk assessment, consists of sediment from 0 to 6 inches in depth, in waters between +2 and -10 feet mean low tide) was therefore the habitat type pertinent in the injury assessment for the bayou. The GIS images resulting from the assessment revealed that shallow benthic habitat was limited within the bayou, with a total of only 6.9 acres above the PCLs (Figure 2-2). In order to expedite the NRDA process, the Trustees and PRPs agreed to adopt a “worst case scenario” approach to injury scaling for the bayou sediments. This approach assumed that contamination of bayou sediments has resulted in a complete loss of benthic services in perpetuity. Further conservative assumptions were made to account for potential impacts from dredging of shallow benthic habitat and re-distribution of sediment-borne contaminants. Although the assumptions are overly conservative, they allowed the group to move forward in a timely manner at a relatively low cost.

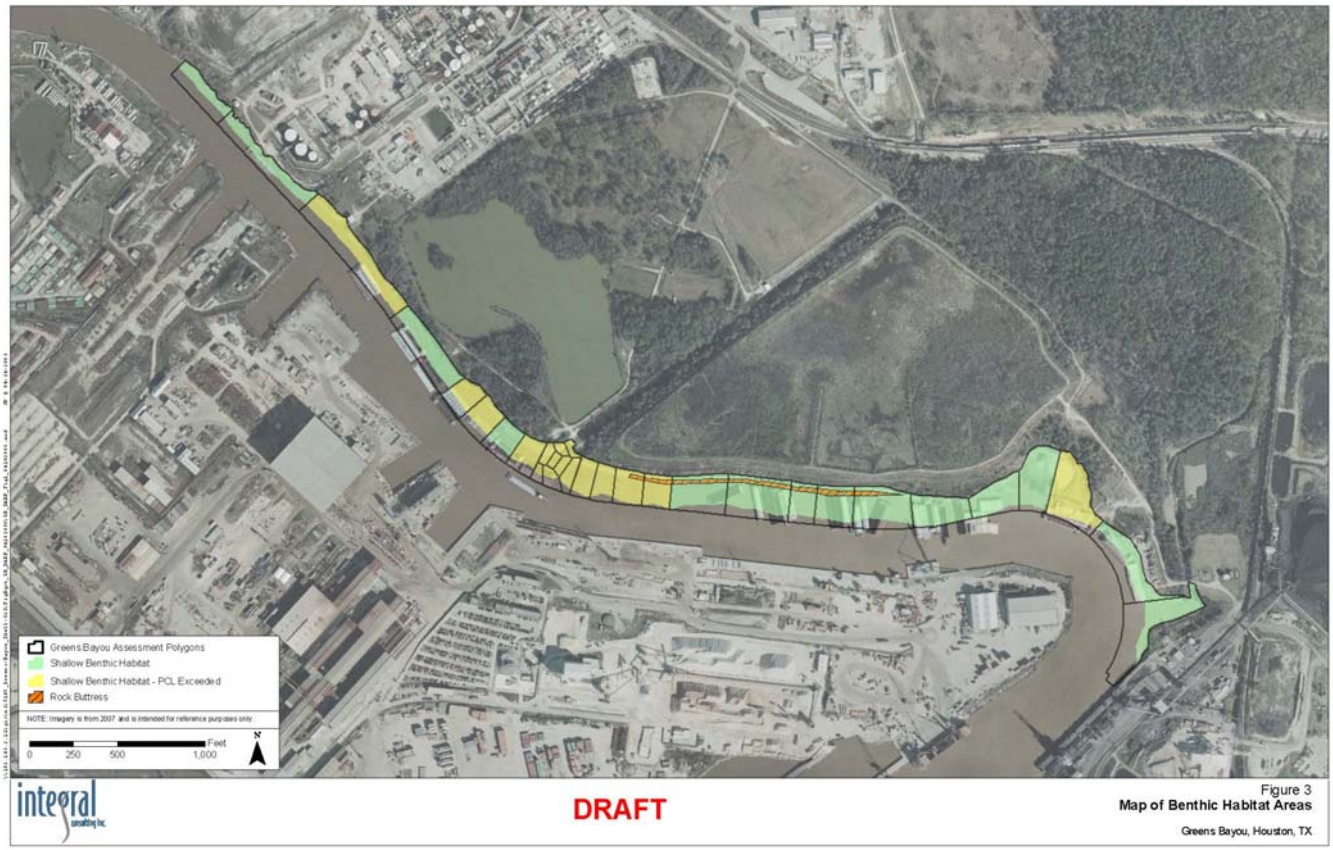

Figure 2-2– Benthic Habitat Areas in Greens Bayou Above COC PCLs.

2.4.2 Terrestrial Injury Assessment and Loss Quantification

The evaluation of the terrestrial injury was similar to that of the bayou sediments. Based upon the design of the CDF and actions taken to prepare for its construction, the Trustees created a spatial representation of the impacts to the affected area by plotting the data on aerial photographs using GIS tools. ArcMap was used to calculate the area of three different habitat types within the CDF footprint: 16.8 acres of prairie habitat; 5.3 acres of wetlands habitat; and 12.5 acres of woodlands habitat. Estimates of the extent or degree of injury for each habitat area (percent resource services lost due to removal of habitat) were then developed using peer-reviewed scientific literature, and best professional judgment consistent with the Trustees' collective resource expertise. In the event of technical uncertainty, conservative assumptions or inputs (i.e., in favor of the natural resources and leading to higher estimates of injury) were used in the analysis in lieu of conducting additional studies.

Calculation of time-based injury durations was performed using conservative estimates of the duration of the recovery period for the individual habitat areas based on impacts from CDF construction. Areas outside the CDF footprint which were cleared, as well as prairie habitat within the CDF footprint, were assigned conservatively estimated inputs of years to partial or full recovery. For wetlands and woodlands habitat inside the CDF footprint, the injuries were assumed to continue in perpetuity for purpose of calculating losses. Figure 2-3 indicates the habitats impacted by the CDF construction.

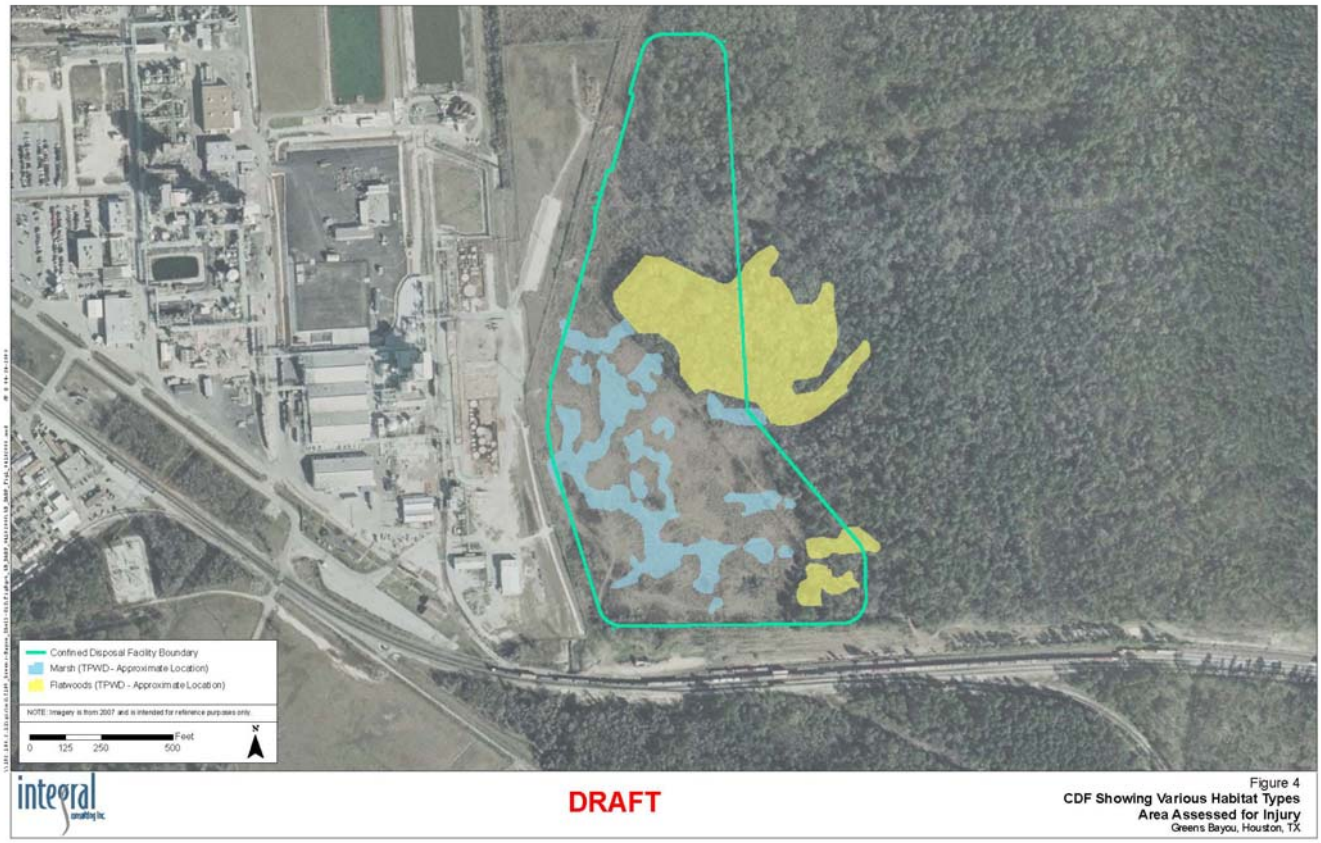

Figure 2-3 – Habitat Types Impacted by CDF Construction.

This injury assessment approach resulted in a conservative estimate of the total potential number of forested wetlands service acre-years lost due to the natural resource injuries attributable to the CDF construction at the Site. This quantification of total services lost is expressed as the number of discounted service acre years (DSAYs) lost due to the assessed injuries. In this context, the assessed DSAYs represent the amount of total habitat services lost, in acre-years (adjusted to the present time).

3 THE AFFECTED ENVIRONMENT

In restoration planning, the Trustees emphasis has been on the areas and resources directly affected by the historical releases of hazardous substances to the Greens Bayou Site from the PRPs' facilities and construction of the CD; however, the Trustees have also recognized that the injured resources are part of a larger ecological system - the upper Galveston Bay Estuary. Accordingly, in development of this Final DARP/EA, appropriate restoration opportunities within that system have been considered. Under this approach, natural resource Trustees are better able to compensate for resource injuries while also taking into account the multiple ecological and human use benefits of restoration within the larger ecosystem.

This section provides additional information on the physical, biological and cultural environments within the upper Galveston Bay Estuary, in which the restoration actions identified in this Final DARP/EA would occur, consistent with NEPA requirements. The information in this section, together with other information in this document, provides the basis for the Trustees' evaluation of the potential environmental impacts of the alternative restoration actions listed in Section 7 (Evaluation of Restoration Alternatives). The scope of the environmental impacts addressed in this Final DARP/EA include those on wildlife, fish and invertebrates, essential fish habitat, threatened and endangered species, farmland and urban development, recreational resources, water and sediment quality, air quality, cultural resources, hazardous and toxic waste, and environmental justice.

3.1 THE PHYSICAL ENVIRONMENT[5]

The Greens Bayou Site is located in the Texas Gulf Coast Physiographic Province on the north bank of Greens Bayou approximately 1 mile upstream from the Houston Ship Channel. The Site consists of almost 217 acres of PRP property, as well as the HCFCD ditch and Greens Bayou. The PRP facilities are situated almost 2500 feet north of the bayou on approximately 134 acres of land. The terrestrial portion of the Site is divided into two parcels by Haden Road, which separates the facilities (the north parcel) from the less developed portions (south parcel) of the Site. The southern parcel is comprised of nearly 83 acres of property, which encompasses a recreational area, retired waste disposal areas, the Site of the CDF, and surrounding properties.

5 Much of the information provided in this section was obtained from the Conceptual Site Model – Greens Bayou and Surrounding Areas, Groundwater Services, Inc. 2004 or the Human Health and Ecological Risk Assessment of Greens Bayou and the HCFCD Ditch, CPF Associates, Inc. 2003.

The aquatic portion of the Site includes a recreational pond, the HCFCD ditch, and Greens Bayou.

3.1.1 The Terrestrial Environment

The northern parcel of land (upon which the facilities are located) is more developed than the southern parcel, with only the buffer zones surrounding the facilities remaining undeveloped. The GBB facility occupies nearly 115 acres, and the ISKM facility is located on approximately 19 acres. The facilities are bordered by Haden Road to the southwest, the Wah Chang tract to the east, and a railroad right-of-way to the west. The HCFCD ditch also runs along the northern property and separates the southern parcel into two units. GBB and ISKM are currently operating the facilities for chemical manufacturing purposes, thus habitat is very limited in this portion of the Site. The undeveloped areas in the northern parcel include the Westside-North Area, which wraps around the GBB facility from Haden Road to the HCFCD ditch, and the Wah Chang Tract, which borders the facilities to the east across from the HCFCD ditch. The Westside-North Area is a relatively small grassy field around part of the GBB facility. The Wah Chang Tract was owned by the PHA before the lawsuit, and PHA planned to use the land as a dredge disposal area for future dredging events in Greens Bayou. The habitat in the tract is mixed, with forested wetlands, herbaceous wetlands, and grasslands all found within the property. GBB purchased about 60 acres of the Wah Chang Tract as part of the settlement agreement with the PHA because the property had been impacted by releases from the facilities. The tract will be the location of the CDF for sediments removed from Greens Bayou and thus will be impacted by construction and placement of the CDF. The planned footprint of the CDF occupies 30 acres with a 20 foot dike surrounding the perimeter. Trees and brush were removed to clear the area for construction of the CDF. Further impacts to the habitat will result from building the dike and filling the CDF (pre-existing habitat will be permanently displaced).

The southern parcel of land is divided by the HCFCD ditch into two units, one composed of the Greens Bayou Dredge Disposal Area (GDDA) and the other comprised of a mixture of GBB and ISKM properties. The approximately 83 acre GDDA, located to the south-southeast of the HCFCD ditch, is owned by the PHA and was used for the disposal of dredge materials from Greens Bayou until 2000. The GDDA has been impacted by historical releases from the Site, and is no longer receiving dredged materials. West of the HCFCD ditch is a mixture of GBB and ISKM properties, including former waste disposal areas and recreational areas. The property is largely undeveloped and infrequently used at this time. In the past, GBB had a waste disposal area of approximately 15 acres (now the Retired Waste Disposal Area, or RWDA) where a landfill for general refuse from the GBB facility was located. The RWDA also received waste from the manufacture of various chemical products from 1968 to 1978. In 1980, the landfill was closed, and a slurry wall was constructed around the RWDA a year later to restrict groundwater

movement from the area. An electrical substation (transformer area) is also located in the southern parcel. It occupies 5.1 acres and supplies power to the facilities. The majority of this parcel is known as the ISKM recreational area (nearly 66 acres). The recreational area contains mixed habitat, including grasslands, wooded areas, and also a large freshwater pond. Since closure of ISKM's facilities and release of its employees, the recreation area is minimally used and maintenance is limited to mowing and vegetation maintenance and some facility maintenance. Figure 3-1 shows the layout of the Greens Bayou Site and surrounding properties.

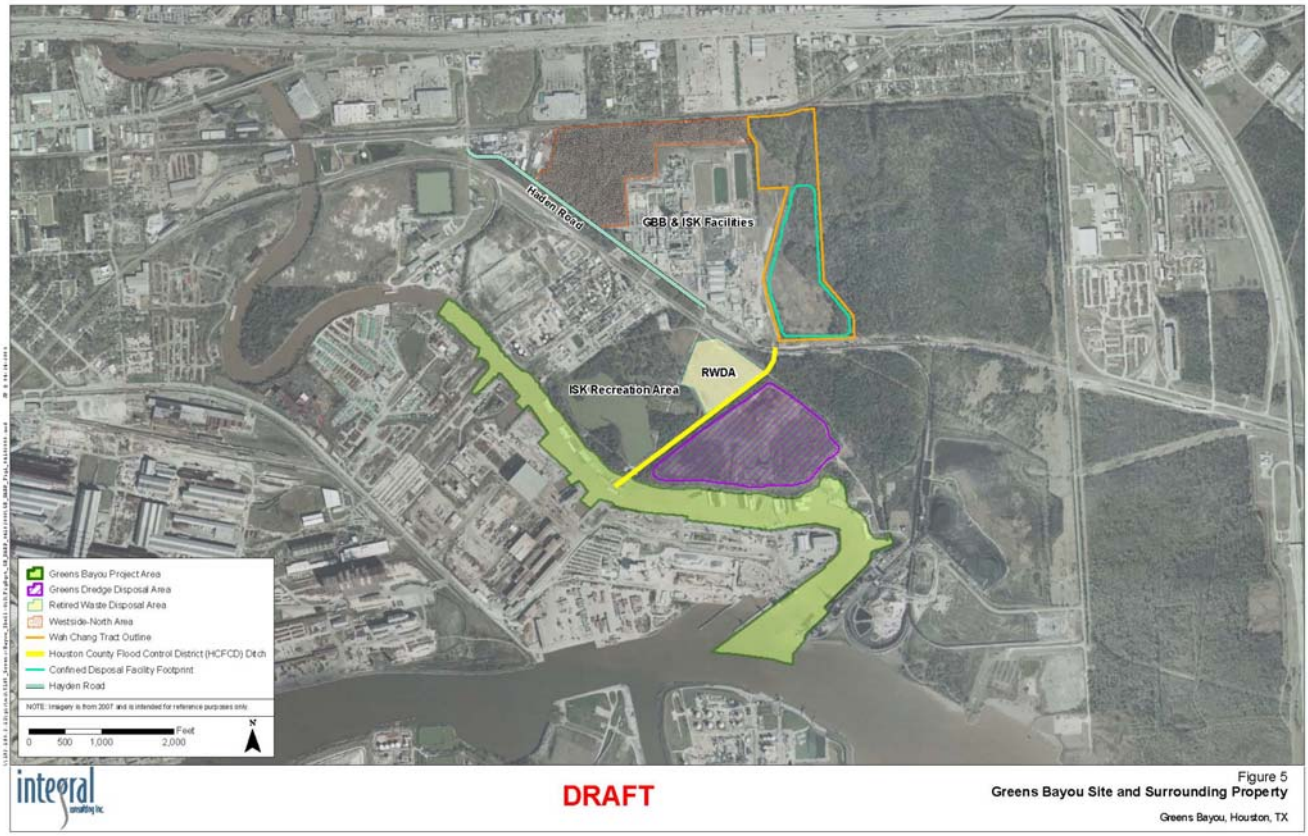

Figure 3-1 – Map of Greens Bayou Site and Surrounding Properties.

3.1.2 The Aquatic Environment

Harris County Flood Control District Ditch

In 1958, construction of the HCFCD ditch was completed. The ditch originates north of the GBB facility near the stormwater basin, flows through the northern parcel (near the eastern border) and divides the southern parcel (separating the GDDA from the RWDA and ISKM recreational area) before entering Greens Bayou. A culvert was built on the GBB facility

property in 1995 to connect flow between the Retired Neutralization Pond Area and the southern facility boundary at the Port Terminal Railroad Association tracks. Otherwise the ditch is largely unlined and open. The southern portion of the HCFCD ditch (which separates the southern parcel of the Site) varies in width from 15 to 80 feet and has an average water depth of 1 to 2 feet. Water flow in the ditch is variable and highly influenced by precipitation and discharge from the Site facilities. This part of the HCFCD ditch was also tidally influenced by Greens Bayou until 2002, when a sediment retention dam was constructed to prevent ditch sediments from contributing to sediment contamination within the bayou.

The ditch receives stormwater runoff from the Site and surrounding properties, and has a total drainage area of 670 acres. Water levels in the ditch are also influenced by groundwater elevation in surrounding transmissive zones. If groundwater elevation rises, the water level in the HCFCD ditch also rises. If groundwater elevation decreases (as results from extraction systems put in place for remediation), the level of water in the ditch decreases as well.

Greens Bayou

Greens Bayou is an urban stream within the larger San Jacinto River watershed. The bayou originates in northwest Harris County and flows east-southeast for approximately 45 miles to its confluence with the Houston Ship Channel (HSC), nearly 16 miles upstream from upper Galveston Bay. The Greens Bayou watershed is mostly developed with a mixture of residential, commercial and industrial uses. The bayou drains roughly 196 square miles, and receives a significant input from effluent discharged by 96 outfalls (88 domestic and 8 industrial). Like many waterways in the southwest, effluent dominates the volume of flow in Greens Bayou, comprising approximately 81% of the total flow at the point of intersection between the bayou and IH-10. The average flow (as calculated by geometric mean of data taken from 1971 to 2001) is 690 cubic feet per second, although flow can increase substantially during storm events.

The upper 32 miles of Greens Bayou is characterized as freshwater while the lower 13 miles is tidally influenced. The bayou is classified as an oligohaline estuary, and salinity ranges from relatively fresh (<2 parts per thousand [ppt]) to slightly saline (5 ppt). Higher levels of salinity may be found at depth, with levels as high as 8 ppt reported. The bayou is also influenced by groundwater from the Site since a transmissive zone flows towards Greens Bayou.

Greens Bayou borders the southern parcel of the Site, adjacent to the ISKM recreational area and the GDDA (between river stations 30+00 and 80+00). The maximum depth of this section is approximately 20 feet, with an average maximum depth of 15 to 17 feet. This portion of the bayou is classified as Segment 1006 of the Houston Ship Channel Tidal zone. Due to the nature of the HSC, its designated uses are limited to navigation and industrial supply. Although these

are the only human uses of the bayou in this section, people have been observed fishing in the section of Greens Bayou further upstream near the intersection of the bayou with IH-10.

Houston Ship Channel

The Houston Ship Channel is estuarine and tidally influenced and is part of the greater Galveston Bay watershed. Major water bodies within this watershed include the San Jacinto River, Greens Bayou, Buffalo Bayou, the HSC, and Brays Bayou. The HSC is a highly industrialized waterway that supports one of the busiest ports in the world. The HSC is approximately 530 feet wide, 45 feet deep and 50 miles long, although the dimensions have changed considerably over the past hundred years as navigational demands increased. The shoreline is predominantly utilized by large refineries, petrochemical facilities, related petrochemical support facilities, barge mooring stations, and tug boat marinas.

The HSC is known as Buffalo Bayou upstream of the Turning Basin, where it combines with White Oak Bayou and flows through downtown Houston. Moving farther east, the HSC intersects Greens Bayou and then the San Jacinto River before reaching its conclusion in upper Galveston Bay. The San Jacinto River watershed provides 28% of the freshwater inflow to the Galveston Bay Estuary. As seen in Figure 3-2, this watershed is linked to the Galveston Bay Estuary, therefore, processes which occur upstream in the tributaries impact the estuary.

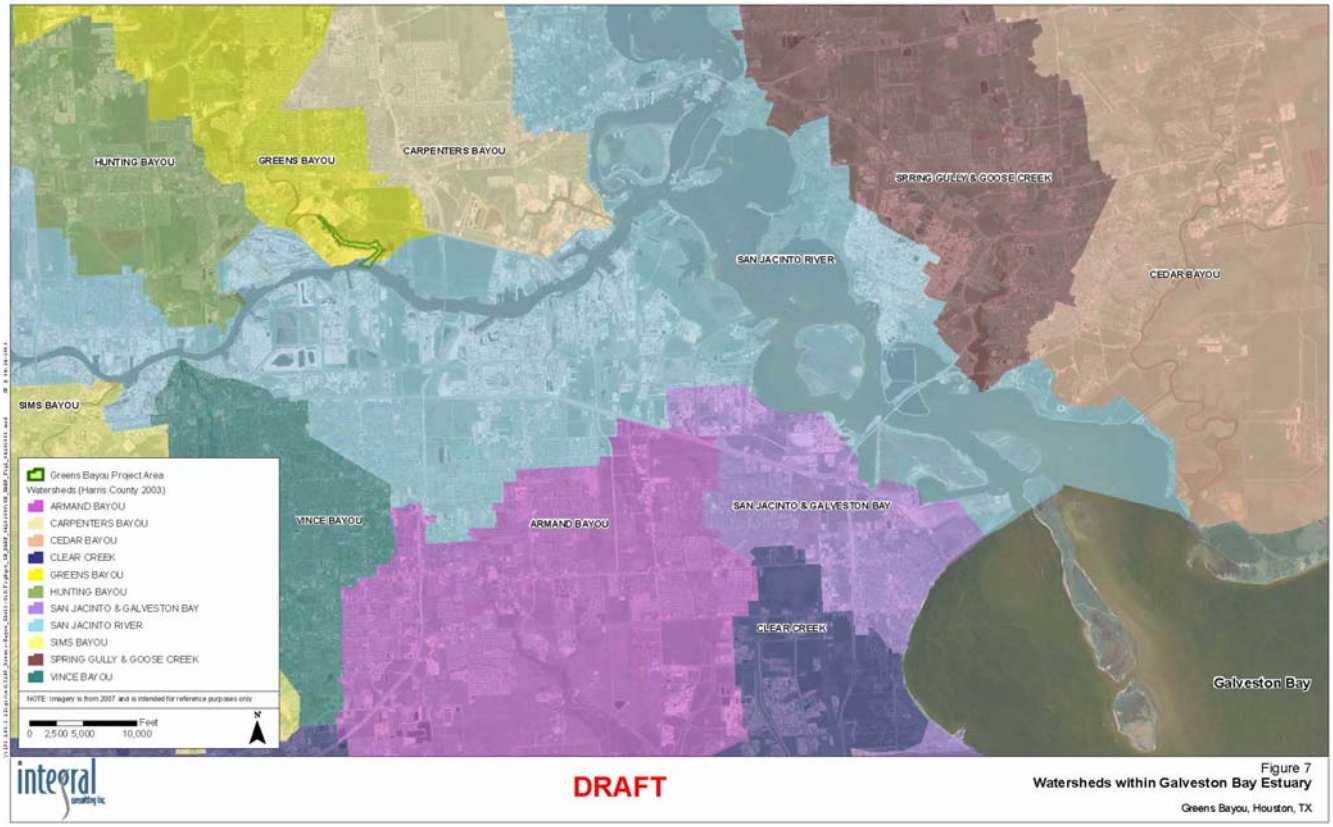

Figure 3-2 – Aquatic Environment of Greens Bayou and Surrounding Watershed.

Galveston Bay Estuary

The Galveston Bay Estuary is the seventh largest estuary in the United States and the largest in Texas. Galveston Bay Estuary is a system composed of four main bodies (Galveston Bay, Trinity Bay, West Bay, and East Bay) and several small, shallow, productive side bays. The estuary is typically 6 to 12 feet deep. The surface area of the estuary is approximately 600 square miles.

The upper estuary contains significant amounts of coastal wetlands that provide nursery areas for the estuarine fishery resources and important habitat for avian and mammalian fauna. Approximately 61% of the estuarine shoreline is vegetated by intertidal emergent plant communities, or coastal wetlands, totaling 108,200 acres. A Galveston Bay National Estuary Program study confirmed that a well balanced number of species still remains in all trophic levels, indicating a generally healthy estuarine community. The upper portion of the estuary is designated by the TCEQ for contact recreation, high quality aquatic habitat, and shell fish waters.

The restoration actions selected in Section 6 would occur in the upper Galveston Bay, within the Spring Creek nature preserve and the Baytown Nature Center. The Spring Creek preserve is located in the Woodlands area of Harris County, a largely residential community composed of various types of bottomland hardwood, upland prairie/range, and some forested wetlands. The Baytown Nature Center is located in the city of Baytown in Harris County, and was constructed from a former residential subdivision which was abandoned due to subsidence. The remnants of former residences were removed and the area was converted into a complex of intertidal wetlands, freshwater ponds, and coastal prairie typical of the area. This Final DARP/EA is focused on the effects of the contamination found within Greens Bayou and the impacts due to construction of the CDF, which have resulted in injury to or loss of benthic and terrestrial resources. Selected compensation for these losses or injuries includes the preservation of wooded wetlands habitat and terrestrial resources in the Spring Creek preserve and construction of intertidal wetlands in the Baytown Nature Center, shown in Figure 3-3.

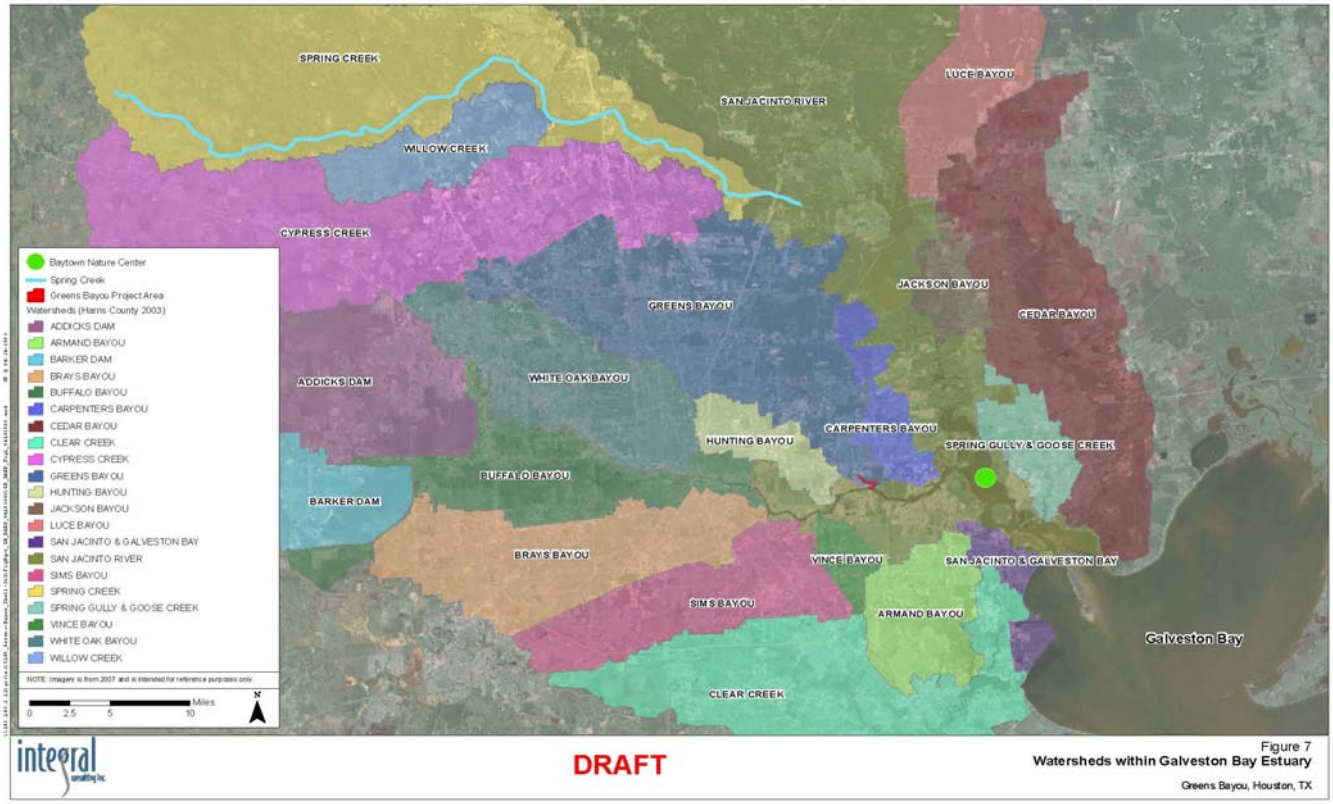

Figure 3-3 – Locations of Proposed Restoration Projects within the Galveston Bay Watershed.

3.2 THE BIOLOGICAL ENVIRONMENT

The upper Galveston Bay watershed provides important habitat for wildlife including migratory waterfowl, shorebirds, and wading birds and also serves as a valuable nursery and breeding

habitat for numerous estuarine-dependent sport and commercial fish and shellfish. The watershed, including Greens Bayou and its surrounding environment, has several types of habitats including estuary habitats of various salinities, fresh and salt marshes, and forests.

Salt Marsh

Salt marshes can be found at and around the margins of bays and estuaries, backs of barrier islands, and old flood tide deltas near closed inlets with regular saltwater tides. Salt marsh vegetation is dominated by smooth cordgrass (*Spartina alterniflora*) at the lower elevations (low marsh) typically between mean low tide and mean high tide. Zonation of vegetation occurs between mean tide and mean high tide with zones of black needlerush (*Juncus romerianus*), smooth cordgrass, and sometimes other brackish marsh species. Salt marsh communities are highly productive due to the dynamic environment in which they are found. In this setting, organic matter is regularly removed and sediment deposited by the tides. Under optimal conditions (*i.e.*, presence of a coarse-grain sediment source) tidal sedimentation causes a rise in the marsh surface and landward migration of the marsh. Sediment may also be deposited on the shoreline, causing estuarine-ward progradation of the marsh. Marshes on the backsides of barrier islands may be subject to episodic burial by sand overwash. Salt marshes are distinguished from all other community types by the dominance of smooth cordgrass, as well as by their tidal, saltwater environments. Relatively narrow zones of brackish marsh at the upper edge are considered part of the salt marsh, but larger expanses in the heads of creeks and in the interior of large marsh islands are considered separate brackish marsh communities.

Brackish/Intermediate Marsh

This marsh type is found along the margins of bays and estuaries somewhat removed from connection with the sea, so that salinity is diluted by freshwater inflow and tidal range is generally less than in salt marshes. Those marshes in areas with substantial regular lunar tides have a regular input of nutrients, which makes them highly productive. In addition to high inflow of nutrients, regularly flooded marshes are typically supplied with abundant sediment and may produce tidal mud flats and estuarine-ward progradation of the marsh. Areas with only irregular wind tidal flooding have much less nutrient input, less mineral sedimentation, and accumulate relatively more organic matter. They lack mud flats and their estuarine edges are scarped and erosional. As sea level rises, mineral or organic sedimentation causes the marsh surface to rise; the landward edge will migrate landward; and changes in tidal inlets may cause changes in salinity.

Brackish marshes are distinguished by their tidal environment and usually by the dominance of black needle rush. There is a primary difference in dynamics between the regularly flooded marshes in the southern portion of the coastal zone and the predominantly irregularly flooded

marshes in the northern coastal zone. Areas exposed to wave action from large estuaries may also be different in dynamics from narrow marshes in small tributaries.

Tidal Freshwater Marsh

This marsh type is found at the margins of estuaries, or drowned rivers and creeks, where they are regularly or irregularly flooded with freshwater tides. Historically, this marsh type was extensive, but its range has steadily reduced since the mid-1940's due to numerous factors including subsidence, sea-level rise, saltwater intrusion, and altered hydrology as a result of river and channel dredging. Tidal freshwater marshes are sustained largely through tidal flooding, which brings in nutrients derived from seawater and varying amounts of sediment to the community. Regularly flooded marshes are reported to have high productivity, equivalent to salt marshes at the same latitude (Odum *et al*. 1984). Irregularly flooded marshes and marshes in areas with little mineral sediment are assumed less productive. Tidal freshwater marsh is distinguished from adjacent swamp forest and upland forests by the lack of a dominant tree or shrub layer.

Wetland Forest (Evergreen, Deciduous, and Mixed)

Wetland forests, besides being broken into evergreen, deciduous, and mixed are segmented by their flooding frequency. Those areas that experience permanent to semi-permanent flooding are deepwater swamps while those receiving only seasonal riverine pulses are generally characterized as bottomland hardwood forests. The distinction is not only made because of flooding regime, but the species composition that occurs as a result. Deepwater swamps are typically characterized by bald cypress (*Taxodium distichum*) and tupelo (*Nyssa* spp.). Bottomland hardwood forests usually occur as an ecotone between aquatic and upland ecosystems but have distinct vegetation and soil characteristics. The vegetation in bottomland hardwood forests is dominated by diverse community of trees that are adapted to the wide variety of environmental conditions on the floodplain. Typical species are black willow (*Salix nigra*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), laurel oak (*Quercus laurifolia*), American elm (*Ulmus americana*), and sweetgum (*Liquidambar styraciflua*), to name a few.

Aquatic Biota

The upper Galveston Bay watershed supports a diverse assemblage of aquatic life, including plants (both vascular and non-vascular) and animals (invertebrates, fish, mammals, reptiles, etc.). These organisms depend upon the watershed to provide habitat for foraging, mating, rearing young, and other important life functions. Several of the organisms found within the Galveston Bay system are among those vital to the economy of Texas, as well as a significant element of outdoor recreational opportunities.

The waters of the Greens Bayou watershed and Upper Galveston Bay support species important for commercial and recreational usage and provide habitat for the following organisms: white shrimp (*Litopenaeus setiferus*) and brown shrimp(*Farfantepenaeus aztecus*), blue crab (*Callinectes sapidus*), eastern oyster (*Crassostrea virginica*), spotted seatrout (*Cynoscion nebulosus*), sand seatrout (*Cynoscion arenarius*), Atlantic croaker (*Micropogonius undulatus*), red drum (*Scienops ocellatus*), black drum (*Pogonius cromis*), southern kingfish (*Menticirrhus americanus*), Gulf kingfish (*Menticirrhus littoralis*), sheepshead (*Argosargus probatocephalus*), southern flounder (*Paralichthyes lethostigma)*, striped mullet (*Mugil cephalus*), sea catfish (*Galeichthys felis*), Gulf menhaden (*Brevoortia patronus*), and gafftopsail catfish (*Bagre marinus*). In addition, numerous other estuarine and marine resources are found in San Jacinto River and Upper Galveston Bay Estuary including bay anchovy *(Anchoa mitchilli*), silver perch (*Bairdiella chrysoura*), bull shark (*Carcharhinus leucas*), sheepshead minnow (*Cyprinodon variegatus*), gizzard shad (*Dorosoma cepedianum*), Gulf killifish (*Fundulus grandis*), code goby (*Gobiosoma robustum*), pinfish (*Lagodon rhomboides*), spot (*Leiostomus xanthurus*), silversides (*Menidia* spp.), Gulf flounder (*Paralichthys albigutta*), Spanish mackerel (*Scomberomorus maculatus*), bay squid (*Lolliguncula brevis*), hard clam (*Mercenaria mercenaria*), grass shrimp (*Palaemonetes pugio*), and common rangia (*Rangia cuneata*).

Estuarine organisms of commercial, recreational and ecological importance typically have inshore and offshore components of their life histories. Many species in the Galveston Bay estuary spawn offshore or near estuary passes, and their larvae or post larvae migrate into the estuarine nursery area to grow and develop prior to offshore migration and maturation. The oyster is the exception in that it is completely estuarine. Other taxa such as birds, reptiles, and mammals use estuarine habitats for feeding, refuge, and reproduction. Many estuarine dependent species of fish are harvested from Galveston Bay including: flounder; Atlantic croaker; spotted seatrout, sand sea trout; and red drum. In addition, five species of invertebrates (oysters, blue crabs, and three penaeid shrimps) are harvested from the Galveston Bay Estuary. During their juvenile stages, these organisms utilize estuarine habitats such as marshes, seagrass beds, oyster reefs and mudflats for feeding and protection. Many species are more abundant in vegetated habitats such as emergent marshes and submerged aquatic vegetation than in adjacent non-vegetated habitats. Fishery production is directly proportional to wetlands acreage.

The sediments within the Greens Bayou watershed and Upper Galveston Bay Estuary support benthic organisms, including annelid worms, small crustaceans (amphipods, isopods, copepods, and juvenile decapods), mollusks, and other small bottom-dwellers in salt marshes and unvegetated subtidal sediments. Among these benthic organisms are herbivores (eating algae or other live plant material), detritivores (feeding on decaying organic matter in surface sediments

or sediment-bound nutrients and organic substances that are not generally available to epiphytic or pelagic organisms), carnivores (preying on other benthic organisms), and omnivores (a combination). These organisms provide the nutritional base for developing stages of many finfish and shellfish and, thus, affect all trophic levels in the Greens Bayou watershed and Upper Galveston Bay Estuary. The activities of benthic organisms are important in conditioning wetlands and subtidal habitats and in the decomposition and nutrient cycling that occur in these areas. In sum, benthic communities provide important ecological services primarily related to food production, decomposition and energy cycling that affect nearly all organisms within an estuarine system. A potential adverse impact on benthic populations has the potential to impact biota in nearly all trophic levels of the lower San Jacinto River and Upper Galveston Bay Estuary.

The shorelines of the lower San Jacinto River and upper Galveston Bay area are home to a variety of plant species which are typical of species found in estuarine wetlands, including cordgrasses (*Spartina alterniflora* and *S. patens*), saltwort (*Batis maritima*), glass wort (*Salicornia virginica*), seashore saltgrass (*Distichlis spicata*), saltmarsh bulrush (*Scirpus maritimus*), sea oxeye (*Borrichia frutescens*), and marsh elder (*Iva frutescens*).

Terrestrial Biota

The southern marshes and wetland forests of Texas are home to a wide variety of wildlife. White-tailed deer (*Odocoileus virginianus*) are abundant throughout the state. Common small mammals include bats (order Chiroptera), swamp rabbit (*Sylvilagus aquaticus*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana)*, striped skunk (*Mephitis mephitis)*, eastern fox squirrel (*Sciurus niger*), nutria (*Myocastor coypus*), and beaver (*Castor canadensis)*.

More than one-half of the bird species of North America are resident in the state or spend a portion of their migration there. Species of migratory wildfowl are the most abundant. They include several species of ducks and geese that spend winters on the tidal marshes along the Gulf coast. The most common of the state's water birds include the laughing gull (*Larus atricilla*), royal tern (*Sterna maxima*), brown pelican (*Pelecanus occidentalis*), and black skimmer (*Rynchops niger*). Birds found in the wetlands include the marsh wren (*Cistothorus palustris*), seaside sparrow (*Ammodramus maritumus*), red-winged blackbird (*Agelaius phoeniceus*), Wilson snipe (*Charadrius wilsonia*), woodcock (*Scolopax minor*), and species of sandpipers (*Actitis* spp.).

Alligators (*Alligator mississippiensis)* are common in southern Texas bayous. Other reptiles found in the state include turtles, lizards, and both poisonous and non-poisonous snakes. The snakes found in Texas include the coral snake (*Micrurus fulvius tenere*), western pygmy rattler

(*Sistrurus miliarius streckeri*), canebrake rattler (*Crotalus horridus*), copperhead (*Agkistrodon contortrix*), Texas rat snake (*Elaphe obsoleta lindheimeri)*, speckled kingsnake (*Lampropeltis getula holbrooki*), and water moccasin (*Agkistrodon piscivorus*). Common reptiles also found within the terrestrial areas include the Texas diamondback terrapin (*Malaclemys terrapin littoralis),* skinks (Family *Scincidae*) and red-eared slider (*Chrysemys scripta elegans*).

3.3 THE CULTURAL AND HUMAN ENVIRONMENT

The Site is located in the southeastern part of the city of Houston in Harris County, Texas. The city of Houston was established at the headwaters of Buffalo Bayou shortly after Texas won its independence from Mexico in 1836 in the Battle of San Jacinto that took place near the confluence of Buffalo Bayou (now the Houston Ship Channel) and the San Jacinto River. In this battle, General Sam Houston's Texian troops, after facing defeats at Goliad and the Alamo, defeated the Mexican Army led by General Santa Anna. The battleground is preserved as the TPWD San Jacinto Battleground State Historic Site (approximately 6 miles downstream from the Site).

The region was primarily focused on rice farming and cattle ranching until it was transformed in the early 1900's by the discovery of oil at Spindletop and Goose Creek, a tributary to the lower San Jacinto River below the confluence with Buffalo Bayou near what is now the City of Baytown. The region was further changed in 1914 with the development of the Houston Ship Channel by dredging Buffalo Bayou to a depth of 25 ft and extending the channel through Galveston Bay to the city of Galveston, the region's primary port at the time. Between 1920 and 1940, the region developed into a major petrochemical complex and shipping center. Greens Bayou was significantly altered during this time, as World War II spurred the production of armaments. War ships were manufactured for the Navy at a property across the bayou from the Site. The bayou was dredged and widened to accommodate these vessels. Following the war, additional development occurred along Greens Bayou and the Houston Ship Channel. Greens Bayou currently supports the docks of several companies as well as providing moorage for numerous barges. The HSC is home to 150 companies and in 2006 it facilitated the entry and exit of a total of 7,550 vessels to the Port of Houston (PHA website). The Port of Houston is one of the busiest in the US, and currently ranks number 1 in terms of foreign waterborne tonnage shipped, second in total waterborne tonnage, and tenth in total waterborne tonnage in the world. Houston has developed into the 4th largest city in the United States and the population of the Houston metropolitan area is approaching 5 million people.

In addition to impacting Texas' commercial/industrial economy, Greens Bayou and the Houston Ship Channel directly influence the recreational and commercial fishing industry via the Upper

Galveston Bay estuary. Greens Bayou flows into the Houston Ship Channel, which in turn flows into the Upper Galveston Bay estuary. Recreational fishing occurs throughout the estuary, and the primary species fished include blue crab, red drum, black drum, spotted sea trout, southern flounder and Atlantic croaker. The Upper Galveston Bay area supports several important commercial fisheries. Large quantities of shrimp, oysters, and blue crab are harvested in upper Galveston Bay, as well as in the surrounding salt marshes and throughout the rest of the estuary. White shrimp, brown shrimp, and eastern oysters are economically important species found in the system. Commercial harvest of finfish also occurs at low levels. These human activities are dependent upon the condition of the coastal and marine habitats.

3.4 Threatened and Endangered Species

The Endangered Species Act (ESA) of 1973 (16 U.S.C. §§1531, *et seq*.) requires federal agencies to conserve endangered and threatened species and to conserve the ecosystems upon which these species depend. Numerous endangered and threatened species are seasonal or occasional visitors to the Upper Galveston Bay Estuary coastal ecosystem (Estuary). Most species would be present in the Estuary incident to migration through the area. None of these species were considered to be at risk of injury due to the discharge of hazardous substances from the Greens Bayou Site. The Estuary's habitats provide general support for any threatened and endangered species migrating through or utilizing these communities. Table 3.1 provides a list of federally recognized endangered or threatened species reported to reside in or migrate through the Greens Bayou watershed area.

Table 3-1 – Federal and State Threatened and Endangered Species Potentially Utilizing the Greens Bayou Watershed, Harris County, Texas.

COMMON NAME	SCIENTIFIC NAME	STATUS
Mammals		
Plains spotted skunk	*Spilogale putorius interrupta*	
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	ST
Southeastern myotis bat	*Myotis austroriparius*	
West Indian manatee	*Trichechus manatus*	FE, SE
Birds		
American peregrine falcon	*Falco peregrinus anatum*	FDL, SE
Arctic peregrine falcon	*Falco peregrinus tundrius*	FDL, ST
Bald eagle	*Haliaeetus leucocephalus*	FDL, ST
Black Rail	*Laterallus jamaicensis*	
Brown pelican	*Pelecanus occidentalis*	FE, SE

Henslow's sparrow	*Ammodramus henslowii*	
Mountain plover	*Charadrius montanus*	
Snowy plover	*Charadrius alexandrinus*	
Southeastern snowy plover	*Charadrius alexandrinus tenuirostris*	
White-faced ibis	*Plegadus chihi*	ST
White-tailed hawk	*Buteo albicaudatus*	ST
Whooping crane	*Grus americana*	FE, SE
Wood stork	*Mycteria americana*	ST
Reptiles		
Alligator snapping turtle	*Macrochelys temminckii*	ST
Green sea turtle	*Chelonia mydas*	FT, ST
Leatherback sea turtle	*Dermochelys coriacea*	FE, SE
Loggerhead sea turtle	*Caretta caretta*	FT, ST
Smooth green snake	*Liochlorophis vernalis*	ST
Timber (canebrake) rattlesnake	*Crotalus horridus*	ST
Amphibians		
Houston toad	*Bufo houstonensis*	FE, SE
Fish		
American eel	*Anguilla rostrata*	
Creek chubsucker	*Erimyzon oblongus*	ST
Plants		
Giant sharpstem umbrella-sedge	*Cyperus cephalanthus*	
Houston daisy	*Rayjacksonia aurea*	
Texas meadow-rue	*Thalictrum texanum*	
Texas prairie dawn	*Hymenoxys texana*	FE, SE
Texas windmill-grass	*Chloris texensis*	
Threeflower broomweed	*Thurovia triflora*	

Notes:

FE, FT - Federally Listed Endangered/Threatened
FDL - Federally Delisted
SE, ST - State Listed Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

3.5 Essential Fish Habitat

Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (PL 94-265) in 1996 that established procedures for identifying Essential Fish

Habitat (EFH) and required interagency coordination to further the conservation of Federally managed fisheries. Rules published by the NMFS (50 CFR Sections 600.805 - 600.930) specify that any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity which could adversely affect EFH is subject to the consultation provisions of the MSFCMA as described in the implementing regulations. This section and the associated impacts sections were prepared to meet these requirements. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." When referring to estuaries, it is further defined as "all waters and substrates (mud, sand, shell, rock and associated biological communities) within these estuarine boundaries, including the sub-tidal vegetation (seagrasses and algae) and adjacent tidal vegetation (marshes and mangroves)" (Gulf of Mexico Fishery Management Council (GMFMC), 1998). The selected project site and alternative sites are located in an area that has been identified by the GMFMC as Essential Fish Habitat (EFH) for adult and juvenile brown and white shrimp, red drum, and Spanish mackerel *(Scomberomorus maculatus),* and by the NMFS as EFH for bonnethead shark, blacktip shark, and bull shark. EFH for these species in the vicinity of the selected and alternative sites includes estuarine emergent wetlands; estuarine mud, sand and shell substrates; and estuarine water column. Detailed information on Federally managed fisheries and their EFH is provided in the 1998 EFH amendment of the Fishery Management Plans for the Gulf of Mexico, prepared by the GMFMC, and in Appendix B of the 2006 Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan prepared by the NMFS.

The following describes the preferred habitat, life history stages, and relative abundance of each EFH managed species based on information provided by GMFMC (1998) and the NMFS (2006).

Brown shrimp

Brown shrimp eggs are demersal and occur offshore. The larvae occur offshore and begin to migrate to estuaries as postlarvae. Postlarvae migrate through passes on flood tides at night mainly from February to April with a minor peak in the fall. In estuaries, brown shrimp postlarvae and juveniles are associated with shallow vegetated habitats but also are found over silty sand and non-vegetated mud bottoms. Postlarvae and juveniles have been collected in salinity ranging from zero to 70 ppt (parts per thousand). The density of late postlarvae and juveniles is highest in marsh edge habitat and submerged vegetation, followed by tidal creeks, inner marsh, shallow open water and oyster reefs; in unvegetated areas muddy substrates seem to be preferred. Juveniles and sub-adults of brown shrimp occur from secondary estuarine channels out to the continental shelf but prefer shallow estuarine areas, particularly the soft, muddy areas

associated with plant-water interfaces. Sub-adults migrate from estuaries at night on ebb tide on new and full moon. Abundance offshore correlates positively with turbidity and negatively with hypoxia (low levels of oxygen in the water). Adult brown shrimp occur in neritic Gulf waters (i.e., marine waters extending from mean low tide to the edge of the continental shelf) and are associated with silt, muddy sand, and sandy substrates (GMFMC, 1998). Adult brown shrimp are considered common in the project vicinity from April to October. Juveniles are abundant year-round, peaking from April to October. Marine habitat is critically important to the reproduction and survival of shrimp. Adult brown shrimp occur throughout the Gulf's marine habitat to depths of about 110 meters. Larval shrimp feed on phytoplankton and zooplankton. Postlarvae feed on phytoplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae but also on algae and detritus (Pattillo et al., 1997). The habitat of these prey is essentially the same as that required by shrimp, estuarine and marine.

White shrimp

White shrimp are offshore and estuarine dwellers and are pelagic or demersal, depending on life stage. Their eggs are demersal and larval stages planktonic; both occurring in nearshore marine waters. Postlarvae migrate through passes mainly from May to November with peaks in June and September. Migration is in the upper 2 meters of the water column at night and at middepths during the day. Postlarval white shrimp become benthic once they reach the estuary, where they seek shallow water with muddy-sand bottoms high in organic detritus or marsh where they develop into juveniles. Postlarvae and juveniles inhabit mostly mud or peat bottoms with large quantities of decaying organic matter or vegetative cover. Densities are usually highest in marsh edge and SAV, followed by marsh ponds and channels, inner marsh, and oyster reefs. White shrimp juveniles prefer salinities of less than 10 ppt and can be found in tidal rivers and tributaries. As juveniles mature, they move to coastal areas where they mature and spawn. Adult white shrimp move from estuaries to coastal areas, where they are demersal and inhabit soft mud or silt bottoms (GMFMC, 1998). In the project vicinity, adult white shrimp are common from July to March, while juveniles are highly abundant year-round. Marine habitat is critically important to the reproduction and survival of shrimp. Adult white shrimp occur throughout the Gulf's marine habitat to depths of about 40 meters. Larval shrimp feed on phytoplankton and zooplankton. Postlarvae feed on phytoplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae but also on algae and detritus (Pattillo, et al., 1997). The habitat of these prey is essentially the same as that required by shrimp, estuarine and marine.

Red drum

Red drum occupy a variety of habitats, ranging from depths of 40 meters offshore to very shallow estuarine waters. Spawning occurs in the Gulf near the mouths of bays and inlets in the fall and winter months. Eggs hatch mainly in the Gulf and larvae are transported into the estuary where they mature and before moving back to the Gulf to spawn. Adult red drum use estuaries, but tend to spend most of their time offshore as they age. They are found over a variety of substrates including sand, mud, and oyster reefs, and can tolerate a wide range of salinities (GMFMC, 1998). Adult and juvenile red drum are common year-round in the project vicinity. Estuaries are especially important to the larval, juvenile, and sub-adult red drum. Juvenile red drum are most abundant around marshes, preferring quiet, shallow, protected waters with muddy or grassy bottoms (Simmons and Breuer, 1962). Sub-adult and adult red drum prefer shallow bay bottoms and oyster reef substrates. Estuaries are also important to the prey species of red drum. This is essential to larvae, juvenile, and early adult red drum since they spend all of their time in the estuary. Larval red drum feed mainly on shrimp, mysids, and amphipods, while juveniles feed on more fish and crabs (Peters and McMichael, 1987). Adult red drum feed mainly on shrimp, blue crab, striped mullet, and pinfish. Protection of estuaries is important to maintain the essential habitat for red drum and because so many prey species of red drum are estuarine dependent (GMFMC, 1998).

Spanish mackerel

Spanish mackerel are pelagic, occurring at depths to 75 meters throughout the coastal zone of the Gulf of Mexico. Adults are usually found along coastal areas, extending out to the edge of the continental shelf; however, they also display seasonal migrations and will inhabit high salinity estuarine areas at times. The occurrence of adults in Gulf estuaries is infrequent and rare. Spawning occurs in offshore waters during May through October. Nursery areas are in estuaries and coastal waters year-round. Larvae are most often found offshore from depths of 9 to 84 meters. Juveniles are found offshore, in the surf area, and sometimes in estuarine habitats. Juveniles prefer marine salinities and are not considered estuarine-dependent. The substrate preference of juveniles is clean sand; the preferences of other life stages are unknown (GMFMC, 1998). Adult and juvenile Spanish mackerel are considered common in the project vicinity from April to October. Estuaries are important habitats for most of the major prey species of Spanish mackerel. They feed throughout the water column on a variety of fishes, especially herrings. Squid, shrimp, and other crustaceans are also eaten. Most of their prey species are estuarine-dependent, spending all or a portion of their lifecycle in estuaries. Because of this Spanish mackerel are also dependent on the estuaries to some degree, and therefore, can be expected to

be detrimentally affected if the productive capabilities of estuaries are seriously degraded (GMFMC, 1998).

Bonnethead Shark

Bonnethead sharks can be found on sand or mud bottoms in shallow coastal waters. The bonnethead shark is viviparous, reaching sexual maturity at about 30 inches. The pups are born in late summer and early fall, measuring 12 to 13 inches (Pullin et al., 2007.). Juveniles inhabit shallow coastal waters up to 82 ft deep, inlets, and estuaries over sand and mud bottoms (NMFS, 2006b; Pullin et al., 2007.). They feed mainly on small fish, bivalves, crustaceans, and octopi (Pullin et al., 2007.). Juveniles and adults occur year round in the project area.

Blacktip Shark

Blacktips are fast moving sharks, occurring in shallow waters and offshore surface waters of the continental shelf. Blacktips are viviparous and young are born in bay systems in late May and early June after a year long gestation period. The reproductive cycle occurs every 2 years. Juveniles are found in all Texas bay systems in a variety of habitats and shallow coastal waters from the shore to the 82 ft isobath (NMFS, 2006b). They feed mainly on pelagic and benthic fishes, cephalopods and crustaceans, and small rays and sharks (Pullin et al., 2007.). Neonate and juvenile blacktip sharks occur year round in the project area.

Bull Shark

Bull sharks are coastal and may be found inhabiting shallow waters, especially in bays, rivers, and lakes. They frequently move between fresh and brackish water and are capable of covering great distances. Adults are often found near estuaries and freshwater inflows to the sea (Pullin et al., 2007.). Bull sharks are viviparous, have a gestation period of a little less than one year, and it is assumed the reproductive cycle occurs every 2 years. Neonates and juveniles are found in estuarine and coastal waters less than 25m deep in shallow coastal waters, inlets, and estuaries (NMFS, 2006b). They feed on bony fishes, sharks, rays, shrimp, crabs, squid, sea urchins, and sea turtles (Pullin et al., 2007.). Neonate and juvenile bull sharks occur year round in the project area.

In addition to being designated EFH for the seven federally managed species listed above, Galveston Bay provides nursery and foraging habitat that supports various life stages of forage species and recreationally important marine fishery species such as spotted seatrout, southern flounder, grey snapper, Atlantic croaker, black drum, Gulf menhaden, striped mullet, blue crab,

stone crab, pink shrimp, spot, pinfish, sheepshead, gizzard shad, bay anchovy, sheepshead minnow, Gulf killifish, and silversides. Such organisms serve as prey for other fish managed under the MSFCMA by the GMFMC (e.g., red drum, mackerels, snappers, and groupers) and for highly migratory species managed by the NMFS (e.g., billfishes and sharks). Wetlands and SAV provide other estuarine support functions, including: 1) providing a physically recognizable structure and substrate for refuge and attachment above and below the sediment surface; 2) binding sediments; 3) preventing erosion; 4) collecting organic and inorganic material by slowing currents; and 5) providing nutrients and detrital matter to the Galveston Bay estuary. Moreover, Galveston Bay provides habitat for many benthic animals, including marine worms and crustaceans which are consumed by higher trophic level predators such as shrimp, crabs, and black drum. Benthic organisms also have a key role in the estuarine food web because they 1) mineralize organic matter, releasing important nutrients to be reused by primary producers; 2) act as trophic links between primary producers and primary consumers; and 3) aggregate dissolved organics within estuarine waters, which are another source of particulate matter for primary consumers.

Table 3-2 – Major Essential Fish Habitat Categories for Managed Species in the Galveston Bay System.

Species	Life Stage	Ecotype	Essential Fish Habitat
Brown Shrimp	postlarvae/juvenile	marine	marsh edge, SAV, tidal creeks, inner marsh
	subadults	estuarine	mud bottoms, marsh edge
White Shrimp	postlarvae/juvenlle/ subadults	estuarine	marsh edge, SAV, marsh ponds, inner marsh, oyster reefs
Red Drum	postlarvae/juvenile	estuarine	SAV, estuarine sand/mud bottoms, marsh/water
	subadults	marine/estuarine	interface
	adults	marine/estuarine	sand/mud bottoms, oyster reef
			sand/mud bottoms, oyster reef
Spanish Mackerel	juvenile	marine/estuarine	open water, clean sand substrate
	adult	marine/estuarine	open water, clean sand substrate
Bonnethead	juvenile	marine/estuarine	<25m depth, sand/mud

Shark	adult	marine/estuarine	bottoms <25m depth, sand/mud bottoms
Blacktip Shark	neonate juvenile	marine/estuarine marine/estuarine	<25m depth, sand/mud bottoms <25m depth, sand/mud bottoms
Bull Shark	neonate juvenile	marine/estuarine marine/estuarine	<25m depth, sand/mud bottoms <25m depth, sand/mud bottoms

Sources: GMFMC, NMFS.

4 PROPOSED INJURY AND SERVICE LOSS EVALUATION

This section of the Final DARP/EA describes the Trustees' assessment of natural resource injuries due to hazardous substances released from the Greens Bayou Site facilities.

The evaluation and estimate of potential natural resource injuries presented in this section were developed by the Trustees, within a joint technical workgroup formed by the Trustees and the PRPs as part of a cooperative NRDA process. In evaluating and estimating injuries within this workgroup, a 'Conservative Injury Evaluation' (CIE)[6] approach was applied. The workgroup used historical data, scientific literature on contaminant effects, and the results of the Greens Bayou ecological risk assessment and related studies. All available relevant sediment, toxicity and tissue data resulting from remedial investigations conducted for the Greens Bayou Site, as well as other historical information on the presence of contaminants in the Site were used. The data were then assembled into a relational database/GIS for analysis.

Although developed cooperatively within the workgroup, the assessment approach and resource injury and loss evaluation presented in this section is that of the Trustees, as the Trustees are solely responsible for ensuring that this assessment plan and its outcome are consistent with the goals of the NRDA process.

4.1 SCOPE OF INJURY ASSESSMENT

As a threshold evaluation, the nature and extent of the contamination at the Greens Bayou Site that could be attributed to historical releases of hazardous substances from the facilities was examined. Areas with hazardous substances potentially from either facility were identified as

[6] The CIE approach uses conservative values and assumptions, i.e., those favoring natural resources and the public's interests in injured resources, to address or resolve uncertainties in assessment analyses. The approach, thus, results in an upper-end estimate of how much injury occurred or how much restoration is required. CIE assumptions are occasionally used in initial analyses to provide the Trustees with an upper-end estimate of compensatory restoration requirements. Also CIE can aid Trustees in determining the appropriate level of effort to apply in obtaining more refined estimates. Sometimes, as is the case for most of the assumptions used in this assessment, the cost to develop more precise estimates or further refine parameters used in the analysis would exceed the potential resulting change in the cost of restoration. In these instances, the use of conservative assumptions in the final analysis, rather than developing more precise point estimates, results in an overall cost savings to the public's trust agencies and PRPs while still protecting the public's interest in obtaining sufficient restoration for the injuries.

'areas of potential concern'. Within these general areas, the potential for natural resource injuries was then considered further based on the presence of hazardous substances at levels of concern (*i.e.*, concentrations with potential to adversely affect natural resources or services). Areas in which COCs were not likely to pose a substantial potential for injury to natural resources or services were excluded from further analysis in this process.

This threshold evaluation considered information from many sources, including the results of the work to characterize contaminants in Greens Bayou carried out by the Port of Houston Authority and the PRPs, the Greens Bayou Site Ecological Risk Assessment (ERA); records and information bearing on past and present operations from these facilities; scientific literature; as well as the Trustees' knowledge and understanding of the ecosystem in this area. Because much of this information arises from recent, comprehensive investigations of the Site conducted or supported by the TCEQ, the PRPs, and the Trustees, there is a high technical confidence that areas identified in this evaluation are appropriate for evaluating injury to natural resources and services associated with the PRPs' releases.

This threshold evaluation indicated that the potential for injury to natural resources associated with historical releases of hazardous substances from the former OCC and GBB and ISKM facilities is limited to Greens Bayou and the location of the CDF, including the associated habitat and the biota utilizing this area. Accordingly, the Trustees' injury and service loss evaluation focused on resource injuries and losses in this area.

4.2 PATHWAYS TO TRUST RESOURCES

Identifying and understanding the COCs for the Site, as well as their pathways to, and potential effects on, ecological receptors is critical to the Trustees' approach to injury assessment. A *pathway* is defined as the route or medium (for example, water or soil) through which hazardous substances are transported from the source of contamination to the natural resource of concern (43 C.F.R. § 11.14).

Records and information bearing on past and present operations at the former OCC and current GBB and ISKM facilities, including reports of releases in court documents, indicate the facilities released a number of different constituents, but principally those related to agricultural products, including lindane and DDT (and their metabolites) (See Subsection 4.3 – Contaminants of Concern).

Results of the Greens Bayou Site ERA and other relevant data revealed that sediments in Greens Bayou were contaminated with hazardous substances that are characteristic of agricultural

chemical manufacturing constituents and that facility wastes, spills and past housekeeping practices at the PRP facilities are, or have been, sources of the hazardous substances that have come to be located in Greens Bayou sediments. Fish and other aquatic receptors known to utilize these areas are able to come in contact with the contamination in these sediments.

4.3 CONTAMINANTS OF CONCERN

One of the earliest steps in this NRDA process involved the identification of hazardous substances that should be included in the list of COCs. To develop this list, the Trustees worked cooperatively with the TCEQ during and after their preparation of the remedial investigation and ERA for the Site. The remedial investigation identified the nature and extent of hazardous substances and the ERA assessed ecological risks to biota due to contaminant exposures. For the Greens Bayou Site, that process led the Trustees to focus on various organochlorine insecticides and their metabolites including DDT (and metabolites), lindane and hexachlorobenzene as the contaminants posing a threat to natural resources.

The Greens Bayou remedial investigation detected DDT, benzene hexachloride (HCH) and hexachlorobenzene (HCB, and metabolites) in the sediments of Greens Bayou at concentrations exceeding screening guidelines (Effects Range Medium, ERM).[7] The Greens Bayou ERA indicates the primary COCs within the bayou that pose a potential residual ecological risk to biota due to exposure are DDT and its metabolites (DDD, DDE). Thus, the Trustees focused the NRDA on natural resource injuries due to these COCs. However, the cumulative effect of other COC's which exceeded PCLs was also considered in the evaluation of injury to benthic organisms.

Dichlorodiphenyltrichloroethane (DDT)

DDT is an organochlorine insecticide that breaks down to the metabolites DDD and DDE in the environment. All three isomers may be toxic to ecological receptors, therefore the assessment focused on them collectively (as DDTr). DDTr is highly hydrophobic (repelled from water) and is fairly soluble in organic solvents, fats and oils (lipophilic). Thus, DDTr tends to accumulate in the lipids of organisms (is bioaccumulative) and levels of DDTr in the tissues of organisms tend to increase at higher trophic positions in the food chain (biomagnifies). Further, DDTr is chemically stable, has low volatility, and a slow rate of biotransformation and degradation (ATSDR, 2002). When released into the environment, DDTr sorbs to soil or sediment and is highly persistent with a mean half-life around 17 years in sediments (MacKay, 1999). DDTr is a neurotoxin which inhibits normal ion exchange at the cellular level (resulting in central nervous

7 See section 5.4 for a discussion of these guidelines, the Effects Range Low and Effects Range Medium.

system impairment) and also is an endocrine disrupting compound (its chemical structure mimics estrogen at sufficient exposure thereby resulting in reproductive and endocrine impairments) (ATSDR, 2002). DDTr is known to cause eggshell thinning in exposed birds and is acutely toxic to aquatic receptors (ATSDR, 2002).

4.4 ASSESSMENT STRATEGY

As noted earlier, the Trustees and PRPs formed a joint technical workgroup and used a CIE approach[8] to evaluate and estimate potential resource injuries attributable to releases from the PRPs' facilities. In applying the CIE approach, the workgroup made use of all available evidence, including data from site investigations, values from existing scientific literature and the substantial collective experience within the workgroup.

In considering whether the hazardous substances in Greens Bayou were sufficient to cause harm to natural resources or resource services in these areas, the Trustees used the GIS database to compare contaminant concentrations from the two relevant sediment quality guidelines[9] to those measured in the sediment to determine the geographic extent of the potential for natural resource injuries. The spatial analysis was also used to compare shallow benthic habitat areas with locations of elevated sediment contaminants. This analysis revealed that the risk to resources was not equally distributed over the study area, but was limited in spatial extent. The highest risks were found to be confined to sediments located near the mouth of the HCFCD ditch and depositional areas upstream and downstream from the ditch. The Trustees also considered potential for ecological impacts due to re-suspension and re-distribution of sediment borne contaminants following dredging as well as removal of shallow benthic habitat due to dredging.

The Greens Bayou Site ERA concluded that hazardous substances in Greens Bayou sediments did not pose unacceptable risks to upper trophic level organisms (e.g., fish, birds, reptiles, mammals), but that contaminants in sediments did pose a risk to benthic (i.e., sediment dwelling) organisms. Since the Greens Bayou ERA found ecological risk was confined to benthic organisms, the Trustees' evaluation of potential natural resource injuries in the bayou relied primarily on available sediment contaminant chemistry data, toxicity test results, and scientific literature.

Construction of the CDF was also identified by the Trustees to be an activity that resulted in a loss of terrestrial resources. The habitat provided by the area sited for the CDF consisted of

[8] See footnote 3 for explanation of CIE approach.

[9] See section 5.4 for a discussion of these guidelines, the Effects Range Low and Effects Range Medium.

mixed open grassland (wet and dry prairie) and forested wetland. Response activities which have been implemented or are projected to be implemented as a result of the release of COCs from the Site, as detailed in the dredging permit application, have resulted in, or will result in, the loss of forested wetlands, prairie, and other valuable habitats. These response activities include the removal of mixed forest wetlands, herbaceous wetlands, and grasslands due to the clearing and construction associated with the planning and implementation of the CDF, which will receive and hold the impacted sediments removed from Greens Bayou. Wildlife is attracted to this area due to the limited nature of such habitat in the highly developed Houston corridor.

The assessment completed by the Trustees quantified the resources provided by the restoration alternatives evaluated. The scale (or size) of the selected restoration action should be one which provides a gained value to just offset the value of the losses. The process of determining the size of restoration is called restoration scaling. Restoration scaling requires a framework for quantifying the value of losses and for quantifying the benefits of restoration so the losses and benefits can be compared. The Trustees used HEA as the framework for quantifying losses and benefits (NOAA, 2000). The data collected during the preassessment, response and subsequent surveys were evaluated and used as inputs for the HEA. Discussion of the HEA is provided in the following section.

4.5 DESCRIPTION OF HABITAT EQUIVALENCY ANALYSIS

HEA is an accounting procedure that allows parties to identify "debits" (estimating habitat injuries or other resource service losses) due to exposure to hazardous substances or remedial activities, and to identify the scale of restoration required to compensate for assessed injuries or losses. It also allows the "debits' to be balanced against the ecological services to be gained (credited as 'compensation') from proposed habitat restoration projects. The scale, or size, of a restoration project should be such that it provides enough ecological service gains to offset the total of the losses.

The ecological service losses quantified using a HEA are used to identify the restoration requirements needed to compensate for injuries (generally in the form of habitat acreage). In this context, restoration is scaled to provide comparable habitat resources and ecological services (equivalency) between the lost and restored habitat resources and ecological services, adjusted through discounting to account for the difference in time when services gained through restoration are delivered.

The HEA requires the development of injury parameters to quantify lost resources and services. The parameters needed to estimate losses to natural resources include the size of the injury, the degree of injury, and how that degree of injury changes over time. The degree of injury is determined by the condition of key or representative resources or services in the habitat (for example, primary production or macrofaunal density). The losses are quantified or converted to habitat acres and then quantified as lost service acre-years, where a service acre-year is the loss of one acre of habitat and its resources and services for a year.

Because the losses occur in different time periods, they are not directly comparable. People place more value on the use or consumption of goods and services in the present rather than postponing their use or consumption to some future time. To make the losses that occur in different time periods comparable, a discount factor is applied to the losses to determine discounted service acre-years (DSAYs). In general, HEA is a technique that balances "debits" (habitat or other injuries) that have occurred as a result of a release of hazardous substances against compensatory "credits" (habitat restoration projects) and uses a discount factor to account for the difference in time that the restoration services are delivered.

Other parameters are necessary to quantify the benefits of restoration actions in a HEA. They include 1) the date when the habitat restoration action begins, 2) the time until the habitat provides full services, 3) the risk to service losses of the habitat restoration, 4) the level of services provided between the time when the restoration action begins and when it provides full services, and 5) the relative services of the created or enhanced habitat compared to the injured habitat before the injury. These parameters, along with the size of a restoration action and the discount rate, define the DSAY benefits that result from a restoration action. The task is to determine the size of the restoration action such that the DSAY benefits just offset the losses.

The Trustees consider the HEA to be an appropriate analytical tool for use to assess benthic and terrestrial resource losses for this Site. To quantify losses using the HEA, information or estimates of ecological service losses used to define the resource injuries are needed.

5 EVALUATION OF INJURY

The Trustees' evaluation of the potential for injuries to natural resources, including recreational services losses, for this Site is summarized in the following subsections.

5.1 EVALUATION OF POTENTIAL INJURIES TO SURFACE WATER RESOURCES

The Trustees evaluated the potential for injury to organisms living in the water column due to contamination within Greens Bayou. Because contaminant concentrations in bayou surface water samples taken for the ERA were below relevant water quality standards, direct exposure was not considered during the injury assessment. The potential for injury to aquatic receptors exposed to contaminants sorbed to suspended sediments following dredging was a pathway of concern to the Trustees. This pathway was evaluated in the ERA and the conclusion was that due to the temporary nature of the exposure (coupled with the limited geographical extent of the impact and physical controls planned to reduce loss of dredged sediments) the risk to exposed aquatic organisms was negligible.

The Trustees also examined the potential for interim water column losses due to past injury back to the year 1981[10]. Although past injuries and interim losses may have in fact occurred, quantifying any such loss retroactively is difficult given the limited supporting data available prior to 1999, and is unlikely to yield very accurate results. Additionally, in considering whether to address past losses, the Trustees recognized that the water quality standards used to evaluate the potential for injury to aquatic organisms are technically conservative (i.e., are more likely to over-estimate potential risk). The Trustees also considered the nature of the exposure to aquatic organisms. Unlike benthic organisms, which are relatively sedentary, plankton and juvenile fish drift with water currents, thus reducing their exposure to contaminants present in the water column in these areas resulting in exposures more temporary in nature than for benthic organisms. This further reduces the likelihood that significant losses of aquatic organisms occurred in the past. Finally, the contaminants released by the PRPs tend to be hydrophobic in nature and thus tend to partition (or bind) to sediments, rather than remain in the water column. For these and all preceding reasons, the Trustees found no significant potential for injury to water column organisms in the past.

As a final consideration, the Trustees recognized that most potential restoration projects undertaken to compensate for benthic injuries would ecologically benefit other resources,

[10] The year in which CERCLA became effective.

including water column organisms. Indeed, all the restoration alternatives evaluated in Section 6, except the "No Action" alternative, would benefit water column organisms and the potential for multiple environmental benefits for each alternative has been considered in identifying the selected restoration projects to compensate for the benthic resource injury.

Because contaminant levels in surface waters do not currently pose a risk of injury to aquatic receptors, and historical data suggest a relatively small potential for past injury, the Trustees propose no further evaluation of injury to water column organisms.

5.2 EVALUATION OF POTENTIAL INJURIES TO HIGHER TROPHIC LEVEL ORGANISMS

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

The direct exposure route is frequently the most significant source of contaminants to fish, rather than piscivorous birds or mammals, because fish are continuously exposed through the surface waters and sediments that comprise their habitat. However, because no recent water column contaminant concentration for this Site exceeded its corresponding Ambient Water Quality Criteria value, only sediment exposure is relevant. As was the case with the evaluation of potential for injury to planktonic organisms, the contaminant levels in surface waters of Greens Bayou are below levels likely to cause injury to most fishes. Fish species that live in close association with sediments (e.g., blue catfish, flatfishes) have a potential for injury through direct contact with organochlorine contaminated sediments. In the injury assessment for this Site, however, the Trustees opted to treat these species as part of the benthic community since the pathway and potential effects among sediment dwelling species are similar. Losses due to potential injuries to these fish species are, therefore, considered and encompassed in the analysis of injury to benthic resources.

The contaminants linked to the historical releases from the PRPs facilities and observed to be present at high concentrations in the sediments of Greens Bayou and the HCFCD ditch (i.e., DDT, HCH and metabolites) tend to biomagnify (increase in concentration from lower to higher trophic levels, or magnify up the food chain). Therefore, the potential for injury to higher trophic level organisms via indirect exposure to contaminants through their food chain (i.e., through consumption of lower level consumers of prey items from Greens Bayou and HCFCD ditch sediments) is higher than if there were substantial concentrations of contaminants that do not biomagnify. Thus, the Greens Bayou Site ERA evaluated the risk of injury through indirect exposures for representative bird and wildlife species common to the bayou. The great blue

heron (*Ardea herodias*), neotropic cormorant (*Phalacrocorax brasilianus)*, spotted sandpiper (*Actitis macularia)*, and raccoon were all specifically considered and served as surrogates for other potentially affected, upper trophic level organisms. The Greens Bayou ERA concluded that the potential risk to all of these organisms from the contamination present in the bayou is negligible (CPR Associates, Inc & GB Biosciences, 2003, 2004, 2005).

Additionally, the Trustees recognize that most potential restoration undertaken to compensate for benthic injuries would ecologically benefit other resources, including birds. As was true for surface water resources, the restoration alternatives evaluated in Section 6, except the No Action Alternative, would each benefit potentially affected birds either directly or indirectly. The potential multiple environmental benefits for each alternative has been considered in identifying the selected restoration projects to compensate for the benthic resource injury, and the selected alternatives will provide many benefits to potentially affected avian species.

Because available information indicates that Greens Bayou sediment contamination does not pose significant risk for injury to exposed higher trophic level organisms, the Trustees propose no further evaluation of injury to these resources relating to releases from the PRPs' facilities.

5.3 Evaluation of Potential Lost Recreational Use of Resources

Many natural resources support recreational activities or other public uses and these human uses are considered part of the array of services these resources provide. The uses can, at times, be affected by the presence of hazardous substances.

The Trustees considered the potential for loss of recreational uses within the bayou, including fishing, swimming, water skiing, wildlife viewing, and boating, but found no information indicating that services of this nature have been lost or diminished due to any contaminants released by the PRPs. The industrial nature of the area is very prohibitive to recreational activities. Access to Greens Bayou is very limited to the public. The primary recreational use is fishing from the banks of the bayou accessible to pedestrians at the intersection of the bayou and IH-10.

The area of Greens Bayou impacted by hazardous substances is known as Segment 1006 of the Houston Ship Channel Tidal zone. The designated uses of this segment are limited to navigation and industrial uses. Recreational use of the HSC is prohibited. Terrestrial access to the bayou is also restricted as the surrounding land is largely comprised of private industrial properties. No public boat ramps or other types of public access points are found along the bayou. Further, the Trustees could find no information indicating any active public use of the Site for recreation.

The Trustees, therefore, found little likelihood of lost recreational use of surface waters due to the contamination in Greens Bayou.

Based on this analysis, the Trustees found that no recreational losses are likely to have occurred due to releases from the PRPs facilities. On that basis, the Trustees propose no further evaluation of recreational losses due to the PRPs' releases. This outcome is also consistent with results of the Human Health Risk Assessment conducted for the Greens Bayou Site (CPF Associates, Inc & GB Biosciences, 2003, 2004, 2005).

5.4 EVALUATION AND ASSESSMENT OF INJURY TO BENTHIC RESOURCES (HABITAT AND ORGANISMS)

The Trustees considered whether the contaminant levels present in the sediments of Greens Bayou were sufficient to cause harm to the organisms living within, upon, or closely associated with those sediments, or otherwise adversely affect ecological services provided by this habitat. Organisms common to the area were considered in this analysis, including invertebrates and fish species that are viewed predominantly as bottom dwelling species (e.g., flatfishes, catfishes).

Benthos is a broad term that describes aquatic organisms (primarily invertebrates) living on or in the sediments of an aquatic ecosystem. Benthic organisms often feed on organic detritus (decaying material) that is mixed with the top few centimeters of sediment or is trapped in the silty fines that cover the sediment surface. Most other trophic niches (herbivores, predators, scavengers, etc.) are also represented in the benthic community. Benthic communities constitute an important part of the estuarine food web by utilizing sediment-bound nutrients and organic substances that are not generally available to epiphytic or pelagic organisms. The ecological services provided by benthos that can be affected by Site contaminants include:

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

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

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

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

Whole sediment toxicity tests, which expose biota to sediments taken from Greens Bayou, were conducted during the Surface and Subsurface Sediment Investigation conducted for the Port of Houston. This investigation also included the collection of sediment samples for analytical testing. Results of these studies confirmed the presence of elevated levels of contaminants in bayou sediments. The Greens Bayou site ERA found that contaminants, primarily organochlorine insecticides such as DDT, DDD, DDE, HCH, and HCB were associated with the observed toxicity in its sediment (CPF Associates, Inc & GB Biosciences, 2003, 2004, 2005). Therefore, benthic resources were identified as an injury category and retained for further analysis.

The Trustees also compared COC concentrations from individual sample locations to scientifically recognized screening values that are considered guidelines for sediment quality: the Effects Range Low (ERL) and Effects Range Medium (ERM) guidelines developed by Long and Morgan (1990) and Long *et al*. (1995). ERM and ERL are screening values which were calculated from a large compilation of effects-based sediment data. ERM and ERL values exist for some of the most commonly assessed contaminants, and will correspond to that particular contaminant. Adverse biological effects may occur at contaminant concentrations ranging between the ERL and the ERM. Above the ERM, adverse effects are more likely and below the ERL adverse effects are less unlikely. TCEQ ecological risk assessment guidance recommends that protective concentration levels (PCLs) by default are calculated as the mean of the ERL and

ERM for a contaminant (TNRCC, 2001). In this injury evaluation, the PCL represented a conservative threshold for loss of ecological services. This information also supported the inclusion of benthic resources as an injury category in this assessment.

5.4.1 Sediment Quality Guidelines in Benthos Injury Assessment

ERL and ERM sediment quality guidelines, developed by NOAA, are predictive numerical indicators of potential injury to sediment-dwelling organisms due to ingestion and bioaccumulation of sediment contaminants. Adverse biological effects (such as organ impairment or death) are improbable below ERL and probable at contaminant concentrations at or above the ERM and (Long & Morgan, 1990; Long & MacDonald, 1998). Long *et al*. (1998) found that the probability of observing toxicity to sediment dwelling organisms generally increases with increased ERM quotients (Figure 5-1).

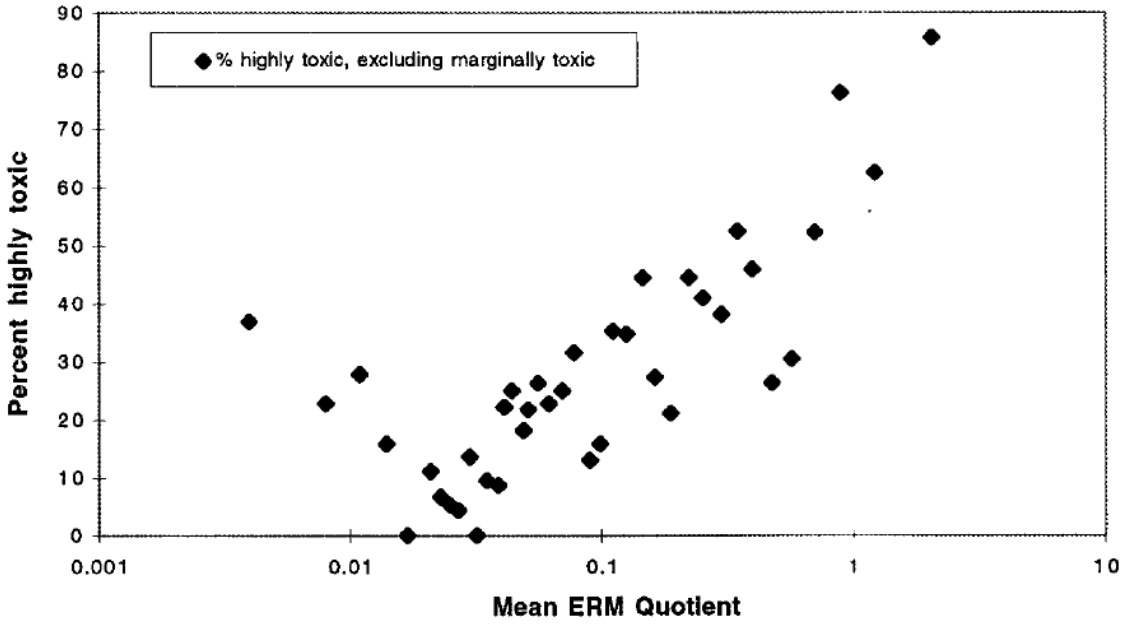

Figure 5-1 – The Relationship between the Incidence of Toxicity in Amphipod Survival Tests and Mean Effects Range — Median (ERM) Quotients (Long and MacDonald, 1998).

The team selected a conservative threshold for injury based upon the PCL of the sediment contaminants. With the exception of DDTr, for which the PCL was established through a review of relevant literature, the PCL is calculated as the mean of the ERL and ERM, since this is the range within which adverse effects may occur. The COCs for sediments in Greens Bayou, their ERLs, ERMs, and PCLs are presented in Table 5.1.

Table 5-1 – Sediment COCs with Corresponding ERL, ERM and PCL Values (mg/kg dry weight).

Contaminant of Concern	ERL	ERM	PCL
DDTr			0.157
HCB	0.020	0.24	0.13
α HCH	0.006	0.1	0.053
β HCH	0.005	0.21	0.1075
γ HCH	0.00032	0.00099	0.00066

5.4.2 Strategy for Estimating Benthos Injury

In evaluating and estimating losses, the Trustees identified the various sources of injury for benthic resources in Greens Bayou. Benthic habitat in Greens Bayou is limited to shallow zones outside the Federal Navigation Channel, and is defined as those areas within a depth of 0 to 6 inches in sediments, in waters between +2 and -10 feet mean low tide, and extending from sampling area polygon 2RE1 to 6E1. Figure 5-2 depicts the shallow benthic habitat area in Greens Bayou.

Figure 5-2 – Shallow Benthic Habitat and DMMUs within Greens Bayou.

For areas of benthic habitat, the Trustees identified three sources with potential to injure the resources – COCs, dredging, and resuspension/redistribution of COCs following dredging. Elevated levels of COCs result in a loss of benthos through toxic mechanisms. The dredging of Greens Bayou (for remediation) results in loss of benthos by removing habitat. Loss of benthos through toxic mechanisms is also anticipated following dredging due to resuspension and redistribution of contaminated sediments. Areas of Greens Bayou affected by these injury categories are shown in Figure 5-3. Losses are quantified by determining the time required for the injured resources to recover to pre-release and pre-remedy conditions through natural or enhanced means, as applicable, and the severity of injury. For each injury category (COCs, dredging, resuspension), the losses to benthic habitat were quantified by determining the likely severity of injury based on the available scientific information on potential biological effects.

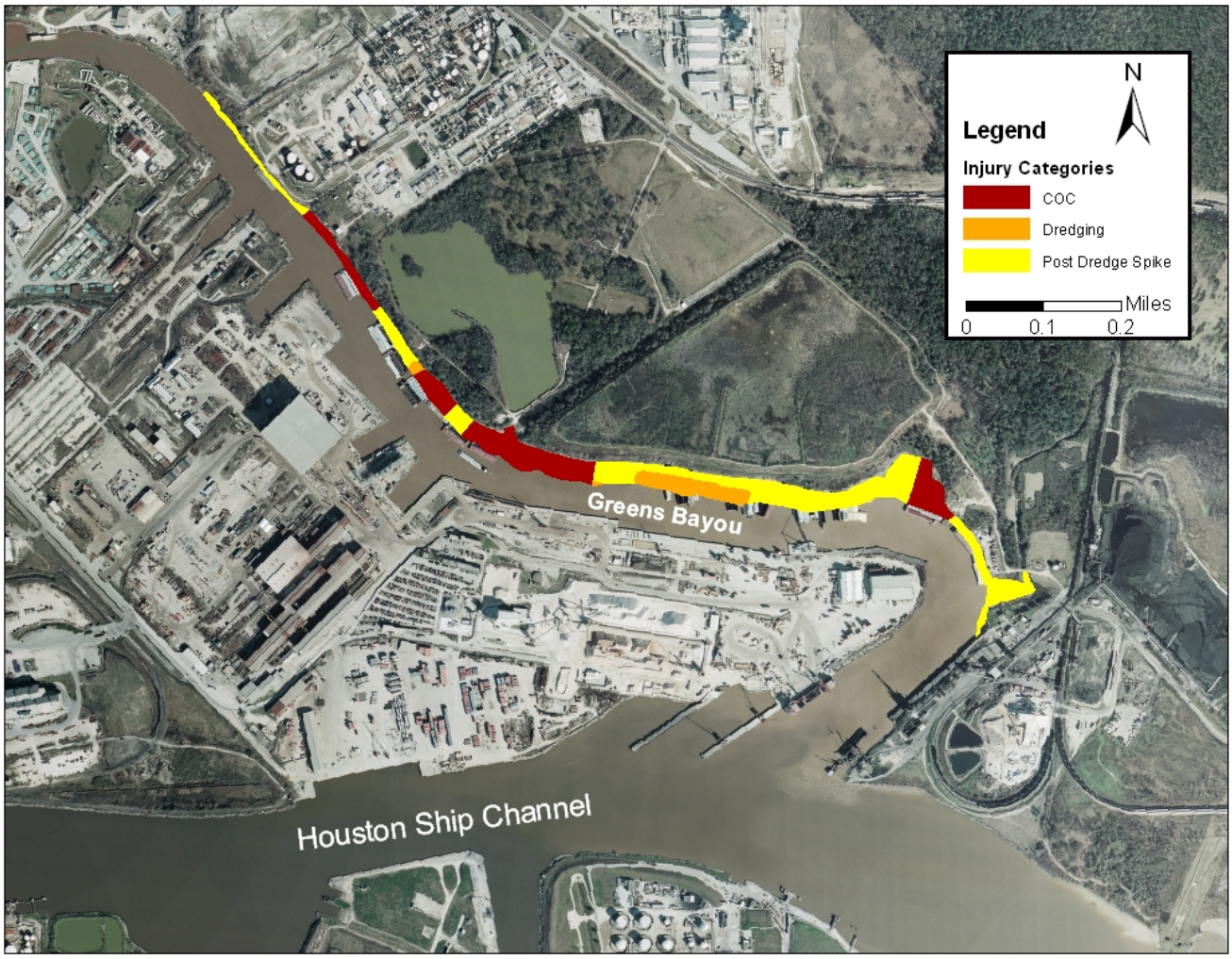

Figure 5-3 – Greens Bayou Sediment Injury Categories.

5.4.3 HEA Injury Parameters

Inputs to the HEA for this injury assessment were based on sediment chemistry analytical results and conservative assumptions. A number of generic, conservative assumptions were associated with all of the areas that were assessed: 1) the discount rate is 3%, 2) the base year (the year from which a discount is applied) is the year 2007, 3) recovery times depend upon the source of the loss/injury, and 4) restoration will be initiated in 2008.

5.4.4 Greens Bayou Benthos Injury Estimate

Results of Greens Bayou sediment chemistry analyses conducted between 1997 and 2004 indicate that the contamination present in Greens Bayou sediments has the potential to cause injury to exposed benthic organisms. Although some organisms do live in these sediments, the

Trustees and PRPs conservatively agreed this area could be assessed as suffering a complete loss of benthic services (i.e., 100% injury) due to the contamination present and, further, that this level of injury could be assessed as having been constant in the past and as remaining at this level for perpetuity. Similarly, areas of benthic habitat that will be dredged were also assumed to be completely lost upon removal of the sediments and would remain injured in perpetuity. Removal of these sediments is planned by the PRPs as part of the settlement with the Port of Houston Authority. The Trustees and PRPs also agreed to the conservative assumption that shallow benthic habitat not impacted by COCs or dredging would be injured due to resuspension and redistribution of contaminated sediments after dredging. The injury was assumed to result in a partial (50% injury) loss of benthic services with complete recovery in 100 years. The results of the injury analysis for the Greens Bayou benthos are presented in Table 5.2.

Table 5-2 – Benthic Injury HEA Input Parameters and Results.

Source of Impact to Greens Bayou sediments	**COC Impacts**	**Dredge Impacts**	**Post Dredge Resuspension Impacts**
Base Year	2007	2007	2007
Discount Rate	3%	3%	3%
Date the Resource Injury Occurs	1981	2008	2008
Extent of Injury (acres)	6.97	2.10	10.3
Initial Level of Injury (% Loss of Service)	100.0%	100%	50%
Level of Injury After First Recovery Phase (%LOS) and Year	0% in 2007	0% in 2308	0% in 2108
Level of Injury After Second Recovery Phase (%LOS) and Year	100% in 2307	0% in 2308	0% in 2308
Level of Injury After Third Recovery Phase (%LOS) and Year	0% in 2308	0% in 2308	0% in 2308
End of the Recovery Period (Year)	2308	2308	2308
Total Lost Benthic DSAYs	516.05	62.07	116.61
Wetland Equivalent DSAYs (marsh equivalency factor 5:1, benthic DSAY/5)	103.21	12.41	23.32
Total Wetland Equivalent DSAYs		**139**	

5.4.5 Equivalent Injured Acres Ratio

The assessed benthic resource losses are for benthic injuries occurring in soft unvegetated bottom sediments, also referred to as open water habitats. The restoration project selected for use to compensate for these losses involves creation and enhancement of brackish marsh. To

determine the amount or scale of restoration needed to offset losses, the DSAYs lost due to injuries have to be compared to DSAYs gained through restoration across these habitat types (open water versus marsh). The comparison is complicated by differences in functions or ecological productivity levels between these habitats. To translate the habitat losses into their 'equivalent' in the target restoration habitat, it is necessary to identify a conversion factor or ratio to be used to adjust for the differences in relative productivity across these habitat types.

To accomplish this, the habitat productivity of the injured open water habitat was first compared to the habitat productivity of a natural wetland. The Trustees reviewed the method used to develop a wetland conversion factor for the Lavaca Bay National Priorities List Case (marsh equivalency factor: 5 acres of water bottom = 1 acre of tidal wetland) (Lavaca Bay, TX, Trustees, 2000). The Trustees decided that this same ratio, or 'marsh equivalency factor', could be used as a conversion factor for these same habitats in Greens Bayou because, in their professional knowledge, similar habitat functions were represented.

The benthic habitat ratio was applied by dividing the site-specific, unvegetated bottom sediment DSAYs assessed for the losses by the marsh equivalency factor. The result is a conversion of the benthic losses to their equivalent in lost services of marsh, *i.e.* Equivalent DSAYs (EqDSAYs). The results in Table 5.2 are presented as EqDSAYs Lost. The DSAYs to be gained from the selected restoration action are estimated and compared to the EqDSAYs Lost in Section 7.1.5.

5.4.6 Summary of Proposed Injury Analysis for Benthic Resources

The Trustees found benthic resources in Greens Bayou to be injured due to the effects of elevated concentrations of hazardous substances releases attributable to the PRPs facilities and the remediation planned to address this contamination. Using the CIE approach, the Trustees have quantified the injuries in terms of the ecological services of the benthos lost over time, until recovery to baseline conditions, using historical data and data collected for both the Greens Bayou Site ERA and RAP and based on sediment benchmark concentrations known or suspected to result in adverse effects in benthic populations. Consistent with the CIE approach, the analysis incorporated conservative technical judgments and assumptions regarding likely effects on benthos, including those of remedial actions known or expected within Greens Bayou and the greater Site.

The quantification of benthic losses considered the present condition of the resource, the potential reduction in ecological services due to the injury, and accounted for service losses expected to occur due to the implementation of the remedy (dredging of the bayou). Because the

selected restoration action has a higher ecological productivity than the habitat within which the injuries occurred (open water bottom), a marsh equivalency ratio of 5-to-1 was applied to convert benthic losses to their 'equivalent' in the target restoration habitat. The results of this analysis (see Table 5.2) indicate that compensation for assessed benthic resource losses is achieved by providing the ecological services of a constructed intertidal wetland equivalent to 139 DSAYs.

5.5 EVALUATION AND ASSESSMENT OF INJURY TO TERRESTRIAL RESOURCES (HABITAT)

Construction of the CDF was identified by the Trustees to be an activity that resulted in a loss of terrestrial resources. The habitat provided by the area sited for the CDF consists of mixed open grassland (wet and dry prairie) as well as herbaceous and forested wetlands. Response activities which have been implemented or are projected to be implemented as a result of the release of COCs from the Site, as detailed in the dredging permit application, have resulted in, or will result in, the loss of forested wetlands, prairie, and other valuable habitats. These response activities include the removal of mixed forest wetlands, herbaceous wetlands, and grasslands due to the clearing and construction associated with the planning and implementation of the CDF, which will receive and hold the impacted sediments removed from Greens Bayou. Wildlife is attracted to this area due to the limited nature of such habitat in the highly developed Houston corridor.

Under the CIE approach, the Trustees have quantified the injuries in terms of the ecological services of the terrestrial environment lost using historical data and aerial photographs. Consistent with the CIE approach, the analysis incorporated conservative technical judgments and assumptions regarding likely affects on the terrestrial environment, including those of remedial actions known or expected within Greens Bayou and the greater Site.

5.5.1 Strategy for Estimating Terrestrial Injury

To evaluate the impacts due to the selected remedial alternative, the CDF area was divided into three distinct habitat types: prairie, wetlands, and woodlands. As part of the HEA, the Trustees assumed the CDF would ultimately be capped and planted with Coastal Bermuda grass (*Cynodon dactylon*) or something similar after dredged materials were in place. The Trustees also assumed construction of the CDF would begin in 2008 and that the area would return to maximum habitat production (i.e., complete grassy vegetative cover) in 2010. To calculate the minimum amount of acreage required to compensate for lost services for each major habitat category, each base injury calculation discussed needed to be scaled to a specific type of

restoration project. The amount of constructed habitat required was calculated by multiplying the base lost DSAY for each type of injured habitat by a conversion factor based on the percentage of total ecological services provided relative to the target habitat restoration action.

5.5.2 HEA Injury Parameters

Inputs to the HEA for this injury assessment were based on the construction plan for the CDF, previous wetlands delineations completed at the Site, historical aerial photographs, and conservative assumptions. The following assumptions were associated with all of the areas that were assessed: 1) the discount rate is 3%, 2) the base year (the year from which a discount is applied) is the year 2007, 3) the onset of injury was calculated beginning in 2006, 4) initial injuries/losses result in 100% loss of services, 5) the CDF will be constructed in 2008, 6) construction will be completed and the area covered with grassy vegetation by 2010, and 7) post-capping, some level of ecological services will flow from the CDF area albeit a much smaller level of services than originally provided. The inputs of the injury analysis for the terrestrial habitat within the CDF are presented in Table 5.3.

Table 5-3 – Terrestrial Injury HEA Input Parameters.

	Prairie		**Wetlands**		**Woodlands**	
Area Injured :	16.8	acres	5.3	acres	12.5	acres
	% injury	Year	% injury	Year	% injury	Year
Initial level of Injury	100	2006	100	2006	100	2006
End of First recovery Phase	100	2010	100	2010	100	2010
End of Second Recovery Phase	75	2306	95	2306	97.5	2306
End of recovery period	0	2306	0	2306	0	2306

5.5.3 Greens Bayou CDF Injury Estimate

The assessed terrestrial injury to prairie, woodlands, and wetlands habitats was restricted to the footprint of the CDF. Habitats present in this area were assumed to be totally destroyed by the process of building levees around the perimeter and then filling the CDF with contaminated sediments dredged from Greens Bayou. The Trustees took into consideration that once the dewatering of the CDF had been accomplished, the area would be capped and covered with grassy vegetation most likely dominated by coastal Bermuda grass. Long term management of the capped area would likely focus on the removal of any woody vegetation to ensure the integrity of the cap and ensure that this grassy cover will be maintained in perpetuity. Since

coastal Bermuda grass provides minimal ecological benefits relative to the types of communities that previously existed prior to CDF construction, the level of services provided once the cap was in place was generally judged to be very low. Results of HEA calculations based on the parameters outlined above indicated that construction of the CDF will result in the loss of 465 DSAYs of prairie habitat, 179 wetland habitat DSAYs and 431 DSAYs of woodland habitat.

The calculation of preservation acreage involved developing a generalized HEA for the preservation of 1 acre of wooded wetlands habitat to estimate the potential ecological losses associated with development of the preservation property that would be forestalled. The injured acreage was a mixture of grassy uplands, wetlands, and woodlands interspersed throughout.

5.5.4 Equivalent Injured Acres Ratio

The Trustees determined that the selected restoration target for terrestrial losses is the preservation of wooded wetland habitat. This is largely based on the high construction costs, long term commitment and risks associated with the construction of wooded habitats, another option for this mix of affected habitats. So, to facilitate restoration planning, the Trustees chose to convert the injury values for the three affected habitat types to wooded wetlands equivalent injury values. To translate the habitat losses into their 'equivalent' in the target restoration habitat, it is necessary to identify a conversion factor or ratio to be used to adjust for the differences in relative productivity across these habitat types. To determine the amount or scale restoration needed to offset losses, the DSAYs lost due to injuries have to be compared to DSAYs gained through restoration across these habitat types (prairie/woodland/wetland versus wooded wetland). The comparison is complicated by differences in functions or ecological productivity levels between these habitats.

The conversion factors for the terrestrial habitat types were developed in a similar approach to the benthic habitat factor. The Trustees relied on past experience and best professional judgment to identify ratios for each of the habitat types impacted by the CDF footprint. Based on the relative ecological services provided by the prairie habitat, a habitat conversion factor (HCF) of 0.2 was used to convert the 465 DSAYs of prairie habitat losses to 93 DSAYs of wooded wetlands habitat equivalent losses. Based on the relative ecological services provided by the wetland habitat, an HCF of 0.5 was used to convert the 179 DSAYs of wetland habitat losses to 90 DSAYs of wooded wetlands habitat equivalent losses. The relative ecological services provided by the woodland habitat were considered comparable to the services provided by wooded wetlands habitat so an HCF of 1.0 was used. For all habitat types the total wooded

wetlands habitat equivalent losses for the CDF is 614 DSAYs. The results of the injury analysis for the Greens Bayou CDF are presented in Table 5.4.

Table 5-4 – Results of Terrestrial Resources Injury Analysis.

	Prairie	Wetlands	Woodlands
Total Lost DSAYs	465	179	431
Wooded wetlands Conversion factor	0.2	0.5	1
Wooded wetlands equivalent DSAYs	93	90	431
Total Wooded wetland equivalent DSAYs	614		

5.5.5 Summary of Proposed Injury Analysis for Terrestrial Resources

The Trustees determined that terrestrial resources were impacted by construction of the CDF planned to contain the contaminated bayou sediments. Using the CIE approach, the Trustees have quantified the injuries in terms of the ecological services of the terrestrial environment lost over time, until recovery to maximum habitat conditions, using historical data and aerial photographs. Consistent with the CIE approach, the analysis incorporated conservative technical judgments and assumptions regarding the services provided by individual habitat types.

The quantification of terrestrial habitat losses considered the past condition of the resource, the reduction in ecological services due to the removal of habitat for construction of the CDF, and accounted for service losses expected to never recover after implementation of the CDF. Because the selected restoration action, preservation of wooded wetlands, has a higher ecological productivity than some of the habitats within the CDF footprint, all habitat types were converted to wooded wetland habitat equivalents. The results of this analysis indicate that compensation for assessed terrestrial habitat losses is achieved by providing ecological services equivalent to 614 wooded wetland equivalent DSAYs.

6 THE RESTORATION PLANNING PROCESS

The goal of restoration planning under CERCLA is to identify actions appropriate to restore, rehabilitate, replace or acquire natural resources or services equivalent to those injured or lost as a result of releases of hazardous substances. The restoration planning process may involve two components: primary restoration and compensatory restoration. Primary restoration actions are designed to assist or accelerate the return of a resource, including its services, to pre-injury or baseline conditions. In contrast, compensatory restoration actions serve to compensate for the interim loss of resource services due to injury, pending the return of the resource to baseline conditions or service levels. The scale of a compensatory restoration project depends on the nature, extent, severity, and duration of the resource injury. Primary restoration actions that speed resource recovery reduce interim losses, as well as the amount of restoration required to compensate for those losses.

In this instance, remedial actions undertaken or anticipated at the Site (*i.e.*, removal of contaminated sediments in Greens Bayou and an adjacent drainage ditch through dredging and onsite disposal of material, followed by capping of remaining contaminated sediments in the drainage ditch with cement to inhibit erosion and re-mobilization of the contaminated sediments) are expected to protect natural resources in the vicinity of the Site from further or future harm. As a result of the remedial action, benthic resources in Greens Bayou are assumed to be impacted by the conversion of shallow benthic habitat (-10 to +2 feet mean low tide) to deep benthic habitat due to the removal of contaminants at depth in sediment. There is also potential for shallow benthic habitat to become impacted subsequent to dredging due to re-suspension and redistribution of impacted sediments in areas that are not capped with cement. Clearing and construction associated with the planning and implementation of the CDF, to be used for containment of the contaminated material, have resulted in or will result in the loss of forested wetlands, prairie, and other valuable habitats. These impacts (benthic habitat conversion, potential redistribution of impacted sediments, and loss of forested wetlands and prairie) result from implementation of the proposed remedial actions and are of a nature that precludes the impacted Site from returning to baseline conditions. Therefore, it is not possible for the Trustees to consider or plan for primary restoration actions. Accordingly, this Final DARP/EA focuses only on defining appropriate compensatory restoration actions.

The Trustees have approached restoration planning with the view that the injured resources and associated services lost are part of an integrated ecological system and that the Upper Galveston Bay system, including the lower Buffalo Bayou and San Jacinto River watersheds, represents the

relevant geographical area for appropriate restoration actions. This helps to ensure that the benefits of restoration actions are related, or have an appropriate nexus, to the resource injuries and service losses being assessed for the Site.

In accordance with the NRDA regulations, the Trustees identified and evaluated a reasonable range of project alternatives capable of restoring ecological services comparable to those lost due to injury to natural resources at the Site. The alternatives identification and evaluation process addressed in Sections 6 – 8 of this final DARP/EA are consistent with the NEPA's requirement for an analysis and comparison of a reasonable range of alternatives for the proposed action. These alternatives were identified by first searching for potential projects within the watershed. The Trustees considered five restoration alternatives potentially capable of providing compensatory restoration for the injuries resulting from the release of hazardous substances associated with the Greens Bayou Site. All five potential restoration alternatives were evaluated based on the criteria presented in Section 6.2, and selected alternatives were then scaled to ensure that its size would appropriately compensate for the injuries resulting from the incident. The Trustees employed a service-to-service scaling method, where restoration actions provide natural resources and/or services of the same type and quality, and of comparable value as those lost. The "No Action" alternative was also included for consideration, as required by NEPA and the CERCLA NRDA regulations. Each alternative, the results of that evaluation, and the restoration action(s) that the Trustees are proposing for implementation on the basis of that evaluation, are identified in the remaining sections of this document.

6.1 RESTORATION STRATEGY

The initial search and screening process led the Trustees to identify a preferred strategy for effecting restoration to compensate for benthic and forested wetland/prairie losses under this plan - estuarine marsh creation or enhancement and forested wetland preservation, respectively. Converting other habitats to open water bottom is generally not favored or appropriate as a restoration strategy as it necessitates the loss of important resources and services that other habitats provide. Estuarine wetlands support benthic resources, have the capacity to replace the array of ecological services lost, and are ecologically more productive than open water bottom as a habitat, making this approach to providing compensatory services more efficient. Further, intertidal marshes in coastal Texas, including those within Upper Galveston Bay, are continually being converted to open water habitat due to inundation from subsidence, erosion, and salt-water intrusion. Their increasing prevalence due to these processes makes open water areas a lesser-valued habitat, and an undesirable means of effecting restoration. Estuarine marsh creation or enhancement helps address a critical problem in this environment - the loss of these wetlands in the estuary. Creation or enhancement of forested wetlands is generally not desired, compared to

other available options, due to the time required to achieve full service value for this habitat type, large efforts required to be successful and the associated costs. While other habitat types, including herbaceous wetlands and grasslands, have also been impacted or will be impacted by the proposed remedial actions, forested wetlands have the capacity to replace the array of ecological services lost, and are ecologically more productive than freshwater herbaceous wetlands and grassland habitats, making this approach to providing compensatory services more efficient. Consistent with this strategy, all project alternatives considered in this plan represent opportunities to preserve forested wetlands and create or enhance estuarine marsh in Upper Galveston Bay.

6.2 RESTORATION EVALUATION CRITERIA

Consistent with the NRDA regulations, the following criteria were used to evaluate restoration project alternatives and identify the project preferred for implementation under this plan:

- *Criterion # 1: The extent to which each alternative is expected to meet the Trustees' restoration goals and objectives*: The primary goal of any compensatory restoration project is to provide a level and quality of resources and services comparable to those lost due to the assessed injuries. In meeting that goal, the Trustees consider the potential relative productivity of the habitat to be restored and whether the habitat is being created or enhanced. Proximity to the injury and future management of the restoration site are also considered because management issues can influence the extent to which a restoration action meets its goals.
- *Criterion # 2: The cost to carry out the alternative*: The benefits of a project relative to its cost are a major factor in evaluating restoration alternatives. Factors that can affect and increase the costs of implementing the restoration alternatives may include project timing, access to the restoration site (*e.g.*, with heavy equipment or for public use), acquisition of state or federal permits, acquisition of land necessary to complete a project, measures necessary to provide for long-term protection of the restoration site, and the potential liability from project construction.
- *Criterion # 3: The likelihood of success of each project alternative*: The Trustees consider technical factors that represent risk to successful project construction, project function, or long-term viability of the restored habitat. Alternatives that are susceptible to future degradation or loss through contaminant releases or erosion are considered less viable. The Trustees also consider whether difficulties in project implementation are likely and whether long-term maintenance of project features is likely to be necessary and/or feasible.
- *Criterion # 4: The extent to which each alternative will avoid collateral injury to natural resources as a result of implementing the alternative*: Restoration actions should not

result in additional losses of natural resources and should minimize the potential to affect surrounding resources during implementation. Projects with less potential to adversely impact surrounding resources are generally viewed more favorably. Compatibility of the project with the surrounding land use and potential conflicts with endangered species are also considered.

- *Criterion # 5: The extent to which each alternative benefits more than one natural resource or service*: This criterion addresses the interrelationships among natural resources, and between natural resources and the services they provide. Projects that provide benefits to more than one resource and/or yield more beneficial services overall, are viewed more favorably. For example, although recreational benefits are not an explicit objective in this Final DARP/EA, the potential for a restoration project to enhance recreational use of an area was considered favorably.
- *Criterion # 6: The effect of each alternative on public health and safety*: Projects that would negatively affect public health or safety are not appropriate.

6.3 SCREENING OF POTENTIAL PROJECT ALTERNATIVES

The NRDA regulations give the Trustees discretion to prioritize the above criteria and to use additional criteria as appropriate. In developing this Final DARP/EA, Criterion # 1 listed above has been a primary consideration, because it is paramount to ensuring that the restoration action will compensate the public for the injuries to benthic and forested/wetland/prairie resources attributed to Site releases and the remedial process, consistent with the proposed assessment of compensation requirements for the Site. The following are brief descriptions of the projects identified as alternatives to compensate for injuries associated with hazardous substance releases from the Greens Bayou Site, followed by a summary (Table 6.1) of each project's ability to satisfy the project selection criterion # 1 listed in the CERCLA NRDA regulations, the extent to which each alternative is expected to meet the Trustees' restoration goals and objectives:

Potential Restoration for Benthic Resources

- *Salt marsh creation at the Baytown Nature Center*: this alternative involves marsh creation through excavation of fill material overburden and filling of submerged areas to achieve intertidal elevations.
- *Salt marsh creation and protection in Burnet Bay*: this alternative involves marsh creation through the construction of containment levees to be filled with dredge material resulting from ongoing maintenance of docks on the Houston Ship Channel.
- *Salt marsh creation on Buffalo Bayou*: this alternative involves marsh creation at several small sites in the tidally influenced portions of Buffalo Bayou.

Potential Restoration for Terrestrial Resources

- *Forested wetland preservation adjacent to Spring Creek, near the intersection of Riley Fuzzel Road and the Hardy Toll Road*: this alternative involves the acquisition and enforcement of a conservation easement affecting 100 acres of forested wetlands on a single parcel adjacent to Spring Creek in Montgomery County, with the County government holding title to the property and a local land trust holding the conservation easement.
- *Forested wetland preservation adjacent to Spring Creek, near Wilderness Road*: this alternative involves the acquisition and enforcement of a conservation easement affecting 100 acres of forested wetlands on many small parcels adjacent to Spring Creek in Montgomery County, with the county government holding title to the property and a local land trust holding the conservation easement.

No Action Alternative

No action would be taken to restore, rehabilitate, replace or acquire natural resources or services equivalent to those lost due to hazardous substance releases from the Greens Bayou Site or the remedial actions taken to prevent further or future harm at the Site.

Table 6-1 – Summary of Each Project's Ability to Satisfy Criterion # 1 Listed in the CERCLA NRDA Regulations: The extent to which each alternative is expected to meet the Trustees' restoration goals and objectives.

Restoration Project Alternative	No significant impediments to implementation	Strong nexus to injured habitats	Amount of habitat function enhancement	Avoids injury to existing resources	Retain for detailed analysis
Salt marsh creation at the Baytown Nature Center	+	+	+	+	Yes
Salt marsh creation and protection in Burnet Bay	-	+	+	+	Yes
Salt marsh creation on Buffalo Bayou	-	+	+	+	No*
Forested wetland preservation (near Riley Fuzzel Rd. @ Hardy Toll Rd.)	+	+	+	+	Yes

Restoration Project Alternative	No significant impediments to implementation	Strong nexus to injured habitats	Amount of habitat function enhancement	Avoids injury to existing resources	Retain for detailed analysis
Forested wetland preservation (Wilderness Rd.)	-	+	+	+	No*
No Action	+	-	-	+	Yes

(++) indicates very positive, (+) indicates positive, (0) indicates neither positive nor negative, (-) indicates negative, and (--) indicates a very negative relationship between the project and that criterion. (*) Section 7 provides the rationale for not carrying these alternatives forward for more detailed analysis.

The selected restoration alternatives – salt marsh creation at the Baytown Nature Center and forested wetland preservation adjacent to Spring Creek near the intersection of Riley Fuzzel Rd. and the Hardy Toll Rd., Montgomery County, TX – are identified above in bold. Section 7.0 provides further information regarding the basis for choosing the selected restoration alternatives and the evaluation of the remaining non-selected alternatives.

7 EVALUATION OF RESTORATION ALTERNATIVES

Detailed evaluations of the selected restoration alternatives as well as brief evaluations of the non-selected alternatives are provided in the following subsections.

7.1 SELECTED RESTORATION ALTERNATIVE: MARSH CREATION IN THE BAYTOWN NATURE CENTER

The first of two compensatory restoration alternatives selected by the Trustees following the application of the evaluation criteria presented in Section 6.2 is salt marsh creation in the Baytown Nature Center. The description and analysis of the project below, as well as how the restoration project was scaled to restore natural resource and service injuries, are based on a project-specific preliminary design concept rather than detailed engineering plans. If the alternative is selected in the Final DARP/EA, the project will undergo pre-project engineering to design the marsh. These steps prior to construction are not expected to reduce the anticipated benefits of the project or affect the analyses conducted for ESA, EFH, or NEPA. Should significant changes in the project concept, scope, resulting benefits, compliance with environmental regulations, or cost arise during the detailed engineering and design of the project, the Trustees may re-evaluate their preference for this alternative.

7.1.1 Restoration Site Description

The first of the two selected restoration projects would occur within the Baytown Nature Center (the Nature Center). The Nature Center (Figure 7-1) consists of a 450-acre peninsula bordered to the north by Burnet Bay, to the south by Scott Bay, and to the west by Crystal Bay and the Houston Ship Channel (the Nature Center and the San Jacinto Battleground State Historical Park are opposite one another on the east and west sides, respectively, of the Houston Ship Channel). The Nature Center forms part of the western border of the City of Baytown, and is 56 km northwest of Bolivar Roads, the main pass connecting the Galveston Bay system to the Gulf of Mexico. The Nature Center is publicly owned and managed by the City of Baytown, Parks and Recreation Department.

The Baytown Nature Center was established at the site of the former Brownwood subdivision, after severe subsidence and chronic flooding left the area uninhabitable. Several natural resource restoration projects have been previously implemented at the site, including a project implemented by the Trustees (with construction completed in 1995 and monitoring completed in

2003) as settlement for NRDA liabilities associated with the French Limited Superfund Site. That project resulted in the creation of approximately 40 acres of salt marsh, 10 acres of upland islands supporting freshwater ponds, and 10 acres of tidal channels. Additional NOAA Community-based habitat restoration projects have also been undertaken at the Nature Center, primarily resulting in marsh enhancement through planting native vegetation. Six tracts within the 450-acre Nature Center have been identified as potential areas for additional salt marsh creation and enhancement.

The selected project area has public access via Bayway Drive, as well as through a pedestrian trail system and fishing piers within the Nature Center. The area provides extensive opportunities for non-consumptive (*e.g.*, bird watching, photography, and boating) and consumptive (*e.g.*, fishing and crabbing) recreational activities. The Baytown Nature Center has been designated a special use area by the City of Baytown. It is open daily all year round, except during extreme inclement weather. Gates open 30 minutes before sunrise and close 30 minutes after sunset. There is an entrance fee of $3 per person. Yearly passes may also be purchased for a fee of $25 per individual or $50 per family (up to 6 people). Motor vehicles are allowed only on designated roads and in parking areas. No vehicles, including bicycles, are allowed in natural areas, except by special permit.

Because there were no appreciable losses to recreational resources, the restoration plan was not intended to compensate for lost public uses directly. While promoting public access to restoration projects is generally desirable, the fact that the Nature Center provides some public access is, in effect, a bonus; consequently, while the entry fees will potentially impair access to the restoration project within the Center, the modest size of the fee is likely to have only limited impact on access and any resulting impaired access will not detract from the project's achieving its restoration goals.

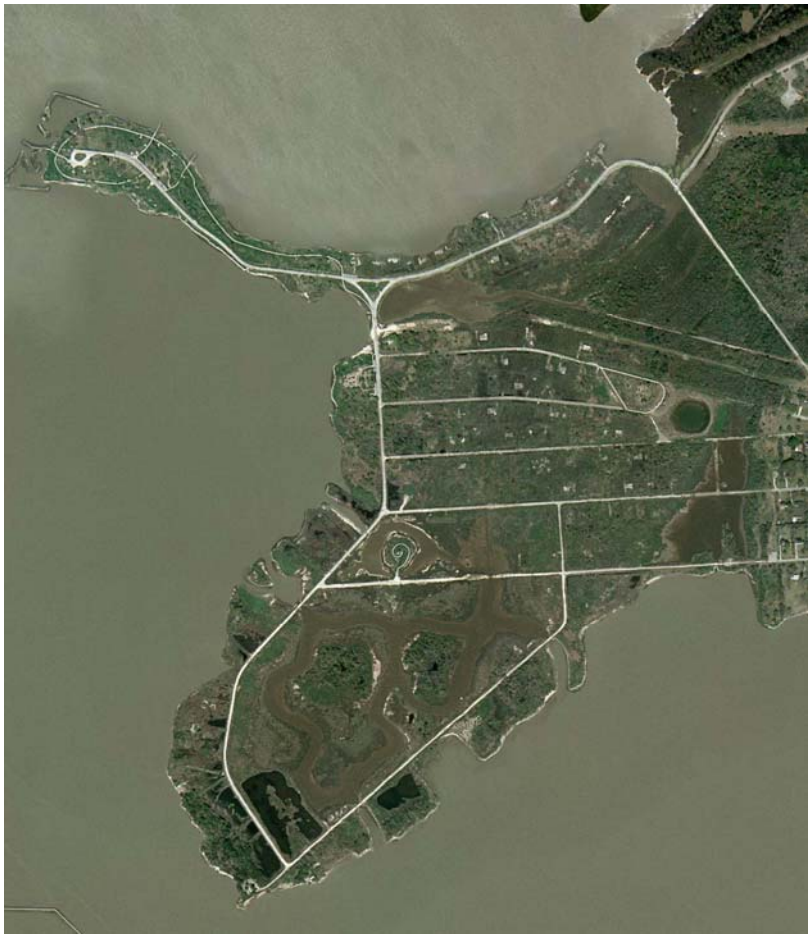

Figure 7-1 – Baytown Nature Center.

7.1.2 Restoration Action

The selected restoration action involves marsh creation through excavation of fill material overburden and filling of adjacent submerged areas to achieve intertidal elevations. Terrestrial uplands will be excavated to elevations similar to adjacent marshes. Material will be excavated from the artificial upland areas using a combination of backhoes and bulldozers. Some removed soil will be deposited in adjacent shallow open water areas to increase existing elevations to levels that will support emergent wetlands. This action is expected to provide approximately 10.89 acres of intertidal flats which will be planted using plugs of smooth cord grass.

The goals of the selected project are (1) to increase tidal exchange, thereby increasing the benthic productivity of the project area, and (2) to create an additional 10.89 acres of sustainable, functionally equivalent brackish marsh.

7.1.3 Evaluation of Selected Restoration

The Nature Center has been the site of several wetland habitat creation and enhancement projects since it was established, but portions of the Nature Center are still in need of restoration as they function at reduced levels due to poor hydrologic exchange caused by improper elevations (resulting from excessive subsidence or overburden of fill material). The site condition and features present opportunities to create and enhance brackish marsh through the re-establishment of elevations needed to support marsh vegetation and restoration of proper hydrologic exchange, respectively. Marsh creation and enhancement projects of this nature have been sponsored by both the state and federal government in coastal Texas and are generally highly successful and cost-effective.

Optimizing wetland habitat by converting uplands and adjacent shallow open water areas to marsh is a relatively non-disruptive restoration alternative to existing habitat and organism usage. Converting uplands such as those at the BNC that were previously the site of a residential development and filling subsided areas to raise the substrate elevation into the intertidal zone is effective in increasing the productivity of these areas. These areas also contain remnant landscaping vegetation that typically has minimal ecological or wildlife use and in some cases have subsided to become less productive non-vegetated mud bottoms. Some impacts to natural resources such as temporary turbidity or other localized effects on surface water quality may occur as a result of this type of work, but these effects are generally minimal and of short duration.

Marsh restoration can be implemented at this site without additional land acquisition costs because the restoration site is within the Baytown Nature Center, which is owned by the City of Baytown. Conducting a habitat restoration project within the Nature Center will result in a larger area of protected, heterogeneous habitat than would be possible at other locations that are privately owned or not presently under active conservation.

7.1.4 Ecological and Socio-Economic Impacts

Excavation and filling activities associated with the construction of brackish emergent marsh will affect noise levels and the pursuit of recreational activities in the vicinity of the project area. However, these effects will be short-term and are not expected to influence long-term use of the area by the public. Beyond the short-term effects mentioned above, the area is expected to foster and enhance the ecological value and continued public use of the affected portion of the Baytown Nature Center through the improvements to the environment. Increases in productivity should improve species abundance and diversity at the site and enhance public use of the area,

especially for environmental education, recreational fishing and bird watching. The implementation of this project should not affect the local economy or its citizens; therefore, no socio-economic effects are expected.

For more information on the ecological and socio-economic effects of the selected project, refer to Section 8.0 – which discusses NEPA considerations.

7.1.5 Habitat Equivalency Analysis – Project as Compensation (the 'Credit Model')

As explained in Subsection 4.5**,** HEA is a model that is used to calculate "debits" (estimating habitat injuries or other resource service losses) due to adverse effects resulting from exposure to hazardous substances, and to balance these "debits" against the ecological services to be gained (credited as "compensation") from the selected habitat restoration action. The scale, or size, of a restoration project should be such that it provides enough ecological service gains to offset the total of the losses.

A HEA was used by the Trustees to determine whether this project would be adequate to compensate for the losses described in Section 5.0. To quantify the benefits of restoration, HEA uses several project-specific factors, including the elapsed time from the onset of injury to the implementation of the restoration action, the relative productivity of restored habitats (that is, the proportional equivalence of ecological services provided by the compensatory project relative to the baseline productivity of the injured habitat), the time required for the restored habitat to reach its maximum level of services and the project lifespan.

To identify an appropriate *relative productivity* input parameter for the marsh creation component, the Trustees relied on information found in the scientific literature regarding the levels of functional equivalency in herbaceous marshes throughout a project's life for primary productivity, soil development, nutrient cycling, food chain support, and fish and shellfish production (Broome 1990; Broome *et al.* 1986; Cammen 1975; Craft *et al.* 1988; Craft *et al.* 1999; Currin *et al.* 1996; Langis *et al.* 1991; LaSalle *et al.* 1991; Levin *et al.* 1996; Lindau and Hossner 1981; Minello 1997; Minello and Webb 1997; Moy and Levin 1991; Peck *et al.* 1994; Scatolini and Zedler 1996; Seneca *et al.* 1985; Thompson *et al.* 1995).

Using this information, the Trustees estimated the created marsh component would likely yield 71.3% of the services of a fully functioning marsh in 15 years and would likely plateau at that level of service through the remainder of its project lifespan. The Trustees assumed services

revert to 0% at the end of the project lifespan. The estimated marsh services to be gained by implementing this project are presented in Table 7.1, and reflect application of a 3% annual discount rate.

Table 7-1 – Estimated Marsh Services from Selected Restoration Project.

Calculation of Total Discounted Acre-Years of Resources Services Gained Through Habitat Construction		
Scenario :	Estuarine Emergent wetlands Construction	
Area Constructed (acres) :	1.0	
Base Year :	2007	
	% services	Year
Initial level of services	0	2008
End of First Maturation Phase	71.3	2023
End of Second Maturation Phase	71.3	2038
End of Third Maturation Phase	0	2040
End of Fourth Maturation Phase	0	2150
End of Fifth Maturation Phase	0	2250
End of Maturation period		2250
Total DSAYs Gained	12.76	

7.2 SELECTED ALTERNATIVE – FORESTED WETLAND PRESERVATION ADJACENT TO SPRING CREEK NEAR THE INTERSECTION OF RILEY FUZZEL ROAD AND THE HARDY TOLL ROAD

The selected forested wetland preservation project would consist of acquisition of the 100 acres of property, with title to be held by the government of Montgomery County, and enforcement of a conservation easement to be held by Legacy Land Trust, a local organization. Third party rights of enforcement for the conservation easement would also be reserved by the Trustees.

7.2.1 Restoration Site Description

The selected alternative would occur on property adjacent to Spring Creek, situated approximately 1.5 km due north of the intersection of Riley Fuzzel Rd. and the Hardy Toll Rd. in southern Montgomery County (Figure 7-2). The Spring Creek watershed drains to the Lake Houston reservoir on the San Jacinto River. The site is 95% covered by bottomland hardwood forest canopy and comprises both riparian floodway and regularly or permanently flooded wetlands. The property is located within the boundaries (near the middle) of the Spring Creek

Greenway conservation initiative sponsored by Harris and Montgomery Counties, Legacy Land Trust, and many others.

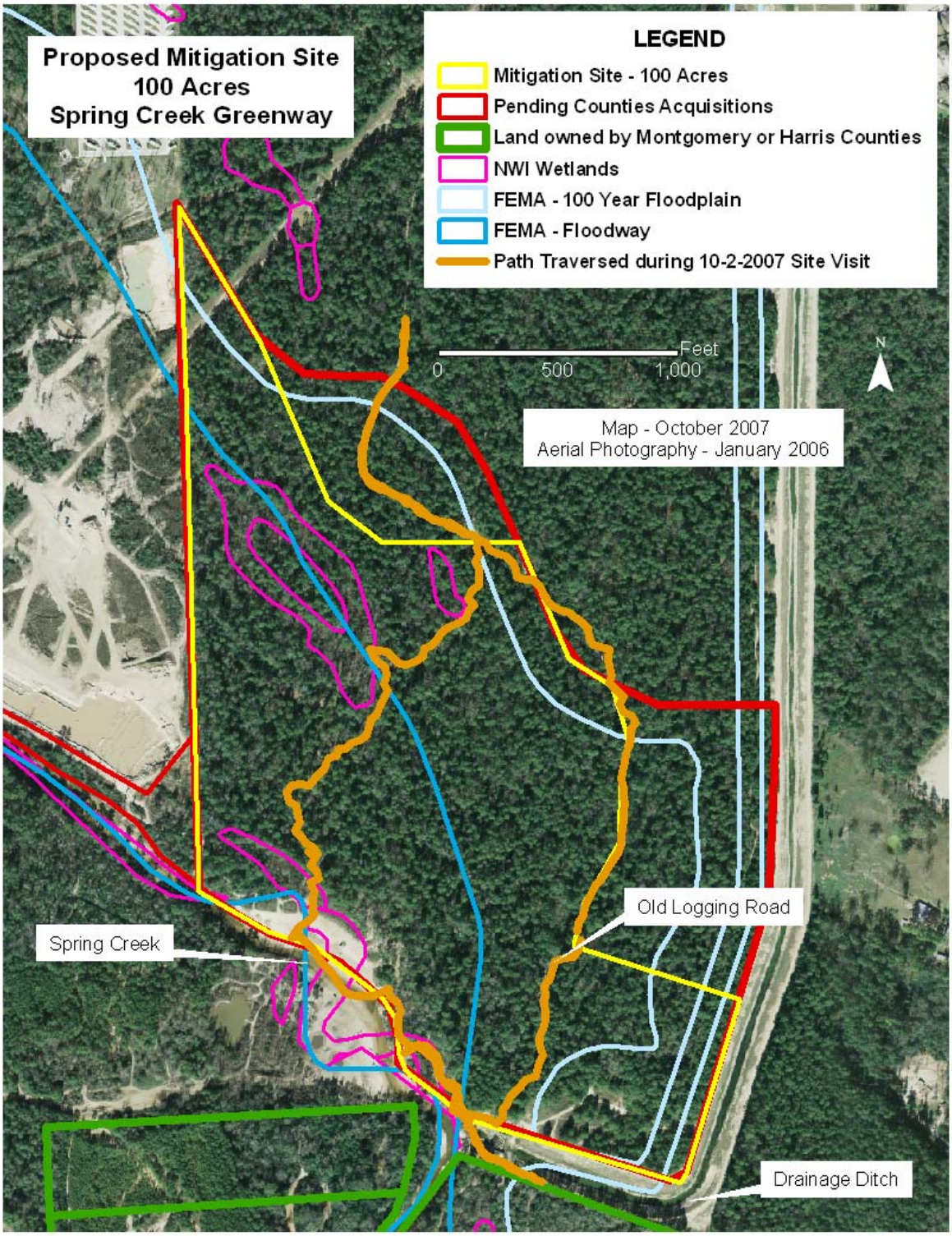

Figure 7-2 – Spring Creek Greenway Selected Preservation Property.

7.2.2 Restoration Action

The proposed restoration action consists of fee simple acquisition of 100 acres of forested wetlands threatened by development for sand and gravel mining, timber harvesting, and residential housing construction. The property will be acquired from a willing seller with clear title, with title to be held by the government of Montgomery County. A conservation easement for the same property will be held by Legacy Land Trust, and conservation easement fees will be provided for baseline biological monitoring, annual monitoring, and legal enforcement of the easement provisions. Third party rights of enforcement will also be retained by the Texas State Trustees and USFWS.

The goals of the selected project are (1) to remove the potential for mining, timber, or residential development of the property currently threatening the ecological integrity of the site, and (2) to ensure the continued provision of ecological services from the preserved property comparable to those lost due to injury to natural resources associated with the planning and implementation of the CDF.

7.2.3 Evaluation of Selected Restoration

Acquisition and preservation of existing, functional habitat is feasible and can, under certain circumstances, be highly beneficial. Given the difficulties, costs and long term efforts associated with the construction of wooded habitats, the acquisition and protection of existing forested wetlands is a more feasible option. The unique qualities, valuable location, and imminent destruction of the site proposed for preservation under the selected alternative further increase the level of benefits derived by exercising this option. No increase in service flows would occur through acquisition or protection alone, however, the ecological losses associated with the imminent development of the identified tract would be prevented by preserving the tract in perpetuity.

The property proposed for conservation under the selected alternative is located within a 15,000-acre, 33-mile long area targeted under the Spring Creek Greenway initiative led by Montgomery County (Precinct 3) and Harris County (Precinct 4), near other parcels that are currently in public ownership by Harris and Montgomery Counties and which are protected by conservation easements. Given this proximity, preservation of the site yields additional integrated ecosystem benefits by reducing forest fragmentation, and maintaining linked riparian habitat that provides multiple ecosystem benefits (habitat conservation, improved water quality, and enhanced water quality). The development threats facing the site are significant and warrant the assignment of

an increase in service flows from the site as a result of the acquisition and conservation easement enforcement. Habitat preservation projects of this nature have been sponsored by both the state and federal government in coastal Texas and are generally highly successful and cost-effective.

7.2.4 Ecological and Socio-Economic Impacts

The acquisition and enforcement of a conservation easement over this property will not affect noise levels in the vicinity of the project area. Public access to the site and its recreational use will be fostered and enhanced by the project. The property is not currently open to public access under private ownership. Under the terms of the conservation easement, limited public access to the site will be allowed through a low-impact trail system along the creek. The benefits of continued ecological functioning (maintaining the water quality improvement function of the site, maintaining the site as a flood zone buffer, etc.) and biological productivity of the site will accrue to the local community. The potential impacts of removing the property from local tax rolls are considered to be offset by anticipated increases in adjacent property values resulting from the protection of the site. Implementation of this project should not otherwise significantly affect the local economy or its citizens; therefore, no socio-economic effects are expected.

For more information on the ecological and socio-economic effects of the selected project, refer to Section 8 – which discusses NEPA considerations.

7.2.5 Habitat Equivalency Analysis – Project as Compensation (the 'Credit Model')

A HEA was used by the Trustees to determine the scope of the preservation of Spring Creek habitat necessary to compensate for the injuries to natural resources resulting from the planning and implementation of the CDF described above.

To identify an appropriate *relative productivity* input parameter for the forested wetland preservation component, the Trustees considered the ecological function of the preserved area in comparison to the potential elimination of these services given the development pressure on the site. This approach results in a HEA input of 100% service flow from the preserved site immediately upon its acquisition and protection under conservation easement. That level of service continues through the remainder of its project lifespan (i.e., the length of the conservation easement). The estimated forested wetland services to be gained by implementing this project are presented in Table 7.2, and reflect application of a 3% annual discount rate.

The particular parcel identified for preservation is at risk of development as well as sand and gravel mining. An adjacent tract has already been converted to a sand and gravel mine and there are indications that the facility would like to expand its operations. The Trustees assumed that this expansion would take place gradually over 30 years. While not completely destructive, the mining of sand and gravel results in the removal of much of the existing vegetation that serves as a source of food and cover for wildlife resources and helps stabilize soils and banks, thereby reducing erosion and sediment loading to Spring Creek. Based on the adjacent mining operations, the Trustees determined that the level of injury associated with the mining operations was 72%, so that only 28% of the ecological services would flow from the identified preservation site if it were converted to a sand and gravel mine. This condition was assumed to last in perpetuity. Based on the above scenario also presented in Table 7.2, for each acre of forested wetland habitat preserved, a loss of 6.17 forested wetland equivalent DSAYs would be prevented. The minimum amount of acreage required for preservation was derived by dividing the total wooded wetland equivalent DSAYs losses by the calculated preservation gains per acre of habitat or 6.17 DSAYs. Since the total wooded wetland equivalent DSAY losses were determined to be 614, the total required wooded wetland habitat preservation required is approximately 100 acres.

Table 7-2 – Anticipated Ecological Service Gains from Forested Wetland Selected Project.

Calculation of Total Discounted Acre-Years of Resources Services Gained Through Habitat Preservation		
Scenario :	Preservation of Forested Wetlands	
Area Constructed (acres) :	1.0	
Base Year :	2007	
	% services	Year
Initial level of services	0	2008
End of First Maturation Phase	28	2038
End of Second Maturation Phase	28	2308
End of Third Maturation Phase	0	2308
End of Fourth Maturation Phase	0	2308
End of Fifth Maturation Phase	0	2308
End of Maturation period		2308
Total DSAYs Gained	6.2	

7.3 NON-SELECTED ALTERNATIVE – SALT MARSH CREATION OR PROTECTION IN BURNET BAY

This project involves the creation or protection of salt marsh in Burnet Bay, located in Harris County. The proposed project location is bordered to the west by the Crosby-Lynchburg Road, to the south by the Houston Ship Channel, and to the north and east by the city of Baytown and the Baytown Nature Center (Figure 7-3). A project partially funded by the NOAA Community-based Restoration Program is planned for implementation at the site by the Galveston Bay Foundation (GBF), and an alternatives analysis studying conceptual designs for that project has been completed identifying a selected alternative for restoration of the intertidal marsh lost at this site.

7.3.1 Evaluation of Non-Selected Restoration Alternatives

The resource improvements and benefits of this project would occur on property owned by the Port of Houston Authority. Public access to the site would be available via boat and from the shoulder of Crosby-Lynchburg Rd., and despite the limitations and inconvenience of this access, the site is utilized by the public for recreational or subsistence fishing. Nevertheless, project planners have determined that the goal of the proposed project should not include the encouragement of additional public use for fishing, because Burnet Bay is located adjacent to significant industrial infrastructure on the Houston Ship Channel and is listed by the TCEQ as an impaired water body due to contamination by PCBs and in particular by dioxin. These contaminant issues have resulted in human consumption limit advisories for the area. In compensating for public claims, the Trustees generally favor implementing restoration in publicly accessible areas. No significant socio-economic effects would be expected due to the implementation of this project.

In addition to restricting public use of the site, contaminants have been a primary concern for construction planners. Sediment sampling has been performed to ensure that construction on the site will not re-suspend sediments with unacceptable contaminant loads. The results of this testing has shown that deeper areas on the west side of Burnet Bay contain soft, silty sediments with levels of dioxin and other contaminants near or exceeding NOAA-published screening thresholds (SQuiRT tables, Buchman, 2007). However, the shallower, sandy soils underlying former uplands or intertidal wetlands on the east side of Burnet Bay where construction is planned, were shown to contain acceptable levels of dioxin and minimal contamination.

While construction of this project would increase marsh functions over a sizable area, the incremental areal extent and degree of ecological influence to be gained from the NRDA project would be difficult to distinguish from the ongoing grant-funded work undertaken by GBF.

Following the alternatives analysis performed for the site, the selected alternative chosen for construction by GBF consists of construction of large containment cells to be filled by dredge material derived from maintenance dredging by adjacent docking facilities (dredge material disposal options for these facilities are very limited). Permitting requirements for this design will likely include contaminant testing of future dredged material prior to placement within the cells, and the unknown timing of this placement makes it impossible to determine the credits gained by any funding dedicated to the project by the Trustees. GBF has indicated that given the current funding available to the project, a remaining, unfunded component of the project that NRDA funds could ideally be used to support consists of the installation of an erosion protection structure for the created marsh (i.e., concrete revetment mat or rip-rap laid on the outer edge of a terrace or containment levee facing the Houston Ship Channel to dissipate wind, wave, and ship wake energy from the southern edge of the project, most exposed to fetch). Dedicating NRDA settlement funds to this project component would require a clear understanding of erosion rates or potential erosion rates produced by this fetch in order to derive a value for credits gained by building the protective features. Erosion rates are not clearly understood at this time, making it impossible for the Trustees to complete a full evaluation of this restoration alternative.

7.4 NON-SELECTED ALTERNATIVE – SALT MARSH CREATION IN BUFFALO BAYOU

This project involves the creation of salt marsh at several locations along Buffalo Bayou, located in Harris County. This project, suggested by the Buffalo Bayou Partnership (BBP), is conceptual in nature and has not been developed to the point that specific locations for implementation have been identified. BBP has identified several potential sites for potential implementation, including the Buffalo Bend Nature Park, the mouth of the Tapley Tributary, the mouth of Japhet Creek, and a property owned by BBP at the southwest corner of Lockwood Rd. None of these sites have been studied adequately to propose a specific restoration technique.

The lack of a clear project concept, design, restoration technique, or cost estimate, makes any evaluation of the credits provided by its implementation, its likelihood of success, collateral resource injury resulting from its implementation, or its cost-effectiveness impossible.

7.5 NON-SELECTED ALTERNATIVE – FORESTED WETLAND PRESERVATION ON SPRING CREEK NEAR WILDERNESS ROAD

This project involves the acquisition and enforcement of a conservation easement on 100 acres of forested wetland adjacent to Spring Creek near Wilderness Rd. in Montgomery County. The project is sponsored by Legacy Land Trust as part of the Spring Creek Greenway initiative, and

is similar in scope and concept to the selected alternative for forested wetland preservation near the intersection of Riley Fuzzel Rd. and the Hardy Toll Road.

This alternative presents greater challenges to implementation relative to the selected alternative for forested wetland preservation, because the tracts identified for acquisition are not unified in a single property parcel or under a single owner. While the ecological benefits to be derived from either project are likely similar, the challenges presented by and potential additional costs involved in the multiple property transactions required to undertake this alternative reduce its potential benefits in terms of time to implementation and cost-effectiveness.

7.6 NON-SELECTED ALTERNATIVE - NO ACTION

Under the "No Action" alternative, the Trustees would take no action to restore, rehabilitate, replace or acquire natural resources or services equivalent to those lost due to hazardous substance releases from the Greens Bayou Site or the remedial actions taken to prevent further or future harm at the Site. Remedial actions proposed for or undertaken at the Site are of a nature that precludes natural recovery under this option. Interim resource services losses are also not compensated under this option.

The Trustees' natural resources damage assessment indicates benthic resources have been injured due to hazardous substances released from the Greens Bayou Site and will be further impacted by planned remedial actions. Total ecological services losses equivalent to 139 estuarine wetland equivalent DSAYs have been lost due to contaminant related injury. The Trustees have also determined that remedial actions planned for the Site will injure terrestrial habitat and that ecological services equivalent to 614 DSAYs of wooded wetland habitat will be lost. Response actions undertaken or planned for this Site will not fully allow the injured resource to recover, and these actions will not compensate the public for the resource services lost over time due to the injuries. Such compensation serves to make the public and the environment whole.

CERCLA allows the public to be compensated for such losses based on actions that restore, replace, or provide services equivalent to those lost. Within the Galveston Bay watershed, there are feasible and appropriate opportunities to restore, replace, or provide services equivalent to those lost due to the release of hazardous substances and subsequent benthic, wetland, and grassland injury. Under the "No Action" alternative, restoration actions needed to make the environment and public whole for its losses would not occur. This is inconsistent with the goals of the natural resource damage provisions of CERCLA. The Trustees have determined that the

"No Action" alternative (*i.e.*, no compensatory restoration) should be rejected on this basis, however, as appropriate under NEPA, the No Action alternative is evaluated in this final DARP/EA.

8 NEPA, ESA, AND EFH: ANALYSES AND FINDING OF NO SIGNIFICANT IMPACT

As noted in Section 1.2, NEPA requires federal agencies to produce an EIS if they are contemplating implementation of a major federal action expected to have significant impacts on the quality of the human environment. NEPA defines the human environment in 40 C.F.R. § 1508.14 to include the "natural and physical environment and the relationship of people with that environment". According to 40 C.F.R. § 1508.8, all reasonably foreseeable direct and indirect effects of implementing a project, including beneficial effects and cumulative effects, must be evaluated. Federal agencies prepare an EA to consider these effects and evaluate the need for an EIS. If the EA demonstrates that the proposed action will not significantly impact the quality of the human environment, the agency issues a FONSI, which satisfies the requirements of NEPA, and no EIS is required.

In accordance with NEPA and its implementing regulations, an EA is integrated into this Final DARP/EA. The main body of this document summarizes the environmental setting, describes the purpose and need for restoration, identifies the alternatives considered, assesses their applicability and potential environmental consequences and summarizes the opportunity the Trustees provided for public participation in the development of this Final DARP/EA. The following subsections describe the NEPA significance analysis, FONSI, and likely impacts of the selected restoration project on EFH.

8.1 NEPA SIGNIFICANCE ANALYSIS

This section of the document specifically addresses the factors and criteria that federal agencies are to consider in evaluating the potential significance of proposed actions, as identified in Section 1508.27 of the NEPA regulations (40 C.F.R. § 1508.27). The regulations explain that significance embodies considerations of both context and intensity. In the case of a site-specific restoration project, as proposed in this Final DARP/EA**,** the appropriate context for considering significance of the action is local, as opposed to national or worldwide.

With respect to intensity of the impacts of the proposed restoration action, the NEPA regulations suggest consideration of ten factors:

- likely impacts of the proposed project,
- likely effects of the project on public health and safety,

- unique characteristics of the geographic area in which the project is to be implemented,
- controversial aspects of the project or its likely effects,
- degree to which possible effects of implementing the project are highly uncertain or involve unknown risks,
- precedential effect of the project on future actions that may significantly affect the human environment,
- possible significance of cumulative impacts from implementing this and other similar projects,
- effects of the project on sites listed on the National Register of Historic Places, or likely impacts to significant cultural, scientific or historic resources,
- degree to which the project may adversely affect endangered or threatened species or their critical habitat, and
- potential violations of environmental protection laws.

These factors, together with the federal Trustees' proposed conclusion concerning the likely significance of the selected restoration actions, are reviewed below. Note that a FONSI is appropriately specific to the selection of an alternative, therefore this FONSI assesses the 1508.27 considerations for the selected alternatives comparatively developed and analyzed in Sections 6.0 and 7.0 of this final DARP/EA.

8.1.1 Nature of Likely Impacts

There are two selected actions – marsh creation and forested wetland preservation. The former entails the construction of areas suitable for the establishment of 10.9 acres of marsh within the Baytown Nature Center. This action will increase habitat function at the marsh creation site, and will generally provide improved nursery, foraging, and cover habitat for numerous species of fish that utilize fringe marsh, as well as other species that inhabit or utilize interior estuarine marsh and surrounding areas. The selected actions will benefit the surrounding marshes by restoring landscape continuity and improving landscape-scale hydrology. The increased marsh habitat resulting from this action will also provide improved (from current conditions) and additional areas for birds and other wildlife species to nest, forage, and seek protection.

The second action entails the acquisition of 100 acres of forested wetlands adjacent to Spring Creek and the obtainment of a conservation easement. This action will ensure that forested wetland habitat that is currently in jeopardy of being mined for sand and gravel is preserved in perpetuity, and will remove threats of forested wetland destruction by development; allowing for continued habitat function at the forested wetland preservation site. As a result, areas currently

being used by fish and wildlife for foraging, nesting, and protection will remain in place. Additionally, the parcel to be obtained will be preserved within a greenway; thereby, allowing for the migration of wildlife across a broader section of the landscape.

For both selected actions, aesthetic and recreational benefits to humans will also accrue.

8.1.2 Effects on Public Health and Safety

The Trustees evaluated the potential for the selected restoration actions to impact public health and safety by considering the following: air and noise pollution, water use and quality, geological resources, soils, topography, environmental justice, energy resources, recreation, traffic, and contaminants.

Air Quality:
Marsh creation: Minor temporary adverse impacts would result from the selected construction activities. Exhaust emissions from earth-moving equipment contain air pollutants, but these emissions would only occur during the construction phase of the project, the amounts would be small, and should be quickly dissipated by prevailing winds. There would be no long-term negative impacts to air quality.

Forested wetland acquisition: There are no construction activities associated with this action; therefore, there would be no short or long-term impacts to air quality.

Noise:
Marsh creation: Noise associated with earth-moving equipment represents a short-term adverse impact during the construction phase. It may periodically and temporarily disturb wildlife in the immediate vicinity of the site, or cause movement of wildlife away from the site to other ecologically suitable areas of the Nature Center. Similarly, recreating humans may avoid this area due to noise during construction, but as with wildlife, such disruption will be limited to the construction phase, and there are many comparable substitute recreation sites readily available within the Nature Center. No long-term affects would occur as a result of noise during construction.

Forested wetland acquisition: There is no noise expected as a result of this action as it is a legal transaction; therefore, no short- or long-term affects would occur as a result of its implementation.

Water Quality:

Marsh creation: In the short term, during the period of construction, earth moving activities (either the mining or placement of sediments) will increase turbidity in the immediate vicinity of Nature Center and the adjacent marshes to some degree, though actions during construction will minimize this effect. After construction is completed, the sediments should generally be stable as the material removed from the artificial uplands has already de-watered. Over the longer term, the selected restoration action will re-establish, enhance and increase estuarine marsh at the site, and help improve local water quality via filtration of larger volumes of water as a result of more frequent exchange.

Forested wetland acquisition: There should be no short- or long-term changes in water quality as a result of this action. However, it should be noted that as a result of the preservation of the forested wetland, the parcel will continue to trap sediments and nutrients; thereby, serving the downstream communities by improving overall water quality in the watershed.

Geology:
Marsh creation: The selected restoration action does not include activities with the potential to directly or indirectly affect, positively or negatively, the geology of the area.

Forested wetland acquisition: The selected restoration action does not include activities with the potential to directly or indirectly affect, positively or negatively, the geology of the area.

Energy:
Marsh creation: No energy production, transport, or infrastructure occurs in the immediate vicinity of the restoration site. Further, neither of the components of the selected action involves activities or potential results that could directly or indirectly affect, positively or negatively, energy production, transport, or infrastructure in this area of coastal Texas.

Forested wetland acquisition: No energy production, transport, or infrastructure occurs in the immediate vicinity of the restoration site. Further, neither of the components of the selected action involves activities or potential results that could directly or indirectly affect, positively or negatively, energy production, transport, or infrastructure in this area of coastal Texas.

Recreation:
Marsh creation: The noise and increased turbidity of surface waters arising from earth-moving activities during project construction are expected to discourage and decrease recreational

activities in the vicinity of the site during construction. Any such affect will be limited to the period of construction and should be minor, as there are many comparable substitute recreation sites readily available within the Nature Center. Over the longer term, the selected restoration action will increase the quality, productivity and quantity of marsh habitat in this area. The marsh habitat in the Nature Center is a foundation for many recreational activities (e.g., fishing, bird watching, etc.) and the improvement in site conditions will enhance opportunities for, and quality of, a variety of recreational uses.

Forested wetland acquisition: The preservation of the forested wetland parcel will enable the current level of recreation experienced in the area to continue, but is not expected to positively or negatively affect recreation.

Traffic:

Marsh creation: Land-based equipment traffic will occur at the site during the period of construction. There is little to no other land-based traffic in the Nature Center, so no affects on other land-based traffic will occur. Once construction is complete, the added land-based equipment traffic will end. No long-term impacts to traffic in the area are indicated.

Forested wetland acquisition: No equipment will be used in the acquisition of the parcel of forested wetland. Additionally, there is currently no authorized land-based traffic through the parcel; therefore, there are no expected disruptions to traffic as a result of the implementation of this action.

Contaminants:

Marsh creation: Marsh creation activities are not expected to have any impacts on public health and safety. The marsh that would result from implementation of the restoration project would not present any unique physical hazards to humans. No pollution or toxic discharges would be associated with marsh creation.

Forested wetland acquisition: The parcel to be obtained is not known to be contaminated or a potential source of contamination. Since no actions, besides legal, are being taken as a part of this action, there are no potential affects of contaminants.

8.1.3 Unique Characteristics of the Geographic Area

Marsh creation: The project site is currently comprised of open water, artificial uplands, and emergent marsh. These habitats are not unique in the Galveston Bay Estuary. Artificial uplands and open water are displacing highly functional wetland habitat, resulting in a current net loss of habitats and habitat productivity compared to a pre-artificial disturbance condition. The marsh creation would improve wetland habitat function, but would not displace or diminish unique geographic areas. No unique or rare habitat would be destroyed due to the conversion of artificial uplands to wetlands.

Forested wetland acquisition: The characteristics of the forested wetland are not unique, but their prevalence on the periphery of Houston, TX is less common. Due to development associated with a growing city, parcels such as that near Spring Creek will maintain the unique characteristics of the area.

8.1.4 Controversial Aspects of the Project or its Effects

The potential for controversy associated with the selected actions was evaluated by considering the potential effects of the project actions on area historic sites, cultural resources, ecological resources, and local aesthetics, and human populations. The State Historic Preservation Officer reviewed the selected project site and concurred that there are no known historic sites or resources in the area to be affected. Additionally, the federally recognized Tribes of Texas are not located in the vicinity of the projects. Ecologically, there are known techniques for increasing the productivity of the site. Aesthetics at the marsh creation project site will be affected by equipment and activities associated with project construction, but these affects will cease when construction is complete. In the long-term, the creation and enhancement of marsh at the site will enhance the aesthetics of the area. For the forested wetland preservation, the area aesthetics will be maintained through its acquisition. Further, because humans do not reside in the general vicinity of either selected restoration site, the action selected does not conflict with local residential uses or involve potential environmental justice considerations. Overall, the selected projects appear to have no elements or affects that are controversial or likely to cause adverse public reaction. As described in previous sections of this final DARP/EA, the public had an opportunity to review and comment on this final DARP/EA, and the trustees received no comments prior to selection of the implementation alternatives.

8.1.5 Uncertain Effects or Unknown Risks

The project site is within the Baytown Nature Center, a publicly protected and managed area. Nature Center personnel were consulted in evaluating potential project effects and risks. Given

the setting and information available, the Trustees do not believe there is any meaningful uncertainty as to potential effects or unknown risks to the environment associated with implementing the selected actions.

8.1.6 Precedential Effects of Implementing the Project

Wetland creation projects and habitat preservation are regularly implemented along the Texas coast to address erosion and habitat degradation, and have been used as a means of compensating the public for other natural resource damage claims arising in Texas. Therefore, the selected project does not in and of itself represent or create a precedent for future settings of a type that would significantly affect the quality of the human environment.

8.1.7 Possible, Significant Cumulative Impacts

Project effects will be cumulative in the sense that the creation of marsh and the preservation of forested wetlands at these sites will provide ecological services into the future. The selected projects are not expected to have a significant cumulative effect on the human environment since they alone, or in combination with other wetland restoration projects in the vicinity, should not change the larger current pattern of hydrologic discharge, boat traffic, economic activity or land-use in their vicinities or the watershed. The selected actions will only restore and preserve habitat that originally existed and occurred naturally at this location within the landscape. Further, the actions selected are intended to compensate the public, *i.e.*, make the public and the environment whole, for resources injuries caused by releases of hazardous substances into the watershed. The selected restoration actions are not part of any systematic or comprehensive plan for the restoration of coastal wetlands in Texas or the larger Gulf coast.

8.1.8 Effects on Sites Listed on the National Register of Historic Places or Significant Cultural, Scientific or Historic Resources

No federally recognized Texas Tribes nor cultural, scientific or historic resources are known to be located in the vicinity of the projects. A letter was sent to the State Historic Preservation Officer on October 16, 2008, requesting concurrence with the determination that the selected projects will not adversely affect any areas of cultural significance or registered historic places. The State Historic Preservation Officer response to the Trustees determination will be considered prior to selection of the implementation alternatives and will be included in the Administrative Record.

8.1.9 Effects on Endangered or Threatened Species, and Their Critical Habitat

The ESA is directed at conserving endangered and threatened species, and the habitats upon which they depend. Under the Act, all federal agencies are required to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of habitat designated as critical for such species, unless the agency is granted an exemption for its action. The DOC, acting through NOAA, and the DOI, acting through the USFWS, publish lists of the endangered and threatened species and have been delegated primary authority to oversee federal compliance with the ESA.

The federal Endangered Species Act (ESA) directs all federal agencies to conserve endangered and threatened species and their habitats and encourages such agencies to utilize their authorities to further these purposes. Under the act the National Marine Fisheries Service and USFWS publish lists of endangered and threatened species. Section 7 of the act requires that federal agencies consult with these two agencies to minimize the effects of federal actions on endangered and threatened species. Prior to implementation of these projects, the Trustees have conducted Section 7 consultations.

The Trustees believe implementation of the restoration actions selected in this Final DARP/EA will not adversely impact any threatened or endangered species, or habitats critical to such species, under the ESA. The Trustees have conferred with the USFWS and NOAA's NMFS concurrent with public review of the Final DARP/EA to ensure that the selected restoration actions will be in accordance with the ESA. Based on correspondence with those agencies, it was determined that the selected projects are not likely to adversely affect any listed species.

As noted in the Final DARP/EA, several federal and state-listed species may frequent the areas impacted by the Site. They also frequent areas where the Trustees are considering restoration projects. The selected actions – creation of estuarine marsh within the Baytown Nature Center and the preservation of forested wetlands near Spring Creek, Montgomery County, TX – are not likely to adversely affect threatened or endangered species or their designated critical habitats. Some listed species, such as the brown pelican, white-face ibis, and bald eagle, would benefit from the restoration projects. Should it be determined that any of the projects would adversely affect a threatened or endangered species, the Trustees would work to identify and implement appropriate safeguards for the protection of such species as described above. If no safeguards could be identified, the Trustees would consider redesigning the project of substituting another project as necessary to protect threatened or endangered species.

8.1.10 Violation of Environmental Protection Laws

Wetland creation and habitat preservation projects similar to the selected projects have been implemented along the Texas coast consistent with federal, state and local laws designed to protect the environment. The selected projects have no unique attributes or characteristics in that regard. Therefore, the Trustees have no reason to believe, and do not anticipate, that any federal, state or local laws would be violated incident to or as a consequence of the implementation of the selected actions.

8.2 FINDING OF NO SIGNIFICANT IMPACT

Under 40 C.F.R. §§ 1501.5 and 1501.6, for the purposes of this NEPA analysis, NOAA is the lead agency and USFWS is a cooperating agency. Based on the analysis of the available information presented in this document, the federal Trustees have preliminarily concluded that implementation of the marsh creation project in the Baytown Nature Center and the preservation of forested wetlands near Spring Creek in Montgomery County, TX, as selected herein, will not significantly impact the quality of the human environment. All potential beneficial and adverse impacts have been considered in reaching this conclusion. Because no information indicating the potential for significant impacts was revealed through the public review and comment process on this Final DARP/EA, an EIS will not be prepared for the selected restoration action.

Issuance of a Finding of No Significant Impact (FONSI) based upon an Environmental Assessment would fulfill and conclude all requirements for compliance with NEPA by the federal Trustees.

8.3 LIKELY IMPACTS OF THE SELECTED PROJECT ON ESSENTIAL FISH HABITAT

During the construction phase of the marsh creation project, some short-term and localized adverse impacts will occur. As a result of earth-moving activities, there will be localized increases in turbidity and sedimentation near the project area. These conditions may affect fish and filter feeders in the local area, by clogging gills, increasing mucus production and smothering organisms found in the shallow open-water area. Mobile fish and invertebrates would probably not be affected, since these would most likely leave the area, and return after project completion. Increased noise levels due to the operation of earth-moving equipment would also cause mobile fish to leave the area until operations (the source of the noise) end.

The EFH would be positively impacted by the re-establishment and creation of marsh achieved through the selected restoration action. The areas of marsh serve as habitat for prey species of

some of the managed fish as well as provide a nursery for the larvae and juvenile stages of many managed species.

The forested wetland preservation is not likely to adversely affect EFH as it will remain an intact parcel of land within the landscape.

9 COMPLIANCE WITH OTHER KEY STATUTES, REGULATIONS AND POLICIES

The two major environmental statutes that guide the restoration of the injured resources and lost services for the Greens Bayou Site are CERCLA and CWA. These statutes set forth a specific process of environmental impact analysis and public review. Additionally, the Trustees must comply with several additional federal, state, and local applicable statutes, regulations and policies. Relevant, and potentially relevant, statutes, regulations, and policies are discussed below.

In addition to compliance with these statutes and regulations, the Trustees should consider relevant environmental or economic programs or plans that are ongoing or planned in or near the affected environment, and they should ensure that restoration projects neither impede nor duplicate such programs or plans. By coordinating restoration projects identified in this document with other relevant restoration programs and plans, the Trustees can enhance the overall effort to restore and improve the environment and resources affected by the Site. Several of the restoration actions identified in this DARP/EA involve activities conducted in wetlands and waters of the United States. Therefore, these activities are subject to review and approval by the appropriate regulatory agencies. Compliance with other key statutes, regulations, and policies are presented in the following subsections.

9.1 RIVERS AND HARBORS ACT OF 1899, 33 U.S.C. § 401 *ET SEQ.*

The Rivers and Harbors Act (RHA) regulates development and use of the nation's navigable waterways. Section 10 of the Act prohibits unauthorized obstruction or alteration of navigable waters and vests the U. S. Army Corps of Engineers with authority to regulate discharges of fill and other materials into such waters. Restoration actions that must comply with the substantive requirements of CWA Section 404 must also comply with the substantive requirements of Section 10. Compliance with the RHA is addressed as part of the CWA Section 404 permitting process.

9.2 COASTAL ZONE MANAGEMENT ACT, 16 U.S.C. § 1451 *ET SEQ.*, 15 C.F.R. PART 923

The goal of the Coastal Zone Management Act (CZMA) is to encourage states to preserve, protect, develop, and, where possible, restore and enhance the nation's coastal resources.

Section 1456 of the CZMA requires that any federal action inside or outside of the coastal zone be consistent, to the maximum extent practicable, with the enforceable policies of a state's federally approved Coastal Zone Management Program. Regulations adopted under the CZMA outline procedures applicable to determining the consistency of federal actions with state approved plans. The Trustees believe the restoration action selected in Section 6 of this Final DARP/EA is consistent with the Texas CZMA Program. NOAA and USFWS – the involved federal trustee agencies - will be submitting this determination to the Texas Natural Resource Trustees for review and concurrence.

9.3 FISH AND WILDLIFE CONSERVATION ACT, 16 U.S.C. § 2901 *ET SEQ.*

This Act encourages all federal agencies to use their statutory and administrative authorities, to the maximum extent practicable and consistent with their statutory responsibilities, to conserve and to promote the conservation and protection of non-game fish and wildlife species and their habitats. The selected restoration action will promote and conserve, and have no adverse affect on, fish and bird habitat, including non-game fish and wildlife and their habitat.

9.4 FISH AND WILDLIFE COORDINATION ACT, 16 U.S.C. § 661 *ET SEQ.*

The Fish and Wildlife Coordination Act (FWCA) requires that federal agencies consult with the USFWS, NOAA's NMFS, and state wildlife agencies regarding activities that affect, control, or modify waters of any stream or bodies of water, in order to minimize the adverse impacts of such actions on fish and wildlife resources and habitat. For restoration projects that move significant amounts of material into or out of coastal waters or wetlands, such as the restoration project selected herein, these consultations are generally incorporated into the process of complying with Section 404 of the CWA, the RHA, or other required federal, permit, license, review or consultation requirements.

The Trustees have coordinated directly with the USFWS, the NMFS, and the Texas Parks and Wildlife Department (the appropriate state wildlife agency under the FWCA) in developing the restoration plan proposed herein and believe that the selected restoration projects will have a positive effect on fish and wildlife resources.

9.5 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT, AS AMENDED AND REAUTHORIZED BY THE SUSTAINABLE FISHERIES ACT (PUBLIC LAW 104-297) (MAGNUSON-STEVENS ACT), 16 U.S.C. §§1801 *ET SEQ*.

The Magnuson-Stevens Act, as amended and reauthorized by the Sustainable Fisheries Act (Public Law 104-297), established a program to promote the protection of essential fish habitat (EFH) through the review of projects that affect or have the potential to affect such habitat that are conducted under federal permits, licenses, or other authorities. Once EFH is identified and described in fishery management plans by the appropriate fishery management council(s), federal agencies are obliged to consult with the Secretary of Commerce, via consultation with NOAA's NMFS, with respect to any action proposed to be authorized, funded or undertaken by such agency that *may* adversely impact any EFH.

The Trustees do not believe that the selected restoration projects will result in net adverse impact on any EFH designated under the Act but have undertaken an informal EFH consultation with NMFS before finalizing that determination.

9.6 MARINE MAMMAL PROTECTION ACT, 16 U.S.C. § 1361 *ET SEQ*.

The Marine Mammal Protection Act provides authority for the long-term management and protection of marine mammals, including maintenance of their ecosystem. It establishes a moratorium on the taking and importation of marine mammals and marine mammal products, with limited exceptions involving scientific research, incidental taking, subsistence activities by Alaskan natives, and hardship. The DOC is responsible for whales, porpoise, seals, and sea lions. The DOI is responsible for all other marine mammals. The selected restoration actions are not expected to affect any marine mammals.

9.7 MIGRATORY BIRD TREATY ACT, 16 U.S.C. § 703 – 712

The Migratory Bird Treaty Act provides for the protection of migratory birds. The selected restoration actions will have no adverse effect on migratory birds. Under the selected restoration actions, no migratory birds will be pursued, hunted, taken, captured, killed, attempted to be taken, captured or killed, possessed, offered for sale, sold, offered to purchase, purchased, delivered for shipment, shipped, caused to be shipped, delivered for transportation, transported, caused to be transported, carried, or caused to be carried by any means whatever, received for shipment, transported or carried, or exported, at any time, or in any manner. While the Act does not specifically protect the habitats of migratory birds, conditions may be included in project

permits (e.g., restricting construction activities to avoid nesting season) in order to avoid or minimize negative impacts to migratory birds and to ensure compliance with the Act.

9.8 MIGRATORY BIRD CONSERVATION ACT, 16 U.S.C. § 715 *ET SEQ.*

The Act provides authority for the U. S. DOI to acquire and manage lands for conservation of migratory birds. The selected restoration actions will occur within the Baytown Nature Center and the Spring Creek Preserve, lands that are managed for the conservation of migratory birds and other wildlife. The selected restoration projects will preserve and create habitats that are important to the USFWS' efforts to conserve migratory birds and wildlife, consistent with this Act.

9.9 NATIONAL HISTORIC PRESERVATION ACT, 16 U.S.C. § 470 *ET SEQ*, & ARCHAEOLOGICAL RESOURCES PROTECTION ACT, 16 U.S.C. § 470AA-MM.

These statutes require federal agencies, or federally funded entities, to consider the impacts of their proposed actions on historic properties and cultural or archeological resources. The selected restoration projects do not involve and will not occur near any site listed on the National Register of Historic Places and the Trustees have no information indicating that there are known sites or properties eligible for listing on the National Register of Historic Places, or any cultural or archeological resources, in the vicinity of the project areas. A letter was sent to the State Historic Preservation Officer on October 16, 2008, requesting concurrence that the selected restoration projects will not adversely affect any culturally significant areas or historic places. The State Historic Preservation Officer response will be included in the Administrative Record. No federally recognized Texas Tribes are located in the vicinity of the restoration projects, thus a consultation was not necessary.

9.10 INFORMATION QUALITY ACT, PUBLIC LAW 106-554

Information disseminated by federal agencies to the public after October 1, 2002, is subject to guidelines developed by each agency pursuant to Section 515 of Public Law 106-554 that are intended to ensure and maximize the quality of information (i.e., the objectivity, utility and integrity) each agency disseminates to the public. This Final DARP/EA is an information product covered by information quality guidelines established by NOAA and DOI for this purpose. The quality of the information contained herein has been certified to be consistent with applicable guidelines.

9.11 EXECUTIVE ORDER NUMBER 11514 (35 FED. REG. 4247) – PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY

This Executive Order directs federal agencies to monitor, evaluate, and control their activities in order to protect and enhance the quality of the nation's environment, to inform and seek the views of the public about these activities, to share data gathered on existing or potential environmental problems or control methods, and cooperate with other governmental agencies. The selected projects and the release of this Final DARP/EA are consistent with the goals of this Order. The selected projects are the product of inter-governmental cooperation and will protect and enhance the environment. The restoration planning process has and continues to provide the public with information about the restoration effort.

9.12 EXECUTIVE ORDER 12898 (59 FED. REG. 7629) - ENVIRONMENTAL JUSTICE

This Executive Order directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. There are no low-income or ethnic minority communities that would be adversely affected by the selected projects. The selected restoration projects will enhance the quality of the environment for all populations.

9.13 EXECUTIVE ORDER NUMBER 11988 (42 FED. REG. 26,951) – FLOODPLAIN MANAGEMENT

This Executive Order requires federal agencies to reflect consideration of flood hazards and the natural and beneficial values served by floodplains in carrying out responsibilities involving federally financed or assisted construction and improvements and federal activities and programs affecting land use. While a selected restoration project will take place within a floodplain, it is consistent with this Order as it involves activities that will serve only to restore, expand and preserve the beneficial values of the floodplain.

9.14 EXECUTIVE ORDER NUMBER 11990 (42 FED. REG. 26,961) - PROTECTION OF WETLANDS

This Executive Order directs federal agencies to take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out agency responsibilities for acquiring, managing, and disposing of federal lands and facilities; providing federally undertaken, financed, or assisted construction and improvements; and conducting federal activities and programs affecting land use, including water and related land

resources planning, regulating, and licensing activities. The selected restoration projects are compliant with this Executive Order as they will operate to create additional wetlands, and protect existing wetlands and the services they provide.

9.15 EXECUTIVE ORDER NUMBER 12962 (60 FED. REG. 30,769) - RECREATIONAL FISHERIES

This Executive Order directs federal agencies to, among other things, foster and promote restoration that benefits and supports viable, healthy, and sustainable recreational fisheries. The selected projects will enhance or create habitats that will help support and sustain recreational fisheries in the upper Galveston Bay watershed.

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