CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX A

BIOLOGICAL ASSESSMENT

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I. INTRODUCTION AND BACKGROUND INFORMATION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, requires that, *"Each Federal agency shall, in consultation with and with the assistance of the secretary, insure that any action authorized, funded, or carried, out by such agency…. Is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species…"*. This Biological Assessment (BA) provides the information required pursuant to the ESA and implementing regulation (50 CFR 402.14), to comply with the ESA. Additional jurisprudence includes the National Environmental Policy Act (NEPA) of 1969, 42 U.S.C. section 4321, *et seq.;* the Fish and Wildlife Conservation Act of 1958 (PL 85-624; 16 U.S.C. 661 *et seq*.); the Marine Mammal Protection Act of 1972; and the Bald Eagle Protection Act of 1940.

A. Overview. This Study addresses navigation improvement planning for the GIWW at and in the vicinity of Calcasieu Lock, Calcasieu Parish, LA. This Study was developed from the results of the GIWW Locks, Louisiana Reconnaissance Report, completed in May 1992. The Report involved a systems analysis of the GIWW locks west of the Mississippi River. It documented the need for replacements or improvements at Bayou Sorrel, Calcasieu, and Port Allen locks. This resulted in a 905(b) Reconnaissance Report specifically for Calcasieu Lock that was completed in 2001 and which found justification and Federal interest in further feasibility level study of the navigation delays and potential solutions at Calcasieu Lock.

B. Purpose of Project. The principal problem to be addressed is the delays to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is critical.

Opportunities exist to increase navigation efficiency through improved operational routines and potential modification of the existing structure to accommodate existing and future traffic. Further opportunities exist to reduce or eliminate navigation delays due to drainage. A drainage event occurs when a rainfall or storm surge event within the Mermentau Basin results in a 3ft. reading at the Calcasieu East gage. This causes operations at Calcasieu Lock to switch from a locking operation with sector gates closed; preventing salinity intrusion, to a drainage operation with sector gates open forcing tows to wait to transit the lock until the gage moves below 3feet. Altering the existing lock structure to decrease the impacts of drainage events on transiting tows will result in shorter lockage times and delays for tows staging at either segment of the GIWW (east or west). Fewer barge reconfigurations to allow for transit during drainage events will increase cycling times of tows through the lock. An additional or wider lock chamber would allow for passing of flows through the old lock or through a new wider lock that can accommodate drainage events and lockages. Redirecting completely or partially drainage flows away from the existing lock will reduce or eliminate the delays that result.

II. PROJECT AREA

A. Project Location. Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Calcasieu Parish, LA, approximately 10 miles south of Lake Charles, LA (figure A-1). Calcasieu Lock is a critical component of the LA portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins. Therefore the primary Study area is the Lock and immediate vicinity; however a broader approach was taken in assessing environmental, economic and hydraulic conditions and potential impacts. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast was evaluated.

The Calcasieu River and Pass Ship Channel is located in southwest Louisiana in Calcasieu and Cameron Parishes, extending from Lake Charles, LA, southward into the Gulf of Mexico. The existing Calcasieu River and Pass Navigation project provides deep-draft navigation access to oil refineries, chemical plants, liquefied natural gas (LNG) plants, and other facilities along the Calcasieu River.

The Calcasieu River and Pass Ship Channel project provides a 35- to 40-foot project depth channel from deep water in the Gulf of Mexico. The gulf reach of the channel is 42 feet deep, 800 feet wide, and it extends about 32 miles from the minus 42-foot Mean Low Gulf (MLG) contour to the Gulf shore. A 40- by 400-foot channel extends from the gulf shoreline about 34 miles upstream to the wharves of the Port of Lake Charles, and a 35- by 250-foot channel that extends further upstream another 2 miles to the vicinity of the Interstate 10 bridge in Lake Charles, LA. Turning basins are located at Mile 29 and Mile 36.

Construction of the Calcasieu Lock largely halted Calcasieu Ship Channel (CSC)-induced saltwater intrusion into the Mermentau Basin via the GIWW. At the same time, deepening of the CSC increased tidal amplitude, resulting in higher high tides and lower low tides. Thus, when the tide ebbs, a greater head differential is established on either side of the Calcasieu Lock. This increase in head resulted in a more efficient drainage pathway for Mermentau River freshwater inflows because the drainage potential is so much greater there than at the Catfish Point Control Structure, where drainage opportunity is very limited.

The Calcasieu Lock (figure A-2) is located at the intersection of the Calcasieu River and mile 238 of the GIWW. It serves as a barrier preventing saltwater intrusion from the Calcasieu from entering the rice-growing areas of the Mermentau Basin via the GIWW. It is also provides flood risk management benefits when used to drain the Mermentau Basin after storm events. It operates in conjunction with Leland Bowman Lock and Catfish Point and Schooner Bayou control structures.

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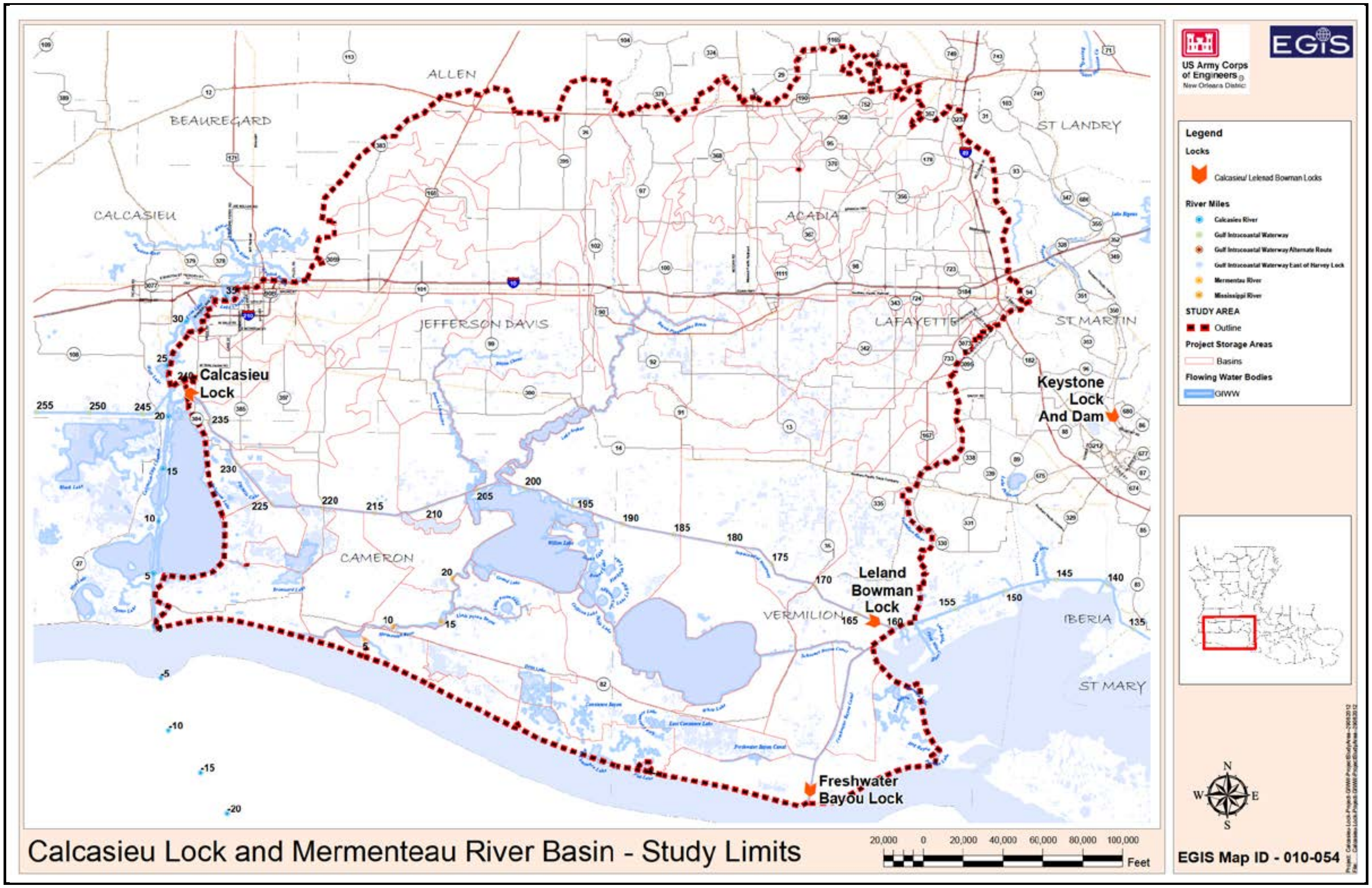

Figure A-1. Calcasieu Lock Study Area

Figure A-2. Aerial View of Calcasieu Lock

B. Project Area Description. The project area consists of open water ponds and lakes, cheniers, Gulf shorelines, and freshwater, intermediate, brackish, and saline marsh. Visser et al. (2000), expanding on previous studies by Penfound and Hathaway (1938) and Chabreck (1970), classified freshwater marsh in the Chenier Plain as a combination of *Panicum hemitomon* (maidencane) and *Sagittaria lancifolia* (bulltongue arrowhead); Intermediate marsh as *Cladium jamaicense* (sawgrass), *Spartina patens* (saltmeadow cordgrass), and *Schoenoplectus californicus* (California bulrush); brackish marsh as saltmeadow cordgrass, *Schoenoplectus americanus* (chairmaker's bulrush), *Schoenoplectus robustus* (sturdy bulrush); and saline marsh as *Spartina alterniflora* (smooth cordgrass), *Juncus roemerianus* (needlegrass rush), and *Distichlis spicata* (saltgrass). Submerged aquatic vegetation (SAV), such as *Ruppia maritima* (widgeongrass), also occurs in the area.

Additionally, the following four communities, documented by the Louisiana Natural Heritage Program, are important in that they contribute to the diversity and stability of the coastal ecosystem and may be present within the study area.

- **Coastal Live Oak-Hackberry Forest.** Also known as chenier maritime forest, this natural community formed on abandoned beach ridges primarily in southwest Louisiana. Composed primarily of fine sandy loams interbedded with sand and shell debris, these ridges range in height from 4 to 5 feet above sea level. Live oak and hackberry are the dominant canopy species. Other common species include red maple, sweet gum, water oak, green ash, and American elm. Of the original 100,000 to 500,000 acres in Louisiana, only 2,000 to 10,000 acres remain.
- **Coastal Dune Grassland.** Coastal dune grasslands occur on beach dunes and elevated backshore areas above intertidal beaches. Louisiana's coastal dunes are poorly developed because of the high frequency of overwash associated with hurricanes and storms, and a limited amount of eolian-transported sand. Vegetative cover ranges from sparse to fairly dense and is dominated by salt spray tolerant grasses. Coastal dune grasslands are estimated

to have occupied less than 2,000 acres in pre-settlement times, and 50 to 75 percent was thought to remain prior to the 2005 hurricanes. Some of the most extensive examples of coastal dune grasslands in Louisiana occur in the Chenier Plain.

- **Coastal Prairie.** The Coastal Prairie can be divided into two main types, upland dry to mesic prairies at the northern end of its range, and marsh fringing prairies on “islands” or “ridges” in the marsh at the southern end of its range. The soil conditions and frequent burning from lightning strikes prevented invasion by woody trees and shrubs and maintained the prairie vegetation. Coastal prairie vegetation is extremely diverse and dominated by grasses. Remnant Louisiana coastal prairies, once covering an estimated 2.5 million acres, have been reduced to less than 1 percent of the original extent. Some of the larger prairie remnants are marsh fringing, wet prairies found in Vermilion and Cameron Parishes.
- **Freshwater Marsh.** Freshwater marsh is generally located adjacent to intermediate marsh along the northern extent of the coastal marshes. Salinities are usually less than 2 parts per thousand (ppt) and normally average about 0.5-1 ppt. Freshwater marsh has the greatest plant diversity of any of the marsh types. Although the freshwater marshes, as previously described, compose a large amount of the entire coastal marsh acreage, the Louisiana Natural Heritage Program ranks this community as imperiled because it has undergone the largest reduction in acreage of any of the marsh types over the past 20 years due to saltwater intrusion. Some of the largest contiguous tracts of freshwater marsh in Louisiana occur in Vermilion and Cameron Parishes.

III. SPECIES AND HABITAT IN THE PROJECT AREA

A. Wildlife. Coastal Louisiana's wetlands support millions of neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, as well as many different furbearers, rabbits, deer, and alligators. Louisiana coastal wetlands provide neotropical migratory birds an essential stopover habitat on their annual migration route. The coastal wetlands in the Study area provide important and essential fish and wildlife habitats used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements.

The Chenier Plain provides habitat for a large variety of wintering waterfowl, breeding wading birds, and migratory land birds. Cheniers attract thousands of trans-Gulf migrant birds during their peak migratory months of April to May and August through October. The majority of these birds fly to and from parts of Mexico, and the cheniers offer the birds an important stop-over on their migration. Millions of ducks and geese also use the area from September through February. Over 300 species of birds have been recorded in the area, making this region a popular destination for visiting birders, wildlife photographers, and hunters.

Both resident species and non-resident migratory species of birds are found in the Calcasieu River area. The forested lands and cheniers provide nesting habitat for songbirds including the mockingbird, yellow-billed cuckoo, brown thrasher, and northern parula. At least 82 species of migratory birds regularly use these wooded habitats as important stop-over habitat during annual migrations (Lester et al. 2005). The marshes provide important areas for winter grounds and resting and feeding grounds for migratory waterfowl including green-winged teal, blue-winged teal, mottled duck, gadwall, American widgeon, and lesser scaup. Year round resident bird species include wild turkey, doves, bobwhite quail, swallows, and sparrows. Birds of prey include owls, red-tailed and red-shouldered hawks, and kestrels. Wading and aquatic birds such as anhinga, great egret, and great blue herons typically occur in wooded swamp and scrub-shrub habitat. White and brown pelicans, herons, egrets, ibises, and gulls are also found feeding in the estuarine marshes and open water habitats in the study area. Other non-game species including boat-tailed grackle, red-winged blackbird, olivaceous cormorant, belted kingfisher, and sedge wren also utilize estuarine marshes.

The Mermentau River basin also provides habitat for similar species of wintering waterfowl, breeding wading birds, and migratory land birds. Over 300 species of birds have been recorded in the basin. Trans-Gulf migrant warblers, vireos, tanagers, thrushes, and other birds are found in large numbers during peak migration (April to May and August to October).

Mammals present in the study area include important game species such as white-tailed deer, eastern cottontail and swamp rabbits, and gray and fox squirrels; furbearers such as river otter, muskrat, and nutria; and other mammal species such as striped skunk, coyote, nine-banded armadillo, and Virginia opossum. Smaller mammals including the cotton rat, marsh rice rat, and white-footed mouse provide a food source for both larger mammals and avian carnivores.

Reptiles found in the Study area include the American alligator and the diamond-backed terrapin. Reptiles which use the forested uplands in the previously used disposal areas and other higher elevations include the ground skink, five-linked skink, green anole, western ribbon snake, and numerous other species. Small-mouthed salamander, green tree frog, bullfrog, and southern leopard frog are some of the amphibians that are known to occur in the vicinity of the Study area.

B. Fisheries. Louisiana's coastal estuaries are the most productive in the Nation. Louisiana has historically been an important contributor to the Nation's domestic fish and shellfish production, and one of the primary contributors to the Nation's food supply for protein. Most of the economically important saltwater fishes and crustaceans harvested in Louisiana spawn offshore and then use estuarine areas for nursery habitat (Herke 1995). Landings in 2010 for commercial fisheries in coastal Louisiana, estimated at one billion pounds, were the largest for any state in the contiguous U. S. and second only to Alaska [National Marine Fisheries Service (NMFS) 2011]. These landings represent over twelve percent of the total landings in the U.S., with a value of approximately $247.9 million. Total fish and shellfish landings for ports in the vicinity of the Study area (Cameron and Intracoastal City) were 411 million pounds in 2010 with a dockside value of approximately $38 million (NMFS Fisheries Statistics Division 2011 – personal communication).

The Chenier Plain is also a popular destination for recreational fishing. The area's diverse wetland ecosystems provide habitat for a variety of fresh- and saltwater fish and shellfish, including shrimp, crawfish, blue crab, spotted sea trout, red drum (redfish), and red snapper. Freshwater sport fish include largemouth bass, crappie, bluegill, and catfish. Furthermore, the Study area provides important habitat for a variety of smaller fishes and crustaceans (e.g., grass shrimp, silversides, anchovies), which are important prey items for many of the commercially and recreationally important species.

IV. FEDERALLY PROTECTED SPECIES ACCOUNTS

The USFWS provided a list of threatened and endangered species potentially occurring within the project area in a planning aid report completed in February 2012. This list was updated by consulting the Service's website (http://www.fws.gov/lafayette/pdf/LA_T&E_Species_List.pdf, list updated August 31, 2012) of endangered, threatened, and candidate species of Louisiana, and noting the distribution in Calcasieu and Cameron parishes. These species are listed in table A-1 and descriptions of the species and their associated habitats can be found in the text that follows.

Table A-1. Threatened and Endangered Species Potentially Occurring in the Project Area

Species	Federal	State	Critical Habitat	Calcasieu Parish	Cameron Parish
American Alligator (*Alligator mississippiensis*)	E	E		✓	✓
Green sea turtle (*Chelonia mydas)*	T	T			✓
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	T	T			✓
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	E			✓
Kemp's Ridley sea turtle (*Lepidochelys kempii*)	E	E			✓
Leatherback sea turtle (*Dermochelys coriacea*)	E	E			✓
Loggerhead sea turtle (*Caretta caretta)*	T	T			✓
Piping Plover (*Charadrius melodus)*	T	T	✓[2]		✓
West Indian Manatee (*Trichechus manatus*)	E	E			✓
Sprague's pipit (Anthus spragueii)	C[1]	NL[3]		✓	✓

[1] C = candidate species
[2] critical habitat is used for foraging, sheltering, and roosting habitat of wintering populations
[3] NL = not listed

A. American Alligator. Alligators have been shown to be an important part of their ecosystem, and are thus regarded by many as a "keystone" species, a status that encompasses many functions from control of prey species to the creation of peat through their nesting activities (University of Florida, 1998). Populations of the American alligator were severely affected in the early parts of this century, due to hunting of the animal for its skin. In 1967, this species was listed as an endangered species, and hunting was prohibited. As a result, the alligator has undergone a successful recovery. Alligator hunting is allowed again; however, an alligator hunter must possess alligator CITES tags to harvest alligators. These tags are issued by the LDWF on property containing sufficient alligator habitat capable of sustaining an alligator harvest. Alligator hunters apply for alligator tags prior to the season.

The alligator is classified by USFWS as "Similarity of Appearance to a Threatened Taxon." The species to which it is similar is the American crocodile (*Crocodylus acutus)*, an endangered species. The alligator can be distinguished from the crocodile by its head shape and color. The crocodile has a narrower snout, and unlike the alligator, has teeth in the lower jaw that are visible even when its mouth is shut. In the United States, the American crocodile is found only in southern peninsular Florida. Because of its similarity to the crocodile, the USFWS regulates the legal trade in alligator skins, or products made from them, to protect the crocodile, whose skin is similar in appearance, but illegal in the commercial market.

B. Green Sea Turtle. The threatened green sea turtle is one of seven species of sea turtles found throughout the world. An adult green sea turtle carapace (top of shell) can measure more than 3 feet (1 meter) in straight carapace length, and weigh 220 pounds (100 kilograms). This species has a smooth carapace with four pairs of lateral scutes (plates), a single pair of prefrontal scales, and a lower jaw-edge that is coarsely serrated, corresponding to strong grooves and ridges on the inner surface of the upper jaw. The term "green" applies not to the external coloration, but to the color of the turtle's subdermal fat.

Green sea turtles have a circumglobal distribution in tropical and sub-tropical waters. In the United States, this species occurs in the Atlantic Ocean around the Virgin Islands, Puerto Rico, and along the Atlantic and Gulf coasts of the continental United States from Massachusetts to Texas (NOAA Fisheries/FWS, 1991). Green sea turtles utilize shallow estuarine habitats and other areas with an abundance of marine algae and sea grasses, their principal food sources. Terrestrial habitats are limited to nesting sites, which are typically located on high-energy beaches with deep sand and little organic content. Nesting within the project area is highly unlikely, as green sea turtles prefer to nest on high-energy beaches with deep sand and little organic content. Further, the Minerals Management Service (MMS) (1997) indicates that reports of green sea turtle nesting in the northern Gulf are “isolated and infrequent.” This species is not listed for Calcasieu Parish.

C. Gulf Sturgeon. The Gulf sturgeon (*Acipenser oxyrhynchus desotoi*), federally listed as a threatened species, is an anadromous fish that occurs in many rivers, streams, and estuarine waters along the northern Gulf coast between the Mississippi River and the Suwannee River, Florida. Spawning occurs in coastal rivers between late winter and early spring (i.e., March to May). Adults and sub-adults may be found in those rivers and streams until November and in estuarine or marine waters during the remainder of the year. Sturgeon less than 2 years old appear to remain in riverine habitats and estuarine areas throughout the year, rather than migrate to marine waters. Habitat alterations such as those caused by water control structures that limit and prevent spawning, poor water quality, and over-fishing have negatively affected this species.

Based on distribution information from the NOAA Fisheries (2007), the present range of the Gulf sturgeon extends from Lake Pontchartrain and the Pearl River system in eastern Louisiana and western Mississippi east to the Suwannee River is Florida. The project area is not within the current range of the Gulf sturgeon, as it is not listed for Calcasieu Parish.

D. Hawksbill Sea Turtle. The endangered Hawksbill Sea Turtle is one of seven species of sea turtles found throughout the world. One of the smaller sea turtles, it has overlapping scutes (plates) that are thicker than those of other sea turtles. This protects them from being battered against sharp coral and rocks during storm events. Adults range in size from 30 to 36 inches (0.8-1.0 meters) carapace length, and weigh 100 to 200 pounds (45-90 kilograms). Its carapace (upper shell) is an attractive dark brown with faint yellow streaks and blotches and a yellow plastron (under shell). The name "hawksbill" refers to the turtle's prominent hooked beak.

The hawksbill sea turtle is one of the most infrequently encountered sea turtles in offshore Louisiana. However, a hawksbill was reported near Calcasieu Lake in 1986 (Fuller *et al*., 1987). Hawksbills generally inhabit coastal reefs, bays, rocky areas, passes, estuaries, and lagoons, where they are found at depths of less than 70 feet. Nesting occurs on undisturbed, deep-sand beaches, from high-energy ocean beaches to tiny pocket beaches several meters wide bounded by crevices of cliff walls; these beaches are typically low-energy, with woody vegetation near the waterline. In the continental United States, nesting sites are restricted to Florida where nesting is sporadic at best (NOAA Fisheries/USFWS, 1993). This species is not listed for Calcasieu Parish. Due to the lack of suitable foraging and nesting habitats, there is a low probability of this species occurring within the project area.

E. Kemp's Ridley Sea Turtle. The Kemp's ridley sea turtle is the smallest of all living sea turtles. Adult and juvenile Kemp's ridleys are primarily restricted to the Gulf of Mexico, although juveniles have been recorded from throughout the Atlantic Ocean. Nesting occurs from April through July and is essentially limited to an 11-mile stretch of coastline near Rancho Nuevo, Tamaulipas, Mexico. No Kemp's ridley sea turtle nesting habitat occurs near the project site (i.e., sandy beaches), and nesting has not been known to occur in the area. The estuarine and offshore waters of Louisiana are considered important foraging areas. Adults are primarily shallow-water benthic feeders that specialize on portunid crabs. Other food items include shrimp, snails, bivalves, sea urchins, jellyfish, sea stars, fish, and occasionally marine plants. Juveniles typically feed on *Sargassum* spp. and associated infauna. During the non-breeding season, Kemp's ridley sea turtles prefer warm bays, shallow coastal waters, tidal rivers, estuaries, and seagrass beds with substrates of sand and mud. Juvenile Kemp's ridleys are generally found in Louisiana's coastal waters from May through October, whereas adults are common during the spring and summer near the mouth of the Mississippi River. In the winter, Kemp's ridleys typically move offshore to deeper, warmer waters, but some of the deepwater channels and estuaries in Louisiana might provide important thermal refuge. This species is not listed for Calcasieu Parish.

F. Leatherback Sea Turtle. The leatherback is the largest, deepest diving, and most migratory and wide ranging of all sea turtles. The adult leatherback can reach 4 to 8 feet in length and 500 to 2000 pounds in weight. Its shell is composed of a mosaic of small bones covered by firm, rubbery skin with seven longitudinal ridges or keels. The skin is predominantly black with varying degrees of pale spotting; including a notable pink spot on the dorsal surface of the head in adults. A tooth-like cusp is located on each side of the gray upper jaw; the lower jaw is hooked anteriorly. The paddle-like clawless limbs are black with white margins and pale spotting.

Leatherbacks are mainly pelagic, inhabiting the open ocean and seldom entering coastal waters except for nesting purposes. This species has been reported as occurring in shallow coastal waters but not usually near shore (Lee and Socci, 1989). A 1987 aerial survey of shallow Gulf of Mexico waters found that leatherback sea turtles occurred with the highest frequency in offshore Louisiana in October (NOAA Fisheries/USFWS, 1992). The leatherback typically nests on beaches with a deepwater approach. Major nesting beaches include Malaysia, Mexico, French Guiana, Surinam, Costa Rica, and Trinidad. In the continental United States, leatherbacks nest only sporadically in some of the Atlantic and Gulf states; the largest U.S. nesting assemblages are found in the U.S. Virgin Islands, Puerto Rico, and Florida. This species is not listed for Calcasieu Parish.

G. Loggerhead Sea Turtle. Loggerheads were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. Mean straight carapace length of adults in the southeastern U.S. is approximately 36 in (92 cm); corresponding weight is about 250 lbs (113 kg).

Federally listed as a threatened species, loggerhead sea turtles nest within the coastal United States from Louisiana to Virginia, with major nesting concentrations occurring on the coastal islands of North Carolina, South Carolina, and Georgia, and on the Atlantic and Gulf coasts of Florida. In Louisiana, loggerheads are known to nest on the Chandeleur Islands, which is over 250 miles east of the project area. This species is not listed for Calcasieu Parish.

H. Piping Plover. Federally listed as a threatened species, piping plovers are small shorebirds approximately seven inches long with sand-colored plumage on their backs and crown and white underparts. Piping plovers winter in Louisiana, and may be present eight to ten months. They depart for the wintering grounds from mid-July through late October and remain until late March or April. Piping plovers feed extensively on intertidal beaches, mudflats, sandflats, algal flats, and wash-over passes with no or very sparse emergent vegetation. In most areas, wintering piping plovers are dependent on a mosaic of sites distributed throughout the landscape, because the suitability of a particular site for foraging or roosting is dependent on local weather and tidal conditions. Plovers move among sites as environmental conditions change.

On July 10, 2001, the USFWS designated critical habitat for wintering piping plovers (Federal Register Volume 66, No. 132). Their designated critical habitat identifies specific areas that are essential to the conservation of the species. The primary constituent elements for piping plover wintering habitat are those habitat components that support foraging, roosting, and sheltering and the physical features necessary for maintaining the natural processes that support those habitat components. Constituent elements are found in geologically dynamic coastal areas that contain intertidal beaches and flats (between annual low tide and annual high tide), and associated dune systems and flats above annual high tide. Important components (or primary constituent elements) of intertidal flats include sand and/or mud flats with no or very sparse emergent vegetation. Adjacent unvegetated or sparsely vegetated sand, mud, or algal flats above high tide are also important, especially for roosting plovers. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Major threats to this species include the loss and degradation of habitat due to development, disturbance by humans and pets, and predation. There is no critical habitat located within the project area. This species is not listed for Calcasieu Parish.

I. West Indian Manatee. The average body length of an adult West Indian manatee is approximately three meters but some individuals can reach a length of 4.5 meters including the tail. The average weight of these manatees ranges between 200 and 600 kg, however the largest individuals can weigh up to 1,500 kg. Manatees are somewhat seal shaped with forelimbs (flippers) adapted for a completely aquatic life and no hind limbs. Lungs extend the length of the animal's body, which is important in controlling position in the water column. Hair is distributed sparsely over the body and the surface layer of skin is continually sloughing off. This is believed to reduce the build-up of algae on their skin.

The manatee has declined in numbers due to collisions with boats and barges, entrapment in flood control structures, poaching, habitat loss, and pollution. Cold weather and outbreaks of red tide may also adversely affect these animals.

Federally listed as an endangered species, West Indian manatees occasionally enter Lakes Pontchartrain and Maurepas, and associated coastal waters and streams during the summer months (*i.e.*, June through September). Manatees have been regularly reported in the Amite, Blind, Tchefuncte, and Tickfaw Rivers, and in canals within the adjacent coastal marshes of Louisiana. This species is not listed for Calcasieu Parish.

J. Sprague's pipit. Calcasieu Parish is known to be used by the Sprague's pipit (*Anthus spragueii*), a candidate species for Federal listing as a threatened or endangered species. Candidate species are those taxa for which the Service has on file sufficient information regarding biological vulnerability and threat(s) to support issuance of a proposal to list, but issuance of a proposed rule is currently precluded by higher priority listing actions. Sprague's pipit is a small (4 to 6 inches in length) passerine bird with a plain buffy face, a large eye-ring, and buff and blackish streaking on the crown, nape, and under parts. It winters in Louisiana, arriving from its northern breeding grounds in September and remaining until April. Migration and wintering ecology of this species is poorly known, but Sprague's pipit exhibits a strong preference for open grassland (i.e., native prairie) with native grasses of intermediate height and thickness, and it avoids areas with too much shrub encroachment. Its use of an area is dependent upon habitat conditions. This species is a ground feeder and forages mainly on insects but will occasionally eat seeds.

K. Other. In the planning aid report of February 2012, USFWS also included the bald eagle and colonial nesting birds as species of concern.

Bald eagle. Bald eagles nest in Louisiana from October through mid-May, primarily in cypress snags in swamps or near fresh to intermediate marshes or open water in the southeastern parishes. Bald eagles will often return to the same nest for a number of years; however, they may also use alternate nests within the vicinity. Shoreline trees that provide a clear view of the water to locate aquatic prey are often chosen as nest sites. Bald eagles primarily feed on fish, but are opportunistic and will eat a variety of mammals, amphibians, crustaceans, and birds. Wintering habitat used by bald eagles in Louisiana is characterized by abundant, readily available food sources. Most wintering areas are associated with open water where eagles feed on fish or waterfowl.

The bald eagle was removed from the List of Endangered and Threatened Species in August 2007 but it continues to be protected under the Bald and Golden Eagle Protection Act and by the Migratory Bird Treaty Act. Recommendations to minimize potential project impacts to the bird and its nest are provided by the U.S. Fish and Wildlife Service in that agency's National Bald Eagle Management Guidelines publication (USFWS, 2010b). Those guidelines recommend: (1) maintaining a specified distance between the activity and the nest (buffer area); (2) maintaining natural areas (preferably forested) between the activity and nest trees (landscape buffers); and (3) avoiding certain activities during the breeding season.

Brown Pelican and Other Colonial Nesting Birds. The USFWS recommended avoiding any disturbance to waterbird nesting colonies during the breeding season. This would include colonies of nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, as well as brown pelicans.

Formerly federally listed as an endangered species (until November 11, 2009), brown pelicans are large, dark gray-brown water birds with white about the head and neck. Immature brown pelicans are gray-brown above and on the neck, with an underside of white. The adult can reach up to 8 pounds and have wingspreads of over 7 feet.

Brown pelicans nest in colonies mostly on small coastal islands. The nests are usually built in mangrove trees of similar size vegetation, but ground nesting may also occur. Nests vary from practically nothing to well built nests of sticks, reeds, straws, palmetto leaves, and grasses. The eastern subspecies nests mostly in early spring or summer, although fall and winter nesting have been recorded in some localities. Normal clutch size for the brown pelican is three eggs. Feeding occurs primarily in shallow estuarine waters with the birds seldom venturing more than 20 miles out to sea except to take advantage of especially good fishing conditions. Sand spits and offshore sand bars are used extensively as daily loafing and nocturnal roost areas. Major threats to this species have been chemical pollutants, colony site erosion, disease, and human disturbance.

V. DESCRIPTION OF PROPOSED ACTION

Alternative 1 (TSP). The TSP provides for the movement of flows from drainage events out of the Mermentau Basin consistent with the authorized purpose of the project. The project features are as follows.

Dredging. The main feature of Alternative 1 (TSP) is a new channel to carry freshwater flows from the Mermentau Basin around the south side of the existing Calcasieu Lock to Bayou Choupique. This channel, constructed by hydraulic dredging, would be about 3,650 feet long and 300 feet wide at the top. The channel would be dredged to -12 MLG, with a channel bottom width of 80 feet, and 1V on 3H side slopes. A total of about 170,000 cy of dredged material would be generated from construction of the channel. Dredged material would be placed within the project area in two or more areas of open water totaling about 35 acres. Placement of dredged material into these disposal sites is intended to convert open water to estuarine marsh. For disposal of dredged materials, a pipeline would be routed through the existing open water using floating or submerged pipeline. To control scouring, about 17,200 tons of rip rap would be placed in the channel approximately 300 feet on either side of the water control structure at a thickness of 3 feet.

Culvert Structure. A gated water control structure would be constructed inside the channel at about its midpoint to control the passage of freshwater flows. The culvert structure consists of five openings (9' x 14' each) that would allow for the passage of the additional flow. The structure is pile-founded, reinforced concrete with cast iron sluice gates that can be closed when salinity levels in the ship channel are too high. The structure is 82-ft wide and 100-ft long. The invert of the structure is (-) 6.0, with the top of the structure at (+) 14.0. The top of the culvert is at (+) 5.0, which is higher than the anticipated flow line thru the area, so water cannot overtop the structure. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this phase.

The structure would be dewatered for maintenance purposes with the use of steel bulkheads on either side of the sluice gates. The operation of the gates would be done remotely, with hydraulic motors. Therefore, there is no requirement to man the structure during events in which the structure is opened. Power was assumed to be provided from the Calcasieu Lock area.

Mitigation. For Alternative 1, approximately 11 acres of forested spoil bank and 14 acres of brackish marsh would be directly impacted by constructible elements as based on Geographic Information System analysis (table A-2). The forested spoil bank habitat consists of a forested area at the higher elevations and scrub-shrub vegetation at the lower elevations. Brackish marsh includes areas of emergent vegetation as well as associated open water.

Table A-2. Impacts to Habitat Shown in Acres

		Marsh					
		Brackish		Intermediate			
Alternative 1 (New Channel With Gate)	**Forested Spoil Bank**	**Emergent**	**Open Water**	**Emergent**	**Open Water**	**Marsh Total**	**Total Habitat Impacts**
Acres	11.0	9.7	4.3	0	0	14.0	25.0

Mitigation for unavoidable losses to brackish marsh (14 acres) and forested spoil bank (11 acres) would be required and included as part of Alternative 1 (TSP). Marsh mitigation would consist of placement of about 50,000 cy of dredged material into a 10-acre open water area adjacent to the new channel to restore brackish marsh. Forested spoil bank mitigation would include implementation of tree stand improvements in about 15 acres of remaining forested habitat, plus the purchase of about 8 acres of credits from an approved bottomland hardwood mitigation bank serving the project area. Placement of about 120,000 cy of remaining hydraulically dredged material in about 25 acres of on-site open water areas to restore brackish marsh would be an incidental environmental benefit.

The assumed existing elevation for the disposal locations is -2.0 MLG, with placement to +1.5 MLG. To contain dredged material at these locations, earthen closures and weirs would be constructed around all disposal sites. All borrow material needed for closures and weirs would come from within the disposal areas. About 4,000 LF of earthen closures (8.6 cy/lf) would be constructed to elevation +5.0 MLG, with a 5 ft crown, and 1V on 4H side slopes. About 16,500 LF of earthen weir containment (2.5 cy/lf) would be built along the existing marsh to elevation +3.5 MLG, with a 5 ft crown, and 1V on 4H side slopes.

A detailed description of the proposed mitigation plan is presented in Appendix I, Mitigation Plan.

Access/Staging. Construction access to the site would be via barge. A permanent access road would be constructed from the lock to the culvert structure for use by the lock personnel.

The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the extent practicable.

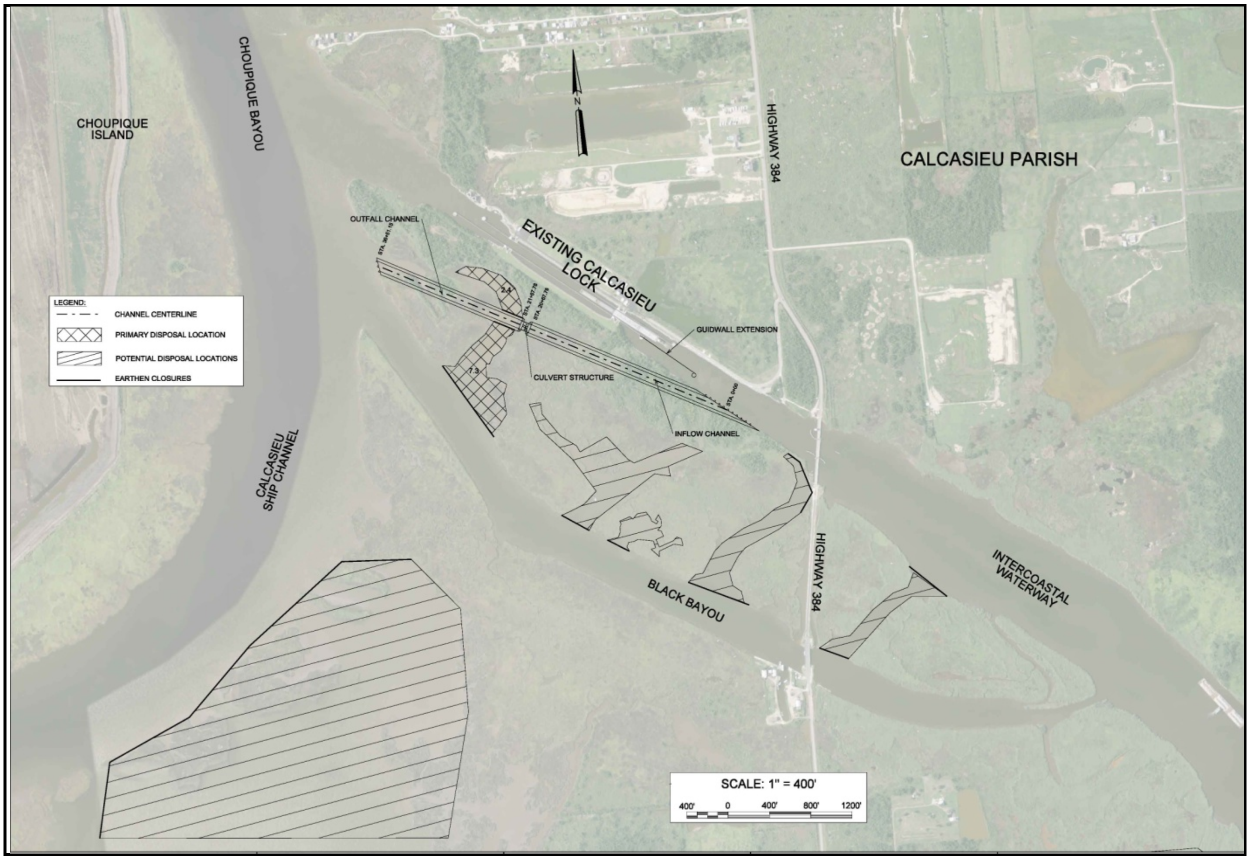

Figure A-3. General Plan for Alternative 1 (TSP)

VI. EFFECTS ASSESSMENT FOR INDIVIDUAL SPECIES

The proposed action was evaluated and the anticipated effects of the action determined in accordance with the ESA. The potential impacts identified with respect to the listed species and proposed action are as follows.

The majority of federally-threatened and endangered species described in the USFWS 2012 planning aid report are not known from Calcasieu Parish and therefore not likely to be found in the vicinity of the project area (table A-1). This includes the green sea turtle, gulf sturgeon, hawksbill sea turtle, Kemp's Ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, piping plover, and West Indian manatee. The proposed action would not affect any of these species.

A. Sprague's Pipit. The Sprague's pipit (*Anthus spragueii*), a candidate species for Federal listing as a threatened or endangered species, is the only species listed for Calcasieu Parish. Because the project area does not support grassland (either natural or managed), and because habitats to be impacted by the project (forested spoil bank and brackish marsh) are not known to be used by Sprague's pipit, the proposed action is not likely to adversely affect this candidate species.

B. Bald Eagle. Regarding the Bald Eagle, the USFWS has indicated that there are no known bald eagle nests in the vicinity of the project area (see Appendix B, USFWS Coordination Letter and Support). Similarly, no nests were observed during a site visit to the project area on December 13, 2012. This bird is not known to use any trees in the project area for feeding, resting, or roosting. Therefore, the proposed action is not likely to harm or harass the bald eagle. If a bald eagle nest is found within 1,500 feet of the project area, the USFWS would need to be contacted to develop measures (e.g., spatial restrictions around active bald eagle nests) to avoid impacts on this species.

C. Brown Pelican and other Colonial Nesting Birds. Regarding colonial nesting birds, including the brown pelican, the USFWS has indicated that there are no known colonial nesting birds in the vicinity of the project area (see Appendix B, USFWS Coordination Letter and Support). The closest known nesting site of the Brown pelican is Rabbit Island in Calcasieu Lake (USACE, 2010), about 15 miles to the southwest of the project area. Likewise, no colonial nests of any such species were observed in the project area during a site visit on December 13, 2012. Therefore, it is unlikely that the proposed action would disturb any colonial nesting birds. If such colonies are found, to minimize disturbance, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present).

VII. SUMMARY OF EFFECTS OF THE PROPOSED ACTION

The effects of the proposed action are summarized in table A-3.

VIII. REFERENCES

U.S. Army Corps of Engineers (USACE). 2010. Endangered Species Biological Assessment. Appendix L, Endangered Species Coordination. Final Calcasieu River and Pass Dredged Material Management Plan and Supplemental Environmental Impact Statement, dated November 22, 2010. USACE, New Orleans District, New Orleans, LA

Table A-3. Summary of Potential Impacts on Federally-listed Species

Species	Federal Status	State Status	Impact
American Alligator (*Alligator mississippiensis*)	T; (S/A)[1]	Not listed.	No effect
Green sea turtle (*Chelonia mydas)*	T	T	No effect - not likely to occur in project area
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	T	T	No effect - not likely to occur in project area.
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	E	No effect - not likely to occur in project area
Kemp's Ridley sea turtle (*Lepidochelys kempii*)	E	E	No effect - not likely to occur in project area
Leatherback sea turtle (*Dermochelys coriacea*)	E	E	No effect - not likely to occur in project area
Loggerhead sea turtle (*Caretta caretta)*	T	T	No effect - not likely to occur in project area
Piping Plover (*Charadrius melodus)*	T; critical habitat	T/E	No effect - not likely to occur in project area
West Indian Manatee (*Trichechus manatus*)	E	E	No effect - not likely to occur in project area
Sprague's pipit (*Anthus spragueii*)	C	Not listed	May affect, but not likely to adversely affect
Bald eagle (*Haliaeetus leucocephalus*)	Not listed	Not listed	May affect, but not likely to adversely affect
Brown Pelican (*Pelecanus occidentalis)*	Not Listed	E	May affect, but not likely to adversely affect
Other Colonial Nesting Birds	Not listed	Not listed	May affect, but not likely to adversely affect

[1] S/A = similarity of appearance

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX B

USFWS COORDINATION LETTER AND SUPPORT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506

August 22, 2013

Colonel Richard L. Hansen
District Commander
U.S. Army Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Colonel Hansen:

Please reference the U.S. Army Corps of Engineers' Calcasieu Lock, Louisiana Feasibility Study to address proposed modifications to, and the possible replacement of, the Calcasieu Lock. The Fish and Wildlife Service, under provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) submits the enclosed supplemental draft Fish and Wildlife Service Coordination Act Report (FWCAR) containing a description of the existing fish and wildlife resources of the project area, discusses future with and without project habitat conditions, identifies fish and wildlife-related impacts of the proposed project, and provides recommendations to avoid, reduce, or compensate for impacts to fish and wildlife. This report supersedes our previous draft FWCAR and incorporates comments from the National Marine Fisheries Service. This draft report does not constitute the report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

To help ensure that fish and wildlife conservation receives equal consideration with other project purposes, the Service recommends that the planning objectives and conservation measures identified in our report be integrated into the plan formulation process. We look forward to actively participating in the current phase of project planning. If your staff has any questions regarding our comments, please have them contact David Castellanos at (337) 291-3112.

Sincerely,

Jeffrey D. Weller
Field Supervisor
Louisiana Ecological Services Office

Enclosure

cc: Southwest Louisiana Refuge Complex, Bell City, LA
EPA, Dallas, TX
NMFS, Baton Rouge, LA
LDWF, Baton Rouge, LA
LDNR, CMD, Baton Rouge, LA
OCPR, Baton Rouge, LA

Fish and Wildlife Coordination Act Report

Gulf Intracoastal Waterway
Calcasieu Lock Feasibility Study
Calcasieu Parish, Louisiana

PROVIDED TO
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

PREPARED BY
DAVID CASTELLANOS
FISH AND WILDLIFE BIOLOGIST

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
LAFAYETTE, LOUISIANA

AUGUST 2013

FISH AND WILDLIFE SERVICE – SOUTHEAST REGION

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INTRODUCTION

The U.S. Army Corps of Engineers (Corps), New Orleans District has initiated the Calcasieu Lock Feasibility Study to identify and address various alternatives to reduce navigation delays currently experienced with traversing the lock. This study is a supplement to the Intracoastal Waterway Locks, Louisiana Reconnaissance Report that focuses on the Calcasieu Lock (U.S. Corps of Engineers 1992). The present study was authorized by resolutions adopted by the Committees on Public Works of the United States Senate and the House of Representatives on September 29 and October 12, 1972, respectively. Navigation delays at Calcasieu Lock are primarily related to hydrologic conditions and how they affect the tonnage passing through the lock. The lock was constructed as a saltwater barrier; it is operated to keep salt water from moving west to east into the Mermentau Basin and to drain flood flows from east to west to the Calcasieu River. Delays can occur when there are excessive stages within the Mermentau Basin. During floods, the lock is frequently left open to drain water from the basin toward the Calcasieu River. During this situation, tows are forced to wait out the drainage event due to head differential and high velocities in the lock chamber. Altering the existing lock structure to decrease the impacts of drainage events on transiting tows would result in shorter transit times for tows staging at either segment of the GIWW (east or west). Fewer barge reconfigurations to allow for transit during drainage events will increase cycling times of tows through the lock. An additional or wider lock chamber would allow for passing of flows through the old lock or through a new wider lock that can accommodate drainage events and lockage's. Redirecting completely or partially drainage flows away from the existing lock would reduce or eliminate the delays that result. The Fish and Wildlife Service (Service) submits the following comments under provisions of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); this document does not constitute the report of the Secretary of the Interior as required by Section 2(b) of that Act. This draft report supplements and supersedes our August 2, 2013, draft FWCA Report that addressed potential impacts and mitigation features for the Calcasieu Lock Feasibility Study, and it incorporates comments received by the National Marine Fisheries Service (NMFS). This report has been provided to the Louisiana Department of Wildlife and Fisheries (LDWF) and the NMFS; their comments will be incorporated into our final report.

DESCRIPTION OF STUDY AREA

The study area is located in the north-central portion of the Calcasieu Estuary, in south-central Calcasieu Parish, Louisiana (Figure 1). There is a relatively large expanse of wetlands and associated shallow open waters between the GIWW and Black Bayou, and to the west and southwest along Calcasieu Lake. Higher lands are associated with dredged disposal areas adjacent to the GIWW. Developed lands (residential, commercial, and agricultural) are located north of the GIWW, east and west of Louisiana Highway 384, and to the south near the community of Grand Lake. Navigation channels such as the GIWW and the Calcasieu River and Pass (CRP) are also prominent landscape features, as are extensive oil and gas industry access channels and pipeline canals.

Calcasieu Lock is one of the five major water control structures operated by the Corps that have a significant influence on water and salinity levels in the Mermentau Basin. It also serves as a hydrologic partition, separating the Mermentau Basin to the east from the Calcasieu-Sabine Basin to the west. Hydrologic connectivity between the two basins is intermittent and primarily occurs when the Calcasieu Lock is opened to evacuate excess water from the Mermentau Basin following significant rainfall events. Those two basins are described in detail below.

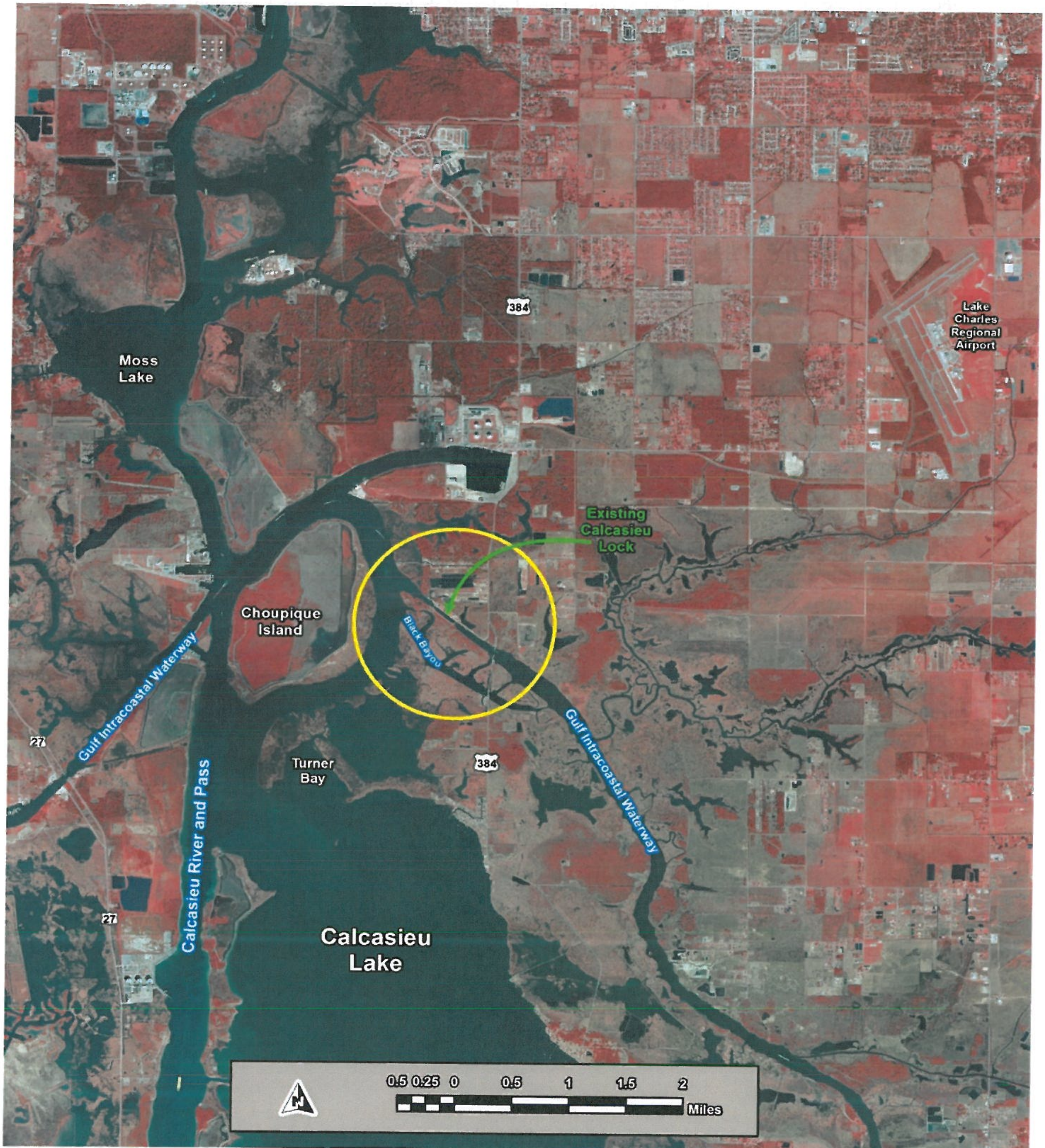
Mermentau Basin

The Mermentau Basin extends from the vicinity of Louisiana Highway 10 between Oakdale and Ville Platte, in Allen and Evangeline Parishes, respectively, southward to the Gulf of Mexico. The Basin encompasses an area of about 4.2 million acres and contains productive agricultural lands and a variety of natural environments (Corps 1999).

The Mermentau Basin is divided into three sub-basins: Upland, Lakes, and Chenier. The latter two sub-basins which comprise the Lower Mermentau Basin would be most likely affected by hydrology changes resulting from the replacement of, and/or the operational changes to, the Calcasieu Lock. Most, if not all, of the Upland Sub-basin, however, lies beyond the immediate influence of the lock. The Upland Sub-basin covers an area of 3,683 mi^2 of predominantly agricultural land (Gammill et al. 2002). The principal agricultural products in this region are rice and crawfish which both require ample supplies of fresh water typically provided via the Corps' management of the Mermentau Basin Project (Corps 1999).

The Lakes Sub-basin, of the Lower Mermentau Basin, is located between the GIWW and Louisiana Highway 82 and historically functioned as a brackish estuary (Corps 2008). Construction of navigation channels, locks, and water control structures has altered the historical north-south river and tidal-driven hydrology and shifted it to an east-west system that drains through the GIWW navigation channel. Corps' locks and water control structures that are located along the perimeter of the Lakes Sub-basin regulate both salinity and water level. The result is that the Mermentau Lakes Sub-basin now functions more as a freshwater reservoir and less as the low-salinity estuary it was prior to these alterations (Gammill et al. 2002). The demand for a reliable fresh water supply for agricultural use was the primary reason for the development of the Mermentau Basin Project (Corps 1999).

The Mermentau Basin Project involves the operation and management of five navigation locks and control structures by the Corps to maintain the Mermentau Lakes Sub-basin as a freshwater reservoir for agricultural use and to reduce the detrimental effects of saltwater intrusion on freshwater habitats. Those five structures are: (1) the Calcasieu Lock located on the GIWW near the intersection of Louisiana Highway 384, (2) the Leland Bowman Lock situated on the GIWW near Intracoastal City, (3) the Freshwater Bayou Lock located on the Freshwater Bayou Canal approximately one mile from the Gulf of Mexico, (4) the Catfish Point Control Structure located on the southwest side of the basin where the Mermentau River exits Grand Lake, and (5) the Schooner Bayou Control Structure found on the east side of the basin in the old Intracoastal Waterway between Freshwater Bayou and White Lake. The target water level inside the basin is 2.0 feet above mean low Gulf and the five Corps structures are operated in concert to maintain



this level (Corps 1999).

The Chenier Sub-basin is located south of the Lakes Sub-basin between Louisiana Highway 82 and the Gulf of Mexico. Approximately one-third of this Sub-basin is comprised of the State-owned and operated Rockefeller Wildlife Refuge. The Chenier Sub-basin is characterized by tidally influenced salt marshes, though hydrology throughout much of the area is managed through impoundments that range in size from hundreds to thousands of acres. The purpose of that management is to control salinity in order to reduce wetland losses and/or sustain recreational and agricultural endeavors (Corps 2008).

Calcasieu-Sabine Basin

The Calcasieu-Sabine Basin lies immediately west of the Mermentau Basin and consists of two semi-distinct sub-basins, the Calcasieu River Basin and the Sabine River Basin. When the GIWW was built in the 1920s, it breached the Gum Cove Ridge which had historically formed a north-to-south oriented hydrologic barrier between the Calcasieu and Sabine Lake systems. That breach now facilitates the movement of salt water westward into the Sabine Basin, and has exacerbated saltwater intrusion problems in the marshes adjacent to the GIWW. The typical water-movement scenario is that south winds push salt water into Calcasieu Lake, westward through the GIWW, and across the Gum Cove Ridge breach. This water is eventually swept down the Sabine River and into Sabine Lake. Currently, salt water that is pushed into Calcasieu Lake remains there because there is little back flow from the Lake. Without the Gum Cove Ridge breach, the current semi-circular flow patterns would not exist, and lake levels would rise more modestly, thus reducing the volume of seawater entering Calcasieu Lake (Lopez et al. 2008).

The widening and deepening of the CRP channel, which included the removal of the channel mouth bar, has increased saltwater and tidal intrusion into the Calcasieu-Sabine Basin, resulting in marsh loss, tidal export of organic marsh substrate, and an overall shift to more saline habitats in the region. In 1968, the Corps completed construction of the Calcasieu River Saltwater Barrier on the Calcasieu River north of the City of Lake Charles. This barrier minimized the flow of salt water into the upper reaches of the Calcasieu River to protect agricultural water supplies (Gammill et al. 2002). The primary saltwater barrier between the Mermentau and Calcasieu Basins is the Corps-maintained Calcasieu Lock, located east of the CRP on the GIWW near its intersection with Louisiana Highway 384. It was designed to prevent saltwater intrusion into the Mermentau Basin. It is operated primarily for navigation and salinity control, but during flooding events the structure is often operated for drainage of the Mermentau Basin. There is a continual effort by the Corps to balance lock operation for flood control to local communities (i.e, Mermentau Basin drainage) with the needs of waterborne commerce (Gammill et al. 2002).

FISH AND WILDLIFE RESOURCE CONDITIONS

Existing Conditions

Major Habitat Types

Fish and wildlife habitat of the proposed study area and vicinity consists of open water ponds lakes, and other waterways, relatively small tracts of forests and scrub-shrub habitat, and intermediate, brackish, and saline marsh. The three major lakes potentially influenced by proposed changes to the Calcasieu Lock are Calcasieu, Grand, and White Lakes (numerous smaller waterbodies could also be affected). Those lakes were formed as bays at the mouths of drowned Pleistocene entrenched river valleys during the Holocene rise in sea level, over the past 5,000 years (Fisk 1944). Marshes within this region of the State began forming about 3,000-4,000 years ago during periods when the Mississippi River followed a more westerly course (Gosselink et al.1979). Expansive mud flats were created by large quantities of riverine sediment that accreted along the Gulf shoreline. Despite substantial hydrologic alterations, wetlands within the project vicinity continue to support nationally significant fish and wildlife resources. They provide important habitat for various species of plants, fish, and wildlife, serve as ground water recharge areas, provide storage areas for storm and flood waters, serve as natural water filtration areas, provide protection from wave action, erosion, and storm damage, and provide various consumptive and non-consumptive recreational opportunities.

Most project-area wetlands west of Louisiana Highway 384, along the northern portion of Calcasieu Lake, have been classified as brackish marshes since 1968 (Chabreck and Linscombe 1968, 1978, 1988, 1997, 2001, and 2007). Most other marshes in the immediate project vicinity are classified as intermediate. The most prevalent habitat types and their associated fish and wildlife values are described below.

Forested Lands

Forests in the vicinity of the proposed study area are primarily located on higher elevations adjacent to marsh and vegetated with Chinese tallow-tree, rough-leaf dogwood, sugarberry, various species of pine, wax myrtle, and deciduous holly. Those forests provide important "stopover" habitat (resting and feeding sites) for song birds that migrate across the Gulf of Mexico. They also provide habitat for other migratory and resident avian species including northern cardinal, northern mockingbird, American woodcock, wood thrush, Louisiana waterthrush, yellow-billed cuckoo, Carolina chickadee, red-tailed hawk, red-shouldered hawk, and barred owl).

Mammals associated with forested lands in the study area include game species (such as eastern cottontail, swamp rabbit, white-tailed deer, and gray and fox squirrel), commercially important furbearers (such as river otter and muskrat), and other mammal species (such as striped skunk, coyote, Virginia opossum, cotton rat, marsh rice rat, and white-footed mouse). Reptiles which utilize study-area forested habitats include the ground skink, five-lined skink, green anole, and western ribbon snake. Some of the amphibians expected to be found in study-area forested habitats include the small-mouthed salamander, green treefrog, bullfrog, and southern leopard frog.

Scrub-Shrub

Typical vegetation in scrub-shrub habitat includes big-leaf sumpweed, common reed, Chinese tallow-tree, eastern baccharis, marsh elder, black willow, wax myrtle and goldenrod. Scrub-shrub habitat occurs on canal spoil banks, abandoned agricultural areas, and drained wetlands. Those habitats often support a variety of wildlife, depending on local conditions; they provide nesting and feeding sites for wading birds, songbirds and other birds, and wildlife escape cover.

Estuarine Marsh and Associated Open Water

Study-area estuarine marshes extend westward from Louisiana Highway 384 toward the Calcasieu River and the northern portion of Calcasieu Lake. They are characterized by low to moderate daily tidal energy and by firm mineral to organic soils. Salinities vary, with peak salinities occurring in the late summer or fall. The lower-salinity estuarine marshes are often classified as intermediate; brackish to saline marshes occur at higher salinity levels. Estuarine marshes are predominantly vegetated with saltmeadow cordgrass, saltmarsh cordgrass, big cordgrass, Olney's bulrush, saltgrass, saltmarsh camphor-weed, seaside goldenrod, cow pea, common reed, marsh mallow, perennial saltmarsh aster, needle rush, and saltmarsh morning-glory. Brackish marsh ponds occasionally support extensive beds of widgeon-grass.

Estuarine marshes reduce erosion in adjacent non-wetland areas by dissipating wave and tidal energy. Such marshes also provide valuable wildlife habitat and important nursery and feeding habitat for estuarine-dependent fishes and shellfishes. Vegetative production rates in estuarine marshes are extremely high, providing an abundance of detritus to support the estuarine food web. The high primary productivity of Louisiana's coastal marshes is largely responsible for that area's role as the "fertile fisheries crescent" (Gunter 1967).

Estuarine marshes provide important habitat for the growth and production of estuarine-dependent species such as blue crab, white shrimp, brown shrimp, Gulf menhaden, Atlantic croaker, spot, red drum, black drum, sand seatrout, spotted seatrout, southern flounder, striped mullet, and other finfishes. Commercial shrimp harvests have been positively correlated with the area of tidal emergent wetlands (Turner 1977 and 1982). Future commercial harvests of shrimp and other fishes and shellfishes would likely be adversely impacted by continued losses in estuarine marsh habitat (Turner 1982).

Wildlife expected to utilize the study-area estuarine marshes include wading birds (herons, egrets, ibises, and roseate spoonbills), rails, migratory waterfowl (green-winged teal, blue-winged teal, mottled duck, gadwall, American widgeon, and lesser scaup), raptors, and songbirds. Brackish marshes having abundant submerged aquatic vegetation often support large numbers of puddle ducks. Shorebirds utilizing estuarine marshes include killdeer, American avocet, black-necked stilt, common snipe, and various other species; seabirds include white pelican, brown pelican, black skimmer, herring gull, laughing gull, and several species of terns. Other nongame birds such as boat-tailed grackle, red-winged blackbird, seaside sparrow, olivaceous cormorant, belted kingfisher, and sedge wren also utilize estuarine marshes.

Estuarine marsh wildlife also includes swamp rabbit, nutria, muskrat, mink, river otter, raccoon, white-tailed deer, and coyote. Reptiles are limited primarily to the American alligator in intermediate and brackish marshes, and the diamond-backed terrapin and gulf salt marsh snake in brackish and saline marshes. Juvenile sea turtles may seasonally utilize bays and saline marsh ponds in the lower Calcasieu Estuary.

Essential Fish Habitat

The project is located within an area identified as Essential Fish Habitat (EFH) by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, Magnuson-Stevens Act; P.L. 104-297). The updated and revised 2006 generic amendment of the Fishery Management Plans for the Gulf of Mexico, prepared by the Gulf of Mexico Fishery Management Council, identifies EFH in the project area to be estuarine emergent wetlands, submerged aquatic vegetation, mud, and estuarine water column. Under the MSFCMA, wetlands and associated estuarine waters in the project area are identified as EFH for various federally managed species including: juvenile brown and white shrimp; eggs, larvae/postlarvae and larvae/postlarvae, juvenile, and adult red drum.

In addition to being designated as EFH for these species, water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, such as striped mullet, Atlantic croaker, gulf menhaden, spotted seatrout, sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the GMFMC (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks) (NMFS 2008).

Developed Lands

Developed areas are located on the higher elevations of the Pleistocene terrace north and south of the GIWW adjacent to the study area and are typically well drained. They include agricultural lands, and commercial and residential developments. Levees are also included in this category; they are frequently mowed, and, as such, provide poor wildlife habitat. Some levees are vegetated with an assortment of scrub/shrub species including marsh elder, eastern baccharis, Chinese tallow-tree, common reed, and goldenrod. These higher-elevation areas may provide low-to-moderate-value habitat for terrestrial wildlife, including some migratory bird species.

Federally Protected Species

Federally listed as an endangered species, West Indian manatees (*Trichechus manatus*) have been occasionally observed along the Louisiana Gulf coast (primarily in southeast Louisiana). The manatee has declined in numbers due to collisions with boats and barges, entrapment in flood control structures, poaching, habitat loss, and pollution. Cold weather and outbreaks of red tide may also adversely affect these animals. Should the proposed project involve activity in aquatic environments during summer months, further consultation with this office will be necessary.

The proposed project area would be located in a Parish known to be used by the Sprague's pipit (*Anthus spragueii*), a candidate species for federal listing as a threatened or endangered species. Candidate species are those taxa for which the Service has on file sufficient information regarding biological vulnerability and threat(s) to support issuance of a proposal to list, but issuance of a proposed rule is currently precluded by higher priority listing actions. Sprague's pipit is a small (4 to 6 inches in length) passerine bird with a plain buffy face, a large eye-ring, and buff and blackish streaking on the crown, nape, and under parts. It winters in Louisiana, arriving from its northern breeding grounds in September and remaining until April. Migration and wintering ecology of this species is poorly known, but Sprague's pipit exhibits a strong preference for open grassland (i.e., native prairie) with native grasses of intermediate height and thickness, and it avoids areas with too much shrub encroachment. Its use of an area is dependent upon habitat conditions. This species is a ground feeder and forages mainly on insects but will occasionally eat seeds.

Although the proposed project would be located within an area that may be inhabited by the Sprague's pipit, there is currently no requirement under the Endangered Species Act for consultation regarding project impacts on that species. In the interest of conserving the Sprague's pipit, we encourage you to avoid project activities that would adversely affect that species or its habitat. Should it be federally listed as threatened or endangered in the future, however, further consultation on possible project impacts to that species could then be necessary.

Although scrub-shrub and forested areas in the project vicinity may provide habitat for bald eagles and colonial nesting waterbirds, project-associated impacts to those species are unlikely because they are not known to occur in the vicinity of the proposed study area. Though improbable, such nest sites and colonies may be present that are not currently listed in our database. We, therefore, recommend that on-site contract personnel be informed of the need to identify bald eagle nest sites and waterbird nesting colonies, and to avoid affecting them during the breeding season. To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present). If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

Brown pelicans (*Pelecanus occidentalis*) may feed in open water habitats of the study area and its vicinity. Their closest known nesting site is Rabbit Island in Calcasieu Lake. In spring and summer, nests are built in mangrove trees or other shrubby vegetation, although ground nesting may also occur. Major threats to this species include chemical pollutants, colony site erosion, disease, and human disturbance. Though unlikely, should the proposed project directly or indirectly affect brown pelicans, further consultation with this office will be necessary.

The American alligator is also found in the study area, but is classified as "threatened due to similarity of appearance"; alligators are not biologically endangered or threatened. As plan formulation progresses, the Corps should continue to consult with the Service regarding potential impacts to threatened and endangered species.

Wildlife Management Areas and Parks

Cameron Prairie and Lacassine National Wildlife Refuges are influenced by Mermentau Basin water levels. Potential project impacts to those refuges would be associated with any change in the water levels caused by Calcasieu Lock replacement structures and their operation. There are no state or national parks, state wildlife refuges or wildlife management areas located near the study area.

Existing Coastal Restoration Projects

The Black Bayou Culverts Hydrologic Restoration project may be directly or indirectly impacted by the currently proposed project alternatives (particularly Alternatives 3, 4 and 5 which would involve the construction of a new lock in the center of the Black Bayou channel). That project was authorized and funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) with the Natural Resources Conservation Service (NRCS) serving as the project sponsor. It was designed to facilitate a more efficient discharge of excess water within the Mermentau Basin, which is believed to have contributed to marsh loss and shoreline erosion. Completed in 2007, it is anticipated that this $7.3 million project will have a beneficial impact on over 72,000 acres of fish and wildlife habitat within the Mermentau Basin. NRCS and the Coastal Protection and Restoration Authority (CPRA [local sponsor for the project]) should be consulted regarding potential impacts to this existing restoration project.

Future Fish and Wildlife Resources

As part of the development of the report entitled Coast 2050: Toward a Sustainable Coastal Louisiana, future wetland acreages were projected through the year 2050. For the

Calcasieu-Sabine Basin, a loss of 38,400 acres (12 percent) of marsh and 170 acres (100 percent) of swamp was projected between 1990 and 2050, at current levels of coastal restoration funding (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Land loss rates within the Calcasieu-Sabine Basin from 1933 to 1990 have averaged approximately 0.5 percent per year. The total Calcasieu-Sabine and Mermentau Basin loss rates are expected to be 12.1 and 13.4 percent, respectively, over the next 50 years. Land loss rates within the study area (northern Calcasieu Lake) have averaged 0.2 percent per year during 1933 to 1955, 0.78 percent per year from 1955 to 1978, 0.2 percent per year during 1974 to 1983, and 0.14 percent per year during 1983 to 1990 (Dunbar et al. 1992).

The major cause of land loss in the Calcasieu-Sabine Basin is saltwater intrusion caused by the larger navigation channels, namely the CRP and the GIWW (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Those major waterways have allowed saltwater intrusion from the Gulf of Mexico to enter Calcasieu Lake and its surrounding marshes. This increased salinity stresses less-saline marsh vegetation and leads to plant death and ultimately conversion of marsh to shallow open water.

Land loss within the Mermentau Basin may be due to a variety of factors including alterations to natural hydrology caused by the GIWW and major ship channels (i.e., the Mermentau River Navigation Channel), and shoreline erosion along major lakes, bays, and the Gulf of Mexico (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). It has also been widely accepted that higher water levels within the Mermentau Lakes Subbasin caused by Corps-managed water control structures has accelerated land loss through at least three main mechanisms: 1) shoreline erosion along area lakes and bays; 2) floatant marsh washout; and 3) interior marsh die-back due to prolonged marsh flooding. However, according to Gammill et al. (2002), ". . . no scientific evidence exists to document the occurrence of these phenomena on a systemic scale in this ecosystem."

Sea level rise and subsidence also cause land loss (Penland and Ramsey 1990). The Calcasieu-Sabine Basin presently is experiencing moderate subsidence rates of 1.1 foot/century (Gagliano 1998, Penland and Suter 1989). The combination of subsidence and sea level rise is called submergence or land sinking. As the land sinks, the marshes become inundated with higher water levels, stressing most non-fresh marsh plants and leading to plant death and conversion of marshes to open water. Other major causes of study-area marsh loss include altered hydrology, storms, shoreline erosion, and development including the direct and indirect impacts of dredge and fill activities (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998).

The continued loss of wetlands represents the most serious fish and wildlife-related problem in the study area. Losses in wetlands would result in gains in open water habitat and, to a lesser extent, developed land. Wetland losses could be expected to cause significant declines in coastal fish and shellfish production, and in the study area's carrying capacity for migratory waterfowl, wading birds, other migratory birds, alligators, furbearers, and game mammals. Wetland losses will also reduce storm surge protection of developed lands, and will likely contribute to water quality degradation associated with excessive nutrient inputs.

As described above, estuarine marsh is the primary type of EFH impacted by continued wetland loss and deterioration. Although an increase in some types of EFH (i.e., mud bottom and estuarine water column) would occur, adverse impacts would occur to more productive types of EFH (i.e., estuarine emergent wetlands). The loss of estuarine emergent wetlands would result in negative impacts to juvenile brown and white shrimp; eggs, larvae/postlarvae, and juvenile Gulf stone crab; and larvae/postlarvae, juvenile and adult red drum.

DESCRIPTION OF TENTATIVELY SELECTED PLAN AND EVALUATED ALTERNATIVES

Tentatively Selected Plan (TSP) (Alternative 1): A 75 ft. Sluice gate (DAC) that is generally within the alignment of the previously proposed south lock. The outfall and intakes will need to be excavated with material being beneficially used for marsh creation. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated.

Alternative 2: A 3,700 cubic feet per second (cfs) pumping station (DAA2) would be constructed generally within the alignment of the previously proposed south lock. The outfall will need to be excavated with material being beneficially used for marsh creation. For safety, a guidewall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated.

Alternative 3: Supplemental Culverts (DAE1) would be added to the Black Bayou NRCS structure to increase its capacity and operate in conjunctions with it. A weir (DAE5) would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). Black Bayou Dredging (DAE4) to the east and west of the NRCS structure will also occur.

Alternative 4: A 2,000 cfs Pumping Station (DAE2) would be constructed adjacent and north of the existing Black Bayou NRCS structure and operate in conjunction with it. The pump would likely be west of the road with pipes running under the roadway. A weir (DAE5) would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). Black Bayou Dredging (DAE4) to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require USACE to take over O&MRRR of the structure once its 20 project life under CWPRA ends. NOTE: Following IPR#1 in February 2013 it was determined that a 1,000 cfs pump would be insufficient to overcome the natural tendency to drain through the lock when the sector gates were open. Additional HH analysis indicated that a 2,000 cfs pump operating in conjunction with the Black Bayou structure would be sufficient to provide the drainage capacity the lock currently provides.

Alternative 5: A 3,700 cfs Pumping Station (DAE3) would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running 16 under the roadway. A weir (DAE5) would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). Black Bayou Dredging (DAE4) to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure.

Selection of the TSP utilized the newly implemented SMART (Specific, Measurable, Attainable, Risk Informed and Timely) Planning methods that have replaced the standard more detailed alternative analyses that the Service would usually rely upon to develop recommendations to conserve fish and wildlife resources. Therefore, while selection of a Tentatively Selected Plan (TSP) has occurred, changes to the TSP may be warranted based on further planning efforts and review of existing assumptions and modeling (i.e., quality control). Thus the Corps should continue to coordinate with all agencies during the remaining Feasibility phase and the Preconstruction, Engineering, and Design (PED) phase to ensure any new or changed project features, development of any operational plan (e.g., water control plan), further development of the mitigation plan (including monitoring and adaptive management) fully incorporate adequate fish and wildlife conservation measures and that those features can be adequately evaluated with regards to impacts to fish and wildlife resources and/or sufficiency in achieving mitigation.

Future documentation of detailed project planning (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) including mitigation, adaptive management, and monitoring plans should be coordinated with the Service and other natural resource agencies. We should be provided an opportunity to review and submit recommendations on the all work addressed in those reports. The need to prepare a Fish and Wildlife Coordination Act report for any of these documents should be discussed with the Service prior to beginning the detailed design/plan formulation that would be presented in each document.

Furthermore the Service should be contacted during preparation of the Project Management Plan (or equivalent document) for the PED phase to ensure that sufficient funds and time is allotted to complete all tasks necessary to comply with our responsibilities under Section 2(b) of the FWCA.

EVALUATION METHODS FOR SELECTED PLAN AND ALTERNATIVES

Evaluations of the effects of the alternatives to fish and wildlife resources were conducted using the WVA methodology. Implementation of the WVA requires that habitat quality and quantity (acreage) are measured for baseline conditions, and predicted for future without-project and future with-project conditions. Each WVA model utilizes an assemblage of variables considered important to the suitability of that habitat type to support a diversity of fish and wildlife species. The WVA provides a quantitative estimate of project-related impacts to fish and wildlife resources; however, the WVA is based on separate models for bottomland hardwoods, chenier/coastal ridge, fresh/intermediate marsh, brackish marsh, and saline marsh. Although, the WVA may not include every environmental or behavioral variable that could limit population s below their habitat potential, it is widely acknowledged to provide a cost-effective means of assessing restoration measures in coastal wetland communities.

The WVA models operate under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated and expressed through the use of a mathematical model developed specifically for each wetland type. Each model consists of: (1) a list of variables that are considered important in characterizing community-level fish and wildlife habitat values; (2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values; and, (3) a mathematical formula that combines the Suitability Indices for each variable into a single value for wetland habitat quality, termed the Habitat Suitability Index (HSI).

The product of an HSI value and the acreage of available habitat for a given target year is known as the Habitat Unit (HU) and is the basic unit for measuring project effects on fish and wildlife habitat. HUs are annualized over the project life to determine the Average Annual Habitat Units (AAHUs) available for each habitat type. The change (increase or decrease) in AAHUs for each future with-project scenario, compared to future without-project conditions, provides a measure of anticipated impacts. A net gain in AAHUs indicates that the project is beneficial to the fish and wildlife community within that habitat type; a net loss of AAHUs indicates that the project would adversely impact fish and wildlife resources.

We recognize that the newly implemented SMART (Specific, Measurable, Attainable, Risk Informed and Timely) Planning methods that were incorporated into this projects planning process have replaced the standard more detailed impact and mitigation analyses that the Service would usually rely upon to develop mitigation recommendations. The new shortened time frame of the planning process has also reduced the amount of time used to fully develop and refine mitigation alternatives and alternative features. Therefore, extensive additional Service and other natural resource agency involvement prior to finalization of National Environmental Policy Act (NEPA) documents and during ongoing detailed planning, engineering, and design of specific project measures and associated maintenance, along with more-definitive project information that will be available during those planning phases, will be required so that we can continue to fulfill our responsibilities under Section 2(b) of the FWCA.

In addition, calculation of benefits derived from the mitigation area(s) and design (e.g., size, etc.) of those areas presented in this report should not be considered final but preliminary (but sufficient for early feasibility level analysis) based upon existing information gathered. Final design and benefits produced from any mitigation site is contingent upon additional engineering (e.g., settlement curves, etc.) and environmental data, if needed, gathered in future planning/design stages. Additional engineering analysis of mitigation plans (e.g., soil borings, settlement curves, etc.) should be completed prior to finalization of the NEPA document and signing of Record of Decision (ROD) or Finding of No Significant Impacts (FONSI). As the interagency team moves forward in developing project design and operation plans and more extensive modeling/analysis is conducted, habitat assessments previously conducted may need to be revised.

Our evaluation did not address possible beneficial wetland impacts that might be attributed to the ability of the proposed project to maintain and improve the overall health and productivity of the marsh ecosystem within the Mermentau Basin (which may be possible if the existing lock is used for ecosystem-beneficial water level management within the Basin).

IMPACTS OF SELECTED PLAN AND ALTERNATIVES

The most significant direct impact of the TSP (Alternative 1) is the excavation and placement of fill for the new lock within study-area brackish marshes and forested ridge habitat. Our assessment indicated that both Alternatives 1 and 2 would result in a loss of about 25 acres of brackish marsh and forested ridge habitat for a loss of 10.98 AAHUs (Table 1). Approximately 18 acres of EFH habitat would be impacted with implementation of the TSP. Construction of Alternatives 3, 4, or 5 would directly impact 33.7 acres of brackish and intermediate marsh resulting in the loss of 9.07 AAHUs.

Alternatives that had the potential to increase salinity levels within the Mermentau Basin were eliminated from further consideration; therefore impacts to water salinity were not addressed. According to the Corps, the main goal of the project is to decrease the head differential and high water velocity in the lock chamber by modifying the existing lock and redirecting some drainage flow from the Mermentau basin away from the existing lock. Either of these measures would likely increase the drainage efficiency and possibly reduce the duration of high water levels in the basin that could be detrimental to the interior wetlands. Neither measure would be expected to increase flooding duration; therefore, we do not expect indirect impacts to wetlands due to changes in hydrology. If proposed project features are modified so that they may affect the Basin hydrology differently than first described, an analysis of potential secondary impacts to wetlands by proposed project alternatives and features may be necessary. This would include impacts on Mermentau Basin water levels as affected by the replacement lock design and operation, as well as possible continued operation of the existing lock to aid in reduction of excess water levels in that Basin.

Table 1. Preliminary Estimate of the Direct Impacts from the Various Alternatives for the Calcasieu Lock Replacement Study

Alternative (and Location)		Impacts By Habitat Type					
	Upland Forested Ridge Habitat - Existing Spoil Disposal Areas (acres/AAHUs)	Brackish Marsh – emergent vegetated and associated water* (acres/AAHUs)	Intermediate Marsh – Emergent vegetated and associated water (acres/AAHUs)	Open Water within marsh (bayous, ponds)* (acres)	Deeper Open Water not in WVA calculations* (GIWW, Black Bayou) (acres)	Total Impact Acres	Total Impact AAHUs
#1 & 2 (Immediately South of the Existing Lock)	11/7.2	14/3.78	0	4.29	0	**25**	**10.98**
#3, #4, & #5 (Black Bayou)	0	10.5/1.56	23.2/7.51	9.2	64.5	**33.7**	**9.07**

No Federal Action	0	0	0	0	0	**0**	**0**

*Essential Fish Habitat

FISH AND WILDLIFE CONSERVATION MEASURES AND COMPENSATORY MITIGATION

The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include:

(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments.

The Service supports and adopts this definition of mitigation and considers its specific elements to represent the desirable sequence of steps in the mitigation planning process.

The Service's Mitigation Policy (Federal Register, Volume 46, No. 15, January 23, 1981) identifies four resource categories that are used to ensure that the level of mitigation recommended by Service biologists will be consistent with the fish and wildlife resource values involved. Considering the high value of forested ridges and intermediate and brackish marsh for fish and wildlife and the relative scarcity of those habitat types, they are usually designated as Resource Category 2 habitat, the mitigation goal for which is no net loss of in-kind habitat value. Because the "no action" alternative was not selected, avoiding the project impacts altogether is not feasible. Because the excavated channel may require periodic maintenance no rectification mitigation is feasible, therefore, remaining project impacts should be mitigated via compensatory replacement of the habitat values lost.

Project plans should be designed to accomplish the project purpose while avoiding or at least minimizing impacts to fish and wildlife. The potential impacts to fish and wildlife due to the project should be considered equal to all other components during alternative evaluation and selection.

On April 10, 2008, the Corps and the Environmental Protection Agency (EPA) issued regulations governing compensatory mitigation for activities authorized by Department of the Army permits (Federal Register, Vol. 73, No. 70). Those regulations identified a 12-step process for developing a mitigation plan. That 12-step process and additional information can be found can be found at the following addresses: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/final_mitig_rule.pdf).

http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/mitig_info.aspx

If the Corps elects to do project-specific mitigation, then selection of specific mitigation sites and all aspects of mitigation planning, including an alternatives analysis for techniques, locations, design, and means to comply with the 12-step planning process should be coordinated with the Service and all interested Federal and State natural resource agencies. The Service would consider it acceptable to perform the required mitigation through an approved mitigation bank within or in an adjacent watershed.

Mitigation options within the project vicinity are somewhat limited. One option for brackish marsh mitigation for TSP impacts involves marsh creation using dredged material placement within adjacent shallow water. The material could be derived from dredging associated with the replacement of the existing lock and channel, dedicated dredging in Calcasieu Lake, or suitable (uncontaminated) material removed during CRP or GIWW maintenance dredging that would not otherwise be used for marsh creation. Based on preliminary WVA assessments of project mitigation needs, approximately 10 acres of shallow open water would have to be converted to a marsh (which could yield approximately 3.8 AAHUs) to mitigate for the impacts associated with Alternatives 1 or 2.

The Chenier-type forested habitat that would be impacted should be compensated in-kind by enhancement of the remaining forested ridge habitat in the project area or restoration of degraded/developed Cheniers. The Service would also consider bottomland hardwood (BLH) mitigation (including banks) in the project vicinity for the forested ridge habitat impacts because: (1) the habitat soils are spoil material, unlike those of natural Cheniers, thus likely limiting complete succession, (2) the area is dominated by the invasive Chinese tallow tree, and (3) it is located at the extreme northern end of the Chenier Plain where it provides limited functionality of the most significant value of Cheniers as a first stop resting and feeding place for birds migrating across the Gulf of Mexico.

To replace the TSP-related loss of moderate-quality forested ridge habitat, intermediate marsh, and brackish marsh, the Corps and the local sponsor should develop and fund mitigation actions that would produce the equivalent of 10.98 AAHUs (Table 1). The Service and other resource agencies would be involved in evaluating the adequacy of mitigation at any site. The Service recommends that the above planning objectives and conservation measures be integrated into future plan formulation activities for the Calcasieu Lock Replacement project.

The adequacy of mitigation measures to fully offset impacts to Essential Fishery Habitat should be discussed with the National Marine Fisheries Service to determine if additional mitigation is needed to comply with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, Magnuson-Stevens Act; P.L. 104-297, as amended) and its implementing regulations (NMFS 2008).

The preceding impacts and mitigation calculations may be modified as deemed necessary after discussion with the other natural resources agencies (e.g., NMFS and LDWF).

SERVICE POSITION AND RECOMMENDATIONS

The Service's analysis of project alternatives considered for the study area has revealed the potential for significant adverse effects on fish and wildlife resources. Construction of the TSP (Alternative 1) would result in the loss of approximately 11 acres of forested ridge habitat and 14 acres of brackish marsh, for a loss of 7.2, and 3.78 AAHUs respectively. The impacts of the other alternatives evaluated are listed in Table 1. The Service does not object to providing more efficient navigation through the GIWW provided the following fish and wildlife conservation measures are implemented concurrently with project implementation to help ensure that fish and wildlife conservation receives equal consideration with other project purposes:

1. Fully compensate for unavoidable losses of important fish and wildlife habitat. The Corps shall provide in-kind mitigation for impacts to forested ridge habitat, brackish and intermediate marsh habitat to the extent determined for the selected project plan. With construction of the proposed TSP, approximately 11 acres of forested ridge habitat and 14 acres of brackish marsh would be impacted requiring mitigation for 7.2 AAHUs of forested ridge habitat and 3.78 AAHUs of brackish marsh. Calculation of benefits derived from the mitigation area(s) and design (e.g., size, etc.) of those areas presented in this report should not be considered final but preliminary (but sufficient for early feasibility level analysis) based upon existing information gathered. Final design and benefits produced from any mitigation site is contingent upon additional engineering (e.g., settlement curves, etc.) and environmental data, if needed, gathered in future planning/design stages.

2. The assessment of mitigation options for marsh impacts should include an evaluation of the feasibility of disposing project-associated dredged material in a manner that would create marsh in the adjacent shallow open water areas of the project area or in open water to the south of the lock in an area known as the Garrison site. Dredged material that is in excess of that needed for marsh impact mitigation should be used beneficially to create marsh at either or both of these sites (or other adjacent suitable sites). Marsh created beneficially should follow the same design criteria (e.g., initial disposal height, duration till containment dike gapping, etc.) as that used for each specific mitigation site.

3. Because of the expedited schedule, we recommend that the Corps continue to coordinate with the agencies during the remaining Feasibility phase and the Preconstruction, Engineering, and Design (PED) phase to ensure any new or changed project features, development of any operational plan (e.g., water control plan), further development of the mitigation plan (including monitoring and adaptive management) fully incorporate adequate fish and wildlife conservation measures and that those features can be adequately evaluated with regards to impacts to fish and wildlife resources and/or sufficiency in achieving mitigation.

4. Future documentation of detailed project planning (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) and any mitigation plans, including adaptive management and monitoring plans should be coordinated with the Service and other natural

resource agencies. The Service and other natural resource agencies should be provided an opportunity to review and submit recommendations on the all work addressed in those reports. The need to prepare a Fish and Wildlife Coordination Act report for any of these documents should be discussed with the Service prior to beginning the detailed design/plan formulation that would be presented in each document.

5. The Service, LDWF, NMFS and other natural resource agencies should be consulted regarding the adequacy of any proposed mitigation. Draft mitigation plans should be developed in cooperation with those agencies prior to the release of any National Environmental Policy Act documentation. That plan should be consistent to the extent practicable with existing habitat restoration and protection plans for this region, and should address the 12-step process for developing a mitigation plan (Federal Register, Vol. 73, No. 70). If determined to sufficiently offset impacts the Service can adopt and append the proposed mitigation report as an appendix to this report.

6. The adequacy of mitigation measures to fully offset impacts to Essential Fishery Habitat should be discussed with the National Marine Fisheries Service to determine if additional mitigation is needed to comply with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, Magnuson-Stevens Act; P.L. 104-297, as amended) and its implementing regulations.

7. Forested ridge clearing associated with project features should be avoided during the spring and fall to minimize impacts to staging or incoming migratory birds.

8. Water control structures should be designed to allow opening in the absence of an offsite power source after a major storm passage and water levels return to pre-storm levels.

9. There should be no changes to hydrology within the Mermentau Basin due to the proposed project that would adversely affect fish and wildlife resources.

10. The Service and the NMFS request that during development of the PED Project Management Plan (or equivalent document) we be allowed to review the projected funding and schedule to ensure that that sufficient time and funds are available during PED for the Service and NMFS to complete all work needed to fulfill the 2(b) requirements of the FWCA.

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX C

NOAA FISHERIES SERVICE
COORDINATION LETTER

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX D

CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX D
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APPENDIX D
CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

I. INTRODUCTION

A. Purpose and General Description. The *Calcasieu Lock, Louisiana Feasibility Study* (Study) addresses navigation improvement planning for the Gulf Intracoastal Waterway (GIWW) at and in the vicinity of Calcasieu Lock, Calcasieu Parish, LA. This Study was developed from the results of the GIWW Locks, Louisiana Reconnaissance Report, completed in May 1992. The Report involved a systems analysis of the GIWW locks west of the Mississippi River. It documented the need for replacements or improvements at Bayou Sorrel, Calcasieu, and Port Allen locks. This resulted in a 905(b) Reconnaissance Report specifically for Calcasieu Lock that was completed in 2001 and which found justification and Federal interest in further feasibility level study of the navigation delays and potential solutions at Calcasieu Lock. The principal problem to be addressed is the delays to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is critical.

B. Location. Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Calcasieu Parish, LA, approximately 10 miles south of Lake Charles, LA (figure D-1). Calcasieu Lock is a critical component of the LA portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins.

The Calcasieu River and Pass Ship Channel is located in southwest Louisiana in Calcasieu and Cameron Parishes, extending from Lake Charles, LA, southward into the Gulf of Mexico. The existing Calcasieu River and Pass Navigation project provides deep-draft navigation access to oil refineries, chemical plants, liquefied natural gas plants, and other facilities along the Calcasieu River.

The Calcasieu River and Pass Ship Channel project provides a 35- to 40-foot project depth channel from deep water in the Gulf of Mexico. The gulf reach of the channel is 42 feet deep, 800 feet wide, and it extends about 32 miles from the minus 42-foot Mean Low Gulf (MLG) contour to the Gulf shore. A 40- by 400-foot channel extends from the gulf shoreline about 34 miles upstream to the wharves of the Port of Lake Charles, and a 35- by 250-foot channel that extends further upstream another 2 miles to the vicinity of the Interstate 10 bridge in Lake Charles, LA. Turning basins are located at Mile 29 and Mile 36.

Construction of the Calcasieu Lock largely halted CSC-induced saltwater intrusion into the Mermentau Basin via the GIWW. At the same time, deepening of the CSC increased tidal amplitude, resulting in higher high tides and lower low tides. Thus, when the tide ebbs, a greater head differential is established on either side of the Calcasieu Lock. This increase in head resulted in a more efficient drainage pathway for Mermentau River freshwater inflows because the drainage potential is so much greater there than at the Catfish Point Control Structure, where drainage opportunity is very limited.

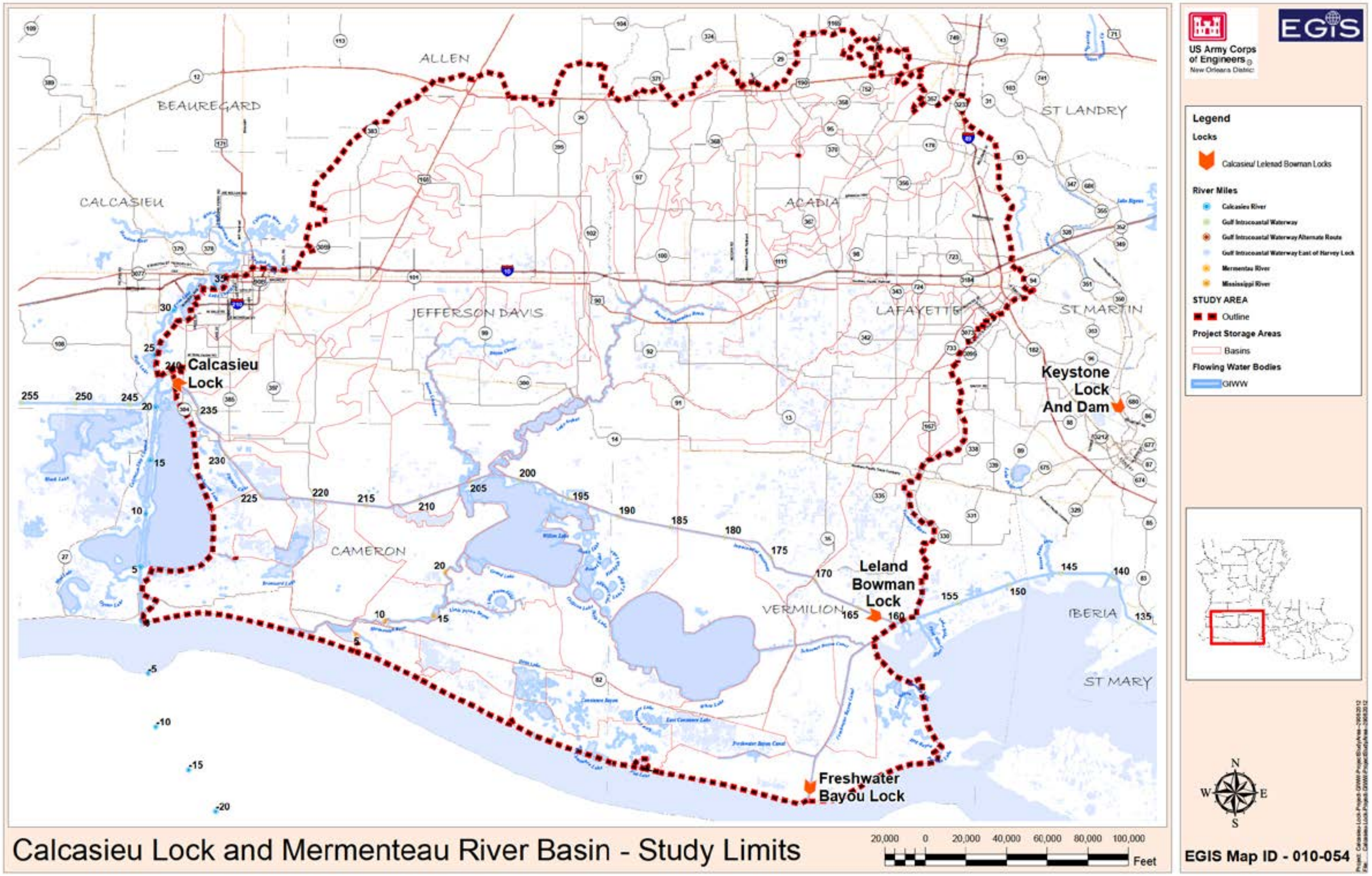

Figure D-1. Calcasieu Lock Study Area

Calcasieu Lock (photograph D-1) is located at the intersection of the Calcasieu River and Mile 238 of the GIWW. It serves as a barrier preventing saltwater intrusion from the Calcasieu River from entering the rice-growing areas of the Mermentau Basin via the GIWW. It is also provides flood risk management benefits when used to drain the Mermentau Basin after storm events. It operates in conjunction with the Leland Bowman Lock and the Catfish Point and Schooner Bayou control structures.

Photograph D-1. Aerial View of Calcasieu Lock

C. Authority. Authorization for the GIWW originally occurred in 1925 and has been modified and supplemented numerous times since then. The Calcasieu Lock was authorized as part of the *Mermentau River, Louisiana Flood Control, Irrigation and Navigation Project* (Mermentau Project) in the River and Harbor Act of 24 July 1946, Public Law No. 525, 79th Congress, 2nd Session, in accordance with the plan outlined in Senate Document No. 231. This document recommended modification of the existing project for the GIWW to provide for a salt water guard lock in the waterway. The document included other closely related improvements for flood control, navigation and salt water intrusion in the Mermentau River and Basin. The plan of improvement pertaining to the GIWW as contained in the project document is as follows:

> *"Gulf Intracoastal Waterway. An earth-chambered salt water guard lock, 425 by 75 by 12 feet, at or near Grand Lake Ridge, Mile 231 west of Harvey Lock."*

The Study is being performed by the US Army Corps of Engineers (Corps), New Orleans District (MVN), under the authority of the following resolutions:

> *A resolution at the request of Senators Long and Edwards of Louisiana, adopted by the Committee on Public Works of the United States Senate on September 29, 1972, that the "Board of Engineers for Rivers and Harbors, be, and is hereby, requested to review the reports on the Gulf Intracoastal Waterway (Louisiana-Texas Section, including the Morgan City-Port Allen Route) submitted in House Document 556, 87th Congress, Second Session, and subsequent reports, with a view to determining the advisability of modifying*

the existing project in any way at this time, particularly with regard to widening and deepening the existing and/or authorized channel."

A resolution at the request of Congressman Jack Brooks of Texas, adopted by the Committee on Public Works of the United States House of Representatives on October 12, 1972, that the "Board of Engineers for Rivers and Harbors, be, and is hereby, requested to review the reports on the Gulf Intracoastal Waterway (Louisiana-Texas Section, including the Morgan City-Port Allen Route) submitted in House Document 556, 87th Congress, second session, and subsequent reports, with a view to determining the advisability of modifying the existing project in any way at this time, particularly with regard to widening and deepening the existing and/or authorized channel."

D. Proposed Project

Alternative 1 (TSP). The TSP provides for the movement of flows from drainage events out of the Mermentau Basin consistent with the authorized purpose of the project. The project features are displayed in figure D-2, and are described as follows.

Dredging. The main feature of Alternative 1 (TSP) is a new channel to carry freshwater flows from the Mermentau Basin around the south side of the existing Calcasieu Lock to Bayou Choupique. This channel, constructed by hydraulic dredging, would be about 3,650 feet long and 300 feet wide at the top. The channel would be dredged to -12 MLG, with a channel bottom width of 80 feet, and 1V on 3H side slopes. A total of about 170,000 cy of dredged material would be generated from construction of the channel. Dredged material would be placed within the project area in two or more areas of open water totaling about 35 acres. Placement of dredged material into these disposal sites is intended to convert open water to estuarine marsh. For disposal of dredged materials, a pipeline would be routed through the existing open water using floating or submerged pipeline. To control scouring, about 17,200 tons of rip rap would be placed in the channel approximately 300 feet on either side of the water control structure at a thickness of 3 feet.

Culvert Structure. A gated water control structure would be constructed inside the channel at about its midpoint to control the passage of freshwater flows. The culvert structure consists of five openings (9' x 14' each) that would allow for the passage of the additional flow. The structure is pile-founded, reinforced concrete with cast iron sluice gates that can be closed when salinity levels in the ship channel are too high. The structure is 82-ft wide and 100-ft long. The invert of the structure is (-) 6.0, with the top of the structure at (+) 14.0. The top of the culvert is at (+) 5.0, which is higher than the anticipated flow line thru the area, so water cannot overtop the structure. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this phase.

The structure would be dewatered for maintenance purposes with the use of steel bulkheads on either side of the sluice gates. The operation of the gates would be done remotely, with hydraulic motors. Therefore, there is no requirement to man the structure during events in which the structure is opened. Power was assumed to be provided from the Calcasieu Lock area.

Mitigation. Mitigation for unavoidable losses to brackish marsh (14 acres) and forested spoil bank (11 acres) would be required and included as part of Alternative 1 (TSP). Marsh mitigation would consist of placement of about 50,000 cy of dredged material into a 10-acre open water area adjacent to the new channel to restore brackish marsh. Forested spoil bank mitigation would include implementation of tree stand improvements in about 15 acres of remaining forested habitat, plus the purchase of about 8 acres of credits from an approved bottomland hardwood mitigation bank serving the project area. Placement of about 120,000 cy of remaining hydraulically dredged material in about 25 acres of on-site open water areas to restore brackish marsh would be an incidental environmental benefit.

The assumed existing elevation for the disposal locations is -2.0 MLG, with placement to a target elevation for marsh of +1.5 MLG. To contain dredged material at these locations, earthen closures and weirs would be constructed around all disposal sites. All borrow material needed for closures and weirs would come from within the project area. About 4,000 LF of earthen closures (8.6 cy/lf) would be constructed to elevation +5.0 MLG, with a 5 ft crown, and 1V on 4H side slopes. About 16,500 LF of earthen weir containment (2.5 cy/lf) would be built along the existing marsh to elevation +3.5 MLG, with a 5 ft crown, and 1V on 4H side slopes.

Access/Staging. Construction access to the site would be via barge. A permanent access road would be constructed from the lock to the culvert structure for use by the lock personnel.

The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the maximum extent practicable. Construction activities would be subject to seasonal restrictions if any Bald Eagle nest or nesting area of the Brown Pelican or other colonial waterbirds were to become established in the project area (see Appendix A, Biological Assessment).

E. General Description of Dredged and Fill Material

1. General Characteristics of Material. Material to be dredged consists of natural coastal marsh substrate or sediments, as well as dredge spoil material that was deposited on the south side of Calcasieu Lock when the lock was originally constructed. Marsh material is predominantly organic and fat clays. The dredge spoil likely includes a greater proportion of silts and sands. The USACE “Definite Project Report, Calcasieu Lock” dated February 1949 characterizes soils at the lock site from the surface to -13.0 feet as consisting of alternate layers and lentils of clay sand, sandy clay, silty clay, clay silt, and silty sand. Material used for construction of earthen closures and weirs at dredge disposal locations would come from within the disposal areas. Rip rap would be used to protect the new channel bottom on either side of the water control structure. Concrete would be used to construct the water control structure.

2. Quantity of Material. The proposed action would require 170,000 cubic yards of earthen material obtained by hydraulic dredging, 17,200 tons of rip rap, about 4,000 LF of earthen closures (8.6 cy/lf), about 16,500 LF of earthen weir containment (2.5 cy/lf), and an undetermined amount of concrete (cy).

3. Source of Material.. All dredge material and earthen material used for containment weirs and dikes would come from within the project area. Rip rap and concrete would be supplied by off-site commercial sources.

F. Description of the Proposed Discharge Sites

1. Location and Size. About 50,000 cubic yards of material would be placed into a 10-acre open water disposal area adjacent to the new channel to restore brackish marsh. The remaining 120,000 cubic yards would be placed in about 25 acres of similar open water locations, either bordering the new channel or in an open water location about one mile southwest of the lock (figure D-2). Rip rap would extend about 300 feet from either side of the water control structure and across the new channel bottom, which would be 80 feet wide.

2. Type of Site. Open water

3. Type of Habitat. Open water and degraded brackish marsh

4. Timing and Duration of Discharge. The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the extent practicable. Construction activities would be subject to seasonal restrictions if any Bald Eagle nest or nesting area of the Brown Pelican or other colonial waterbirds were encountered in the project area prior to commencement of work.

G. Description of Disposal Method. Dredged material would be deposited through a dredge pipe. At the disposal sites, a hydraulic dredge would be used to discharge slurry into shallow water areas and degraded marsh areas. The assumed existing elevation for the disposal locations is -2.0 MLG, with placement to +1.5 MLG, which is assumed to be the elevation of existing adjacent marsh. Slurry would be discharged to an elevation of 3.5 MLG, which is assumed conducive to the development of wetlands habitat following dewatering and compaction. Material would be allowed to overflow over existing emergent marsh vegetation within the proposed disposal areas. Earthen containment dikes and weirs would be used to contain dredged material. Dikes consist of a minimum 5 foot crown width and slopes no steeper than 1 vertical to 4 horizontal. Dikes and weirs would be allowed to degrade naturally and would be breached and/or degraded within 3 years following construction to provide fisheries access if they do not sufficiently degrade following settlement of dredged material.

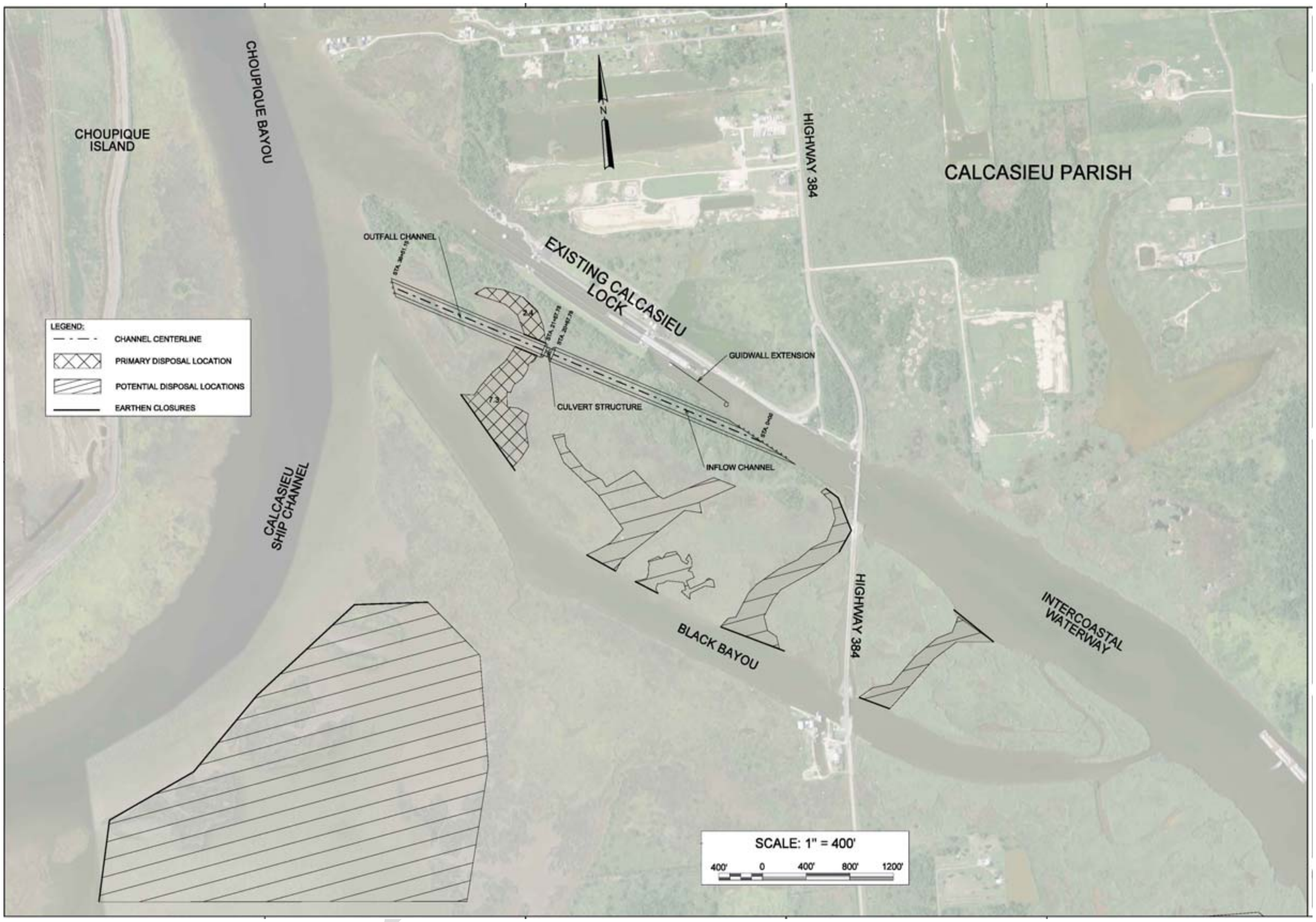

Figure D-2. Tentatively Selected Plan With Primary Disposal Area (Marsh Mitigation Site) and Secondary Disposal Sites Marked

II. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations

1. Comparison of Existing Substrate and Fill. Dredge activities consist of the creation of a new water conveyance channel to elevation -12 MLG for purposes of improving fresh water delivery. This channel would be installed through areas classified as open water, brackish marsh and upland forested habitats. The existing substrate material is primarily organic and fat clays to a 4 foot depth. This fill overlies swamp deposits composed of stiff to very stiff oxidized clays interbedded with layers and lenses of silts and sands are found beneath the swamp deposits.

2. Changes to Disposal Area Elevation. The assumed existing elevation for the disposal locations is -2.0 MLG, with placement to +1.5 MLG. Generally the disposal of dredge material would increase elevations in these areas from about 1to 3.5 feet. Dredging would reduce ground or substrate elevations in the newly created channel (bottom elevation, -12 MLG) by 10 to 20 feet along its 3,650 ft length. The crown elevations of earthen closures and weirs would be constructed above +1.5 MLG (+5.0 MLG and +3.5 MLG, respectively). Dikes and weirs would be allowed to degrade naturally and would be breached and/or degraded within 3 years following construction.

3. Migration of Fill. Dredged material placed for marsh nourishment would be contained within confinement dikes and weirs and is not expected to shift or move. Confinement dikes would be allowed to degrade naturally following the settlement of dredged material. If confinement dikes do not sufficiently degrade to provide fisheries and tidal ingress/egress following settlement of dredged material, they would be mechanically breached and/or degraded.

4. Duration and Extent of Substrate Change. The restoration project would cause temporary changes, due to construction and dredging, and permanent changes, as a result of construction of the new channel and disposal of dredged material to restore marsh. Substrate would be permanently altered in the locations of the new channel and disposal sites. These features are essential to fulfill project objectives.

5. Changes to Environmental Quality and Value. With no action, there would be no net change in environmental quality. Navigation would continue to be hampered by drainage flows through the Calcasieu Lock.

The proposed action would have an initial negative direct impact on existing wetland vegetation (brackish marsh), upland vegetation (forested spoil bank), wildlife and fisheries resources, and essential fish habitat within the construction footprint. However these effects would be temporary and no permanent effects would be expected because of proposed compensatory mitigation for the brackish marsh and forested spoil bank habitats affected. Additionally the new channel would operate to maintain the same drainage levels as currently provided by the existing lock, thus freeing the lock to be used for navigation more often, and improving the drainage of the Mermentau Basin. The project is anticipated to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the Nation.

6. Actions to Minimize Impacts. The selected features have been designed to work with the natural, fluid, soft environment of coastal Louisiana. Direct wetland impacts have been minimized to the extent possible while striving to accomplish project objectives. As previously stated, one of the project goals is to maintain freshwater circulation and redistribution within the study area while improving navigation passage. Drainage levels would not be altered because the new channel and structure would be operated to provide the same drainage level as the existing Calcasieu Lock provides. Material hydraulically dredged to construct the new bypass channel would be used to fill open water areas on site in order to serve the dual purpose of restoring brackish marsh and making a more effective channel. A portion of the dredged material would be used to fulfill mitigation requirements for 11 acres of brackish marsh impacts. The remaining material would be deposited into other open water areas adjacent to the new channel or in an area of degraded marsh along the east shore of Calcasieu Lake about a mile southwest of the lock. Use of the remaining material would create or restore about 25 acres of brackish marsh and provide incidental benefits to the project. Forested spoil bank mitigation would include implementation of tree stand improvements in about 15 acres of remaining forested habitat, plus the purchase of about 8 acres of credits from an approved bottomland hardwood mitigation bank serving the project area. Impacts associated with construction of features may include: increased total suspended solids and turbidity, increased dissolved nutrient levels, mobilization of existing contaminants in sediments, and decreases in dissolved oxygen levels. These impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs) and other applicable best management practices (BMPs). Impacts associated with soil compaction, rutting, rill, and gully erosion at surface alteration construction sites would be kept to a minimum by use of proper construction techniques such as silt curtains, temporary vegetative cover during construction, and re-grading and permanent vegetation establishment at the end of construction.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Alteration of Current Patterns and Water Circulation. Major flow channels within the project area are the Calcasieu River Ship Channel (CSC) and the GIWW. The Calcasieu Lock currently maintains the salinity barrier between the GIWW and Mermentau Basin. At the same time, deepening of the CSC increased tidal amplitude, resulting in higher high tides and lower low tides. Thus, when the tide ebbs, a greater head differential is established on either side of the Calcasieu Lock. This increase in head resulted in a more efficient drainage pathway for Mermentau River freshwater inflows because the drainage potential is so much greater there than at the Catfish Point Control Structure, where drainage opportunity is very limited. The increase in head results in flow too dangerous for navigation traffic to lock through. The project would create a new channel that would be used in conjunction with a gated structure to manage this drainage and reduce head at the lock thus enabling safe navigation through the lock more frequently. It would change the current patterns and water circulation at a localized level, shifting the drainage channel just south of the Calcasieu Lock.

2. Interference with Water Level Fluctuation. There would be no expected change in stage with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

3. Salinity Gradient Alteration. There would be no expected change in salinity gradients with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

4. Cumulative Effects on Water Quality

a. Salinity. There would be no expected cumulative change in salinity levels with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

b. Clarity. There would be no expected cumulative change in clarity with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

c. Color. There would be no expected cumulative change in color with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

d. Water Chemistry and Dissolved Gasses. There would be no expected cumulative change in water chemistry with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

e. Temperature. There would be no expected cumulative change in water temperature with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

f. Nutrients. There would be no expected cumulative change in nutrient levels with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

5. Changes to Environmental Quality and Value. There would be no expected change in environmental quality and value with the proposed action. The new channel would be used to manage drainage to the same levels as currently done with the Calcasieu Lock.

6. Actions Taken to Minimize Impacts. The future quality of Louisiana's coastal waters depends on a responsible, watershed approach to managing these activities. There are a number of present and future activities that would continue to occur without the proposed actions of the project and would affect surface water quality conditions in the coastal plain of Louisiana. Although there are Federal, state and local regulations in place to ensure protection of Louisiana's public health and natural resources, water quality conditions would likely improve with the programs in place. There are also Federal, state, local, and private ecosystem restoration projects being studied and undertaken to improve water quality conditions within the coastal area.

However, there are some activities that may potentially have negative effects on water quality and would continue to occur with or without the proposed project.

- Industrial, commercial, and residential development along the coast. With this activity comes increased point and nonpoint source pollution from sources such as wastewater treatment facilities and urban runoff from new development. Also, activities associated with maintaining and improving navigation along the coast would continue to occur.

- Flood–damage reduction projects would continue to be planned, designed, and constructed especially in areas highly susceptible to flood damages due to hurricanes and tropical storm events. With these activities, more alterations to the hydrology of the coast would potentially occur leading to areas of degraded water quality. Some projects, such as the Morganza to the Gulf Hurricane Protection Project, are incorporating resource sustainable design techniques that may aid in protecting significant resources such as surface waters of the state.

- The most notable activity that would continue to occur without the proposed Calcascieu Lock plan is the ongoing erosion/subsidence or land loss of the coastal areas. This would continue to unearth the expansive oil and gas infrastructure along the coast of Louisiana. This would be a precarious situation, especially during storm events and within navigable waterways. Exposed pipelines are vulnerable to navigation vessels striking them, which could lead to discharges into the Gulf of Mexico as well as other coastal water bodies. In the event of discharges, extensive ecological damage would probably occur. The owner(s) of the infrastructure could incur expensive fines and cleanup costs and vessel operators could be seriously injured. There are other forms of infrastructure that could potentially be exposed due to coastal erosion including wastewater collection systems and other commercial industry related systems.

Potential impacts associated with surface alteration sites would be minimized, as much as practicable, through the implementation of SWPPPs and other applicable BMPs. Impacts associated with soil compaction, rutting, rill, and gully erosion at surface alteration construction sites would be kept to a minimum by use of proper construction techniques such as silt curtains, temporary vegetative cover during construction, and regrading and permanent vegetation establishment at the end of construction. The occurrence of increased turbidity in the proposed project area waters would be temporary and minor.

C. Suspended Particulate / Turbidity Determinations

1. Alteration of Suspended Particulate Type and Concentration. Short-term direct impacts associated with construction of features could include increased total suspended solids and turbidity. These impacts would be minimized, as much as practicable, through implementation of appropriate Best Management Practices. Any increases in suspended solids and turbidity levels due to dredging related activities in the immediate project area would be minor, temporary, and highly localized. There would be no permanent impacts to suspended solids or turbidity.

2. Particulate Plumes Associated with Discharge. Any minor increases in suspended sediment and turbidity levels during dredge disposal would be temporary and highly localized. Minor reductions in dissolved oxygen levels associated with dredged material deposition would be temporary. Potential impacts associated with surface alteration sites would be minimized, as much as practicable, through the implementation of SWPPPs and other applicable BMPs. Impacts associated with soil compaction, rutting, rill, and gully erosion at surface alteration construction sites would be kept to a minimum by use of proper construction techniques such as silt curtains, temporary vegetative cover during construction, and regrading and permanent vegetation establishment at the end of construction.

3. Changes to Environmental Quality and Value. Increases in suspended solids and turbidity are expected to be a temporary result of construction activities that would return to normal levels after construction completion. No permanent change to environmental quality or values would be expected.

4. Actions to Minimize Impacts. Construction operations are expected to temporarily increase the concentration of suspended particulates. Particulates suspended during project construction would dissipate after construction activities are complete. Temporary increases in suspended particulates would be minimized as much as possible through BMPs such as creating containment berms, use of silt fencing, silt curtains, and seeding, to prevent the unnecessary transport of sediments within the construction and placement areas.

D. Contaminant Determinations. As reported in the Phase I ESA (Appendix M, *Hazardous, Toxic and Radioactive Waste*), during records research and site reconnaissance it was determined that no HTRW materials or RECs were observed or discovered at the sites of the proposed alternatives or adjacent properties. Should at anytime during the project HTRW concerns arise, USACE would take immediate actions to investigate the concerns. Should an HTRW issue be determined and the development of a response action required, USACE would coordinate with the appropriate Federal and state authorities to implement an approved response action.

Consistent with ER 1165-2-132, an HTRW investigation of the project area was conducted. Based upon findings from this investigation, the potential for direct impacts to the project area from implementation of the proposed action would be low and would likely continue to be low into the future.

Existing contaminants in sediments from the Calcasieu River and Calcasieu Lake may have been mobilized into the project area. Such contaminants include primarily trace metals and hydrophobic organic compounds. Such contaminants could be suspended during construction activities. However, they are not expected to occur within the project area in such quantities that they would impair water quality or be harmful to humans, fish, or wildlife.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on Plankton. No permanent impact to plankton is expected with the proposed action. Drainage and flows would be maintained at current levels. During actual construction activities of project features there would only be short-term minor adverse impacts to plankton populations due to increases in turbidity, low dissolved oxygen, and introduction of dredged sediments into shallow open water areas.

2. Effects on Benthos. Smothering of non-mobile benthic organisms could occur during construction. These impacts would be minimized, as much as practicable, through implementation of appropriate Best Management Practices. Construction of proposed features and dredging activities would destroy existing benthic communities at the proposed construction sites. Colonization of neighboring mitigation sites by benthos is expected after construction completion and would offset any loss as a result the construction of project features.

3. Effects on Nekton. Nekton comprise animals largely from three clades; vertebrates, mollusks, and crustaceans. Direct impacts to nekton from implementation of the proposed action would result from construction of project features. Impacts from construction of the channel and water control structure may include direct mortality due to burial; injury or mortality due to increased turbidity (e.g. gill abrasion, clogging of feeding apparatus); modified behavior, and short-term displacement. Dredging and placement of borrow material associated with dikes, weirs, and marsh creation would negatively impact benthic organisms and benthic feeders in dredge channels and disposal areas. Sessile and slow-moving aquatic invertebrates would be disturbed by the dredge activity or buried by the placed material. Construction activities would temporarily increase turbidity, temperatures, and biological oxygen demand (BOD), and decrease dissolved oxygen. These temporary conditions would likely displace more mobile nekton from the construction area. Following construction, displaced nekton would likely return to the project area and colonize the disposal areas.

4. Effects on the Aquatic Food Web. Louisiana's coastal wetlands are the richest estuaries in the country for fisheries production. Commercially and recreationally important species such as brown and white shrimp, blue crabs, eastern oysters, and menhaden are abundant. Louisiana has historically been an important contributor to the Nation's domestic fish and shellfish production, and is one of the primary contributors to the Nation's food supply for protein. While Louisiana has long been the Nation's largest shrimp and menhaden producer, it has also recently become the leading producer of blue crabs and oysters.

Phytoplankton are the primary producers of the water column, and form the base of the estuarine food web. Zooplankton provide the trophic link between the phytoplankton and the intermediate level consumers such as aquatic invertebrates, larval fish, and smaller forage fish species (Day et al. 1989). Although temporary direct impacts would occur through construction of project features, conditions for the aquatic food web are expected to return to current levels after construction is completed.

5. Effects on Threatened and Endangered Species. Federally listed threatened and endangered or candidate species known from Calcasieu and Cameron parishes that may occur in the project area include: American Alligator (*Alligator mississippiensis*), Green sea turtle (*Chelonia mydas*), Gulf Sturgeon (*Acipenser oxyrinchus desotoi*), Hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), Leatherback sea turtle (*Dermochelys coriacea*), Loggerhead sea turtle (*Caretta caretta*), Piping Plover (*Charadrius melodus*), West Indian Manatee (*Trichechus manatus*), and Sprague's pipit (*Anthus spragueii*). No adverse effects are expected to occur to any of these species, as described in Appendix A, Biological Assessment.

6. Effects on Other Wildlife. Direct adverse impacts to wildlife resources would primarily result from construction activities associated with the various features of the proposed action. Construction of the new channel would result in the loss of 11 acres of forested spoil bank and 14 acres of brackish marsh. Some wildlife species could be temporarily displaced from these areas as disturbance from construction activities could result in unfavorable conditions for nesting, foraging, and/or other activities. However, most species would move to an area with more favorable conditions and return after construction is completed.

Although nesting bald eagles are not known to occur in the project area, project implementation would follow the National Bald Eagle Management Guidelines. In order to minimize any potential impacts to bald eagle nests, the project area would be surveyed for nesting activity prior to any construction. The guidelines recommend:

- maintaining a specified distance between the activity and the nest (buffer area)

- maintaining natural areas (preferably forested) between the activity and nest trees (landscape buffers); and
- avoiding certain activities during the breeding season

In order to minimize any potential impacts to the brown pelican or other colonial nesting waterbirds that may be found in the project area, a qualified biologist would inspect the proposed work site for undocumented nesting colonies during the nesting season prior to construction. To minimize disturbance to colonial nesting waterbirds, the following restrictions on activity would be observed:

- for colonies containing nesting brown pelicans, all activity occurring within 2,000 feet of a rookery would be restricted to the non-nesting period (September 15 through March 31)
- for colonies containing nesting wading birds, anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery would be restricted to the non-nesting period (September 16 through April 1)

In summary, the project would not have any lasting permanent effects on wildlife species.

7. Actions to Minimize Impacts. Formulation of project plans and designs, evaluation of alternative plans, and development of operational scenarios for the preferred alternative, have all been conducted with the objective of minimizing potential negative impacts to the aquatic ecosystem. Study alternatives were developed in accordance with Corps planning guidance at ER 1105-2-100 which directs that projects be designed to avoid the need for compensatory fish and wildlife mitigation. Formulation of project alternatives was conducted in compliance with this guidance. Compensatory mitigation for the loss of 11 acres of impacted marsh would offset losses caused by construction; this mitigation would consist of placing dredged material into 10 acres of open water adjacent to the new bypass channel to restore the area to brackish marsh. In addition, remaining dredged material would be used to restore about 25 additional acres of brackish marsh in the project area which would result in an incidental environmental benefit to the project. The proposed mitigation plan is described in Appendix I, Mitigation Plan. For the loss of forested spoil bank upland habitat, the plan also calls for the implementation of forest management measures consisting of tree stand improvements within the remaining 15 acres of forest, as well as the purchase of about 8 credits from an approved bottomland hardwood mitigation bank serving the project area.

F. Proposed Disposal Site Determinations. Discussions pertaining to turbidity and suspended particulates are summarized under Section II. C in this document. Contaminants were discussed previously under Section II. D of this Evaluation. Implementation of the proposed project would have no significant adverse effects on municipal or private water supplies; recreational or commercial fisheries; water related recreation or aesthetics; parks; national monuments; or other similar preserves. Any adverse impacts would be minor and of short-term duration. An application for State water quality certification under Section 401 of the Clean Water Act is being submitted to the Louisiana Department of Environmental Quality.

G. Determination of Cumulative Effects on the Aquatic Ecosystem. Cumulative effects on the coastal ecosystem would primarily be related to the incremental impact of all past, present, and future actions affecting water quality within the Mermentau Basin such as: increase in fresh water areas; stabilization or decrease in salinities; increase in sediment introduction to the coastal zone, with accompanying minor increases in trace metals associated with bed sediments; increased total suspended sediments; increased turbidity; increased organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures along with fewer water temperature fluctuations; and increased dissolved oxygen levels. Likewise, there are no adverse alterations or destructions of unique or valuable habitats (except for brackish marsh, which the Louisiana Department of Wildlife and Fisheries regards as a rare (S3S4) natural community within the state), critical habitat for endangered species, important wildlife or fishery breeding or nursery areas, designated wildlife management or sanctuary areas, or natural forestlands. No adverse cumulative or secondary impacts to the biological productivity of wetland ecosystems are anticipated. Adverse disruptions of coastal wildlife and fishery migratory patterns are not anticipated.

H. Determination of Secondary Effects on the Aquatic Ecosystem. The project is to replace the functions of the Calcasieu Lock of maintaining the salinity barrier and drainage patterns between the Mermentau Basin and the GIWW in order to allow more frequent use of the lock by navigation. This objective would be accomplished by designing a new channel and gated structure immediately south of the lock. The new bypass channel would have a gated water control structure located near its longitudinal center. This structure would facilitate the passage of freshwater flows from the Mermentau basin to the east, which supports extensive and diverse freshwater marshes. These marshes in general have experienced impeded interior drainage due to modified natural drainage patterns in the coastal zone, and as a result the natural productivity and diversity of these marshes has become impaired. With this water control structure, the project would indirectly improve the ecological integrity of the Mermentau basin's freshwater marshes.

Activities are not expected to contribute to degradation of the coastal marshes. Therefore, the project features associated with implementation of the preferred alternative would not result in significant adverse indirect impacts to water quality, threatened or endangered species, essential fish habitat, water bottoms, plankton, vegetation, wildlife, or fisheries.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. No significant adaptations of the guidelines were made relative to this evaluation

B. No practicable alternatives to the proposed discharges could be identified that would have less adverse impacts on the aquatic ecosystem.

C. Chemical constituents of the dredged material released during dredging and disposal operations are not expected to exceed Louisiana Water Quality Standards.

D. The proposed action is compliant with the Endangered Species Act of 1973, as amended. The proposed action would not significantly affect endangered or threatened species or their critical habitats.

F. The proposed action is compliant with specified protection measures for marine sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972. All disposal sites and effects are inland waters. No effects would occur in ocean waters beyond the shoreline of the Gulf of Mexico.

G. Evaluation of Extent of Degradation of the Waters of the United States

1. Effects on Human Health and Welfare

a. Municipal and Private Water Supplies. Implementation of this Tentatively Selected Plan is not anticipated to have any direct impacts to drinking water supply or agricultural water use. The project would operate to maintain the current salinity drainage levels.

b. Recreational and Commercial Fisheries. Oyster seed beds, oyster leases, and commercial fishing does not currently occur within the project footprint. Recreational fishing is popular at the potential open water disposal site located to the southwest of the lock along the east shore of Calcasieu Lake, but less so at potential disposal sites within Black Bayou adjacent to the lock. Adverse effects to fishing opportunities related to construction activities would be temporary. Fishing opportunities would return upon construction completion.

c. Plankton. No permanent impact to plankton is expected with the proposed action. Drainage and flows would be maintained at current levels. During actual construction activities of project features there would only be short-term minor adverse impacts to plankton populations due to increases in turbidity, low dissolved oxygen, and introduction of dredged sediments into shallow open water areas.

d. Fish. Impacts to fisheries would be temporary. Fish would be expected to leave the area of construction, but return upon project completion.

e. Shellfish. Permanent impacts to shellfish would not be expected from the proposed action. Area conditions would be maintained to the same levels as pre-project conditions.

f. Wildlife. Wildlife is not expected to be impacted permanently by the project. Wildlife would be expected to leave the project area during construction, but return upon construction completion. All habitat losses would be mitigated on site.

g. Special Aquatic Sites. There are no special aquatic sites within the project area.

2. Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems. There are no long-term adverse effects associated with the discharge of fill on the life stages of aquatic life and other wildlife dependent on aquatic ecosystems within the project area. Impacts from dredging activities, disposals, and structural feature construction would be minimized, through the implementation of SWPPPs and other applicable BMPs. Impacts associated with soil compaction, rutting, rill, and gully erosion at construction sites would be kept to a minimum by use of proper construction techniques such as silt curtains, temporary vegetative cover during construction, and regrading and permanent vegetation establishment at the end of construction. Upon project completion, conditions are expected to return to pre-project levels.

3. Effects on Aquatic Ecosystem Diversity, Productivity and Stability. Construction of the Tentatively Selected Plan would result in short-term construction-related impacts within parts of the project area and would include some disturbance of fish and wildlife habitat. However, these impacts

would be temporary and would occur only during construction, and are not expected to alter the long-term productivity of the natural environment.

4. Effects on Recreational, Aesthetic, and Economic Resources. Impacts to recreational and aesthetic resources would be a result of construction activities and would be temporary. They would return to pre-project conditions after construction completion. Economic resources would expect a positive impact because the project would reduce unsafe currents and allow navigation traffic to be able to use Calcasieu Lock on a more frequent basis.

G. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem. As stated in Section II. E. (7) of this evaluation, formulation of project plans and designs, evaluation of alternative plans, and development of operational scenarios for the Tentatively Selected Plan, have all been conducted with the objective of minimizing potential negative impacts to the aquatic ecosystem. Habitats impacted by construction of the project would be mitigated primarily on-site but also off-site at an approved mitigation bank located in the project area's watershed. Therefore, there are no unavoidable adverse impacts as a result of the implementation of reasonable alternatives for this project. Placement of material excavated for construction of project features was designed in the context of beneficial use, to be used for marsh creation which would directly benefit habitat for wildlife and fish in the immediate vicinity of construction, offsetting loss of any habitat because of construction.

IV. EVALUATION RESPONSIBILITY

Evaluation Prepared By: Timothy K. George, Supervisory Ecologist, Regional Planning & Environmental Division North, St. Louis, USACE

Evaluation Reviewed By: Brian L. Johnson, Chief, Environmental Compliance Branch, Regional Planning & Environmental Division North, St. Louis, USACE

The proposed plan for the Calcasieu Lock Louisiana Feasibility Study which incorporates sites for dredging, excavation, disposal, and the placement of fill, complies with the requirement of guidelines, and includes appropriate and practicable methods to minimize adverse effects to the aquatic ecosystem.

Date:
Edward R. Fleming
Colonel, US Army
Commander & District Engineer

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX E

CONSISTENCY DETERMINATION

CALCASIEU LOCK LOUISIANA
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APPENDIX E

CONSISTENCY DETERMINATION

FIGURES

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX E

CONSISTENCY DETERMINATION

I. INTRODUCTION

Section 307 of the Coastal Zone Management Act of 1972, 16 U.S.C. 1451 et. seq. requires that "each federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs." In accordance with Section 307, a Consistency Determination has been prepared by the U.S. Army Corps of Engineers (USACE), New Orleans District (MVN) for the proposed navigation improvement planning for the Gulf Intracoastal Waterway (GIWW) at and in the vicinity of Calcasieu Lock, Cameron Parish, LA. The project area is within the state's designated coastal zone.

In addition to the navigation improvement, the proposed action would require mitigation for brackish marsh and forested spoil bank impacts. On-site compensatory brackish marsh mitigation would consist of placement of dredged material for the development of brackish marsh within a remnant of the historic Black Bayou meander; additional dredged material not required for mitigation would be placed at additional shallow open water disposal sites, potentially including other meander remnants as well as degraded marsh in Calcasieu Lake. Forested spoil bank mitigation would occur on-site as well as off-site at an approved mitigation bank. Coastal Use Guidelines were written in order to implement the policies and goals of the Louisiana Coastal Resources Program (LCRP), and serve as a set of performance standards for evaluating projects. Compliance with the LCRP, and therefore, Section 307, requires compliance with applicable Coastal Use Guidelines.

II. PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose of the proposed action is to maximize the efficiency of the Calcasieu Lock thereby contributing to the overall efficiency of GIWW as a nationally significant navigation system, while continuing to provide water management capability and salinity control to the Mermentau River Basin. The primary objective of the proposed action is to reduce drainage event induced navigation delays at Calcasieu Lock while minimizing the impacts to the surrounding area. The principal problem to be addressed is the delays to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. Navigation delays at Calcasieu Lock are primarily related to hydrologic conditions and how they affect the tonnage passing through the lock. The lock was constructed as a saltwater barrier, and it is operated to keep salt water from moving west to east into the Mermentau Basin, and to drain flood flows from east to west to the Calcasieu River. Delays can occur when there are excessive stages within the Mermentau Basin. During floods, the lock is frequently left open to drain water from the basin toward the Calcasieu River. During this situation, tows are forced to wait out the drainage event due to head differential in the lock chamber.

The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is critical. The Calcasieu Lock serves as a barrier preventing saltwater intrusion from the Calcasieu from entering the rice-growing areas of the Mermentau Basin via the GIWW. It is also provides flood risk management benefits when used to drain the Mermentau Basin after storm events. It operates in conjunction with Leland Bowman Lock and Catfish Point and Schooner Bayou control structures. While the problem and opportunities are localized physically at the lock, the range of alternatives has potential impacts at multiple scales.

Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Calcasieu Parish, LA, approximately 10 miles south of Lake Charles, LA (figure E-1). Calcasieu Lock is a critical component of the LA portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins. Therefore the primary study area is the Lock and immediate vicinity; however a broader approach was taken in assessing environmental, economic and hydraulic conditions and potential impacts. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast was evaluated.

The Calcasieu River and Pass Ship Channel is located in southwest Louisiana in Calcasieu and Cameron Parishes, extending from Lake Charles, LA, southward into the Gulf of Mexico. The existing Calcasieu River and Pass Navigation project provides deep-draft navigation access to oil refineries, chemical plants, liquefied natural gas plants, and other facilities along the Calcasieu River

The Calcasieu River and Pass Ship Channel project provides a 35- to 40-foot project depth channel from deep water in the Gulf of Mexico. The gulf reach of the channel is 42 feet deep, 800 feet wide, and it extends about 32 miles from the minus 42-foot Mean Low Gulf (MLG) contour to the Gulf shore. A 40- by 400-foot channel extends from the gulf shoreline about 34 miles upstream to the wharves of the Port of Lake Charles, and a 35- by 250-foot channel that extends further upstream another 2 miles to the vicinity of the Interstate 10 bridge in Lake Charles, LA. Turning basins are located at Mile 29 and Mile 36.

Construction of the Calcasieu Lock largely halted Calcasieu Ship Channel (CSC) -induced saltwater intrusion into the Mermentau Basin via the GIWW. At the same time, deepening of the CSC increased tidal amplitude, resulting in higher high tides and lower low tides. Thus, when the tide ebbs, a greater head differential is established on either side of the Calcasieu Lock. This increase in head resulted in a more efficient drainage pathway for Mermentau River freshwater inflows because the drainage potential is so much greater there than at the Catfish Point Control Structure, where drainage opportunity is very limited.

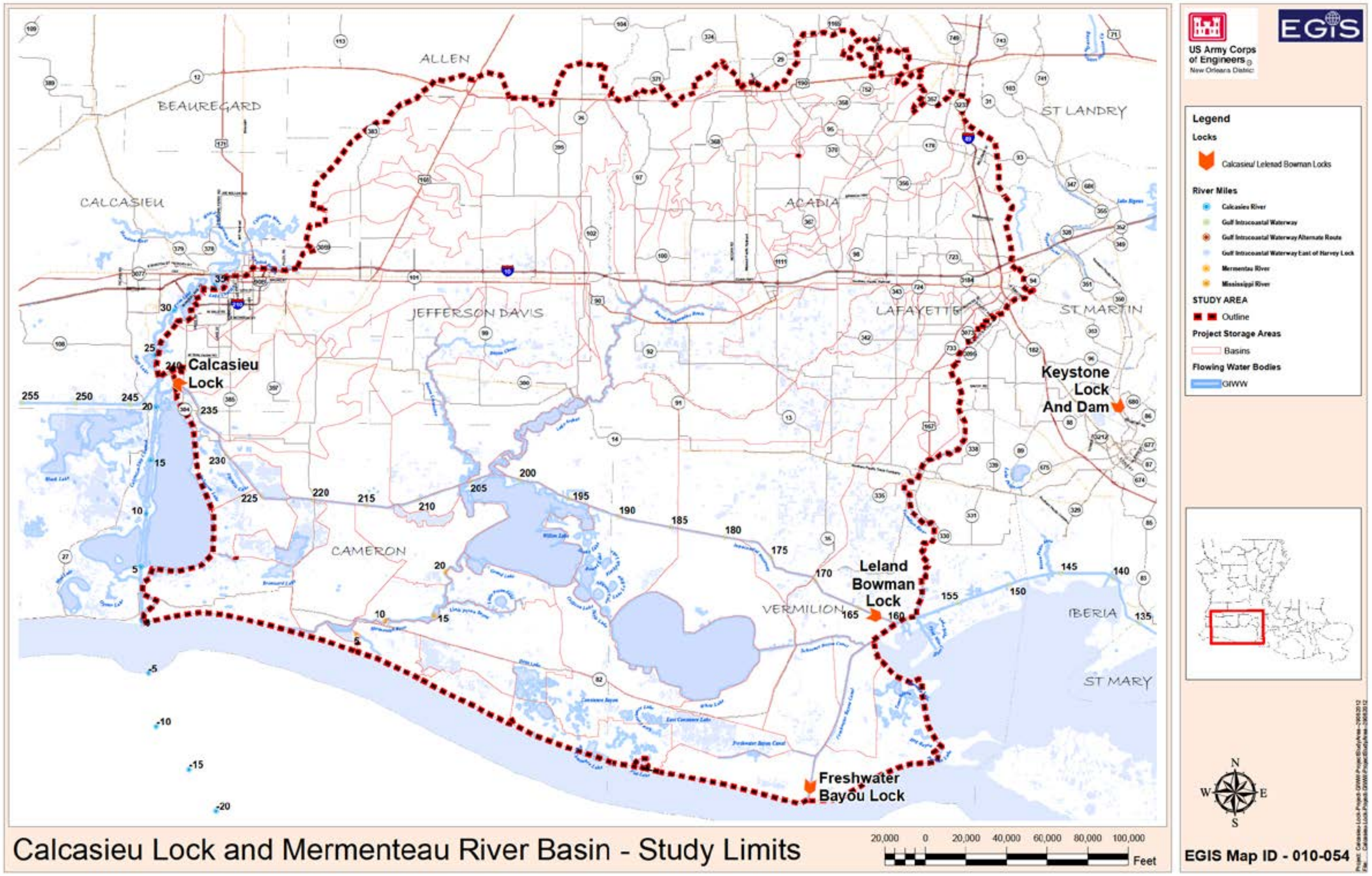


Figure E-1. Map Showing Project Location

III. DESCRIPTION OF THE PROPOSED ACTION

The main feature of the proposed action is a new channel to carry freshwater flows from the Mermentau Basin around the south side of the existing Calcasieu Lock. This channel, constructed by hydraulic dredging, would be about 3,600 feet long and 300 feet wide at the top. The channel would be dredged to -12 MLG, with a channel bottom width of 80 feet, and 1V on 3H side slopes. A 75-foot wide gated water control structure would be constructed inside the channel at about its midpoint to control the passage of freshwater flows. To control scouring, about 17,200 tons of riprap would be placed in the channel approximately 300 feet on either side of the water control structure at a thickness of 3 feet.

Construction access to the site would be via barge. A permanent access road would be constructed from the lock to the culvert structure for use by the lock personnel.

A total of about 170,000 cubic yards (cy) of dredged material would be generated from construction of the channel. Dredged material would be placed within the project area in two or more areas of open water totaling about 35 acres. Placement of dredged material into these disposal sites is intended to convert open water to estuarine marsh.

Mitigation for unavoidable losses to brackish marsh (14 acres) and forested spoil bank (11 acres) would be required and included as part of the proposed action. Marsh mitigation would consist of placement of about 50,000 cys of dredged material into a 10-acre open water area adjacent to the new channel to restore brackish marsh (Figure E-2). This 10-acre mitigation area is part of the 35 acres of disposal areas described above. Forested spoil bank mitigation would include implementation of tree stand improvements in about 15 acres of remaining forested habitat, plus the purchase of about 8 acres of credits from an approved bottomland hardwood mitigation bank serving the project area.

Placement of about 120,000 cys of remaining hydraulically dredged material in about 25 acres of on-site open water areas to restore brackish marsh would be an incidental environmental benefit. These 25 acres of disposal sites plus the 10-acre marsh mitigation site make up the 35 acres of disposal areas described above.

The assumed existing elevation for the disposal locations is -2.0 MLG, with placement to +1.5 MLG. To contain dredged material at these locations, earthen closures and weirs would be constructed around all disposal sites. All borrow material needed for closures and weirs would come from within the project area. About 4,000 LF of earthen closures (8.6 cy/lf) would be constructed to elevation +5.0 MLG, with a 5 ft crown, and 1V on 4H side slopes. About 16,500 LF of earthen weir containment (2.5 cy/lf) would be built along the existing marsh to elevation +1.5 MLG, with a 5 ft crown, and 1V on 4H side slopes.

The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the extent practicable. Construction activities would be subject to seasonal restrictions if any Bald Eagle nest or nesting area of the Brown Pelican or other colonial waterbirds were to become established in the project area (see Appendix A, *Biological Assessment*)

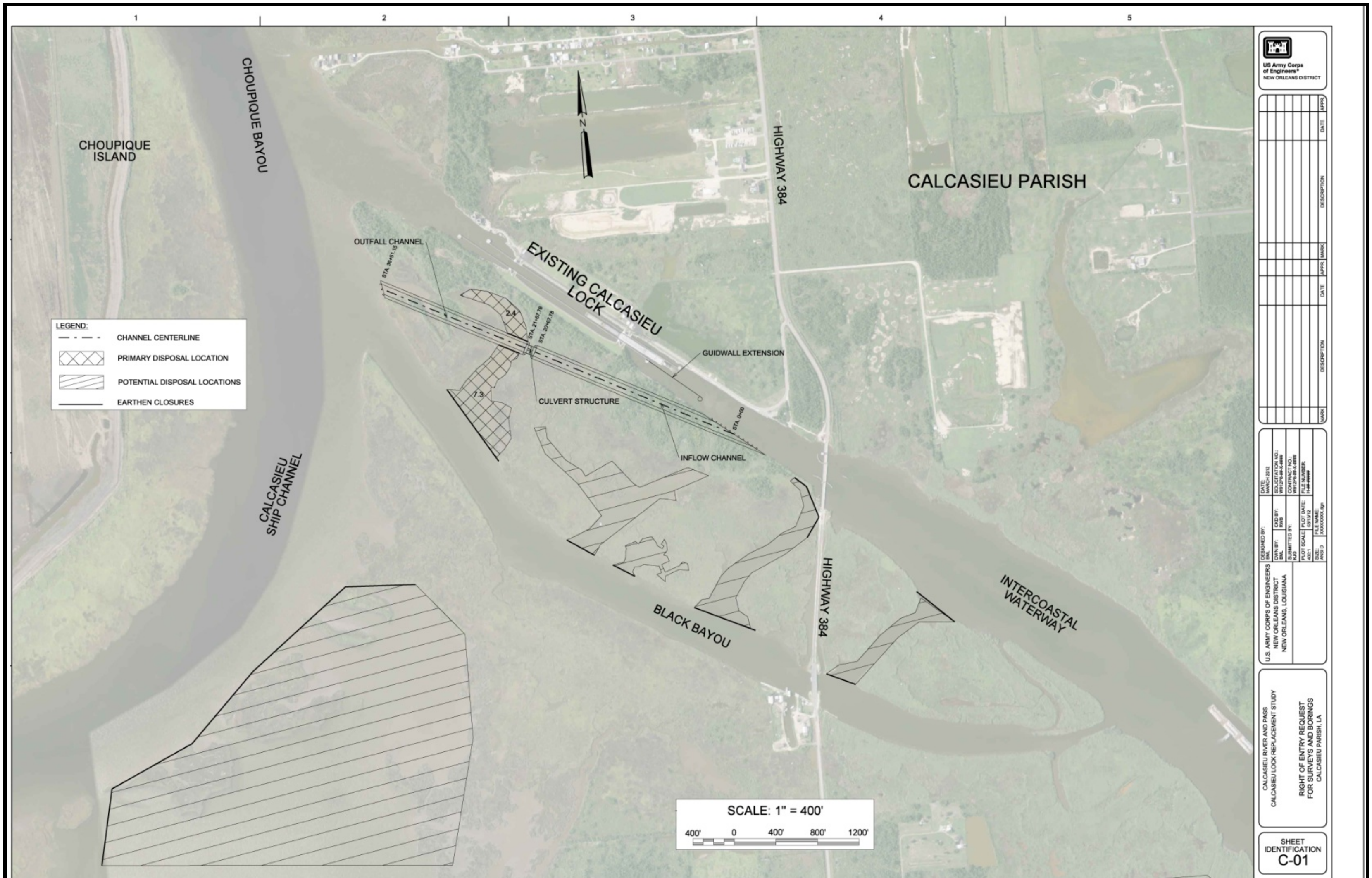


Figure E-2. Proposed Canal and Proposed Open Placement Areas for Brackish Marsh Creation

IV. GUIDELINES APPLICABLE TO ALL USES

Guideline 1.1. The guidelines must be read in their entirety. Any proposed use may be subject to the requirements of more than one guideline or section of guidelines and all applicable guidelines must be complied with.

Guideline 1.2. Conformance with applicable water and air quality laws, standards and regulations, and with those other laws, standards and regulations which have been incorporated into the coastal resources program shall be deemed in conformance with the program except to the extent that these guidelines would impose additional requirements.

Guideline 1.3. The guidelines include both general provisions applicable to all uses and specific provisions applicable only to certain types of uses. The general guidelines apply in all situations. The specific guidelines apply only to the situations they address. Specific and general guidelines should be interpreted to be consistent with each other. In the event there is an inconsistency, the specific should prevail.

Guideline 1.4. These guidelines are not intended to nor shall they be interpreted so as to result in an involuntary acquisition or taking of property.

Guideline 1.5. No use or activity shall be carried out or conducted in such a manner as to constitute a violation of the terms of a grant or donation of any lands or water-bottoms to the State or any subdivision thereof. Revocations of such grants and donations shall be avoided.

Guideline 1.6. Information regarding the following general factors shall be utilized by the permitting authority in evaluating whether the proposed use is in compliance with the guidelines.

1) type, nature and location of use

2) elevation, soil and water conditions and flood and storm hazard characteristics of site

3) techniques and materials used in construction, operation and maintenance of use

4) existing drainage patterns and water regimes of surrounding area including flow, circulation, quality, quantity and salinity; and impacts on them

5) availability of feasible alternative sites or methods – for implementing the use

6) designation of the area for certain uses as part of a local program

7) economic need for use and extent of impacts of use on economy of locality

8) extent of resulting public and private benefits

9) extent of coastal water dependency of the use

10) existence of necessary infrastructure to support the use and public costs resulting from use

11) extent of impacts on existing and traditional uses of the area and on future uses for which the area is suited

12) proximity to, and extent of impacts on important natural features such as beaches, barrier islands, tidal passes, wildlife and aquatic habitats, and forest lands

13) the extent to which regional, state and national interests are served including the national interest in resources and the siting of facilities in the coastal zones as identified in the coastal resources program

14) proximity to, and extent of impacts on, special areas, particular areas, or other areas of particular concern of the state program or local programs

15) likelihood of, and extent of impacts of, resulting secondary impacts and cumulative impacts

16) proximity to and extent of impacts on public lands or works, or historic, recreational or cultural resources

17) extent of impacts on navigation, fishing, public access, and recreational opportunities

18) extent of compatibility with natural and cultural setting

19) extent of long-term benefits or adverse impacts
Response to Guidelines 1.1 – 1.6: *These guidelines are acknowledged and have been addressed through the preparation of responses to the guidelines contained within the specific use categories. The proposed project would be in conformance with all applicable water and air quality laws, standards and regulations, and with those other laws, standards and regulations which have been incorporated into LCRP, and is deemed in conformance with the program except to the extent that these guidelines would impose additional requirements. The proposed activity shall not be carried out or conducted in such a manner as to constitute a violation of the terms of a grant or donation of any lands or water-bottoms to the State or any subdivision thereof. Information regarding potential impacts of the proposed action is provided herein and in the accompanying Environmental Impact Statement.*

Guideline 1.7. It is the policy of the coastal resources program to avoid the following adverse impacts. To this end, all uses and activities shall be planned, sited, designed, constructed, operated and maintained to avoid to the maximum extent practicable significant:

1) reductions in the natural supply of sediment and nutrients to the coastal system by alterations of freshwater flow.
Response: *The proposed project would not reduce the natural supply of sediment and nutrients to the coastal system. There would be minor temporary and localized increases in suspended sediment and turbidity levels during disposal of dredged material.*

2) adverse economic impacts on the locality of the use and affected governmental bodies.
Response: *No adverse impacts on the locality of use or governmental bodies would occur.*

3) detrimental discharges of inorganic nutrient compounds into coastal waters.
Response: *No significant discharges of inorganic compounds are anticipated.*

4) alterations in the natural concentration of oxygen in coastal waters.
Response: *Minor reductions in dissolved oxygen levels may occur during construction and dredge material placement efforts but are expected to be temporary.*

5) destruction or adverse alterations of streams, wetland, tidal passes, inshore waters and water bottoms, beaches, dunes, barrier islands, and other natural biologically valuable areas or protective coastal features.
Response: *Under the proposed action, about 11 acres of forested spoil bank and 14 acres of brackish marsh would be directly impacted by constructible elements, as based on geographic information system analysis. Placement of dredge material in the proposed open water mitigation area may cause temporary increases in turbidity and suspended solids concentrations, and a reduction in light penetration in the immediate vicinity.*

Adversely affects to these habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Natural Resources Conservation Service, and U.S. Army Corps of Engineers.

With regard to all alternatives considered, there would be unavoidable impacts to brackish marsh, intermediate marsh, and forested spoil bank that were considered by the HET to be permanent and for which compensatory mitigation would be required to offset such losses. In contrast, potential impacts to deeper open water habitats like Black Bayou were not regarded as permanent by the HET and did not warrant any such mitigation.

The primary objective of the proposed mitigation plan for the proposed action is to restore in acres the equivalent of -7.2 average annual habitat units (AAHUs) of forested spoil bank and -3.8 AAHUs of brackish marsh. To meet the requirement of "in-kind" mitigation, the HET desired that marsh restoration take the form of brackish marsh restoration. With regard to impacts to forested spoil bank, because this is a man-made habitat, there is no "in-kind" equivalent natural habitat that directly corresponds. Functionally, this habitat is similar to natural coastal levee or chenier forests. It is also similar to coastal bottomland hardwood forests. (The HET chose to use the wetland value assessment (WVA)'s chenier/ridge model rather than the bottomland hardwood forest model to assess forested spoil bank habitat impacts because the former was developed to also include forested spoil bank habitat whereas the latter was not.) Consequently the HET decided that mitigation planning strategies for forested spoil bank habitat would consist of 1) enhancement of existing forested spoil bank habitat, 2) restoration of degraded natural levee or chenier habitat, or 3) creation of "man-made" ridge or chenier habitat. Therefore, to meet the "in-kind" requirement for forested spoil bank habitat, mitigation would take the form of one or more of these approaches.

6) adverse disruption of existing social patterns.
Response: *Not applicable.*

7) alterations of the natural temperature regime of coastal waters.
Response: *Temperature regimes would not be adversely affected.*

8) detrimental changes in existing salinity regimes.
Response: *There would be minor changes in localized salinity regimes - in the vicinity of the confluence of the GIWW and the Calcasieu River.*

9) detrimental changes in littoral and sediment transport processes.
Response: *None anticipated.*

10) adverse effects of cumulative impacts.
Response: *Due to construction of the new bypass channel, about 11 acres of land loss would occur. No project-induced erosion or subsidence would occur, and no significant, secondary, or cumulative impacts of the proposed action would occur. This project would not result in reduced long-term biological productivity of the coastal ecosystem. Long-term biological productivity in the ecosystem would be enhanced through the placement of dredged material for marsh creation.*

11) detrimental discharges of suspended solids into coastal waters, including turbidity resulting from dredging.
Response: *Best management practices (BMPs) for short and long-term control of suspended solids would be implemented during excavation. Although the hydraulically dredged material is not anticipated to significantly alter ambient water quality conditions in the project area, water quality monitoring would be performed in the vicinity of the disposal sites to ensure that yet-to-be obtained Section 410 water quality certification conditions would be met.*

12) l) reductions or blockage of water flow or natural circulation patterns within or into an estuarine system or a wetland forest.
Response: *The proposed action is intended to increase the flow of freshwater out of the Mermentau Basin.*

13) discharges of pathogens or toxic substances into coastal waters.
Response: *No discharge of pathogens or toxic substances is anticipated.*

14) adverse alteration or destruction of archaeological, historical, or other cultural resources.
Response: *No archaeological, historical, or other cultural resource sites would be impacted by construction.*

15) fostering of detrimental secondary impacts in undisturbed or biologically highly productive wetland areas.
Response: *No adverse cumulative or secondary impacts to the biological productivity of wetland ecosystems are anticipated. The use of dredged material to create about 35 acres of emergent brackish marsh at shallow open water disposal sites would result in greater habitat diversity, additional estuarine habitat for economically important species, and improved recreation.*

16) adverse alteration or destruction of unique or valuable habitats, critical habitat for endangered species, important wildlife or fishery breeding or nursery areas, designated wildlife management or sanctuary areas, or forestlands.
Response: *With the proposed action, it is anticipated that there would be no direct or indirect impacts federally listed to threatened or endangered species. No critical habitat for any federally listed threatened, endangered, or candidate species has been designated within the project area or adjacent water bodies, and none of these species are known to breed within the project vicinity. Coordination with the U.S. Fish and Wildlife Service is ongoing and would be concluded prior to the final Environmental Impact Statement. The project would cause the loss of 14 acres of brackish marsh; the Louisiana Department of Wildlife and Fisheries considers brackish marsh as becoming a rare natural community in the state. The project includes on-site mitigation to fully compensate for this loss. The project would adversely affect essential fish habitat; coordination with the National Marine Fisheries Services is ongoing to determine if the proposed marsh mitigation and additional disposal sites to create and restore marsh would offset these EFH impacts. This coordination would be concluded prior to the final EIS. Forestlands affected by the project consist of forested spoil bank habitat that is not natural yet functions similarly to natural ridge or chenier habitat; the project includes on-site and offsite mitigation to compensate for this upland loss.*

17) adverse alteration or destruction of public parks, shoreline access points, public works, designated recreation areas, scenic rivers, or other areas of public use and concern.
Response: *No adverse alteration or destruction of public parks, shoreline access points, public works, designated recreation areas, scenic rivers, or other areas of public use and concern is anticipated*

18) adverse disruptions of coastal wildlife and fishery migratory patterns.
Response: *Adverse disruptions of coastal wildlife and fishery migratory patterns are not anticipated. Short-term, minor disruptions to coastal wildlife would occur during disposal operations; however, these impacts would be minimally disruptive since most wildlife species in the area are mobile and would move to adjacent undisturbed areas during construction activities. Creation and restoration of emergent marsh and other coastal habitat would provide additional resting areas for many migratory neotropic birds, seabirds, waterfowl, and other organisms.*

19) land loss, erosion and subsidence.
Response: *About 11 acres of land would be lost to construction of a new bypass channel around the existing Calcasieu lock. The affected land is a spoil bank created when the lock was constructed in 1950 and dredged material was side cast into marsh along the south side of the lock's south guidewall. No other land loss is expected, nor is any project-induced erosion or subsidence expected. Background subsidence of coastal marsh has been accounted for in the project's Wetland Value Assessment.*

20) increases in the potential for flood, hurricane or other storm damage, or increases in the likelihood that damage will occur from such hazards.

Response: *Because marsh has been shown to provide a greater reduction in hurricane storm surge than open water, restored marsh would offer an incremental benefit in reducing hurricane damage.*

21) reductions in the long-term biological productivity of the coastal ecosystem.
Response: *This project would not result in reduced long-term biological productivity of the coastal ecosystem. Long-term biological productivity in the ecosystem would be enhanced through the placement of dredged material for marsh creation. The proposed action would help offset coastal erosion and provide a low cost method of creating coastal wetlands including additional bird habitat, emergent marsh, and shallow open water supportive of submerged aquatic vegetation and productive fisheries habitat.*

Guideline 1.8. In those guidelines in which the modifier "maximum extent practicable" is used, the proposed use is in compliance with the guideline if the standard modified by the term is complied with. If the modified standard is not complied with, the use will be in compliance with the guideline if the permitting authority finds, after a systematic consideration of all pertinent information regarding the use, the site and the impacts of the use as set forth in guideline 1.6, and a balancing of their relative significance, that the benefits resulting from the proposed use would clearly outweigh the adverse impacts resulting from non-compliance with the modified standard and there are no feasible and practical alternative locations, methods and practices for the use that are in compliance with the modified standard and:

1) significant public benefits will result from the use, or;

2) the use would serve important regional, state or national interests, including the national interest in resources and the siting of facilities in the coastal zone identified in the coastal resources program, or;

3) the use is coastal water dependent. - The systematic consideration process shall also result in a determination of those conditions necessary for the use to be in compliance with the guideline. Those conditions shall assure that the use is carried out utilizing those locations, methods and practices which maximize conformance to the modified standard; are technically, economically, environmentally, socially and legally feasible and practical and minimize or offset those adverse impacts listed in guideline
Response: *Acknowledged.*

Guideline 1.9. Uses shall to the maximum extent practicable be designed and carried out to permit multiple concurrent uses which are appropriate for the location and to avoid unnecessary conflicts with other uses of the vicinity.
Response: *The proposed action would provide for multiple, concurrent uses where appropriate and avoid unnecessary conflicts of other uses in the vicinity.*

Guideline 1.10. These guidelines are not intended to be, nor shall they be, interpreted to allow expansion of governmental authority beyond that established by La. R.S. 49:213.1 through 213.21, as amended; nor shall these guidelines be interpreted so as to require permits for specific uses legally commenced or established prior to the effective date of the coastal use permit program nor to normal maintenance or repair of such uses.
Response: *Acknowledged.*

V. GUIDELINES FOR LEVEES

Guideline 2.1 – 2.6. *The proposed action would not involve the construction of levees, and therefore, these guidelines are not applicable.*

VI. GUIDELINES FOR LINEAR FACILITIES

Guideline 3.1. Linear use alignments shall be planned to avoid adverse impacts on areas of high biological productivity or irreplaceable resource areas.
Response: *Acknowledge.*

Guideline 3.2. Linear facilities involving the use of dredging or filling shall be avoided in wetland and estuarine areas to the maximum extent practicable.
Response: *Acknowledge. All impacts would be mitigated for.*

Guideline 3.3. Linear facilities involving dredging shall be of the minimum practical size and length.
Response: *Acknowledge.*

Guideline 3.4. To the maximum extent practicable, pipelines shall be installed through the "push ditch" method and the ditch backfilled.
Response: *N/A*

Guideline 3.5. Existing corridors, rights of way, canals, and streams shall be utilized to the maximum extent practicable for linear facilities.
Response: *Acknowledge.*

Guideline 3.6. Linear facilities and alignments shall be, to the maximum extent practicable, designed and constructed to permit multiple uses consistent with the nature of the facility.
Response: *Acknowledge.*

Guideline 3.7. Linear facilities involving dredging shall not traverse or adversely affect any barrier island.
Response: *Acknowledge.*

Guideline 3.8. Linear facilities involving dredging shall not traverse beaches, tidal passes, protective reefs or other natural gulf shoreline unless no other alternative exists. If a beach, tidal pass, reef or other natural gulf shoreline must be traversed for a non navigation canal, they shall be restored at least to their natural condition immediately upon completion of construction. Tidal passes shall not be permanently widened or deepened except when necessary to conduct the use. The best available restoration techniques which improve the traversed area's ability to serve as a shoreline shall be used
Response: *N/A*

Guideline 3.9. Linear facilities shall be planned, designed, located and built using the best practical techniques to minimize disruption of natural hydrologic and sediment transport patterns, sheet flow, and water quality, and to minimize adverse impacts on wetlands.
Response: *Acknowledge.*

Guideline 3.10. Linear facilities shall be planned, designed, and built using the best practical techniques to prevent bank slumping and erosion, saltwater intrusion, and to minimize the potential for inland movement of storm generated surges. Consideration shall be given to the use of locks in navigation canals and channels which connect more saline areas with fresher areas.

Response: *Acknowledge. The project includes a salt-water barrier (gated water control structure) in the new bypass channel.*

Guideline 3.11. All non navigation canals, channels and ditches which connect more saline areas with fresher areas shall be plugged at all waterway crossings and at intervals between crossings in order to compartmentalize them. The plugs shall be properly maintained.

Response: *Acknowledge.*

Guideline 3.12. The multiple use of existing canals, directional drilling and other practical techniques shall be utilized to the maximum extent practicable to minimize the number and size of access canals, to minimize changes of natural systems and to minimize adverse impacts on natural areas and wildlife and fisheries habitat.

Response: *Acknowledge.*

Guideline 3.13. All pipelines shall be constructed in accordance with parts 191, 192, and 195 of Title 49 of the Code of Federal Regulations, as amended, and in conformance with the Commissioner of Conservation's Pipeline Safety Rules and Regulations and those safety requirements established by La. R. S. 45:408, whichever would require higher standards.

Response: *N/A*

Guideline 3.14. Areas dredged for linear facilities shall be backfilled or otherwise restored to the pre existing conditions upon cessation of use for navigation purposes to the maximum extent practicable.

Response: *Acknowledge.*

Guideline 3.15. The best practical techniques for site restoration and re-vegetation shall be utilized for all linear facilities.

Response: *Acknowledge.*

Guideline 3.16. Confined and dead end canals shall be avoided to the maximum extent practicable. Approved canals must be designed and constructed using the best practical techniques to avoid water stagnation and eutrophication.

Response: *Acknowledge.*

VII. GUIDELINES FOR DREDGED MATERIAL DEPOSITION

Guideline 4.1. Spoil shall be deposited utilizing the best practical techniques to avoid disruption of water movement, flow, circulation and quality.

Response: *Disruption of the movement, flow, circulation, or quality of water caused by hydraulic dredging deposition, in association with the proposed action, is expected to be short-term and temporary. Any minor increases in suspended sediment and turbidity levels during material deposition would be temporary and highly localized. Controlled and* *monitored deposition of dredged material would ensure placement to proper heights for desired habitat creation.*

Guideline 4.2. Spoil shall be used to the maximum extent practicable to improve productivity or create new habitat, reduce or compensate for environmental damage done by dredging activities, or prevent environmental damage. Otherwise, existing spoil disposal areas or upland disposal shall be utilized to the maximum extent practicable rather than creating new disposal areas.

Response: *Acknowledge. All hydraulically dredged material generated from construction of the new bypass channel would be placed in shallow water areas in or adjacent to the project area to create or restore about 35 acres of brackish marsh habitat . This placement includes the brackish marsh mitigation site.*

Guideline 4.3. Spoil shall not be disposed of in a manner which could result in the impounding or draining of wetlands or the creation of development sites unless the spoil deposition is part of an approved levee or land surface alteration project.

Response: *Acknowledge.*

Guideline 4.4. Spoil shall not be disposed of on marsh, known oyster or clam reefs or in areas of submersed vegetation to the maximum extent practicable.

Response: *The proposed action would not involve the placement of spoil on a marsh, oyster or clam reefs, or areas of submerged vegetation. Submersed aquatic vegetation is uncommon within the project area.*

Guideline 4.5. Spoil shall not be disposed of in such a manner as to create a hindrance to navigation or fishing, or hinder timber growth.

Response: *The proposed action would not create a hindrance to navigation or fishing, or hinder timber growth.*

Guideline 4.6. Spoil disposal areas shall be designed and constructed and maintained using the best practical techniques to retain the spoil at the site, reduce turbidity, and reduce shoreline erosion when appropriate.

Response: *Acknowledge. All disposal areas would be contained and designed for the creation or restoration of brackish marsh.*

Guideline 4.7 The alienation of state owned property shall not result from spoil deposition activities without the consent of the Department of Natural Resources.

Response: *The proposed action would not result in the alienation of state owned property.*

VIII. GUIDELINES FOR SHORELINE MODIFICATIONS

Response: *No shoreline modifications are part of the currently proposed action; the need for any stone armoring along Black Bayou or the GIWW will be determined during the next (preconstruction engineering and design) project phase.*

Guideline 5.1. Non-structural methods of shoreline protection shall be utilized to the maximum extent practicable.

Guideline 5.2. Shoreline modification structures shall be designed and built using best practical techniques to minimize adverse environmental impacts.

Guideline 5.3. Shoreline modification structures shall be lighted or marked in accordance with U.S. Coast Guard regulations, not interfere with navigation, and should foster fishing, other recreational opportunities, and public access.

Guideline 5.4. Shoreline modification structures shall be built using best practical materials and techniques to avoid the introduction of pollutants and toxic substances into coastal waters.

Guideline 5.5. Piers and docks and other harbor structures shall be designed and built using best practical techniques to avoid obstruction of water circulation.

Guideline 5.6. Marinas, and similar commercial and recreational developments shall to the maximum extent practicable not be located so as to result in adverse impacts on open productive oyster beds, or submersed grass beds.

Guideline 5.7. Neglected or abandoned shoreline modification structures, piers, docks, mooring and other harbor structures shall be removed at the owner's expense, when appropriate.

Guideline 5.8. Shoreline stabilization structures shall not be built for the purpose of creating fill areas for development unless part of an approved surface alteration use.

Guideline 5.9. Jetties, groins, breakwaters and similar structures shall be planned, designed and constructed so as to avoid to the maximum extent practicable downstream land loss and erosion

IX. GUIDELINES FOR SURFACE ALTERATIONS

Guideline 6.1. Industrial, commercial, urban, residential, and recreational uses are necessary to provide adequate economic growth and development. To this end, such uses will be encouraged in those areas of the coastal zone that are suitable for development. Those uses shall be consistent with the other guidelines and shall, to the maximum extent practicable, take place only:

1) on lands 5 feet or more above sea level or within fast lands; or

2) on lands which have foundation conditions sufficiently stable to support the use, and where flood and storm hazards are minimal or where protection from these hazards can be reasonably well achieved, and where the public safety would not be unreasonably endangered; and

   - the land is already in high intensity of development use, or
   - there is adequate supporting infrastructure, or
   - the vicinity has a tradition of use for similar habitation or development

Response: *Acknowledge.*

Guideline 6.2. Public and private works projects such as levees, drainage improvements, roads, airports, ports, and public utilities are necessary to protect and support needed development and shall be encouraged. Such projects shall, to the maximum extent practicable, take place only when:

1. they protect or serve those areas suitable for development pursuant to Guideline 6.1; and

2. they are consistent with the other guidelines; and

3. they are consistent with all relevant adopted state, local and regional plans.

Response: *Acknowledge.*

Guideline 6.3. BLANK (Deleted)

Guideline 6.4. To the maximum extent practicable wetland areas shall not be drained -or filled. Any approved drain or fill project shall be designed and constructed using best practical techniques to minimize present and future property damage and adverse environmental impacts.

Response: *Acknowledge. The brackish marsh losses resulting from the tentatively selected plan (Alternative 1) are unavoidable. Construction of the new bypass channel and establishment of the dredged material disposal areas would be designed using best management practices.*

Guideline 6.5. Coastal water dependent uses shall be given special consideration in permitting because of their reduced choice of alternatives.

Response: *Acknowledge.*

Guideline 6.6. Areas modified by surface alteration activities shall, to the maximum extent practicable, be re-vegetated, refilled, cleaned and restored to their predevelopment condition upon termination of the use.

Response: *Acknowledge.*

Guideline 6.7. Site clearing shall to the maximum extent practicable be limited to those areas immediately required for physical development.

Response: *Acknowledge.*

Guideline 6.8. Surface alterations shall, to the maximum extent practicable, be located away from critical wildlife areas and vegetation areas. Alterations in wildlife preserves and management areas shall be conducted in strict accord with the requirements of the wildlife management body.

Response: *Acknowledge.*

Guideline 6.9. Surface alterations which have high adverse impacts on natural functions shall not occur, to the maximum extent practicable, on barrier islands and beaches, isolated cheniers, isolated natural ridges or levees,' or in wildlife and aquatic species breeding or spawning areas, or in important migratory routes.

Response: *Acknowledge. The spoil bank area along the south side of Calcasieu lock is not a natural ridge or chenier (these natural features are located at least 15 miles to the south of the project area).*

Guideline 6.10. The creation of low dissolved oxygen conditions in the water or traps for heavy metals shall be avoided to the maximum extent practicable.

Response: *Acknowledge.*

Guideline 6.11. Surface mining and shell dredging shall be carried out utilizing the best practical techniques to minimize adverse environmental impacts.

Response: *N/A*

Guideline 6.12. The creation of underwater obstructions which adversely affect fishing or navigation shall be avoided to the maximum extent practicable.

Response: *N/A*

Guideline 6.13. Surface alteration sites and facilities shall be designed, constructed, and operated using the best practical techniques to prevent the release of pollutants or toxic substances into the environment and minimize other adverse impacts.

Response: *Acknowledge. Such sites and facilities as well as fill material used for construction would be free from hazardous and regulated solid wastes.*

Guideline 6.14. To the maximum extent practicable only material that is free of contaminants and compatible with the environmental setting shall be used as fill.

Response: *Acknowledge. Fill material used for the construction would be free from hazardous and regulated solid wastes.*

X. GUIDELINES FOR HYDROLOGIC AND SEDIMENT TRANSPORT MODIFICATIONS

Guideline 7.1. The controlled diversion of sediment laden waters to initiate new cycles of marsh building and sediment nourishment shall be encouraged and utilized whenever such diversion will enhance the viability and productivity of the outfall area. Such diversions shall incorporate a plan for monitoring and reduction and/or amelioration of the effects of pollutants present in the freshwater source.

Response: *Acknowledge.*

Guideline 7.2. Sediment deposition systems may be used to offset land loss, to create or restore wetland areas or enhance building characteristics of a development site. Such systems shall only be utilized as part of an approved plan. Sediment from these systems shall only be discharged in the area that the proposed use is to be accomplished.

Response: *It is anticipated that once dredged material settles to marsh elevations, the area would naturally vegetate and become supportive of suitable habitat for a variety of aquatic, terrestrial, and avian wildlife species. Furthermore, this marsh creation would help to offset land loss in the project vicinity. The marsh mitigation site would be planted with appropriate native plant species.*

Guideline 7.3. Undesirable deposition of sediments in sensitive habitat or navigation areas shall be avoided through the use of the best preventive techniques.

Response: *Acknowledged. Best preventative techniques would be utilized to avoid undesirable deposition of sediments into sensitive habitat or navigation areas.*

Guideline 7.4. The diversion of freshwater through siphons and controlled conduits and channels, and overland flow to offset saltwater intrusion and to introduce nutrients into wetlands shall be encouraged and utilized whenever such diversion will enhance the viability and productivity of the outfall area.

Such diversions shall incorporate a plan for monitoring and reduction and/or amelioration of the effects of pollutants present in the freshwater source.

Response: *The proposed action does not include such diversions.*

Guideline 7.5. Water or marsh management plans shall result in an overall benefit to the productivity of the area.

Response: *Acknowledged.*

Guideline 7.6. Water control structures shall be assessed separately based on their individual merits and impacts and in relation to their overall water or marsh management plan of which they are a part.

Response: *Acknowledged. The new bypass channel would have a gated water control structure located near its longitudinal center. This structure would facilitate the passage of freshwater flows from the Mermentau basin to the east, which supports extensive and diverse freshwater marshes. These marshes in general have experienced impeded interior drainage due to modified natural drainage patterns in the coastal zone, and as a result the natural productivity and diversity of these marshes has become impaired. With this water control structure, the project would indirectly improve the ecological integrity of the Mermentau basin's freshwater marshes.*

Guideline 7.7. Weirs and similar water control structures shall be designed and built using the best practical techniques to prevent "cut arounds," permit tidal exchange in tidal areas, and minimize obstruction of the migration of aquatic organisms.

Response: *Acknowledge. The dredged material disposal area would be contained and the retention berms would include dikes or weirs; these would be designed to facilitate tidal exchange and the passage of aquatic organisms into the created or restored marsh.*

Guideline 7.8. Impoundments which prevent normal tidal exchange and/or the migration of aquatic organisms shall not be constructed in brackish and saline areas to the maximum extent practicable.

Response: *The proposed action does not include the creation of impoundments.*

Guideline 7.9. Withdrawal of surface and ground water shall not result in saltwater intrusion or land subsidence to the maximum extent practicable.

Response: *N/A*

XI. GUIDELINES FOR DISPOSAL OF WASTES

Guidelines 8.1 – 8.9. The proposed action would not involve the disposal of wastes; therefore, these guidelines are not applicable.

XII. GUIDELINES FOR USES THAT RESULT IN THE ALTERATION OF WATERS DRAINING INTO COASTAL WATERS

Guideline 9.1. Upland and upstream water management programs which affect coastal waters and wetlands shall be designed and constructed to preserve or enhance existing water quality, volume, and rate of flow to the maximum extent practicable.

Response: *Acknowledged.*

Guideline 9.2. Runoff from developed areas shall to the maximum extent practicable be managed to simulate natural water patterns, quantity, quality and rate of flow.

Response: *Acknowledged.*

Guideline 9.3. Runoff and erosion from agricultural lands shall be minimized through the best practical techniques.

Response: *Acknowledged.*

XIII GUIDELINES FOR OIL, GAS, AND OTHER MINERAL ACTIVITIES

Guidelines 10.1 – 10.14. The proposed action would not involve oil, gas, and other mineral activities; therefore, these guidelines are not applicable.

XIV. CONSISTENCY DETERMINATION

The principal problem to be addressed is the delays to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is critical.

Placement of dredged material in the proposed shallow open water disposal sites would result in the creation of approximately 35 acres of productive brackish marsh habitat (including 10 acres of compensatory wetland mitigation and an estimated 25 acres of additional marsh restoration) , which would ultimately provide valuable fisheries and wildlife habitat and more productive categories of essential fish habitat, and improve shoreline protection and storm surge attenuation capacity in this portion of the Calcasieu River Basin.

The proposed action was planned to avoid adverse impacts on high biological productivity or irreplaceable resource areas. The footprint was minimized to the extent practicable to avoid wetland and open water areas. The proposed actions would provide significant public benefit and would serve important regional, state, and national interest, and the benefits resulting from the proposed action clearly outweighs the adverse impacts.

Based on this evaluation, the US Army Corps of Engineers has determined that the proposed action is consistent, to the maximum extent practicable, with the State of Louisiana's Coastal Resources Program.

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX F

STATE HISTORIC PRESERVATION OFFICER
COORDINATION LETTER

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, ROCK ISLAND DISTRICT
CLOCK TOWER BUILDING- PO BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF

March 21, 2012

Regional Planning and Environmental
Division North (RPEDN)

Ms. Pam Breaux
Louisiana State Historic Preservation Officer
Office of Cultural Development
P.O. Box 44247
Baton Rouge, LA 70804-44247

No known historic properties will be affected by this undertaking. This effect determination could change should new information come to our attention.

[illegible signature] 3-26-12
Pam Breaux Date
State Historic Preservation Officer

Dear Ms. Breaux:

The US Army Corps of Engineers, New Orleans District (District) has been conducting the Calcasieu Lock, Calcasieu Parish, Louisiana Feasibility Study (Study) authorized under resolutions found in House Document 556, 87th Congress, 2nd Session and subsequent reports. Calcasieu Lock is located in southern Calcasieu Parish situated along the Intracoastal Waterway (ICWW), southeast of its junction with the Calcasieu River and northwest of its junction with Black Bayou (Enclosure 1). The existing ICWW Calcasieu Lock and approaches replaced the original navigable channel between 1948 and 1950 through Black Bayou immediately to the south (Kuranda and Cleven 2005:iii; Smith, et al. 2002:40).

The Study focuses on Lock replacement and approach improvements or *in situ* dam replacement (Enclosure 2, Project Area). For the Study, the Area of Potential Effect (APE) is that area of wetlands located between Black Bayou and the ICWW in fractional and the existing Calcasuie Lock complex within sections 20, 21, 27, and 28. The existing Calcasieu Lock (zone 15, 471775 easting, 3328340 northing) is located on the ICWW, east of Choupique Island and the Calcasieu River, in Section 21, Township 11 South, Range 9 West on the 1994 U.S.G.S. 7.5' *Moss Lake, LA* topographical quadrangle.

Calcasieu Lock and adjacent environs are low-lying, flat coastal wetlands within Pleistocene-era, chenier plains (Smith et al. 2002:9). "The landscape is dominated by marsh and mudflats that have aggregated to slightly above sea level..." (Smith et al. 2002:9), having no to low potential for contain prehistoric historic properties. Conversely, the cheniers (prehistoric beaches) located outside of the project area and APE, and have moderate to high potential for containing significant historic properties of all cultural/temporary period, coastal Louisiana. In addition to being an important part of the ICWW, the Calcasieu Lock is part of the Calcasieu River Saltwater Barrier project which is operated by the District to maintain a freshwater reservoir for commercial agricultural use—primarily rice and crayfish—while preserving the basin's sensitive environments from the detrimental effects of saltwater intrusion from the Gulf of Mexico.

2012

Congress authorized the construction of the Calcasieu Lock as part of the River and Harbor Act of 24 July 1946, Public Law Number 525, 79th Congress, 2nd Session. Construction of the Lock began on October 4, 1948 and was completed on December 17, 1950 (Kuranda and Cleven 2005:9). The Lock equipment, associated buildings, appurtenant structures, and esplanade were constructed between 1948 and 1952 (Kuranda and Cleven 2005: 9). In 2005, a report contracted by the New Orleans District determined the Lock ineligible to the National Register of Historic Places (NRHP) due to the lack of significance and integrity (Kuranda and Cleven 2005:23-29). Correspondence from the Louisiana's State Historic Preservation Officer (SHPO), dated September 21, 2005 concurred with this finding (enclosure 3, Kuranda and Cleven 2005:Appendix I). The Calcasieu Lock Replacement Study Product Delivery Team made a site visit May 27, 2011. Archeologist Ron Deiss of the Corps' Rock Island District interviewed New Orleans District Lockmaster Kevin Galley who stated that the Calcasieu Lock esplanade was constructed of fill, possibly made from the removal of construction material during lock construction in the late 1940s and early 1950s.

Approximately 2,000 feet southeast of the Lock is the Black Bayou (Big Lake Road) Pontoon Bridge on State Highway 384. This bridge was built in 1979 (LDOT State Structure Number #07103820402351; status: bridge presently under rehabilitation) and is less than 50 years old. It does not meet eligibility criteria for listing on the NRHP, as promulgated under 36 CFR Part 60(d).

According to Smith, et al. (2002:9), The project area is positioned near the interface of the recent chenier plains and the older Pleistocene Terrace Complex. The region is composed of isolated Pleistocene outcrops surrounded by flat coastal wetlands and the chenier plains. U. S. Fish and Wildlife Service, National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/ identified the APE as wetland based on 2010 (October 1) USFWS data (enclosure 4). Directly adjacent to the Lock and ICWW is slightly higher ground that is dredged material associated with the Corps' 1940s and 1950s lock construction activities.

The references within this correspondence are from reports which have been previously provided for the permanent file of the Louisiana State Historic Preservation Officer, Office of Cultural Development, Baton Rouge, LA.

2005 Kuranda, Kathryn M. and Brian Cleven
Evaluation of the National Register Eligibility of Calcasieu Lock, Calcasieu Parrish, Louisiana (November). Final Report Prepared by R. Christopher Goodwin & Associates, Inc. under Contract DACW29-97-D-0018, Delivery Order 35 for the U.S. Army Corps of Engineers, New Orleans District, New Orleans, LA

2002 Barrett Smith, Susan; Katy Coyle; Erin Thompson; Carrie Humphrey, and William P. Athens

Land Use History of the Calcasieu Lock Facility and the Immediate Vicinity, Calcasieu Parrish, Louisiana (August). Final Report Prepared by R. Christopher Goodwin & Associates, Inc. under Contract DACW29-97-D-0018, Delivery Order 35 for the U.S. Army Corps of Engineers, New Orleans District, New Orleans, LA

1999 Goodwin, R. Christopher; Jean B. Pelletier; David Truby; William Barr; Susan Barrett Smith; Jeremy Pincoske; and Patrick Robblee

Phase I Marine Archeological Remote Sensing Survey of the Calcasieu River Saltwater Barrier Repair Project (April). Final Report Prepared by R. Christopher Goodwin & Associates, Inc. under Contract DACW29-97-D-0018, Delivery Order 13 for the U.S. Army Corps of Engineers, New Orleans District, New Orleans, LA

The references indicate that the Calcasieu Lock, esplanade, and all appurtenant structures and buildings and the Black Bayou (Big Lake Road) Pontoon Bridge are ineligible to the NRHP. In addition, research and the references document that all of the surrounding land is either open water or marsh (wetlands) or construction fill or dredged materials. The lack of potential for archeological and structural resources indicates that the project as proposed would not affect any know or undocumented historic properties.

Pursuant to Section 800.3 of the Council's regulations and to meet the responsibilities under the NEPA of 1969, the Corps has developed a preliminary Interested and Consulting Parties List (enclosure 5). The Corps will comply with any requests to be removed from, or added to, the List. The development and maintenance of the List allows agencies, tribes, individuals, organizations, and other interested parties an opportunity to provide views on any effects of this undertaking on historic and to participate in the review of the Draft Feasibility Study.

With this correspondence, the Corps seeks compliance with section 106 of the National Historic Preservation Act and its implementation regulations 36 CFR Part 800: "Protection of Historic Properties." The SHPO and other interested and consulting parties will be included on the distribution list of the Feasibility Study. Please comment or concur with our determination of **No Historic Properties** for the Study's APE within 30 days of receipt of this letter, or the District will assume concurrence.

e-mail address added

If you have questions concerning the Calcasieu Feasibility Study and proposed lock replacement and approach improvements, please call Mr. Ron Deiss of our Environmental Planning Branch, telephone (309) 794-5185, or write to our address above, ATTN: Regional Planning and Environmental Division North (Ron Deiss).

Sincerely,

ORIGINAL SIGNED BY

Kenneth A. Barr
Chief, Environmental Planning Branch
(RPEDN)

Enclosures

MFR: Standard coordination letter promulgated under Section 106 of the NHPA to LA SHPO and other consulting parties concerning the Calcasieu Lock Replacement Feasibility Study.

(all w/encls):
Dist File (PM-M)
PD-P (Deiss)
PM-M (Plumley)

3/19

RODKEY
PM-M

DEISS
PD-P

3/21
PLUMLEY
PM-M

BARR
PD-P

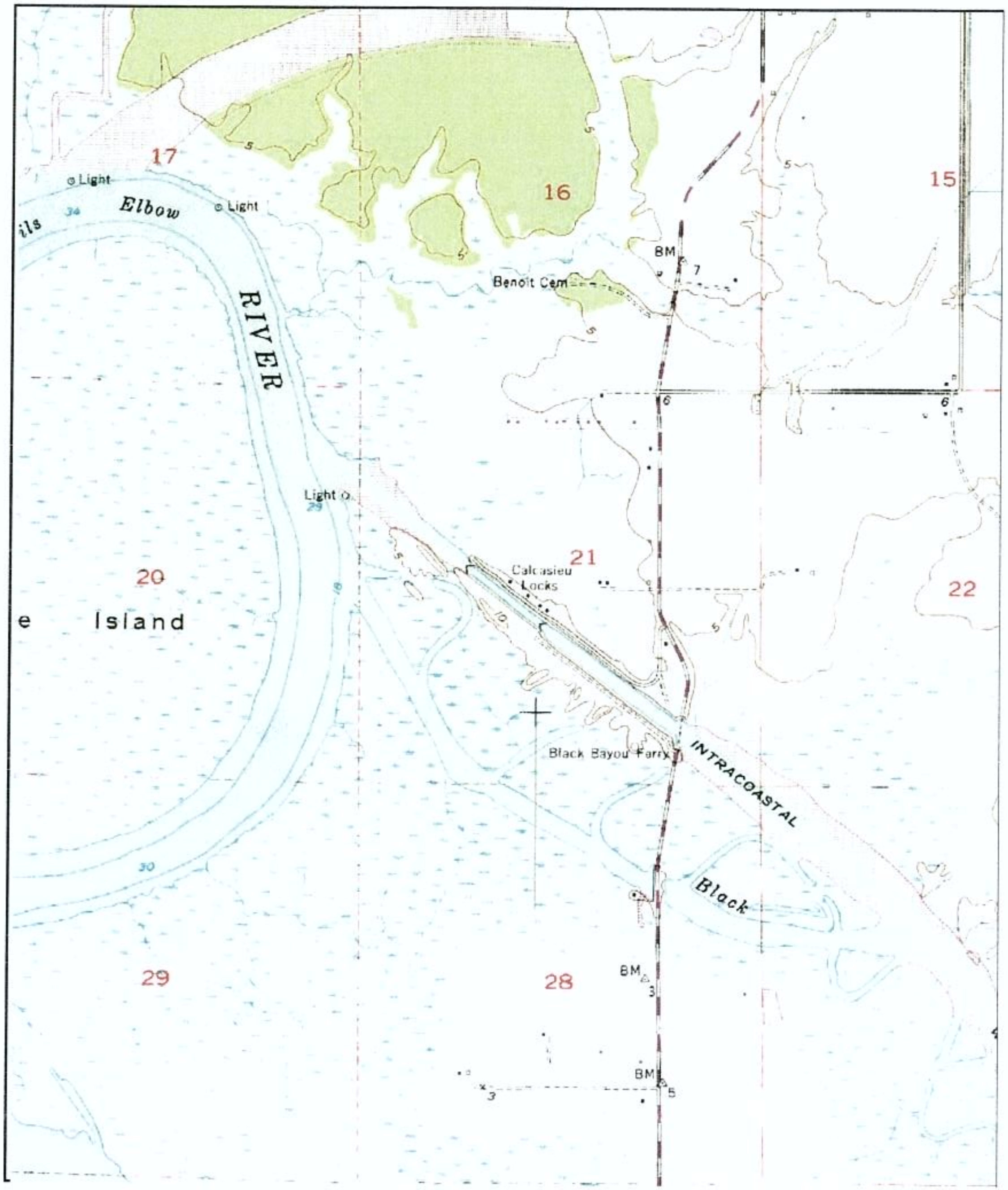
3-21

Calcasieu Lock Looking Northwest Toward Choupique Island and the Calcasieu River

Calcasieu Lock and Pontoon Bridge Looking Southeast

ENCLOSURE 1

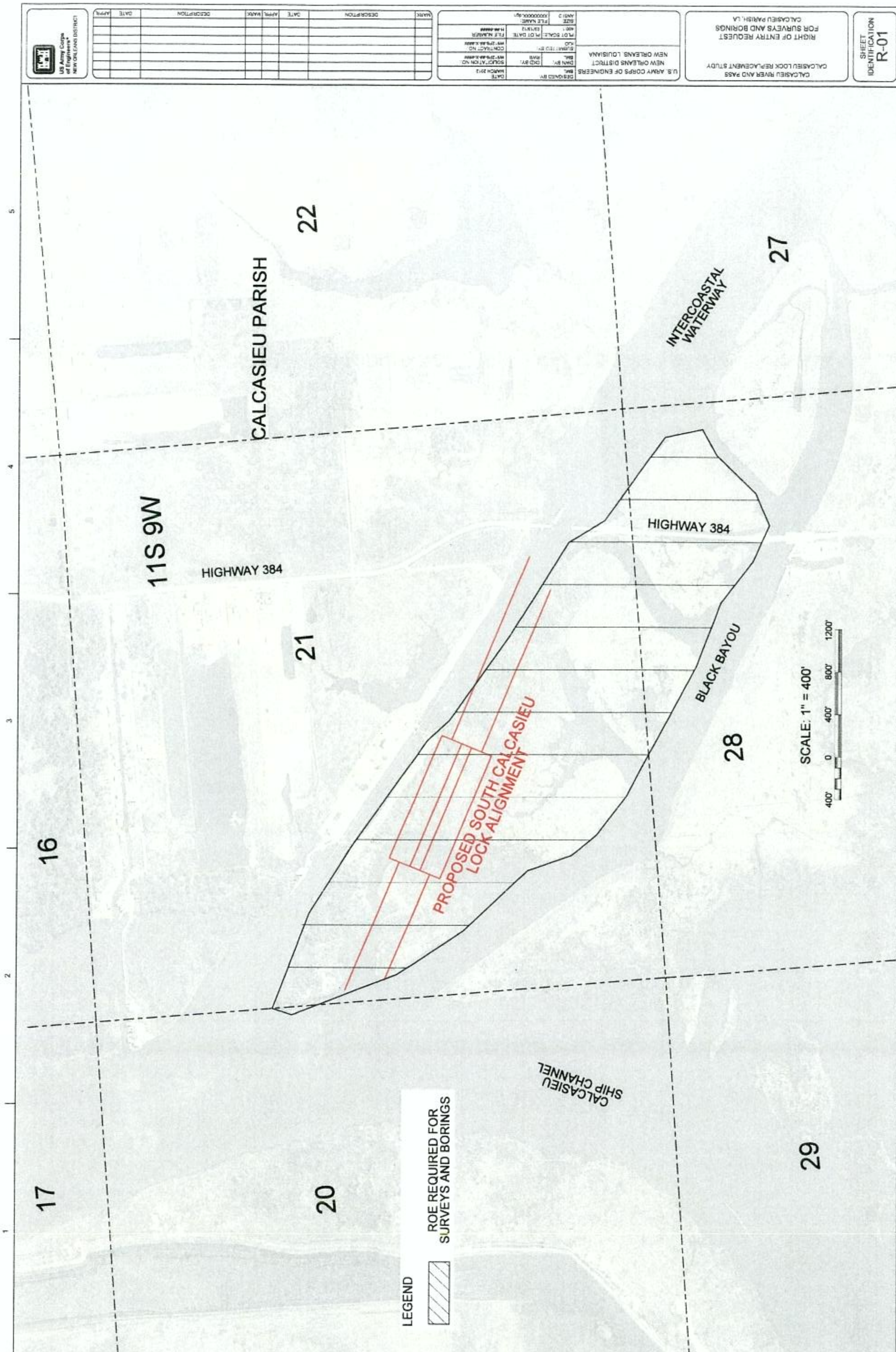
APPENDIX F



Excerpt from the U.S. Geological Survey 1955 7.5' Series Topographic Quadrangle, Moss Lake, Louisiana (revised 1975)

ENCLOSURE 1

APPENDIX F



Calcasieu Lock.dgn 3/13/2012 12:04:14 PM

APPENDIX F

ENCLOSURE 2

MITCHELL J. LANDRIEU
LIEUTENANT GOVERNOR

State of Louisiana

OFFICE OF THE LIEUTENANT GOVERNOR
DEPARTMENT OF CULTURE, RECREATION & TOURISM
OFFICE OF CULTURAL DEVELOPMENT
DIVISION OF HISTORIC PRESERVATION

ANGÈLE DAVIS
SECRETARY

PAM BREAUX
ASSISTANT SECRETARY

September 21, 2005

Mr. David F. Carney, Chief
Environmental Planning
and Compliance Branch
USACE
New Orleans District
P.O. Box 60267
New Orleans, LA 70160-0267

Re: Draft Report
Evaluation of the National Register
Eligibility of Calcasieu Lock (22-2691)
Calcasieu Parish, LA

Dear Mr. Carney:

Thank you for your letter of March 16, 2005, concerning the above-referenced report. We have completed our review and concur with the report's assessment that the Calcasieu Lock would not appear to be eligible for listing on the National Register of Historic Places.

If you have any questions, please contact Mike Varnado of our staff at (225) 342-8160.

Sincerely,

Pam Breaux

Pam Breaux
State Historic Preservation Officer

PB:MV:s

P.O. BOX 44247 • BATON ROUGE, LOUISIANA 70804-4247 • PHONE (225) 342-8160 • FAX (225) 342-8173 • WWW.CRT.STATE.LA.US
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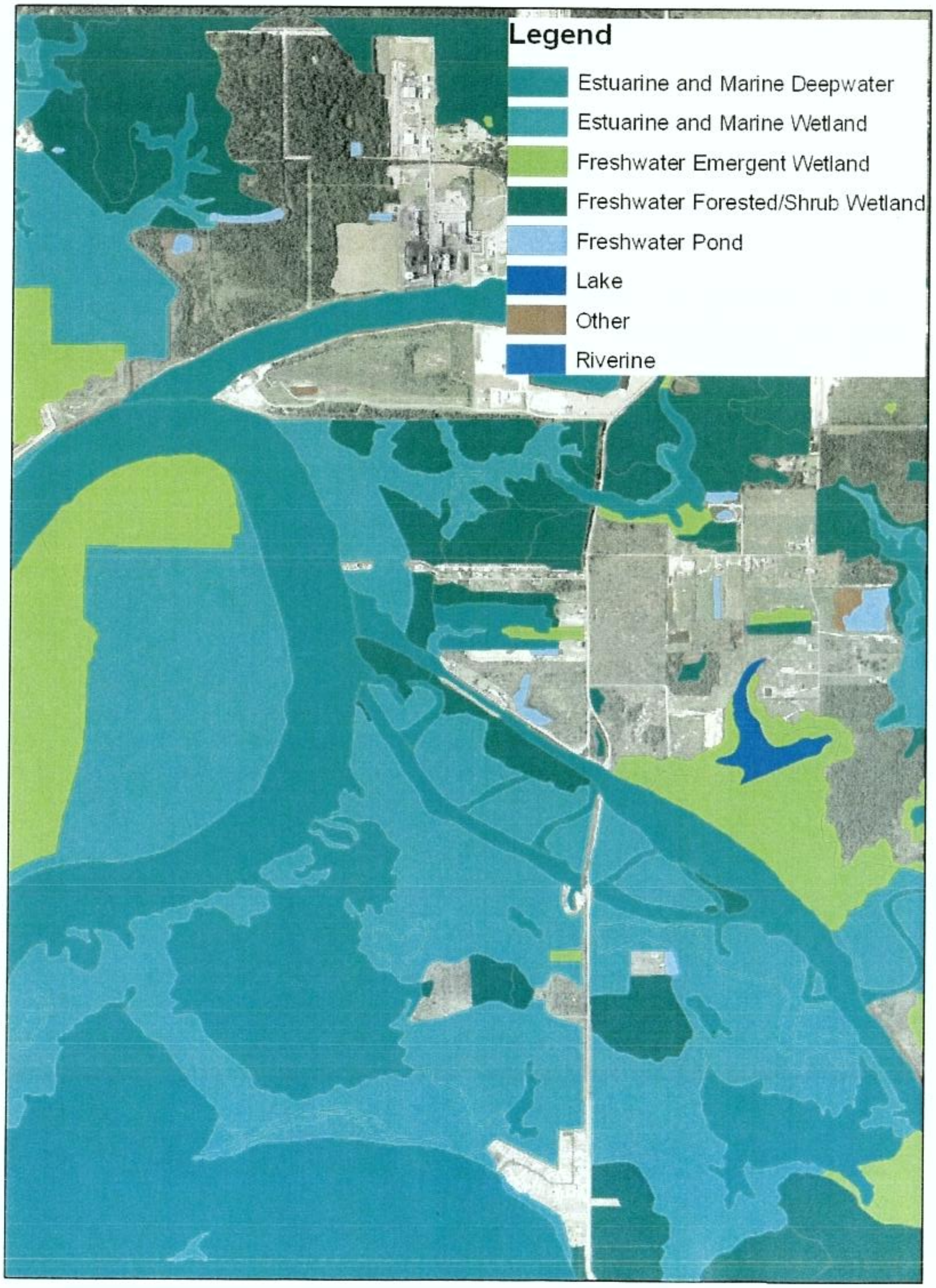

ENCLOSURE 4

APPENDIX F

Calcasieu Lock, Calcasieu Parish, Louisiana Feasibility Study
Interested and Consulting Parties

Calcasieu Historical Preservation Society
P.O. Box 1214
Lake Charles, LA 70602

Ragley Historical Society
377 Burnett Loop
Longville, LA 70652

Imperial Calcasieu Museum, Inc.
204 W. Stillwater
Lake Charles, LA 70601

Kenneth H. Carleton
Tribal Historic Preservation Officer
Mississippi Band of Choctaw Indians
101 Industrial Road
Choctaw, MS USA 39350

Ms. Phyliss Anderson, Chief
Mississippi Band of Choctaw Indians
101 Industrial Road
Choctaw, MS USA 39350

Mr. Kevin Sickey, Chairman
Coushatta Tribe of Louisiana
P.O. Box 818
Elton, LA 70532

Bertney Langley
Cultural Contact, Heritage Department
Coushatta Tribe of Louisiana
P.O. Box 10
Elton, LA 70532

Mr. Kyle Williams, Chairman
Alabama-Cauchatta Tribe of Texas
571 State Park Road 56
Livingston, TX 77351

Ms. Brenda Edwards, Chairwoman
Caddo Nation of Oklahoma
P.O. Box 487
Binger, OK 73009

Robert Cast
Tribal Historic Preservation Officer
Caddo Nation of Oklahoma
P.O. Box 487
Binger, OK 73009

Bobby Gonzalez
NAGPRA Coordinator
Caddo Nation of Oklahoma
P.O. Box 487
Binger, OK 73009

Ian Thompson, Ph.D., RPA
Director/Tribal Historic Preservation Officer
Choctaw Nation of Oklahoma
16th & Locust
Durant, OK 74702-1210

Gregory E. Pyle, Chief
Director/Tribal Historic Preservation Officer
Choctaw Nation of Oklahoma
16th & Locust
Durant, OK 74702-1210

Johnnie Jacobs, Section 106
Choctaw Nation of Oklahoma
16th & Locust
Durant, OK 74702-1210

Mr. Bill Anoatubby, Governor
Chickasaw Nation, Oklahoma
P.O. Box 1548
Ada, OK 74821

Virginia Nail
Tribal Historic Preservation Officer Chickasaw
Nation, Oklahoma
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Choctaw Nation of Oklahoma

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Gregory E. Pyle
Chief

Gary Batton
Assistant Chief

May 8, 2012

Mr. Ron Deiss
ATTN: Regional Planning & Env. Division North
Rock Island District, Corp of Engineers
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

RE: Calcasieu Lock, Feasibility Study, Calcasieu Parish, Louisiana

Dear Mr. Deiss,

Thank you for your correspondence regarding the above-reference project. Calcasieu Parish, LA is outside of the Choctaw Nation of Oklahoma's area of historic interest. I have attached our most recent Areas of Interest by state and county. We respectfully defer to the other Tribes that have been contacted.

Please feel free to contact me with any questions or concerns.

Sincerely,

Director, Historic Preservation Department
Tribal Archaeologist, NAGPRA Specialist
Choctaw Nation of Oklahoma
PO Drawer 1210
Durant, OK 74701

By: Johnnie Jacobs
Section 106 Coordinator
jjacobs@choctawnation.com

Choctaws...growing with pride, hope and success!

APPENDIX F

The Choctaw Nation of Oklahoma takes pride in answering all Section 106 request. And we are in the process of asking that all agencies only send request that are in our areas of interest. This will help us better serve agencies in a timely manner. A list of States and Counties are listed below. However if you have a request that you feel needs to be brought to our attention please feel free to send it to us.

	Alabama	26	Newton	6	Bossier		Mississippi
1	Baldwin	27	Ouachita	7	Caddo		Entire State
2	Choctaw	28	Perry	8	Caldwell		
3	Clarke	29	Phillips	9	Catahoula		Oklahoma
4	Coffee	30	Pope	10	Claiborne	1	Atoka
5	Conecuh	31	Prairie	11	Concordia	2	Bryan
6	Covington	32	Pulaski	12	East Baton Rouge	3	Choctaw
7	Dale	33	Saline	13	East Carroll	4	Coal
8	Escambia	34	Sebastian	14	East Feliciana	5	Haskell
9	Fayette	35	Sevier	15	Evangeline	6	Hughes
10	Geneva	36	St. Francis	16	Franklin	7	Latimer
11	Greene	37	Union	17	Grant	8	LeFlore
12	Hale	38	Yell	18	Iberia	9	McCurtain
13	Houston			19	Iberville	10	Pittsburg
14	Lamar		Florida	20	Jackson	11	Pushmataha
15	Marengo	1	Bay	21	Jefferson		
16	Mobile	2	Calhoun	22	La Salle		Tennessee
17	Monroe	3	Columbia	23	Lafourche	1	Shelby
18	Pickens	4	Dixie	24	Lincoln		
19	Sumter	5	Escambia	25	Livingston		Texas
20	Tuscaloosa	6	Franklin	26	Madison	1	Bowie
21	Walker	7	Gadsden	27	Morehouse	2	Clay
22	Washington	8	Gilchrist	28	Natchitoches	3	Cooke
		9	Gulf	29	Orleans	4	Fannin
	Arkansas	10	Hamilton	30	Ouachita	5	Grayson
1	Arkansas	11	Holmes	31	Plaquemines	6	Lamar
2	Ashley	12	Jackson	32	Pointe Coupee	7	Montague
3	Bradley	13	Jefferson	33	Rapides	8	Red River
4	Calhoun	14	Lafayette	34	Red River	9	Rusk
5	Chicot	15	Leon	35	Richland	10	Smith
6	Clark	16	Liberty	36	St. Bernard		
7	Conway	17	Madison	37	St. Charles		
8	Crawford	18	Okaloosa	38	St. Helena		
9	Crittenden	19	Santa Rosa	39	St. James		
10	Desha	20	Suwannee	40	St. John the Baptist		
11	Drew	21	Taylor	41	St. Landry		
12	Faulkner	22	Wakulla	42	St. Martin		
13	Franklin	23	Walton	43	St. Mary		
14	Hempstead	24	Washington	44	St. Tammany		
15	Hot Springs			45	Tangipahoa		
16	Howard			46	Terrebonne		
17	Jefferson		Kentucky	47	Tensas		
18	Johnson	1	Scott	48	Union		
19	lee			49	Washington		
20	Lincoln	1	Louisiana	50	Webster		
21	Little River	2	Ascension	51	West Baton Rouge		
22	Logan	3	Assumption	52	West Feliciana		
23	Lonoke	4	Avoyelles	53	Winn		
24	Monroe	5	Bienville				
25	Nevada						

Revised 01/05/2012

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX G

PUBLIC INVOLVEMENT

RECORD ACCESS PROCEDURES:

Individuals seeking to access records about themselves contained in this system should address written requests to the Chief, Epidemiology Services Branch, Epidemiologic Research Division, Armstrong Laboratory (AL/AOES), 2601 West Gate Road, Suite 114, Brooks Air Force Base, TX 78235–5241, or comparable official of the Public Health Office serving the Air Force activity/installation. Official mailing addresses are published as an appendix to the Air Force's compilation of systems of records notices.

Written requests should contain the full name and signature of the requester.

Requests in person must be made during normal office duty hours Monday through Friday, excluding national and/or local holidays.

CONTESTING RECORD PROCEDURES:

The Air Force rules for accessing records, and for contesting and appealing initial agency determinations are published in Air Force Instruction 37–132; 32 CFR part 806b; or may be obtained from the system manager.

RECORD SOURCE CATEGORIES:

Records in this system are obtained from DOD and Air Force employees involved in the surveillance, prevention, control, and reporting of diseases and conditions of public health or military significance.

Database is compiled using information from personnel, medical, and casualty records, investigative reports, and environmental sampling data.

EXEMPTIONS CLAIMED FOR THE SYSTEM:

None.

[FR Doc. 01–7168 Filed 3–22–01; 8:45 am]

BILLING CODE 5001–10–M

DEPARTMENT OF DEFENSE

Department of the Army, Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement (EIS) for the Calcasieu Lock, LA, Feasibility Study

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: The Calcasieu Lock is located on the Gulf Intracoastal Waterway (GIWW) in southwest Louisiana. A feasibility study is being conducted to investigate alternatives to reduce navigation delays associated with the lock. A draft EIS is being prepared to accompany the feasibility report.

FOR FURTHER INFORMATION CONTACT: Questions concerning the EIS should be addressed to Mr. Richard Boe at (504) 862–1505. Mr. Boe may also be reached at fax number (504) 862–2572 or by E-mail at richard.e.boe@mnv02.usace.army.mil. Mr. Boe's address is U.S. Army Corps of Engineers, PM–RS, P.O. Box 60267, New Orleans, Louisiana 70160–0267.

SUPPLEMENTARY INFORMATION:

1. *Authority.* The feasibility study is authorized by identical resolutions passed by the Senate and the House of Representatives in 1972 requesting the Board of Engineers for Rivers and Harbors "to review the reports on the Gulf Intracoastal Waterway (Louisiana-Texas Section, including the Morgan City-Port Allen Route) * * * with a view to determining the advisability of modifying the existing project in any way * * *."

2. *Proposed Action.* The proposed action, if determined economically feasible and environmentally acceptable, is the construction of a new lock to replace the existing Calcasieu Lock.

3. *Alternatives.* a. Three potential alignments for a replacement lock have been identified. The first alternative is to align a new lock immediately north of the existing lock. The second alternative consists of a new lock immediately south of the existing lock. The third alternative is a new lock in the center of an existing bypass channel about one-half mile south of the existing lock.

b. The first alignment alternative could probably be implemented without the replacement of the Highway 384 bridge across the GIWW. The other two alignment alternatives would require replacement of the Highway 384 bridge. For each of the alignment alternatives, at least two lock widths will be evaluated—90 and 110 feet. The length of any new lock would be 1,200 feet, to make it compatible with other locks on the GIWW. For any of the lock replacement alternatives, the existing lock may be decommissioned; may be kept operational on a standby basis; or may be used as a water control structure.

c. In addition to the lock replacement alternatives, a water control structure alternative will be evaluated. This alternative would consist of a water control structure to relieve the existing lock of its water control function. The existing Calcasieu Lock is used to pass water from the Mermentau River Basin into the tidal waters of the Calcasieu River and Lake after significant rainfall events in the Mermentau River Basin. During these times of open flow through the lock, navigation traffic is usually stopped and significant delays develop. A water control structure would reduce navigation delays during such occasions.

d. A bridge-only alternative will also be investigated. The existing Highway 384 bridge is a floating, pontoon bridge. Due to the close proximity of the bridge to the lock, vessels entering the lock from the east are considered to be in the lock approach zone as they approach the bridge. To assure the safety of personnel and property, no vessels may be in the lock or entering the lock from the west while a vessel is in the east approach zone. This situation causes delays that may be remedied by the replacement of the bridge with a mid-level or high-level bridge.

4. *Scoping.* a. Scoping is the process for determining the scope of alternatives and significant issues to be addressed in the EIS. For this study, a scoping letter combined with a notice of study initiation will be sent to all parties believed to have an interest in the study. The letter will request input on alternatives and issues to be evaluated and notify interested parties and the local and regional news media of a public scoping meeting that will be held in the local area.

b. Public Meeting. A public scoping meeting will be held in the Calcasieu Parish Police Jury Administrative Building located at 1025 Pithon Street, Lake Charles, Louisiana, at 7 pm, April 3, 2001. All interested parties are invited to comment at this time, and anyone interested in this study should request to be included in the study mailing list.

5. *Significant Issues.* The tentative list of resources and issues to be evaluated in the EIS includes tidal wetlands, aquatic resources, wildlife resources, essential fish habitat, water quality, air quality, threatened and endangered species, recreation resources, and cultural resources. Socioeconomic items to be evaluated in the EIS include navigation, flood protection, business and industrial activity, employment, land use, property values, public/community facilities and services, tax revenues, population, community and regional growth, vehicular transportation, housing, community cohesion, and noise.

6. *Environmental Consultation and Review.* The U.S. Fish and Wildlife Service (USFWS) will be assisting in the documentation of existing conditions and assessment of effects of project alternatives through Fish and Wildlife

Coordination Act consultation procedures. Consultation will also be accomplished with the USFWS and the National Marine Fisheries Service concerning threatened and endangered species. All other necessary environmental compliance will be obtained before a Record of Decision on the EIS is signed. Other compliance requirements include a Clean Water Act Section 404(b)(1) evaluation, a Louisiana Coastal Resources Program Consistency Determination, and a State Water Quality Certification. The draft EIS or a notice of its availability will be distributed to all interested agencies, organizations, and individuals.

7. *Estimated Date of Availability.* The draft EIS is expected to be available in mid-2003.

Gregory D. Showalter,

Army Federal Register Liaison Officer.

[FR Doc. 01–7260 Filed 3–22–01; 8:45 am]

BILLING CODE 3710–84–U

DEPARTMENT OF DEFENSE

Department of the Army, Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement (DEIS) for a Feasibility Study of Navigation Improvements at Port Everglades, Broward County, FL

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: The Jacksonville District, U.S. Army Corps of Engineers intends to prepare a Draft Environmental Impact Statement (DEIS) for the Feasibility Study of Navigation Improvements, Port Everglades Harbor, Broward County, Florida. The study is a cooperative effort between the U.S. Army Corps of Engineers and the Broward County Department of Port Everglades.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action can be directed to Rea Boothby at (904) 232–3453, Environmental Branch, Planning Division, P.O. Box 4970, Jacksonville, Florida 32232–0019.

SUPPLEMENTARY INFORMATION:

1. *Project Background and Authorization.* Port Everglades was originally constructed by local interests between 1925–1928, and was authorized for Federal maintenance by the River and Harbor Act of 1930 and subsequent Acts.

2. *Need or Purpose.* Improvements, including channel deepening and widening, are required to accommodate future commercial fleet and to more effectively transit the existing fleet.

3. *Proposed Solution and Forecast Completion Date.* Widen and deepen every major Federal channel and basin within the project and develop (widen and deepen) the Dania Cutoff Canal. Construction is forecast to begin around March 2003.

4. *Prior Environmental Assessments (EAs) EISs.* An EA was prepared in 1990 to accommodate dredging in the Southport access channel and Turning Notch.

5. *Alternatives.* Alternatives currently considered include no action, and 9 structural alternatives.

6. *Issues.* The EIS will consider impacts on seagrasses (including Johnson Seagrass, a threatened species), mangrove and hardbottom communities, other protected species, shore protection, health and safety, water quality, aesthetics and recreation, fish and wildlife resources, cultural resources, energy conservation, socio-economic resources, and other impacts identified through scoping, public involvement, and interagency coordination.

7. *Scoping Process.*

a. A scoping letter was sent to interested parties in June 1997. In addition, all parties are invited to participate in the scoping process by identifying any additional concerns on issues, studies needed, alternatives, procedures, and other matters related to the scoping process.

b. Public Meeting. A public scoping meeting will be held on March 28, 2001 at 7 P.M. in the Broward County Commission Chambers located at 115 South Andrews Avenue, Ft. Lauderdale, FL. An agency scoping meeting will be held on March 29, 2001 at Port Everglades.

8. *Public Involvement:* We invite the participation of affected Federal, state and local agencies, affected Indian tribes, and other interested private organizations and parties.

9. *Coordination.* The proposed action is being coordinated with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) under Section 7 of the Endangered Species Act, with the FWS under the Fish and Wildlife Coordination Act, with the NMFS concerning Essential Fish Habitat and the State Historic Preservation Officer.

10. *Other Environmental Review and Consultation.* The proposed action would involve evaluation for compliance with guidelines pursuant to Section 404 (b) of the Clean Water Act; application (to the State of Florida) for Water Quality Certification pursuant to Section 401 of the Clean Water Act; certification of state lands, easements, and rights of way; and determination of the Coastal Zone Management Act consistency.

11. *Agency Role.* The Corps and the non-Federal sponsor, Broward County Department of Port Everglades, will provide extensive information and assistance on the resources to be impacted, mitigation measures, and alternatives.

12. *DEIS Preparation.* It is estimated that the DEIS will be available to the public on or about September 2001.

Gregory D. Showalter,

Army Federal Register Liaison Officer.

[FR Doc. 01–7257 Filed 3–22–01; 8:45 am]

BILLING CODE 3710–AJ–U

DEPARTMENT OF EDUCATION

Notice of Proposed Information Collection Requests

AGENCY: Department of Education.

SUMMARY: The Leader, Regulatory Information Management Group, Office of the Chief Information Officer, invites comments on the proposed information collection requests as required by the Paperwork Reduction Act of 1995.

DATES: Interested persons are invited to submit comments on or before May, 22, 2001.

SUPPLEMENTARY INFORMATION: Section 3506 of the Paperwork Reduction Act of 1995 (44 U.S.C. chapter 35) requires that the Office of Management and Budget (OMB) provide interested Federal agencies and the public an early opportunity to comment on information collection requests. OMB may amend or waive the requirement for public consultation to the extent that public participation in the approval process would defeat the purpose of the information collection, violate State or Federal law, or substantially interfere with any agency's ability to perform its statutory obligations. The Leader, Regulatory Information Management Group, Office of the Chief Information Officer, publishes that notice containing proposed information collection requests prior to submission of these requests to OMB. Each proposed information collection, grouped by office, contains the following: (1) Type of review requested, e.g. new, revision, extension, existing or reinstatement; (2) Title; (3) Summary of the collection; (4) Description of the need for, and proposed use of, the information; (5) Respondents and frequency of collection; and (6) Reporting and/or

April 27, 2001

Planning, Programs, and
Project Management Division
Environmental Planning and
Compliance Branch

Scoping Document

Feasibility Report and Environmental Impact Statement
Calcasieu Lock, Louisiana

The U.S. Army Corps of Engineers, New Orleans District, is conducting a study to determine the feasibility of implementing improvements at the Calcasieu Lock. The Calcasieu Lock is located on the Gulf Intracoastal Waterway (GIWW) in Calcasieu Parish, Louisiana. In March 2001, a joint Notice of Study Initiation and Public Scoping Meeting Announcement was mailed to all persons, organizations, and agencies thought to have an interest in the study. A public scoping meeting was held in the Calcasieu Parish Police Jury Administrative Building in Lake Charles, Louisiana, the evening of April 3, 2001. Approximately 30 people including elected officials and representatives of elected officials, representatives of government agencies, landowners, fishing guides, and the general public attended the meeting.

At the meeting, Corps of Engineers representatives presented information about the study process and invited attendees to comment on issues and alternatives that should be evaluated in the study. The following is a list of the comments, categorized by type, recorded at the scoping meeting.

Comments on issues:

- Include impacts of salinity on agriculture
- Mooring problems will occur east of the Black Bayou Channel with the Black Bayou alignment
- Minimize impact of alignment on fisheries
- Use existing lock to help reduce floodwaters in Mermentau Basin
- Compensate for unavoidable losses to fisheries habitat
- Use dredged material to restore wetlands (maintaining fisheries access)
- Increased traffic on GIWW will negatively impact areas west of Calcasieu River through erosion
- Support restoration of marsh in shallow open water
- Consider safety aspects of Highway 384 bridges with respect to navigation and vehicular traffic

- Acreage of wetlands directly lost to project is less important than the total acreage in the basin affected by project
- Consider maintenance of vegetative base (wetlands) as it affects (reduces) flooding (from hurricanes)
- Consider impacts (noise and access) to residents who pre-date canal (GIWW)
- Government Ditch drains developed areas impacted by ability of Calcasieu Lock to pass flows
- Increased upstream development (in Mermentau River Basin) will increase flows at Calcasieu Lock with greater impacts on navigation

Comments expressing concern:

- Concerned about restricted access to the "island" (Grand Lake) across Highway 384 bridges
- Concerned about proximity of Black Bayou alignment to residence (especially noise and erosion from backwash)
- Concerned about access to Big Lake (Calcasieu Lake) with Black Bayou alignment
- Concerned about emergency access during bridge outages
- Concerned about fresh water introduced into tidal system with larger lock (impact on saltwater fisheries)
- Concerned about disposal of dredged material - loss of fish habitat
- Concerned about contamination in dredged sediments
- Concerned about delays to navigation and landside traffic as a consequence of Highway 384 bridges

Comments on alternatives:

- Rotate the south (Black Bayou) alignment to be more parallel to existing lock
- The U.S. Fish and Wildlife Service finds the Black Bayou alignment to be the least acceptable due to wetlands loss - consider realignment to minimize loss
- Note: Construction of new lock with continued operation of existing lock is in Coast 2050 plan

- Comments of support:
- Support new lock and a new bridge, keeping the old lock in operation

Two letters of comment were received in response to the public notice of the scooping meeting. One letter recommended thorough evaluation of potential construction impacts on essential fish habitat and Federally-managed aquatic species, as well as alternatives to avoid, minimize, and compensate for those impacts. Also, the writer recommends thorough evaluation of the potential benefits of the alternatives on alleviating high water levels in the Mermentau Basin. The second letter expressed support for a new lock from the perspective that a new lock would aid in removing excess surface water from the Mermentau Basin.

DISTRIBUTION LIST

DISTRIBUTION LIST FOR PUBLIC REVIEW, SEPTEMBER 2013

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Lake Charles, LA 70602

Ragley Historical Society
377 Burnett Loop
Longville, LA 70652

Imperial Calcasieu Museum, Inc.
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EPA, REGION VI - OFF. OF PLANNING AND
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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX H

VALUE ENGINEERING STUDY REPORT

Final Value Engineering Study Report

Calcasieu Lock Replacement Feasibility Study, Calcasieu, Louisiana

CEMVN-VE-12-04

August 2012

Prepared by

Value Management Strategies, Inc.

APPENDIX H

"Value Leadership"

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Date: August 14, 2012

Frank Vicidomina, PE, CVS, Value Engineering Officer
U.S. Army Corps of Engineers, New Orleans District
2608 Sells St.
Metairie, LA 70003

Subject: Final Value Engineering Study Report
Calcasieu Lock Replacement Feasibility Study, Calcasieu, Louisiana

Dear Frank:

Value Management Strategies, Inc. is pleased to transmit the Final Value Engineering Study Report. This report summarizes the results and events of the study conducted July 16-20, 2012, in New Orleans, Louisiana.

We enjoyed working with you and are looking forward to continuing our efforts to assist the New Orleans District U.S. Army Corps of Engineers in its value engineering efforts.

Sincerely,

VALUE MANAGEMENT STRATEGIES, INC.

Ronald J. Tanenbaum, PhD, PE, GE, CVS
Senior Value Engineer

Copies: (PDF, 15 Copies, 20 CDs) Addressee

APPENDIX H

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

This Value Engineering (VE) Report summarizes the events of the VE study facilitated by Value Management Strategies, Inc., July 16-20, 2012, for the U.S. Army Corps of Engineers (USACE), New Orleans, Louisiana. The Calcasieu Lock Replacement Feasibility Study focuses on upgrading the structure, either through full replacement or modification to structure components and/or operations procedures, so as to reduce lockage delays while providing adequate drainage and blockage of saltwater intrusion.

The intent of this VE study was to identify potentially viable project enhancements and cost-saving measures that may be considered by the Project Delivery Team (PDT). Contained in this report are numerous VE recommendations that have the potential to improve project value by enhancing performance and/or lowering costs.

PROJECT PURPOSE AND DESCRIPTION

The principal problem to be addressed is the delay to navigation induced through operation of the Calcasieu Lock (Lock) for drainage of the Mermentau River Basin, which is part of its authorized purpose. The primary opportunities (needs) are to reduce or eliminate commercial traffic delays and improve the national and regional economic condition. The need to maintain the effectiveness of the Lock as a salinity barrier for the Basin is also critical.

The overall Feasibility Study goal reflects the role Calcasieu Lock plays in a critical navigation system as well as being an integral component to the Mermentau Basin water management system, which requires both drainage capacity and an effective barrier to salinity intrusion. Therefore, the overall goal is to:

- Maximize the efficiency of the Calcasieu Lock, thereby contributing to the overall efficiency of Gulf Intracoastal Waterway (GIWW) as a nationally significant navigation system, while continuing to provide water management capability and salinity control to the Mermentau River Basin.

To support the accomplishment of this Feasibility Study goal, the following specific planning objective was developed for the Calcasieu Lock Feasibility Study:

- Reduce drainage event-induced navigation delays at Calcasieu Lock while minimizing the impacts to the surrounding area.

The project study area is shown in the figure on the following page.

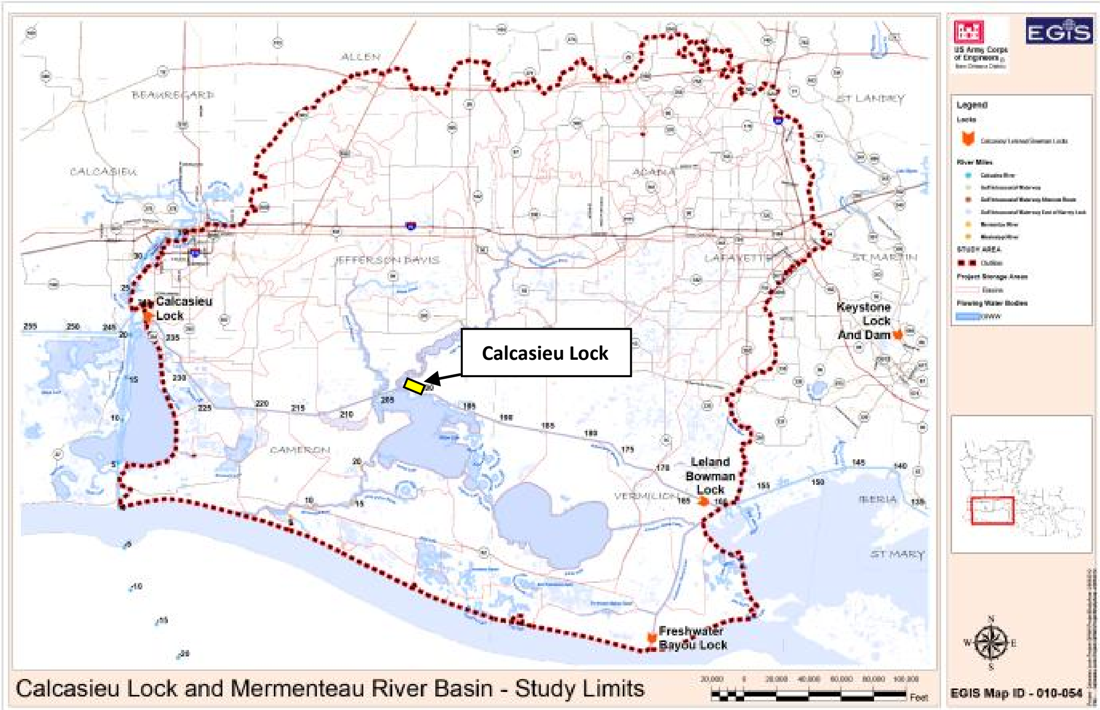

Figure 1 – Project Study Area

VE STUDY OBJECTIVES

Objectives of VE study are as follows:

- Assess current alternatives to improve Lock efficiency and identify possible alternative measures.
- Evaluate effectiveness of current alternatives in providing drainage without impeding navigation and identify possible alternative measures.
- Evaluate current alternatives with regard to their continued effectiveness in providing salinity control the Mermentau River Basin and identify possible alternative measures.
- Generally improve function, improve quality, incorporate life cycle costs, and reduce cost and/or increase performance as appropriate to improve the overall project value.

VE STUDY TIMING

The VE study was performed during the Feasibility Phase of the project.

VE TEAM

The VE Team included the assistance of the project managers, designers, and planning staff from USACE – New Orleans District. The VE Team members are listed on the following page, and a full list of study participants is included in **Appendix A**.

VE Team

Name	Organization	Title
Ron Tanenbaum, PhD, PE, GE, CVS	VMS, Inc.	VE Study Facilitator
Frank Vicidomina, PE, CVS	USACE – New Orleans District	VE Study Co-Facilitator
Terry Sullivan, PE	USACE – Louisville District	Structural Engineer
Mark Watson, GE, CVS, PMP	VMS, Inc.	Geotechnical Engineer
Tim Connell, PE, AVS	USACE – New Orleans District	Team Member
Mariah Brink, AVS	VMS, Inc.	VE Team Assistant

KEY PROJECT ISSUES

The following key project issues were identified during the VE workshop:

- A state highway 384 bridge, several local roads and a few residences are located within the study area. Adverse effects to the existing infrastructure will be minimized to the extent practicable.
- Alteration of drainage patterns or new features to improve navigation efficiency must be accomplished while avoiding and/or minimizing significant impacts to adjacent coastal marshes. Unavoidable impacts need to be mitigated.
- Models need to consider relative sea level rise.
- Any water backup on the GIWW will flood farmlands north of the GIWW before the water reaches other structures.
- Recently constructed culverts at Black Bayou are currently inoperable.
- Public perception is that the lock is incredibly important relative to Basin drainage.

PROJECT ANALYSIS

The VE tools and SAVE International Job Plan were used by the VE Team to analyze the project. The results of these analyses clarified the programmatic objectives and major project functions in terms of performance attributes developed by the team. The key performance attributes, described in detail in **Appendix B** are:

- Navigation Efficiency
- Structure Reliability
- Future Flexibility

Function Analysis defines the functions of the project through an organized use of the Function Analysis System Technique (FAST) diagram that shows how the functions are related to one another. A FAST diagrams was developed for this study and is also shown in **Appendix B.**

Speculation, also known as creativity, is the application of brainstorming techniques to develop a large quantity of ideas rather than focusing on the quality of ideas. A complete list of workshop ideas can be found in **Appendix C**. Additional details on the Value Engineering process applied during this study can be found in **Appendix D**.

SUMMARY OF VE RECOMMENDATIONS

General Findings

Below are general performance-improving and cost-saving measures identified by the VE Team. Specific recommendations are presented and discussed within the *VE Recommendations* section of this report:

- Black Bayou should be re-considered as a drainage outlet, with the following potential options:
    - Utilization of rehabilitated/modified NRCS structure
    - New or supplemental gate or pump station
    - Opportunity to benefit marsh via weir-controlled distribution cuts
- Address potential adverse cross-currents in GIWW between lock and bridge by:
    - Using multiple exit channels, and/or
    - Extending guidewalls to the LA 384 bridge
- Apply pump station efficiency recommendations; may keep the pump station option viable
- Reconsider current alternatives carried forward:
    - Eliminate new lock alternatives
    - Eliminate vessel-assist alternatives
    - Eliminate suspension of drainage alternative
- Consider new VE recommendations (see Alternative Summary List below)

Summary of Recommendations

The VE Team developed the following list of (20) recommendations that may potentially improve the overall project performance and/or cost-effectiveness. These recommendations were developed by referring to the functional categories developed during the function analysis of the study as a stimulus to creative thinking, and the project issues presented in **Appendix B** which were also consulted regularly during the process to assure that all concerns raised in the study were addressed.

The reader should note that this list represents, in most cases, a combination of 'speculation ideas' where appropriate. **Combinations of these concepts can, and should, be considered as possible additional comprehensive options. It should also be noted that a number of recommendations "conflict" with others. That is to say that one option cannot be implemented with the other. Such competing concepts have been published without relative rating or exclusion such that various recommendations may be considered by the PDT.**

Value Engineering recommendations are organized by group headings as listed below and on the following pages:

CALCASIEU LOCK REPLACEMENT FEASIBILTY STUDY

Alternative Summary List

Alt No.	Title
	UTILIZATION OF BLACK BAYOU
1.	Rehabilitate Black Bayou Culvert structure with a weir on the eastern side and develop Black Bayou as drainage diversion
2.	Rehabilitate existing Black Bayou Culvert structure and construct additional sluice gate structure on Black Bayou
3.	Rehabilitate existing Black Bayou Culvert structure and construct supplemental pump station on Black Bayou
4.	Construct new drainage structure on Black Bayou at LA 384 in lieu of adjacent to existing Calcasieu Lock
	DESIGN CONSIDERATIONS
5.	Provide multiple smaller inlets to the south of existing lock for drainage diversion
6.	Extend guidewall on drainage channel side to Louisiana Hwy 384 Bridge
7.	Consider vertical lift gate in lieu of sluice or sector gate for drainage diversion to accommodate temporary navigation
8.	Apply pump station design 'lessons learned'
9.	Provide mooring dolphins at both sides of the lock
10.	If crossing the roadway, use numerous precast conduits (boxes or pipes) to speed construction
11.	Perform hydraulic model of new channel configuration prior to alternative selection
12.	Revisit and verify control points in H&H model with respect to MLG assumptions, sill elevations and water surface elevations for open/close
	PLAN FORMULATION
13.	Eliminate the kevel system on the north side of the Lock from consideration
14.	Do not locate a new lock north of the existing Lock
15.	Address appreciable drainage impact levels in lieu of all drainage conditions
16.	Fully consider various relative sea level rise scenarios as part of Plan Formulation and not as Tentatively Selected Plan sensitivity analysis
17.	Perform VE assessment of final array of alternatives
	RECOMMENDATIONS FROM PREVIOUS REPORTS
18.	Consider design recommendations from recent VE study addressing gate design and maintenance
19.	Consider recommendations from 2003 VE Study as appropriate
20.	Consider lessons learned in the *UMR-IWW System Navigation Feasibility Study* for applicability to GIWW locks, specifically, Calcasieu

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APPENDIX H

VALUE ENGINEERING RECOMMENDATIONS

OVERVIEW

The VE Team identified 20 recommendations that may improve project performance and/or cost-effectiveness. These recommendations are organized and listed in the following four subject groups:

- Utilization of Black Bayou
- Design Considerations
- Plan Formulation
- Recommendations from Previous Reports

Where presented, order-of-magnitude cost estimates compare *relative* VE Recommendations of the current design and proposed change for the sole purpose of estimating the net difference between the two options. In some cases, the estimates do *not* include the total feature cost, but only those components that are changed by the recommendation.

The reader should note that the efforts of the VE Team in developing the recommendations in the short time period of the VE study limits their findings to conceptual level analyses and rough order-of-magnitude cost estimates only. The descriptions contained in the recommendations presented do not represent detailed design nor do they provide detailed cost estimates.

It should also be noted that several recommendations may "conflict" with each other. That is to say that one option cannot be implemented with the other. Such competing recommendations have been published without relative rating or exclusion such that the various options may be considered by the Project Delivery Team.

PERFORMANCE ATTRIBUTES

Performance attributes represent those aspects of a project's scope and schedule that may possess a range of potential values (as opposed to performance requirements which represent essential, non-discretionary aspects). The VE Team developed the following performance attributes to act as criteria for considering the value potential of the creative ideas. Those that were impacted, either as an improvement or a detriment, are discussed for each recommendation. The VE Team enlisted the assistance of the Project Team (when available) to develop these attributes so that the evaluation would reflect their specific requirements.

- **Navigation Efficiency**

  Opportunities exist to increase navigation efficiency through improved operational routines and potential modification of the existing structure to accommodate existing and future traffic; and to reduce or eliminate navigation delays due to drainage. Fewer barge reconfigurations to allow for transit during drainage events will decrease cycling times of tows through the lock. An additional or wider lock chamber would allow for passing of flows through the old Lock or through a newer lock that can accommodate drainage events and lockages. Alternatives/ concepts that support optimizing lockage time, thus reducing navigation delays and improving operational efficiencies without detrimentally impacting drainage and salinity control, would be preferred.

- **Structure Reliability**

  Reliability of the existing, modified and/or new physical structure to accommodate traffic and maintain drainage and saltwater intrusion blockage is key to the success of this project. Considerations include the overall durability, longevity and maintainability of structures, equipment and systems.

- **Future Flexibility**

  The ability to adapt to changes in long-term operational conditions, navigation type and demand, and changing environmental conditions (i.e. relative sea level rise) should be considered for each alternative recommendation proposed.

UTILIZATION OF BLACK BAYOU

In 2007, the Natural Resources Conservation Service (NRCS) and the Louisiana Department of Natural Resources (LA DNR) constructed a Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project (CS-29) to restore drainage under LA Highway 384 at Black Bayou. The project involved construction of ten, 10-foot by 10-foot cast-in-place box culverts under LA Highway 384 (see photographs below). The culverts have aluminum flap gates on the discharge side to prevent saltwater intrusion from the Calcasieu River into the freshwater basin. The flap gates would also be locked closed via manually-installed shear pins when interior water levels drop below acceptable minimum levels (i.e. 0.8 feet NAVD-88). After completion of the project, leakage under the structure was observed. Earthen berm coffer dams were installed to dewater the structure to assess the extent of the leakage.

Black Bayou is obviously hydrologically connected to the GIWW and the Calcasieu River. However, the culvert project was intended to supply freshwater to the marshes on the west side of LA 384 and not necessarily to improve drainage of the basin. The operators of Calcasieu Lock noted that when the culverts were operational, the lock did not observe significant reductions in drainage flows (however, the time that the culverts were operational was during a low water event). The Black Bayou channels are reported to be relatively shallow as compared to the GIWW and Calcasieu River; the inlet from the GIWW is relatively narrow. Thus, in its current condition, it may not support significant drainage capacity.

Upstream (eastern) side of existing Black Bayou Culvert Structure

Downstream (western) side of existing Black Bayou Culvert Structure

Existing conditions and relative location of Black Bayou Culvert structure to Calcasieu Lock
Photo also shows the existing hydrologic connectivity of the area to the south of the Lock

VE Alternatives:

1. Rehabilitate Black Bayou Culvert structure with a weir on the eastern side and develop Black Bayou as drainage diversion

This alternative consists of performing an engineering assessment of the existing Black Bayou Culvert structure, and rehabilitating it such that it can perform as an alternate drainage diversion to the Calcasieu Lock. Until the assessment is conducted, the VE Team can only speculate as to what the rehabilitation scope of work would be, but early indications are that it would require a sheetpile cutoff wall to eliminate seepage under the structure. In order to provide a "maintenance-free" operation, a weir could be constructed on the eastern side of the structure. The weir would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf) in lieu of manually installing the shear pins. In order to maximize the drainage capacity of Black Bayou, the existing channels upstream and downstream of the structure would need to be dredged and the inlet location from the GIWW may need to be relocated or reconfigured. Hydraulic modeling may be necessary to confirm the location of the inlet in order to maximize flows into Black Bayou without creating cross currents or other situations that would be detrimental to navigation.

The existing Black Bayou Culvert structure has a total cross-sectional area of 1,000 square feet (as compared to a total cross-section area of 1,200 square feet of the Calcasieu Lock). As such, this alternative cannot provide 100% of the drainage capability of the current situation (or of the baseline drainage diversion alternatives). However, the likelihood that the Calcasieu Lock would experience the high velocities sufficient to delay navigation should be significantly reduced. In addition, given that the Black Bayou Culvert structure may be capable of handling over 80% of the drainage capacity, the Calcasieu Lock would probably be allowed to continue lock operation during high water events without risk of increasing the water levels in the basin.

As noted above, the original purpose of the Black Bayou Culvert structure was ecological restoration of the bayou. This alternative suggests a "win-win" scenario where the benefits from the increased drainage capacity are combined with the benefits of marsh habitat creation (or restoration). In order to maximize the ecological benefits of this alternative, a series of bank openings and conveyance channels could be installed (similar to what is currently being considered for the Blind River and Amite River diversion projects). These channels in combination with small control weirs to prevent saltwater intrusion could result in:

1. Restoring swamp inundation patterns with freshwater
2. Providing fishery access to previously unavailable habitats
3. Nourishment of existing swamps to increase their productivity to build soils through organic deposition
4. Reintroduction and distribution of sediment and nutrients throughout the ecosystem

The increased ecological benefits of this alternative could also be used to establish an NER justification for this project in addition to the NED justification.

Furthermore, using Black Bayou as the drainage diversion does not require the destruction of hundreds of acres of marsh that would be necessary for the construction of the new channel for the lock or gate structure. Black Bayou already has established channels that would only be deepened by this alternative. The existing marshes and other land would be preserved (and even enhanced as discussed above).

The VE Team recognizes that there may be hurdles and challenges relative to current ownership of the Black Bayou Culvert structure as well as challenges relative to the operations and maintenance of the structure, should the COE decide to utilize Black Bayou as a drainage diversion. However, these challenges should be weighed against the significant cost reduction of this alternative and the fact that the existing Black Bayou Culvert structure appears to be non-functional.

The following photographs illustrate the concepts being proposed by this VE alternative.

Sketch of proposed improvements to Black Bayou

Sketch of the proposed alignment of the earthen-fill weir east of the existing culvert structure

Cost Assumptions:

Rehabilitation of Existing Black Bayou Culvert:

Sheetpile cutoff wall – 450’ x 20’ = 9,000 SF x $50 / SF = $450,000
Dredge Black Bayou – 5’ depth x 200’ wide x 9,000’ = 9,000,000 CF = 333,333 CY x $10 / CY
$3,333,333 or rounded = **$3,000,000**

Rock-lined, Concrete-capped Sheetpile Weir:

Sheetpile cutoff wall with concrete cap - 500’ x 20’ = 10,000 SF x $60 / SF = **$600,000**

Performance Attributes:

Navigation Efficiency – The primary benefit of this alternative relative to navigation is the elimination or significant reduction of high velocities through the existing lock chamber due to the drainage function being handled by the Black Bayou Culverts. If necessary, lock operations could continue during drainage events without increasing the water levels in the basin.

Structure Reliability – Although currently the Black Bayou Culverts are an NRCS structure, this alternative provides an option to improve the functionality of the structure and prevent it from further deterioration or risk of future failure. As compared to the alternative to provide a new lock with sector gates, this alternative would have significantly less maintenance.

Future Flexibility – This alternative does not provide an alternate navigation route that would easily support a future 110-foot lock to be constructed. It may also require the lock to continue handling some drainage function during high rainfall events. During these times, navigation may still be delayed due to the potential for higher velocities in the lock chamber.

2. Rehabilitate existing Black Bayou Culvert structure and construct additional sluice gate structure on Black Bayou

This alternative suggests rehabbing the existing Black Bayou structure and developing Black Bayou as a drainage diversion similar to the previous alternative; however, it also suggests expanding the drainage capacity of Black Bayou by constructing an additional gate structure across LA 384. The rectangle in the photographs below indicates a potential location for the proposed sluice gate structure.

The existing Black Bayou Culvert structure may only be capable of handling up to 80% of the total drainage capacity of the existing lock (and even less of the total drainage capacity of the larger lock alternatives). If it is determined the existing culverts cannot accommodate the basin drainage sufficient to prevent the risk of flooding, additional drainage capacity will need to be provided.

The intent herein is to remove the drainage function from the Calcasieu Lock and allow it to serve salinity control and navigation functions only. As such, this alternative proposes constructing a gate structure on LA 384. The recommended gates would consist of sluice gates with controls being linked to the control house at the Calcasieu lock. Additional dredging would likely be required to connect Black Bayou channel to the new gate structure.

Conceptual sketch showing the proposed location for the new sluice gate structure

Performance Attributes:

Navigation Efficiency – This alternative assumes that the drainage requirements for the Mermentau Basin are such that the existing Black Bayou Culverts do not have sufficient capacity to prevent inundation during high rainfall events. As such, the existing Calcasieu Lock would still have a drainage function which may result in velocities that cause delays to navigation. This alternative would supplement the capacity of the Black Bayou Culverts sufficient to fully remove the drainage function from the Calcasieu Lock, thus eliminating any related delays to navigation.

Structure Reliability – Although currently the Black Bayou Culverts are an NRCS structure, this alternative provides an option to improve the functionality of the structure and prevent it from further deterioration or risk of future failure. As compared to the alternative to provide a new lock with sector gates, this alternative would have significantly less maintenance. The sluice gates may require some periodic maintenance in order to maintain their functionality.

Future Flexibility – This alternative creates the potential of an alternate navigation route that could be used to support the construction of a new lock in the future. However, the sluice gates proposed by this alternative would have to be removed and replaced by the new lock structure. This alternative does increase the flexibility relative to the drainage function of Black Bayou. The increased drainage capacity will allow the system to adjust to heavy rainfall conditions as well as adjust to potential conditions created by sea level rise.

3. Rehabilitate existing Black Bayou Culvert structure and construct supplemental pump station on Black Bayou

This alternative suggests rehabbing the existing Black Bayou structure and developing Black Bayou as a drainage diversion similar to the previous alternatives; however, it also suggests expanding the drainage capacity of Black Bayou by constructing a 1,000 CFS pump station on Black Bayou. The location of the pump station can vary based upon the optimum location for it to readily capture drainage inflows, discharge flows to locations that would maximize the ecological benefits, constructability, and possible proximity to natural gas utility sources. The rectangle in the following photograph indicates a potential location for the new pump station.

The existing Black Bayou Culvert structure is only capable of handling up to 80% of the total drainage capacity of the existing lock (and even less of the total drainage capacity of the larger lock alternatives). If it is determined the existing culverts cannot accommodate the drainage of the basin sufficient to prevent the risk of flooding, additional drainage capacity will need to be provided. The intent herein is to still remove the drainage function from the Calcasieu Lock and allow it to serve salinity control and navigation functions only. As such, this alternative proposes constructing a pump station near the existing Black Bayou Culvert structure. Additional dredging would likely be required to connect Black Bayou channel to the new pump station (see Alternative 8 regarding pump station design).

The pump station has an additional benefit in that it can provide freshwater to the marshes west of LA 384 during drought periods or when the water in the basin is less than the elevation on the west side. This would increase the ecological benefits of Black Bayou by providing freshwater to the area during times it would most be in need of it. The existing Calcasieu Lock and the existing Black Bayou Culvert structure do not have this capability.

Conceptual sketch showing the proposed location for the new pump station

Performance Attributes:

Navigation Efficiency – This alternative assumes that the drainage requirements for the Mermentau basin are such that the existing Black Bayou culverts do not have sufficient capacity to prevent inundation during high rainfall events. As such, the existing Calcasieu Lock would still have a drainage function which may create velocities that result in delays to navigation. This alternative would supplement the capacity of the Black Bayou Culverts sufficient to fully remove the drainage function from the Calcasieu Lock, thus eliminating any related delays to navigation.

Structure Reliability – The pump station would require additional maintenance and operational costs as compared to the gate options. However, it also is the only option that maximizes the benefits to the marshes during low water events.

Future Flexibility – This alternative does increase the flexibility relative to the drainage function of Black Bayou. The increased drainage capacity will allow the system to adjust to heavy rainfall conditions as well as adjust to potential conditions created by sea level rise.

4. Construct new drainage structure on Black Bayou at LA 384 in lieu of adjacent to existing Calcasieu Lock

This alternative consists of constructing a new gate structure hydraulically connected to the Black Bayou channels. The new gate structure could be either a series of sluice gates or could be a vertical lift gate. The new gate structure would be sized to handle 100% of the drainage capacity of the existing Calcasieu Lock; however, it could also be sized to carry additional drainage capacity if deemed beneficial. This would allow the basin to be drained faster when conditions in the Gulf permit basin drainage (i.e. the water elevation in the Gulf is less than the elevation in the basin). New channels would need to be dredged to connect the gate structure to the existing Black Bayou channels (or could be completely new channels). This alternative would be independent of the functionality of the Black Bayou Culvert structure, although ecological benefits could still be considered as the gate structure would increase the hydrologic connection between the basin and the marshes to the west of LA 384.

This alternative has the additional benefit of separating the drainage structure from the lock, thus reducing any potential for impacts to navigation relative to cross-currents created by the drainage flows. Furthermore, the new drainage channels could be utilized as navigation channels either in the interim (if the gate structure supported navigation) or in the future when a new lock is constructed in the location of the gate structure.

The controls for the new gate structure could be located in the Calcasieu Lock control house and could be controlled in conjunction with the needs of navigation and salinity control that will remain the responsibility of the lock.

To facilitate construction, a detour for traffic on LA 384 would need to be constructed. This would likely be accomplished by an earthen fill embankment adjacent to the structure construction, similar to what was constructed when the existing Black Bayou Culvert structure was installed.

Performance Attributes:

Navigation Efficiency – The primary benefit of this alternative relative to navigation is the elimination or significant reduction of high velocities through the existing lock chamber due to the drainage function being handled by the new gate structure. The alternative further enhances navigation due to increasing the distance from the gate structure inlet and outlet channels from the navigation routes, thus effectively negating the issue relative to cross-currents.

Structure Reliability – As compared to the alternative to provide a new lock with sector gates, this alternative would require significantly less maintenance. The sluice gates may require periodic maintenance in order to maintain their functionality, but this is assumed to be minimal.

Future Flexibility – This alternative provides significant increased future flexibility by constructing the channels sufficient to support the future construction of a lock without impacting the existing lock or impacting navigation through cross-currents.

DESIGN CONSIDERATIONS

In any value engineering study, it is the objective of the workshop to seek out alternatives specific to design that would enhance the overall performance of the project and reduce costs. The recommendations in this section may be applicable to specific project components depending on the final alternative(s) carried forward to preliminary design. Some of these recommendations may be considered as "value added alternatives", as they represent an increase in project cost that may be justified by significant improvements in project performance and/or addressing major problems and concerns expressed by the Design Team and the Lock Master.

VE Alternatives:

5. Provide multiple smaller inlets to the south of existing lock for drainage diversion

There is significant concern regarding potentially adverse cross-currents in the GIWW if a proposed new drainage conveyance channel is connected between the Lock and the highway bridge. Current plans are to model the tentatively selected plan and make appropriate modifications based on the results. One possible means to minimize such impact would be the use of multiple outlets with maximum spacing distance from one another in this reach. It is recommended that this concept be incorporated as the base design prior to the modeling validation.

Performance Attributes:

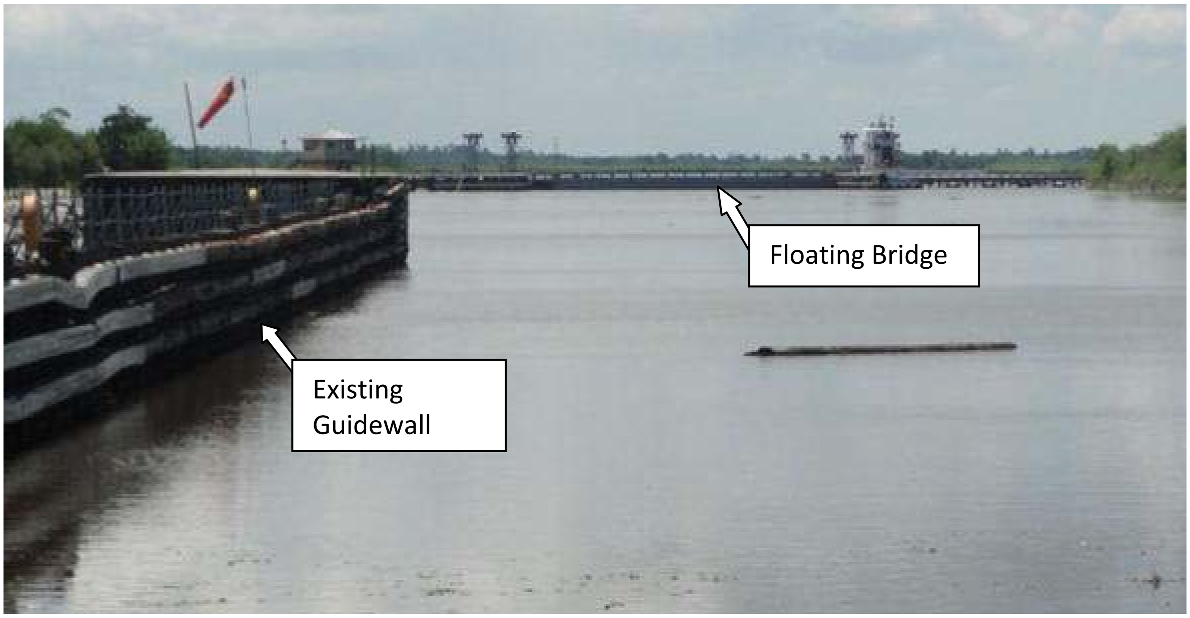
Navigation Efficiency – The recommendation will improve safety and improve relative navigation operations.

Structural Reliability – This recommendation will reduce the risk of guidewall (lock and bridge) damage and improve relative reliability.

Future Flexibility – No significant relative impact.

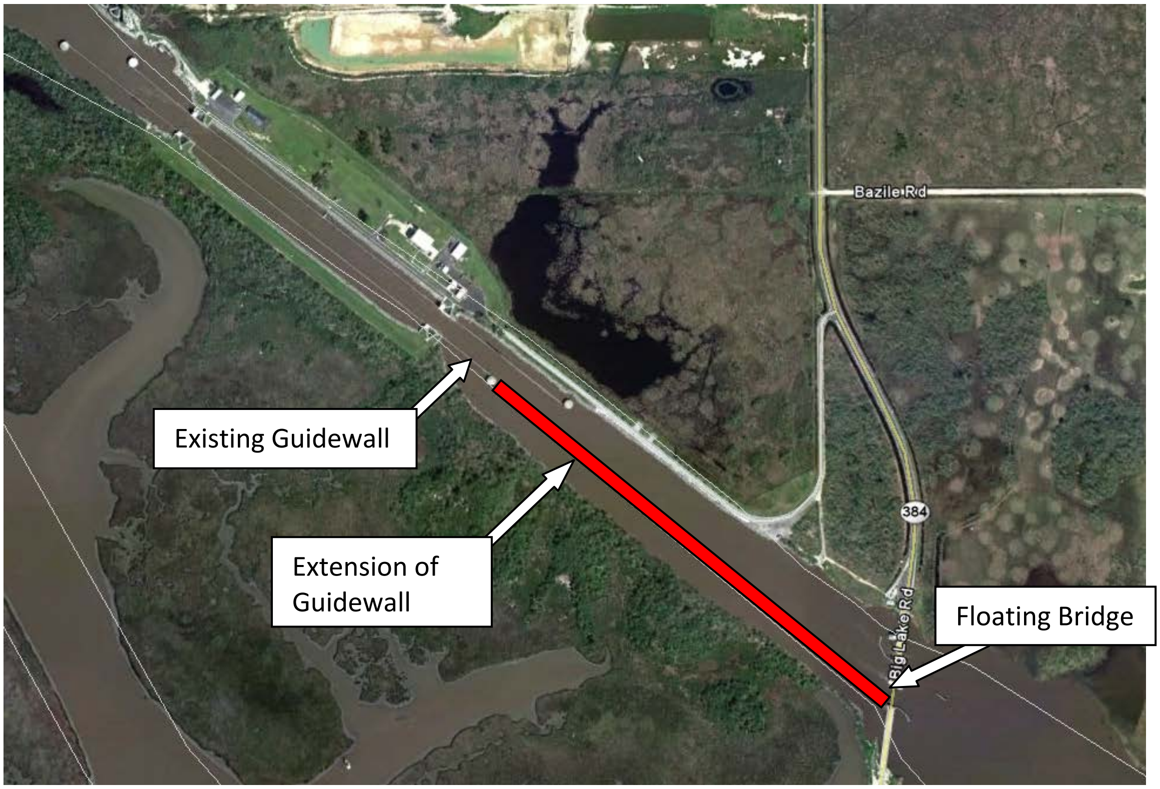
6. Extend guidewall on south side to Louisiana Hwy 384 Bridge

The existing project includes a relatively short (approximately 260 feet long) timber pile-mounted guidewall on the south side of the downbound lock approach. There is also a longer (approximately 565 feet long) timber pile-mounted guidewall on the north side of the downbound lock approach. The existing floating highway bridge crosses the GIWW approach approximately 2,285 feet upstream of the lock. The north guidewall and the floating highway bridge can both be seen in the following photo.



Since the north guidewall is longer, it is surmised that tows preferentially land on this wall during downbound approaches. The addition of extensions to both guidewalls should allow for controlled landings of downbound tows under higher flow conditions than what can be safely accomplished with the existing structure. This proposed change should increase the range of flow conditions under which downbound approaches can be safely accomplished.

Additionally, if new drainage exits are provided between the upper lock approach and the Black Bayou channel, the diverted flow would likely produce outdraft currents that could make downbound approaches considerably more difficult. If a continuous guidewall (approximately 2,000 linear feet as shown in the photo below) was installed on the south side of the approach channel between the downstream end of the bridge exit and the lock, downbound tows could rub along the guidewall surface, promoting more controlled approaches and ultimately lowering the likelihood of damaging collisions.



The advantage of this approach is the potential for producing a generally safer approach environment under all flow conditions. The cost would be highly dependent on whether the proposed guidewall was a simple timber guidewall similar to what currently exists, or if it is a more substantial steel and concrete guidewall. At a unit cost of $4,300/linear foot (basis is *Calcasieu Lock Reliability Report*), the addition of a 2,000 linear foot guidewall would cost approx. $8,600,000.

Performance Attributes:

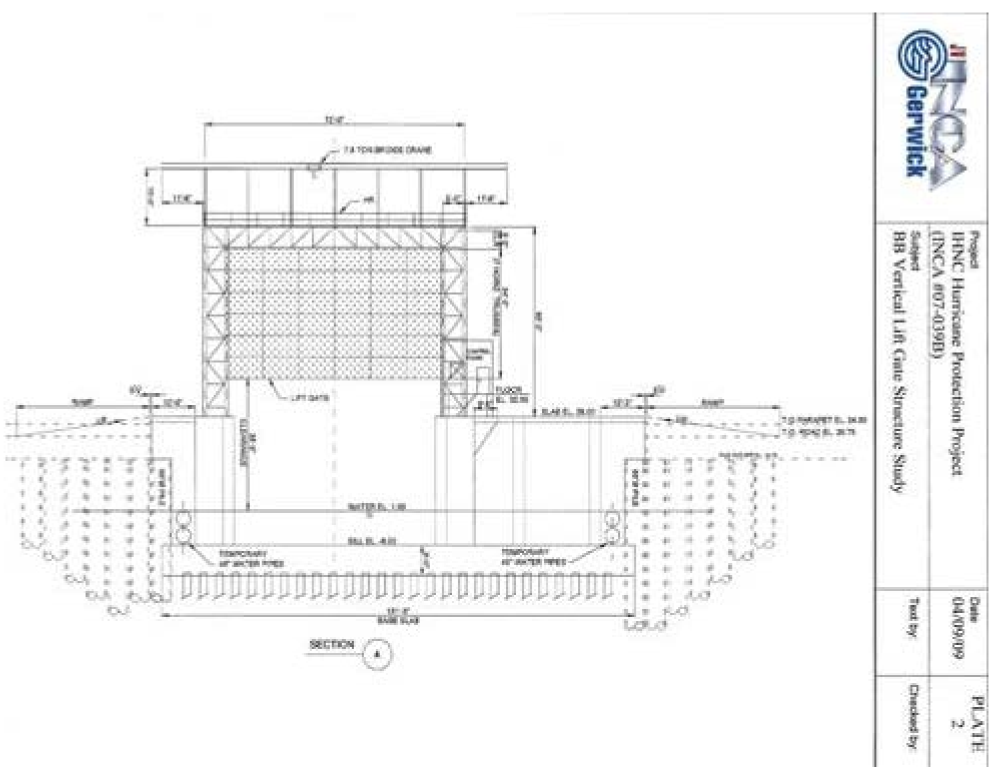
Navigation Efficiency – Increasing the lengths of the guidewalls should increase navigation control and safety, which should result in fewer collisions, ultimately increasing navigational efficiency. The modification of the existing structure should be able to accommodate existing and future traffic, and would reduce navigation delays due to drainage. Having continuous guidewalls between the bridge and the lock should allow navigation to proceed under high velocity flow events with fewer barge reconfigurations. This should decrease cycling times of tows through the lock. This proposal would not detrimentally impact drainage or salinity control.

Structure Reliability – Increasing the lengths of the guidewalls should increase navigation control and safety, which should result in fewer collisions even under more demanding high velocity drainage conditions. Fewer collisions will increase the reliability of the lock structure. Design of the new, lengthened guidewalls should be performed in accordance with the Corps' barge impact criteria to produce a reliable structure that can accommodate an increased volume of traffic arriving at a higher velocity than is allowed under current operating guidelines. A reliable lock structure will have the capacity to stop saltwater intrusion.

Future Flexibility – The extensions to the existing guidewalls should be adaptable to changes in long-term operational conditions, navigation type and demand, and changing environmental conditions (i.e. relative sea level rise). The design should be accomplished in accordance with current Corps guidance on vessel impact, which recommends specific impact loads for various barge combinations for both up-bound and down-bound traffic cases. Although vessel types can change over time, the navigation industry evolves relatively slowly in regard to towboat size and power, barge geometry and speed. The Value Engineering Team believes the types of vessels that transit the Lock will not substantially change in configuration or power over the life of the project.

7. Consider vertical lift gate in lieu of sluice or sector gate for drainage diversion to accommodate temporary navigation

As an alternative to a set of sluice gates or a single sector gate, a vertical lift gate may be considered. This design has been successfully used in recent Hurricane and Storm Damage Risk Reduction projects (50- to 60-foot wide gates) in the greater New Orleans area. Reported cost savings relative to equivalent sector gates has been in the 25% to 50% range. Measurable savings may also be realized as compared to a set of sluice gates for the larger gate plan alternatives (80 to 110 feet). Cost would be expected to be comparable for smaller 50- to 70-foot applications. Although full GIWW required navigation vertical clearance would be impracticable for this type of gate, 50 foot clearance could be achieved without great expense, and it could be considered for lock application if an alternative lock or gate remains/is used in conjunction.



Cross section view of vertical lift gate

Performance Attributes:

Navigation Efficiency – Use of a vertical lift gate would provide some potential navigation capability relative to a sluice gate structure.

Structural Reliability – This recommendation has no significant relative impact to structural reliability.

Future Flexibility – Use of a vertical lift gate would not fully satisfy navigation requirements for a potential future lock upgrade.

8. Apply pump station design 'lessons learned'

Current project alternatives include a pump station option that calls for a pumping plant (or plants) with capacity in the 3,000 – 4,000 cfs range. This is a fairly significant pump station and the application of various 'lessons learned' from among recent MVN, local area and other Corps district projects could improve performance and save significant cost. Such potential changes to recent MVN large pump station design include, but are not limited to, the following:

- Unit redundancy: Corps Engineering Regulations indicate required pump unit redundancy as having the capability of two-thirds of required capacity with one unit out of service. This is not common practice in the water/drainage/wastewater industry where the norm is required full capacity with the largest unit out of service. The Corps Jacksonville District (SAJ) applies the latter to their projects associated with the South Florida Water Management District (SFWMD) Everglades Restoration Program. It is recommended that this SAJ design standard be applied to all Corps pump station designs as it assures adequate performance and offers some indirect potential cost saving advantages as discussed in the next item.

- Screen cleaning system: Current MVN practice calls for fully automatic climber screen cleaning systems that can operate under major hurricane (150 mph wind) conditions. This premium application has proven performance but is very expensive and has very little (if any) manufacturer competition. Arguably, the ability to clean screens during extreme conditions is warranted for urban flood control systems but does not appear to be practical for applications such as this project. SAJ/SFWMD pump station design utilizes a much more economical screen cleaning system that consists of a monorail and rake apparatus. It runs via operator control and is not fully automatic or capable of operating in extreme wind conditions (40 – 60 mph maximum). For extreme hurricane conditions, loss of some pump capacity via potential screen clogging is compensated for by having a redundant pump unit so performance is not significantly jeopardized. Other economical screen cleaning systems other than the monorail type are also available and can compete for selection/utilization. For a large station, the cost savings associated with not requiring a premium cleaning system may more than offset the added cost of a redundant pump unit.

- Discharge configuration: Common practice is to install a discharge siphon to recover head differential between top of wall/pipe and pool-to-pool. For large pump stations that do not operate many hours (such as stormwater pumps), life-cycle cost evaluation clearly indicates net savings associated with eliminating fairly expensive discharge related structure tubes versus the cost of possible additional motor horsepower and long-term added fuel use. Two major pump stations in Louisiana (East Ascension Parish and the West Closure Complex - New Orleans West Bank) have successfully utilized this design. Any major pump station for this project should realize significant cost savings with this configuration.

- Service crane and structure: For most large pump stations, common practice is to include a lifting crane of capacity and geometry to remove the largest piece of equipment from the station. The crane is usually housed in the pump station structure and usually results in significant station height and associated structural cost. It is arguable as to whether or not such a crane is required on-site as it is always a relatively rare and major scheduled event to pull a large unit. If a large crane can be transported to the site, then one could argue that an on-site crane of that large capacity is not needed (note that smaller units are still needed for routine maintenance). If a large crane cannot be practically transported to the pump station for a major maintenance event and an on-site unit is necessary, it does not have to be housed within the pump station building. A rail/gantry system can be used and pump housing roof and/or cover pod can be removed for access. Protection and/or aesthetics of the crane may warrant cover housing in the non-used position. This housing does not have to support the lifting load of the crane, however. The above referenced East Ascension Parish station (see photo below) does not have an on-site large crane. It has steel cover pods over each pump/engine unit and a weather protection roof across the station. Roof panels and pods can be lifted by a portable crane when necessary. This design saves significant cost.

East Ascension Pump Station

- Power supply: Most stormwater pump stations have their own independent power source and are usually diesel fuel (diesel drive and/or electric drive with diesel powered electrical generation capacity). Storage and care of a diesel fuel system is a significant initial and O&M cost item. A potentially more economical fuel is natural gas. If a potential supply is within the vicinity of any proposed pump station, it should be considered. On-site storage is neither necessary nor recommended. Natural gas service is very reliable and not likely to be lost. Service interruption was experienced in the New Orleans area as a result of extreme flooding from Hurricane Katrina. For this project, a similar situation would not matter as the entire system would be breached with storm surge.

Application of the above concepts can save as much as 25% to 50% of current pump station cost. This was the case for the East Ascension Parish station where most of the above recommended design changes were utilized (50% savings versus conventional Jefferson Parish type design as actually bid). Estimated unit cost (total construction) for 'traditional' design pump stations in this capacity range is about $20,000/cfs. Application of the above recommendations may potentially reduce this cost to less than $15,000/cfs or lower.

This difference may be enough to keep the 3,750 cfs pump station option viable. With an estimated annual O&M of $400/cfs, total life cycle cost for this option, not including channel excavation and disposal is as follows:

(First Cost)

3,750 cfs x $15,000/cfs x 1.14 (design and management) = $64,125,000

(O&M)

3,750cfs x $400/cfs-yr = $1,500,000/yr; x Present Worth Factor ~ 20 = **$30,000,000**

TOTAL PRESENT WORTH = $64.13 + $30 = **<u>$94 million (rounded)</u>**

Given currently estimated potential project benefits at about $5.5 million (approximately $110 million present worth) it appears that application of these changes would be critical for the viability of this alternative.

Performance Attributes:

Navigation Efficiency – Recommendation has no significant relative impact when compared to baseline alternative of a new pump station.

Structural Reliability – Potential utilization of a pump station would slightly improve reliability versus a new lock option.

Future Flexibility – Potential utilization of a pumped system provides greater flexibility with regards to the ability to send freshwater to the salt marsh during dry conditions and will not be adversely affected by sea level rise.

9. Provide mooring dolphins at both sides of the lock

In the 27 July 2010 Memo for Record entitled, “July 27, 2010 Drainage Event Navigation Impacts Meeting” the memorandum stated the following: “Subsequent discussion revealed it takes 6 to 8 hours to reconfigure a 2 wide by 3 long (6 pack) tow into two 1 wide by 3 long tows and lock them through. A complicating issue here is the non-availability of mooring buoys. There is no place to “tie off” barges either above or below the lock. Therefore, other towboats or tows must be used to hold one set of barges while the other is being locked. This requires a towboat above and below the lock.” The lack of mooring cells or dolphins appears to be significant hindrance to efficient locking during congested times, and re-configuration of tows in waiting mode.

One layout with possible sites is shown in the following figure; however, actual mooring locations would have to be selected based on input from the navigation industry, coordination with local landowners and government agencies, and may also require input from hydraulic model studies.

Eight potential mooring sites highlighted in red; four east of the lock and four west of the lock

In the inland river system mooring dolphins are generally constructed of sheetpile cells filled with concrete. The cells have integral mooring rings that allow tying off of barges and towboats at various river elevations. Appendix D of EM 1110-2-2602 recommends installation of mooring facilities for tows awaiting lockages, both upstream and downstream of navigation structures. In the New Orleans region and along the GIWW, the inland type of mooring cell is generally not used.

Mooring dolphins fabricated from steel pipe piles

Typical inland mooring cells

The costs of such substantial mooring cells can range widely, depending on their diameter and height. Cells designed for the mooring of vessels at Calcasieu Lock would not have to be designed for a wide range of water elevations – probably to no higher than +10 feet, Mean Low Gulf Datum. The estimated cost of relatively low height mooring dolphins/cells is $250,000 each. Assuming four dolphins/cells would be constructed at both the upstream and downstream ends of the lock, the total cost is estimated to be $2,000,000.

Performance Attributes:

Navigation Efficiency – Providing a series of mooring facilities should increase navigation control and safety, eliminating the need for tows to assist other tows while in waiting mode. This should increase navigational efficiency. These additions to the existing Lock structure should be able to accommodate current and future traffic; and should reduce navigation delays due to drainage. This should decrease cycling times of tows through the Lock. This proposal would not detrimentally impact drainage or salinity control.

Structure Reliability – Providing a series of mooring facilities should increase navigation control and safety, which should increase the reliability of the Lock structure. Design of the new mooring facilities should be performed in accordance with applicable Corps' criteria to produce reliable structures that can accommodate a high volume of traffic.

Future Flexibility – Mooring facilities should be designed to be adaptable to changes in long-term operational conditions, navigation type and demand, and changing environmental conditions (i.e. relative sea level rise). The design should be accomplished in accordance with current Corps guidance on vessel impact, which recommends specific impact loads for various barge combinations for both up-bound and down-bound traffic cases. Although vessel types can change over time, the navigation industry evolves relatively slowly in regard to towboat size and power, barge geometry and speed. The VE Team believes the types of vessels that transit the Lock will not substantially change in configuration or power over the life of the project.

10. If crossing the roadway, use numerous precast conduits (boxes or pipes) to speed construction

If the chosen alternative involves crossing highway 384 with a structure or structures capable of conveying water under highway 384, consideration should be given to using precast box or round culverts. These systems are capable of providing fluid conveyance under the roadway and can be constructed at lower cost and more rapidly than typical cast-in-place concrete structures. Base slabs and gate components can be traditional cast-in-place as required to meet flow regulation requirements.

Pre-cast box culverts under construction – note the sheetpile cofferdam

Performance Attributes:

Navigation Efficiency – This information indirectly affects navigation efficiency, providing alternate flow paths for drainage of the basin, therefore reducing or eliminating the need to stop locking to allow for drainage. This method reduces cost and time necessary to implement this type of alternative.

Structure Reliability – Specific measures must be taken to assure long-term performance of these structures. Of particular concern would be undermining of the culverts which would be eliminated by the placement of a sheetpile cut-off wall incorporated into the base slab. Components would have to be designed and installed with emphasis on assuring long-term reliability and performance of the structure.

Future Flexibility – This recommendation, if implemented solely for providing alternate drainage capacity, does not directly allow for future flexibility with regards to navigation passage.

<u>11. Perform hydraulic model of new channel configuration prior to alternative selection</u>

Several different alternatives are available to achieve the desired effects with varying degrees of value provided by implementation. As the decision makers evaluate the alternatives based upon available technical information, the VE Team recommends that alternatives that appear to induce cross currents be modeled using SHIP simulation prior to final selection to ensure that adverse effects be fully addressed prior to selection. This is necessary due to the relatively narrow range of tidal fluctuations that occur between the interior basin and the exterior basins that produce cross currents and flows which can still adversely affect barge tows navigating Calcasieu Lock. Use of inaccurate model information and results could result in the selection of an alternative that does not enhance the effectiveness of the lock operations and result in little or no added value and, in fact, actually create a more adverse condition.

Performance Attributes:

Navigation Efficiency – This information indirectly affects navigation efficiency providing verification of data used in the selection of the alternative, for which the goal is navigation efficiency improvement.

Structure Reliability – Information on currents, velocities and flows are important as input to the final design of structures that may be constructed.

Future Flexibility – This recommendation does not directly affect future flexibility but is important to verify accuracy of all alternatives, which may or may not provide for future flexibility.

<u>12. Revisit and verify control points in H&H model with respect to MLG assumptions, sill elevations and water surface elevations for open/close</u>

Accurate model input for the hydraulic modeling effort is essential for proper evaluation and selection of alternatives. Of particular concern is a possible difference between actual operating parameters in the field and the operating assumptions used in the modeling efforts to date. The current model assumes full drainage operation beginning at elevation +2.9 feet interior water level while field investigations revealed that drainage actually may begin as early as elevation +2.2 feet on the interior. This may be attributed to the choice of datum (MLG vs. NAVD), but must be verified nonetheless. If it is not due to datum selection, a reanalysis of the model based upon actual parameters used in the field should be performed. Additionally, modeling should include analysis through the full historical ranges of exterior tides as these directly affect the ability to drain the basin and pass navigation.

Performance Attributes:

Navigation Efficiency – This information indirectly affects navigation efficiency providing verification of data used in the selection of the preferred alternative, for which the goal is navigation efficiency improvement.

Structure Reliability – Information on currents, velocities and flows are important as input to the final design of structures that may be constructed.

Future Flexibility – This recommendation does not directly affect future flexibility but is important to verify accuracy of all alternatives, which may or may not provide for future flexibility.

PLAN FORMULATION

The VE Team was tasked to assess the current suite of alternatives that have been carried forward by the Design Team. The intent was to render an independent opinion as to whether all of the currently active alternatives should continue to be considered and carried forward through the remainder of the feasibility level assessment into Preliminary Design Development. Additional plan formulation considerations were also identified. The five VE Alternatives presented below address the VE Team's recommendations regarding future Plan Formulation.

VE Alternatives:

13. Eliminate the kevel system on the north side of the Lock from consideration

A system to assist tows in proceeding safely though a lock is generally considered a positive attribute for a project. However, Calcasieu Lock has a unique operating plan. While the Lock is in the open drainage configuration, underpowered tows require assistance when heading up-bound and down-bound tows that are nearly as wide as the lock would require assistance for control and safety. Assistance provided by a kevel (mule) system would necessitate that the tow requiring assistance must land on the guidewall so deckhands and Operations staff can coordinate to moor the tow to the moving kevel. The kevel would be needed for up-bound tows in order to provide auxiliary power at two locations – for passage over both sector gate sills. Therefore, the kevel rail would need to be continuous all the way from the downstream terminus of the lower, north side guidewall, throughout the length of the lock chamber, and all the way to the upstream terminus of the upstream north side guidewall.

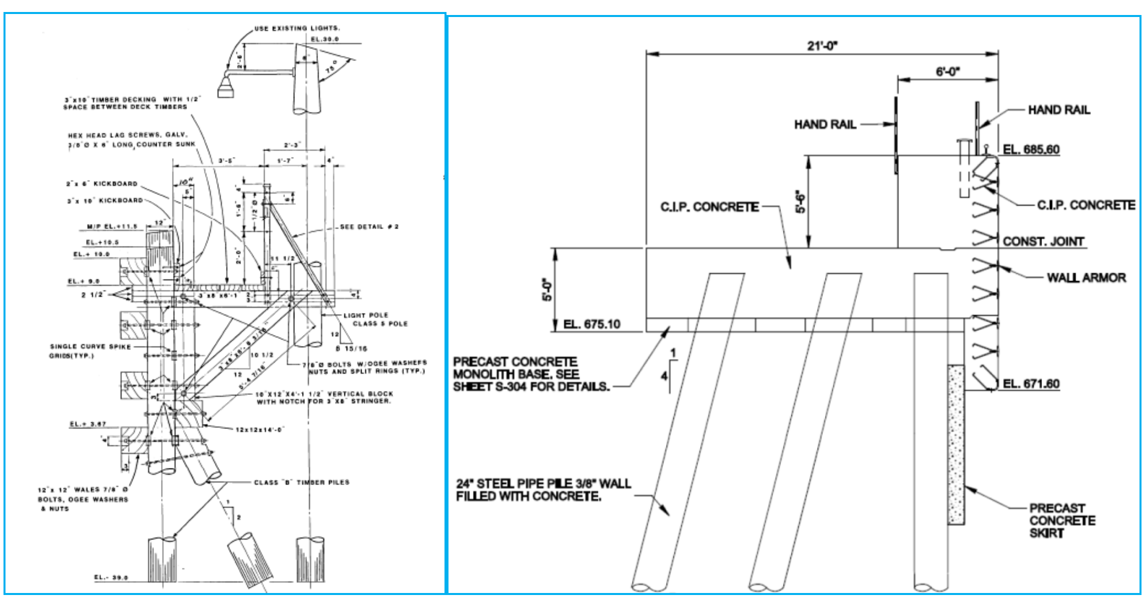
A rail-mounted travelling kevel unit and powered winch system (Photos courtesy St. Paul District)

In the free-draining condition when the lock gates are fully opened at both ends, the "Level 3" current speeds of 6 to 8 mph occur only about 2% to 6% of the time, and "Level 4" current speeds greater than 8 mph occur less than 1% of the time according to the FSM Report (p. 40 of 208, Table

2). This result implies that only a relatively small percentage of vessels have to wait to receive assistance while traveling up-bound in open drainage conditions; however, the number of tows that are underpowered for each Level of current is not known. Thus, the benefits to be realized by providing an operational kevel system are not well understood.

The cost of providing a tow haulage system (moving kevel) is likely unjustifiable. The largest component of the cost would be replacement of the existing lock chamber's north side wall, and both upstream and downstream guidewalls with new walls designed to carry the vertical loads imposed by the motorized kevel and also designed for the lateral and longitudinal forces imposed by the tows' drag forces. The VE Team believes such a system would require significantly more substantial guidewalls and chamber walls than currently exist. For comparison, in the *Calcasieu Lock Reliability Report* the estimated cost of replacement for the guidewalls and the chamber walls was roughly $16.75 million. These walls are simple timber pile founded structural systems (see Typical Section, below) and would need to be replaced with reinforced concrete walls supported with steel pipe piles, designed for the line loads imposed by the tow haulage unit. EM 1110-2-2602 (*Planning and Design of Navigation Locks*) provides the following guidance: "The recommended line capacity of a tow haulage unit with a pair of hoists should be about 5,000 to 7,000 pounds with a maximum speed of 50 to 60 feet/minute. For a single-hoist layout, a maximum line pull of 10,000 pounds is recommended, so as not to break the normal hawsers used on barges." A typical section for the concrete guidewall/chamber wall is shown below, based on St. Paul District's new Lock 3 guidewall.

Although the geometries are different, the rough cost for the Lock 3 wall was about $15,000 per linear foot when it was constructed in 2009-2011. Using this figure, replacement of the approximately 2,000 linear feet of Calcasieu Locks' walls on the right bank would be approximately $30,000,000. This cost does not include the cost of the tow haulage system.



LEFT: Existing Guidewall Typical Section (New Orleans District)
RIGHT: Probable Guidewall Typical Section (St. Paul District)

Performance Attributes:

Navigation Efficiency – Eliminating the proposal to install a powered tow kevel system on the guidewalls and in the Lock chambers should neither increase nor decrease navigation control nor safety from the current status, since the operation of the Lock would not be changed from the current plan. However, when implemented in conjunction with alternatives that would eliminate the drainage function from the Lock, navigation efficiency would be improved.

Structure Reliability – Eliminating the proposal to install a powered tow kevel system on the guidewalls and in the Lock chambers should increase structure reliability over the current status, since the operation of a motorized haulage system would require maintenance relative to alternatives that would eliminate the drainage function from the Lock.

Future Flexibility – This recommendation has no impact relative to future flexibility.

14. Do not locate a new lock north of the existing Lock

As part of this study, the VE Team was asked to revisit the decision of the Design Team to eliminate the alternative to locate a new lock on a northern alignment, from further consideration. The VE Team discussed this option extensively and concur with the Design Team that this location creates many problems that will be costly to resolve. For example, private property may have to be acquired. Additionally, due to the length of the required canal, dredging/disposal costs will be high and the impacted LA Highway Bridge 384 would have to be replaced. Finally, significant mitigation for disturbed wetlands would likely be required. If a new lock is to be constructed, the proposed southern alignment is a better choice.

Performance Attributes:

Navigation Efficiency – The northern alignment would provide a straighter channel than the proposed southern alignment, which may impact how tows can maneuver through the channel due to the anticipated curve on the south alignment. A new bridge would eliminate any delays to either tow or land travel if it is a raised structure.

Structural Reliability – Both options would offer the same structural reliability.

Future Flexibility – Both alignments could offer the same flexibility regarding the alteration of the lock.

15. Address appreciable drainage impact levels in lieu of all drainage conditions

The plan alternatives being considered by the project all attempt, in one way or another, to handle the drainage capacity that the existing Lock is capable of passing. This is assumed to be approximately a 1,200-foot cross-section (16-foot deep chamber x 75 feet wide). The Project Team informed the VE Team that the intent of the project is not technically to increase the basin drainage capabilities; but, at a minimum, the drainage capability cannot be reduced.

Consideration could be given to alternatives that do not provide the drainage capacity of the existing lock. The primary objectives of the project and the NED benefits that are being used to justify the project are related to the reduction of delays to navigation, not to drainage or flood risk reduction. Alternatives that can handle a majority of the drainage capability of the existing Calcasieu Lock (or remove the drainage function from the Lock) should result in significant reduction in flow velocities in the lock chamber and/or will allow the lock to continue lock operations during high water events.

Admittedly, there is a public acceptance issue with this concept given the perception that the Calcasieu Lock is providing such a critical function relative to reducing the potential for flooding or inundation to properties in the Mermentau Basin. However, it would not take a significant effort of hydraulic modeling to approximate the water elevation in the basin as a result of reduced drainage capacity at the Lock. In reality, the actual potential for increased flood risk is relatively low. The only difference from the reduced drainage capacity would come from the amount of time it will take to draw down the water elevation in the basin.

16. Fully consider various relative sea level rise scenarios as part of Plan Formulation and not as Tentatively Selected Plan sensitivity analysis

Different rates of future relative sea level (RSLR) rise will likely affect different project alternatives in a non-equal manner. For example, a pumped drainage plan will not be impacted as much as gravity drainage under a high RSLR scenario. Also, lock options would produce additional NED benefits versus a gate plan. As such, RSLR should be applied during Plan Formulation analysis as opposed to risk/sensitivity application to the prospective Tentatively Selected Plan.

Performance Attributes:

Navigation Efficiency – Recommendation has no significant relative impact.

Structural Reliability – Recommendation has no significant relative impact.

Future Flexibility – Addressing various possible scenarios of RSLR may result in improved future project performance.

17. Perform VE assessment of final array of alternatives

The Design Team requested that the VE Team assess the alternatives that are currently being carried forward (see Table ES-1 on page 35), provide an opinion regarding which alternatives merit further evaluation, and propose any additional alternatives for consideration. The following discussion addresses this request.

Referring to the summary table that follows this recommendation, an apparent large cost versus possible benefits precludes the construction of a new lock; it is recommended that alternatives NSLE and NSLG be eliminated from further consideration. This is supported by the fact that the existing lock, though over 60 years old, has recently been fully rehabilitated including new gates and control facilities, and operates as intended. A wider lock could offer some added benefits of permitting passage of wider tows; however, locks further along the GIWW are only 75 feet wide which would require towage breakdown to permit passage.

The use of kevels or tug boats for vessel assist during drainage periods would require added time to shut down the Lock so that the tows could both hook up and disengage from the vessel assist. The costs associated with construction of the kevel system, as pointed out in VE Alternative 13 above can become excessive. Also, the VE Team was concerned that there may be significant safety risks associated with kevels. Thus, alternatives ELB and ELC are recommended to be eliminated from further consideration.

Also recommended for elimination from further consideration is DAF, Suspension of Lock Drainage. Suspension of lock drainage may impede lock passage by requiring lockage during drainage events, and would likely lead to interior basin flooding. Both of these occurrences would have significant negative economic impacts and would be unacceptable to industry and the general public.

The VE Team supports retaining the balance of the alternatives (ELD, DAA, DAB, DAC, and DAE) for further consideration in the feasibility analysis. Note that the potential viability of the pump station alternative would likely be dependent on implementation of recommendations listed in VE Alternative 8.

In support of the objectives of the feasibility study, and to meet the purpose and need of the project considering the potential funding limitations, the VE Team has recommended four additional alternatives shown at the bottom of the table on the next page. Each of these recommendations is discussed in detail in VE Alternatives 1 through 4 at the beginning of this section of the report.

Performance Attributes:

Navigation Efficiency – Based on the recommendations proposed by the VE Team, the existing Lock would be retained; however, drainage of the basin would be through Black Bayou and, as such, would improve the operational efficiency of the Lock by avoiding drainage-related delays.

Structural Reliability – The structural reliability of the existing Lock remains unchanged. Improvements to the Black Bayou drainage structure should improve its structural reliability.

Future Flexibility – Future flexibility is improved since the recommended approach does not preclude construction of a new lock on the southern alignment should the need arise and funding become available.

Table ES-1: Alternatives to Be Carried Forward and Combinability *(MODIFIED FROM FSM REPORT)*

Category	Specific Measure	Symbol	Potentially Combinable With	Not Combinable With	VE Team Recommendation
New Lock Efficiency Measure	South Lock Alignment 110x1200 feet	NLSE	ELC, ELD, DAA, DAE	NLSG, ELB, DAB, DAC, DAF	Eliminate
	South Lock Alignment 75x1200 feet	NLSG	ELC, ELD, DAA, DAE	NLSE, ELB, DAB, DAC, DAF	Eliminate
Existing Lock Efficiency Measure	New Guidewalls (1200 feet) with Powered Traveling Kevels	ELB	ELC, ELD, DAA, DAB, DAC, DAE	NLSE, NLSG, DAF	Eliminate
	Helper Boats	ELC	All	NA	Eliminate
	Scheduled Lockage's During Drainage Events	ELD	All	NA	Evaluate Further
Drainage Alteration Measure	Pumping Station	DAA	All	NA	Evaluate Further*
	South 110-foot Gate	DAB	ELB, ELC, ELD, DAA, DAE	NLSE, NLSG, DAC	Evaluate Further
	South 75-foot Gate	DAC	ELB, ELC, ELD, DAA, DAE	NLSE, NLSG, DAB	Evaluate Further
	Modification of Black Bayou	DAE	All	NA	Evaluate Further
	Suspension of Lock Drainage	DAF	None	All	Eliminate
New VE Team Alternatives	Rehab Existing Black Bayou Culverts with a Weir on the Eastern Side and Develop Black Bayou as a Drainage Diversion	VEBB1	To Be Determined	To Be Determined	Evaluate Further
	Rehab Existing Black Bayou Culverts and Construct Additional Sluice Gate Structure on Black Bayou	VEBB2	To Be Determined	To Be Determined	Evaluate Further
	Rehab Existing Black Bayou Culverts and Construct a Supplemental Pump Station	VEBB3	To Be Determined	To Be Determined	Evaluate Further
	Construct New Drainage Structure on Black Bayou	VEBB4	To Be Determined	To Be Determined	Evaluate Further

**Only with application of VE recommendations.*

Evaluate Further	New/Evaluate Further	Eliminate

RECOMMENDATIONS FROM PREVIOUS REPORTS

This project shares many similarities with other projects and investigations for which Value Engineering workshops have been performed in the past. Two of these have been reviewed for applicability to all or portions of the proposed work. The relevant components of these past studies are discussed below and presented in more detail in **Appendices E and F.**

VE Alternatives:

18. Consider design recommendations from recent VE study addressing gate design and maintenance

A recently completed VE study, **"**Gate and Lock Maintenance and Design Considerations", August 2011*,* identifies design and maintenance alternatives that may have a significantly positive effect on both major maintenance frequency and duration. Related potential reduction in lock downtime would have a substantial economic benefit in reducing navigation time loss. Such alternatives should fully be considered in initial the design as well as the planning of any lock and/or large gate. The Executive Summary of this document can be found in **Appendix E.**

Performance Attributes (as implied by each referenced recommendation):

Navigation Efficiency – The suggested changes in gate material offer the opportunity to reduce the number of maintenance cycles which would improve overall lock operation efficiency.

Structural Reliability – As stated in the above-referenced report, changing from steel gates to concrete, stainless steel or aluminum gates offers higher reliability levels particularly in reduced potential for corrosion. Also, the use of round members in sector gates improves operation and further reduces concentrated points of corrosion.

Future Flexibility – Alterations to the gate design should not adversely impact any future flexibility of the lock.

19. Consider recommendations from 2003 VE Study as appropriate

A number of proposals from the previous VE study "Value Engineering Study on the Calcasieu Lock, February 2003" are being considered and are reflected in the current array of project alternatives. A number of proposals and design comments from this report should further be considered in plan/project development. See **Appendix F** for further detail.

20. Consider lessons learned in the *UMR-IWW System Navigation Feasibility Study* for applicability to GIWW locks, specifically, Calcasieu

USACE performed a massive regional feasibility study entitled, "Upper Mississippi River – Illinois Waterway System Navigation Feasibility Study" between 1994 and 2002 to develop and begin implementation of ways to improve locking efficiency and increase lock capacity. The product of this effort was a comprehensive document containing dozens of suggestions directed toward minimizing waiting times, increasing navigation vessel control, decreasing the frequency of barge/fixed structure collisions, and maximizing tonnage that can be passed through a typical navigation structure. Some of the recommendations have been approved for implementation, but await funding. These measures include installation of additional mooring structures; use of “switch boats” to assist cut tows through the locks; and implementation of a system wide Traffic Management System. The recommendations contained within the UMR-IWW System Navigation Feasibility Study should be carefully and selectively reviewed for possible implementation at the Calcasieu Lock project. The advantage of this recommendation is the potential for producing a generally safer and more efficient approach environment under all flow conditions. The cost of implementation is unknown.

Performance Attributes:

Navigation Efficiency – The suggestions recommended in the UMR-IWW System Navigation Feasibility Study should increase navigation control and safety, which improve navigational efficiency.

Structure Reliability – Implementing proposals contained within the UMR-IWW System Navigation Feasibility Study should increase structure reliability over the current status, since it should result in fewer damaging barge impacts with the guidewalls, the sector gates and the chamber walls, thus resulting in less maintenance.

Future Flexibility – Implemented proposals from the UMR-IWW System Navigation Feasibility Study should be adaptable to changes in long-term operational conditions, navigation type and demand, and changing environmental conditions (i.e. relative sea level rise). Operational changes should be applicable to changing types of vessels as the years pass. Although vessel types can change over time, the navigation industry evolves relatively slowly in regard to towboat size and power, barge geometry and speed. The VE Team believes the types of vessels that transit the lock will not substantially change in configuration or power over the life of the project.

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APPENDIX A – TEAM CONTACTS

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VALUE ENGINEERING STUDY ATTENDEES

Calcasieu Lock Replacement Feasibility Study

U.S. Army Corps of Engineers, New Orleans District

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APPENDIX B – PROJECT INFORMATION & ANALYSIS

INTRODUCTION

This Value Engineering (VE) Report summarizes the events of the VE study facilitated by Value Management Strategies, Inc., July 16-20, 2012, for the U.S. Army Corps of Engineers (USACE), New Orleans, Louisiana. The Calcasieu Lock Replacement Feasibility Study focuses on upgrading the structure, either through full replacement or modification to structure components and/or operations procedures, so as to reduce lockage delays while providing adequate drainage and blockage of saltwater intrusion.

The intent of this VE study was to identify potentially viable project enhancements and cost-saving measures that may be considered by the Project Delivery Team (PDT). Contained in this report are numerous VE recommendations that have the potential to improve project value by enhancing performance and/or lowering costs.

PROJECT PURPOSE AND NEED

The overall Feasibility Study goal reflects the role Calcasieu Lock plays in a critical navigation system as well as an integral part to a water management system (Mermentau Basin) that requires both drainage capacity and an effective barrier to salinity intrusion. Therefore, the overall goal is to:

- Maximize the efficiency of the Calcasieu Lock, thereby contributing to the overall efficiency of Gulf Intracoastal Waterway (GIWW) as a nationally significant navigation system, while continuing to provide water management capability and salinity control to the Mermentau River Basin.

To support accomplishment of the Feasibility Study goal, the following specific planning objective was developed for the Calcasieu Lock Feasibility Study:

- Reduce drainage event-induced navigation delays at Calcasieu Lock while minimizing the impacts to the surrounding area.

PROJECT DESCRIPTION

The Calcasieu Study addresses navigation improvement planning for the GIWW at and in the vicinity of Calcasieu Lock, Cameron Parish, Louisiana. The study was developed from the results of the GIWW Locks, Louisiana Reconnaissance Report, completed in May 1992. This comprehensive study involved a systems analysis of the GIWW locks west of the Mississippi River. The report documented the need for replacement or improvements at Bayou Sorrel, Calcasieu, and Port Allen Locks. This resulted in a 905(b) Reconnaissance Report specifically for the Lock that was completed in 2001 and which found justification and federal interest in further feasibility level study of the navigation delays and potential solutions at Calcasieu Lock.

The principal problem to be addressed is the delay to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is critical. While the problem and opportunities are localized physically at the Lock, the range of alternatives has potential impacts at multiple scales. Hydraulically, impacts are local and regional in nature as the operation of the Lock is done in conjunction with other structures in the Mermentau Basin. Therefore, potential alterations to existing operations and drainage patterns must be evaluated at those scales. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast must be considered. The GIWW is a large shallow draft inland navigation system that interfaces with the regions deep draft navigation system. Calcasieu Lock is the busiest Lock on the GIWW and 11th in the nation, therefore a systems approach to evaluating economic tradeoffs is being undertaken.

Opportunities exist to increase navigation efficiency through improved operational routines and potential modification of the existing structure to accommodate existing and future traffic. Further opportunities exist to reduce or eliminate navigation delays due to drainage. Altering the existing Lock structure to decrease the impacts of drainage events on transiting tows will result in shorter lockage times and delays for tows staging at either segment of the GIWW (east or west). Fewer barge reconfigurations to allow for transit during drainage events will increase cycling times of tows through the Lock. An additional or wider lock chamber would allow for passing of flows through the old Lock or through a new wider lock that can accommodate drainage events and lockages. Redirecting completely or partially drainage flows away from the existing Lock will reduce or eliminate the delays that result.

Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Cameron Parish, La, approximately 10 miles south of Lake Charles, Louisiana (Figure 1). Calcasieu Lock is a critical component of the Louisiana portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins.

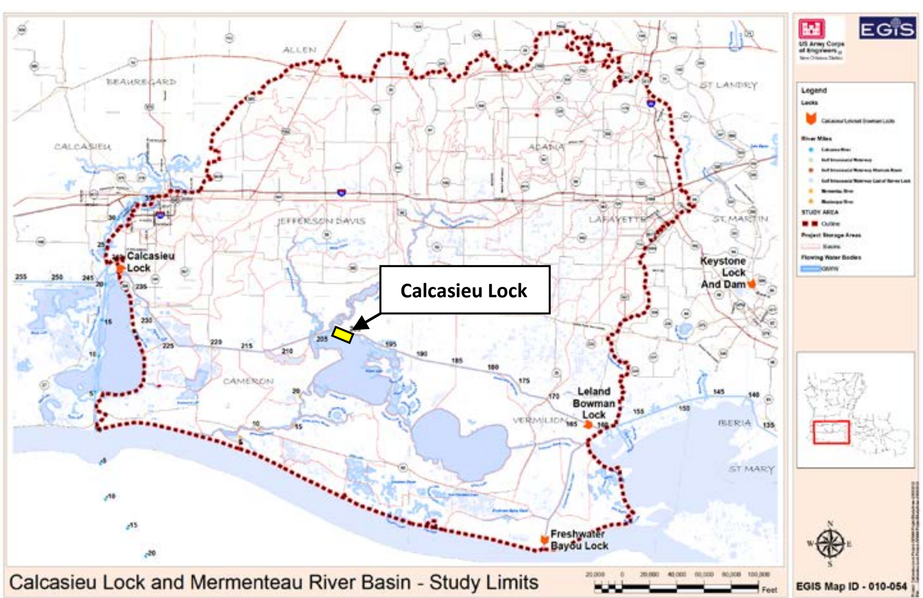


Figure 1 – Project Study Area

GENERAL ALTERNATIVES BEING CONSIDERED

Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including prior studies, the National Environmental Policy Act public scoping process, and the multidisciplinary, Interagency Project Delivery Team. Before alternative plans were formulated, the first step taken was to identify general locations and categories of potential improvements that would satisfy the objectives established previously. The process began with several discussions concerning the objectives discussed in the previous section. This yields an array of general measures from which specific measures were developed. The formulation of these specific measures involved an assessment of the measures as to whether they met the objectives of the study and how likely they were to produce navigation efficiencies through reduction of Lock delays due to drainage. The measures are as follows:

- **New Lock Efficiency Measures:** The use of the existing Calcasieu Lock for drainage purposes creates significant delays during said events. This category of measures looks at addressing this problem by 1) creating new lock facilities for navigation while the existing structure is used for drainage, and 2) creating a new lock facility that has the capacity to pass drainage events and accommodate eastbound tow traffic. Potential measures include new lock chambers at 110-foot and 75-foot width dimensions and either continued use of the existing structure for drainage or closure of the current lock. To more fully explore all options, both earthen lock chambers similar to the existing design and concrete chambers were identified with the primary difference being construction costs.

- **Existing Lock (EL) Efficiency Measures:** The use of the existing Calcasieu Lock for drainage purposes creates significant delays during said events. This category of measures looks at addressing this problem by 1) altering the existing lock to better pass drainage events while reducing delays to navigation, 2) providing measures to assist eastbound tows with transiting the lock during drainage events and 3) implementing scheduled lockage times during drainage events to accommodate the need for both navigation and drainage. Potential measures include replacing the existing sector gates with wider gates that will allow the full width of the exiting chamber to be used for drainage, provision of aids to navigation and scheduling lockages during drainage events.

- **Drainage Alteration (DA) Measures:** The use of the existing Calcasieu Lock for drainage purposes creates significant delays during said events. This category of measures looks at addressing this problem by altering the drainage patterns so the Lock can be used for navigation during drainage events. Measures to be evaluated include pumping, bypass channels with gates, rehabilitation and or expansion of the Black Bayou CWPPRA project and no longer using the Lock for drainage.

INFORMATION PROVIDED TO THE VE TEAM

The following project documents were provided to the VE team for their use during the study:

- Calcasieu Lock Replacement Feasibility Study, Calcasieu, Louisiana, Inland Navigation Project, Feasibility Scoping Meeting Materials, U.S. Army Corps of Engineers, New Orleans District, June 22, 2012.
- Calcasieu Lock Replacement Feasibility Study, Calcasieu, Louisiana, Feasibility Scoping Meeting Draft Report, U.S. Army Corps of Engineers, New Orleans District, June 2012.
- Calcasieu Lock Replacement, Calcasieu Parish, Louisiana, Feasibility Study, U.S. Army Corps of Engineers, New Orleans District, Mississippi Valley Division, Agency Technical Review (ATR), Feasibility Scoping Meeting Package, Review Report, June 11, 2012.
- Calcasieu Lock Assessment, U.S. Army Corps of Engineers, New Orleans District, undated.
- Calcasieu Lock Study, Calcasieu Parish & Vicinity, Louisiana, Section 1 - Hydrology and Hydraulics, Draft Report, U.S. Army Corps of Engineers, New Orleans District, undated.
- Memo of Record: July 27, 2010 Drainage Event Navigation Impacts Meeting, U.S. Army Corps of Engineers, New Orleans District.
- U.S. Army Corps of Engineers, New Orleans District, Alternatives Analysis PowerPoint Presentation.
- Comparative Information from Bayou Sorrel Lock Project.

Note: The information presented in this section of the report may have been excerpted either in part or in full from the documents/information provided to the VE team listed above.

PROJECT ANALYSIS

SUMMARY OF ANALYSIS

The following analysis tools were used to study the project:

- Performance Requirements
- Performance Attributes
- Key Project Factors
- Function Analysis

Performance Requirements

Performance requirements represent those issues that must be met in order for the project to proceed. In essence, these are pass/fail decision points that, if they are violated would negate a suggestion moving forward. Thus, they represent project constraints. The performance requirements identified by the VE team for this project are:

- Alterations of drainage patterns to improve navigation efficiency must be accomplished to maintain the same volume of flow (equivalent capacity) while avoiding and/or minimizing significant flood impacts to the Mermentau Basin.

- Measures considered must not compromise the primary purpose of the existing Lock, which is to prevent saltwater intrusion into the Mermentau Basin via the GIWW.

- With limited alternative routes for bulk cargos being shipped through the Lock, excessive Lock (GIWW) closures that are unacceptable to the navigation industry are to be avoided.

- Meet applicable environmental regulations with appropriate mitigation efforts.

- Stage of water in the Lock should not exceed 2.0 feet after which it must be opened to provide for basin drainage.

Performance Attributes

Performance attributes represent those aspects of a project's scope and schedule that may possess a range of potential values (as opposed to performance requirements which represent essential, non-discretionary aspects). The VE team enlisted the assistance of the project team (when available) to develop these attributes so that the evaluation would reflect their specific requirements. The VE team developed the following list of performance attributes to act as criteria for considering the value potential of the creative ideas.

- **Navigation Efficiency**

  Opportunities exist to increase navigation efficiency through improved operational routines and potential modification of the existing structure to accommodate existing and future traffic; and to reduce or eliminate navigation delays due to drainage. Fewer barge reconfigurations to allow for transit during drainage events will decrease cycling times of tows through the lock. An additional or wider lock chamber would allow for passing of flows through the old Lock or through a newer lock that can accommodate drainage events and lockages. Alternatives/concepts that support optimizing lockage time, thus reducing navigation delays and improving operational efficiencies without detrimentally impacting drainage and salinity control, would be preferred.

- **Structure Reliability**

  Reliability of the existing, modified and/or new physical structure to accommodate traffic and maintain drainage and saltwater intrusion blockage is key to the success of this project. Considerations include the overall durability, longevity and maintainability of structures, equipment and systems.

- **Future Flexibility**

  The ability to adapt to changes in long-term operational conditions, navigation type and demand, and changing environmental conditions (i.e. relative sea level rise) should be considered for each alternative recommendation proposed.

KEY PROJECT FACTORS

In preparing to enter the Evaluation Process, the VE team first participated in an exercise whereby they identified issues they saw to be critical to the project. In doing so, the team members were able to focus on these items and develop recommendations relevant to the project issues in addition to the project functions. Two lists were developed. The first identified project constraints which are described above as Project Requirements, and the second project issues the VE team felt were still open where additional information would eventually be needed for a complete assessment and are presented below.

Project Issues

The following are some of the issues and concerns associated with the project.

- A state highway 384 bridge, several local roads and a few residences are found in the study area. Adverse effects to the existing infrastructure will be minimized to the extent practicable.
- Alteration of drainage patterns or new features to improve navigation efficiency must be accomplished while avoiding and/or minimizing significant impacts to adjacent coastal marshes. Unavoidable impacts need to be mitigated.
- The impact of any alignment on fisheries needs to be addressed; unavoidable losses to fisheries habitat may need to be compensated.
- Use of dredged material to restore wetlands while maintaining fisheries access.
- There are potential issues associated with contaminated dredge sediment.

- Models need to consider relative sea level rise.
- Any water backup on the GIWW will flood farmlands north of the GIWW before the water reaches other structures.
- Black Bayou culverts are inoperable.
- Public perception is that the lock is incredibly important relative to Basin drainage.

RANDOM FUNCTION DETERMINATION

Functions:

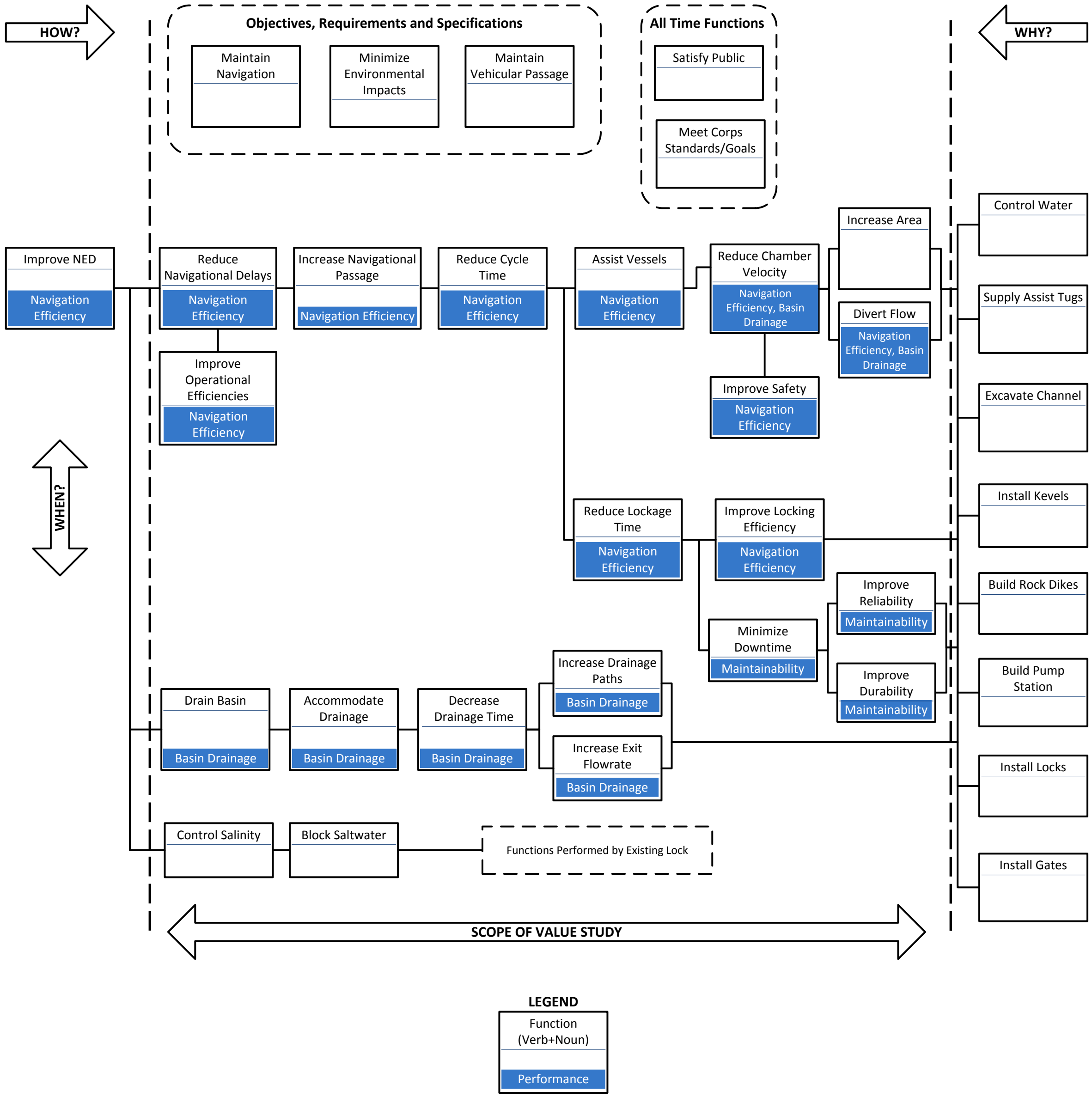
- Maintain Navigation
- Reduce Navigation Delays
- Increase Navigation Passage
- Block Saltwater
- Control Salinity
- Pass Flows
- Increase Drainage
- Accommodate Drainage
- Drain Basin
- Improve Efficiency
- Satisfy Public
- Reduce Cycle Time
- Decrease Down Time
- Reduce Lockage Time
- Minimize Environmental Impacts
- Divert Flow
- Control Water
- Create Alternate Conveyance
- Optimize Gate Design
- Facilitate Operations
- Maintain Vehicular Passage (HWY 384)
- Reduce Chamber Velocity
- Assist Vessels
- Improve Safety
- Increase Cycling Events
- Improve Operational Efficiencies
- Increase Exit-Flow Rate
- Protect Coastal Resources
- Improve NED
- Preserve Agriculture
- Meet Corps Goals
- Improve Reliability
- Improve Durability
- Increase Area
- Decrease Drainage Time

Activities

- Excavate Channel
- Install Gates
- Dispose Material
- Install Locks
- Build Pump Station(s)
- Build Rock Dikes

FAST DIAGRAM

Calcasieu Lock Replacement Feasibility Study



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APPENDIX C – IDEA EVALUATION

SPECULATION/IDEA EVALUATION

The list of ideas created during the speculation phase of the workshop was recorded by the team leader. The Idea Evaluation Form containing all of the ideas, and the rating method applied to each idea is presented in the following pages.

Those ideas that were considered by the team to be feasible were then assigned a recommendation for development as follows:

- DEV = Develop as a VE Alternative/Recommendation
- ABC = Already Being Considered/Being Done
- DIS = Dismissed or Outside Project Scope

During development of the creative ideas, each writer considered the advantages and disadvantages of the individual recommendations to better describe the characteristics of the idea. The expressed advantages and disadvantages contained in each write-up are not reproduced on the form below, and the reader is encouraged to read each recommendation independently for complete information.

The reader will note that, as the evaluation process proceeded, many of the ideas were found to have common themes, and were therefore combined.

IDEA EVALUATION LIST

Idea No.	Title	Rating
1.	Consider smaller (50 – 65-ft) wide drainage gate; open at lower stage	DIS
2.	Re-consider Black Bayou for drainage outlet	DEV
3.	Use NRCS control structure as redundant and/or supplement to new, small Black Bayou drainage structure	DEV w/ 2
4.	Consider two (or more) flow exit points on the GIWW	DEV
5.	Extend guidewall on drainage channel side to LA Hwy 384 Bridge	DEV
6.	Consider vertical lift gate in lieu of sluice or sector gate for drainage diversion to accommodate temporary navigation	DEV
7.	Apply pump station design 'lessons learned'	DEV
8.	Fully consider various relative sea level rise scenarios as part of Plan Formulation and not as Tentatively Selected Plan sensitivity analysis	DEV
9.	Consider design recommendations from recent VE study addressing gate design and maintenance	DEV
10.	Consider recommendations from 2003 VE Study as appropriate	DEV
11a.	Add a weir to Black Bayou on the eastern side	DEV

Idea No.	Title	Rating
11b.	Add a weir to Black Bayou on the eastern side	DEV w/ 2
12.	Build a sluice gates at the lock structure	DIS
13.	Lower the Lock sill to increase the cross-sectional area	DIS
14.	Widen the Lock at the existing location	DIS
15.	Eliminate the kevel system on the north side of the Lock from consideration	DEV
16.	Place a weir on the GIWW multiple transverse drainage points with backflow valves which can drain to the south; maintain minimum pool of 2.0 but do not use Lock for drainage	DIS
17.	Do not locate a new lock north of the existing lock	DEV
18.	Eliminate pump station option	DIS
19.	Consider siphons to transfer water from the GIWW to the south	DIS
20.	Modify Black Bayou inlet to capture and accommodate drainage flows	DEV w/ 2
21.	If Black Bayou is used, consider outflow distribution structures on the downstream side	DEV w/ 2
22.	Rehabilitate the existing Black Bayou structure to handle drainage flows	DEV w/ 2
23.	Remove trash screens from Black Bayou structure if sluice gates are used	DEV w/ 2
24.	Factor sea level rise into H&H model relative to delay times	ABC
25.	Use a barge gate for the 110-foot gate	DIS
26.	Extend the guidewalls to the bridge	(see 5)
27.	Build drainage lift gates on both the north and south sides of the existing Lock (Seabrook design)	DIS
28.	Consider using inflatable dams	DIS
29.	Perform hydraulic model of new channel configuration prior to alternative selection	DEV
30.	Incorporate sea level rise as part of the plan formulation factor	(see 8)
31.	For any new lock, retain the existing lock as operational	ABC
32.	Locate drainage conveyance where new future lock could operate	ABC
33.	Seek ways to identify and quantify NER benefits for each option, in addition to NED	DEV w/ others
34.	Perform VE assessment of final array of alternatives	DEV
35.	Revisit control points in H&H model (MLG assumptions, sill elevation and elevations for open/close)	DEV
36.	Use the GIWW to drain water basin-wide to the east	DIS
37	Create a controlled release drainage basin to the east	DIS
38.	If crossing the roadway, use numerous precast conduits (boxes or pipes) to speed construction	DEV

Idea No.	Title	Rating
39.	Use swing gates in lieu of sluice gates for drainage if modifying the Black Bayou structure	DIS
40.	Use duckbills in lieu of flap gates at the Black Bayou Control structure	DIS
41.	Consider lessons learned in the *UMR-IWW System Navigation Feasibility Study* for applicability to GIWW locks, specifically, Calcasieu	DEV
42.	Put a side sluice gate along the side of the Lock to reduce chamber velocities	DIS
43.	Model a cone-shaped entrance guidewall concept to lengthen the venturi impact	DIS
44.	Tunnel under the lock to carry excess flow	DIS
45.	Use the Mermentau River to drain the basin	DIS
46.	Put temporary points on all barges to make them more hydrodynamic	DIS
47.	Provide supplemental filling mechanisms for locks	DIS
48.	Put in jet nozzles in chamber walls to force flows to the east to counter flows to the west	DIS
49.	Provide method to raise elevation of gulf side during times of drainage	DIS
50.	Provide spare tugs dedicated to overcoming velocities	ABC
51.	Construct up-basin reservoirs	DIS
52.	Rehab Black Bayou culvert where it is and set lock operation time during drainage event	DEV
53.	Provide mooring dolphins at both sides of the lock	DEV
54.	Ensure Black Bayou is controlled in conjunction with the lock	DEV w/ 2
55.	Extend guidewalls on the gulf side	(see 5)
56.	Locate drainage conveyance to maximize benefits to marshes (to the west)	DEV w/ others
57.	Consider a 2,000 cfs pump station	DIS
58.	Address level 2 drainage impact levels in lieu of all drainage conditions	DEV
59.	Construct levees along GIWW	DIS
60.	Encourage landowners to retain water in multiple ways	DIS
61.	Provide all landowners with water retention containers	DIS
62.	Chemically grout soil below the sill; remove the sill and use the soil as the new sill	DIS
63.	Deauthorize the project	DIS
64.	Construct deep water injection wells within the Mermentau basin to remove excess water from the basin	DIS
65.	Construct diversion canal from center of basin to Calcasieu Ship Canal north of the lock	DIS

Idea No.	Title	Rating
66.	Change Lock operation to lock during drainage events	DIS
67.	Locate the drainage conveyance upstream (~0.4 mile south) of Black Bayou	DEV w/ 2
68.	Provide multiple smaller inlets to the south of existing Lock for drainage diversion	DEV
69.	Expand the drainage capacity of Black Bayou culvert structure by constructing gate structure	DEV
70.	Expand the drainage capacity of Black Bayou by constructing a supplemental pump station	DEV

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APPENDIX H

APPENDIX D – VALUE ENGINEERING PROCESS

This report section describes the procedures used during the Value Engineering Study. It is followed by the VE Study Agenda. A systematic approach was used in the VE study and the key procedures followed were organized into three distinct parts: (1) pre-study preparation, (2) VE study, and (3) post-study procedures.

PRE-STUDY PREPARATION

In preparation for the VE study, the facilitator (CVS) and VE team members reviewed the project documents provided to become better prepared for the study (see **Appendix B**). These documents were provided by the New Orleans District of the USACE.

VE STUDY

This VE workshop was a five-day study effort. The SAVE International VE job plan was followed, where applicable, to guide the team in developing alternative solutions and recommendations for consideration in resolving and managing the issues and problems associated with upgrading the structure, either through full replacement or modification to structure components and/or operations procedures, so as to reduce lockage delays while providing adequate drainage and blockage of saltwater intrusion.The standard, five job plan phases are:

- Information Phase (including Function Analysis)
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

Information Phase

At the beginning of the VE study, discussions with the project manager and Project Development Team for the USACE in New Orleanspresented a more detailed review of the issues associated with the project. The presentation and opportunity to obtain responses to questions further enhanced the VE team's knowledge and understanding of the issues. The discussion clarified many of the VE team questions allowing the team to focus on developing recommendations for addressing and managing the issues and problems associated with the proposed project.

During this phase, the VE team further defined the project goals, performance requirements, performance attributes, project issues, and project constraints during the information phase of the study. The phase culminated in the team defining project functions and developing a Function Analysis System Technique (FAST) diagram (see **Appendix B**).

Creative Phase

This VE study phase involved identifying and listing creative ideas. During this phase, the VE team participated in a brainstorming session to identify as many means as possible to provide the necessary functions within the project. Judgment of the ideas was not permitted at this point. The VE team looked for a large quantity of ideas and association of ideas.

The creative idea worksheets listing all ideas suggested during the study are provided in this report (see **Appendix C**). This list should be reviewed, since it may contain ideas that are worthy of further evaluation, and may be used as the problem solutions develop. These ideas could also help stimulate additional ideas by others.

Evaluation Phase

The purpose of the evaluation phase was to systematically reduce/combine the large number of ideas generated during the creative phase to a number of concepts/recommendations that appear promising in meeting the project objectives. The key performance attributes against which the ideas were evaluated include: Navigation Efficiency, Structure Reliability, and Future Flexibility. Once each idea was fully evaluated, it was rated.

Based upon the rating, ideas rated positively where the VE team could assess significant impacts were developed further into Value Engineering Recommendations, and documented in this report. The balance of the ideas that were found to add no value to resolving the issues, or were considered to already being done, were dropped from further consideration.

Development Phase

During the development phase, each idea was expanded into a workable solution. The development consisted of a brief narrative describing the justification for the proposed recommendations. The VE recommendations are included in the VE Recommendations section of this report.

Presentation Phase

The VE study concluded without a preliminary presentation of the VE Recommendations that were developed. A formal outbrief of the findings of the workshop may be scheduled at a later date.

Day 1 – Monday, July 16, 2012 – USACE New Orleans District Office – District Assembly Rooms B-C

8:30	VE Team Set-up
9:00	**Introductions / Brief Overview of the VE Process (Ron Tanenbaum)**
10:00	Project History – Background; Design Overview (Project PMs)
11:30	*Lunch*
12:30	Project History – Background; Design Overview
2:00	VE Objectives/Focus/Opportunities/Performance Attributes (Ron)
2:30	Project Goals, Issues and Constraints (All)
3:30 – 4:30	Function Analysis and FAST Diagram (VE Team)

Day 2 –Tuesday, July 17, 2012 – Meet Under Canopy

7:00 – 6:00 Site Visit – All Day

Day 3 – Wednesday, July 18, 2012 – Homewood Suites Conference Room

8:30	Team Review of Site Visit Observations
9:00	Creativity Session
11:30	*Lunch*
12:30	Evaluation of Ideas
3:00– 4:30	Development of VE Recommendations (Items are assigned to the team member to document recommended recommendations and impacts of those recommendations)

Day 4 – Thursday, July 19, 2012 – Homewood Suites Conference Room

8:30	Development of VE Recommendations (Continues)
11:30	*Lunch*
12:30	Development of VE Recommendations (Continues)
3:00-4:30	VE Team Assessment of Significant Findings and Presentation Preparation

Day 5 – Friday, July 20, 2012 – USACE New Orleans District Office – Homewood Suites Conference Room

8:30 Development of VE Recommendations (Continues)

Presentation/Outbriefing (Delayed to Future Date TBD)

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APPENDIX H

APPENDIX E – SUPPORTING INFORMATION

EXECUTIVE SUMMARY EXERPTED FROM: "Gate and Lock Maintenance and Design Considerations", August 2011

A Value Engineering study, sponsored by the US Army Corps of Engineers (USACE), New Orleans District, was conducted for Gate and Lock Maintenance and Design Considerations, in New Orleans, Louisiana. The study was conducted July 25-29, 2011, at the USACE District Office. This Executive Summary provides an overview of the project, key findings, and the alternatives developed by the value team.

PROJECT DESCRIPTION

The USACE operates and maintains numerous navigation and flood control structures throughout the country including flood gates, lock gates, etc. The gates may be classified as miter, sector, tainter, lift, slide, and sluice gates to name a few. They are typically constructed of mild steel or cast iron and are subject to corrosion and needed maintenance. Some sluice gates are constructed of stainless steel.

For the purpose of this report, the USACE New Orleans District will be used as the example District. The District operates and maintains approximately 24 control structures in the State of Louisiana. Although incomplete (for example, the new West Closure Complex (WCC) and the closure of the Mississippi River Gulf Outlet (MRGO) are not shown on the map), the location of most of these structures is shown later in this section in Figure 1.

These structures primarily utilize miter or sector gates (see Figures 2 through 9 below), with accompanying tainter and sluice gates. These structures serve to protect areas from flooding, particularly from hurricane surge, as well as salt-water intrusion that could damage inland farming, sensitive environments and fisheries. The locks support navigation by passing commercial and private vessels.

The gates require maintenance to address issues that include corrosion (rusting, pitting), seal deterioration, cracking and impact damage. Each gate is unique in dimension and weight to the lock or floodgate it serves. The maintenance cycle, generally desired, is every 10 to 12 years; however, this time frame is often delayed by budgetary constraints, or accelerated by some form of impact damage that makes a gate inoperable. A complete maintenance event is usually done in two consecutive years, where one set of gates will be pulled/rehabilitated at an optimal time of the year, then repeated for the other set of gates the following year.

Representatives from the U.S. Army Corps of Engineers report that several significant components to maintenance exist. These include pulling the gate, which requires a substantial number and/or capacity of cranes as each gate can weigh from 30 to 200 tons, and sand blasting and painting, which comprise the greatest amount of maintenance/restoration time. They further report that sector gates can tolerate more impact and still serve a function whereas miter gates, if hit hard enough, will fall off their anchorages.

These observations may be the reason that all currently proposed new control structures are being planned or designed with sector gates.

In addition to gate corrosion other factors contribute to the necessity for major maintenance. Such items include but are not limited to the loss of function of lubrication systems, hinges, pintles and seals.

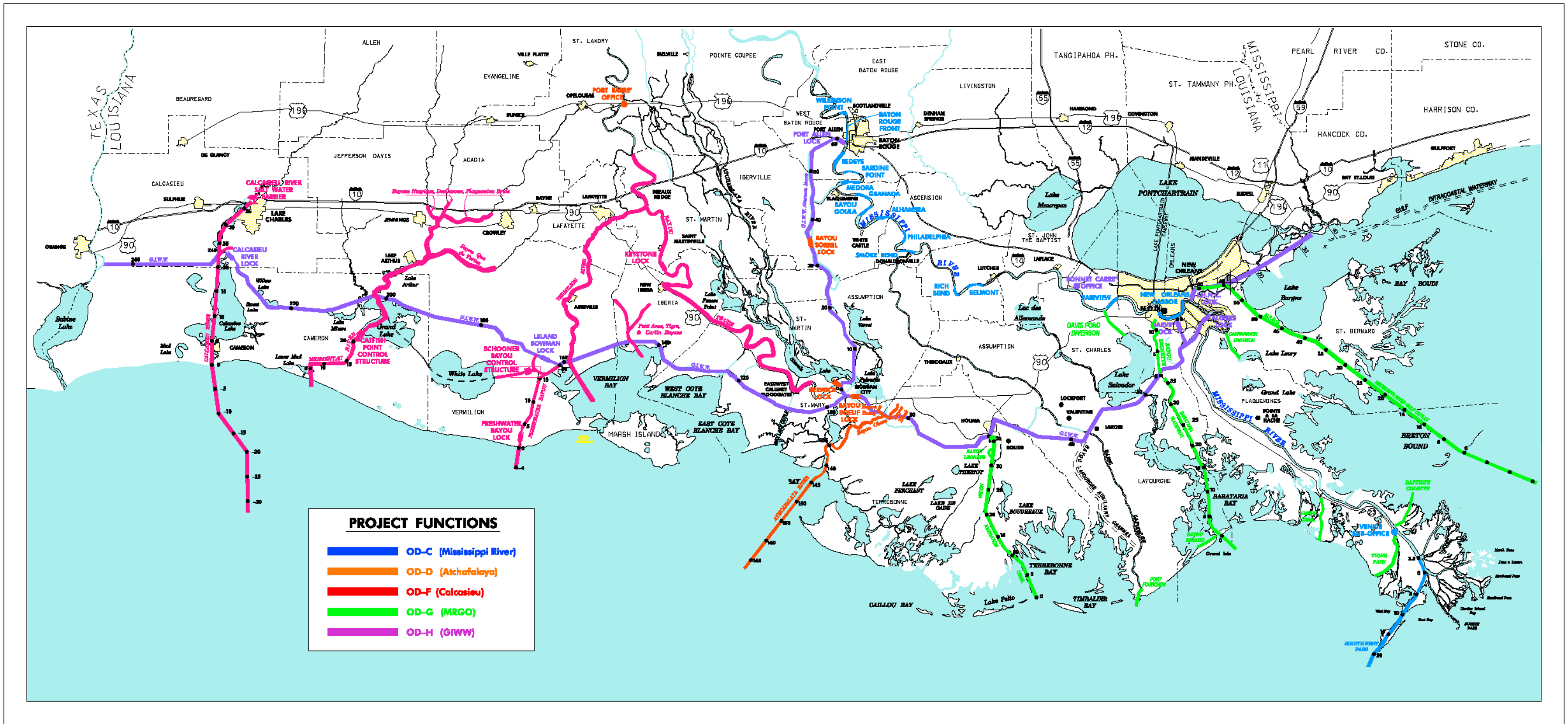

Figure 1 – Navigation and Flood Control Structures in Southern Louisiana Managed by USACE New Orleans District

(Note: MRGO closure and NEW WCC not shown)

VALUE STUDY OBJECTIVES

The objective of the VE study was to address the major maintenance and design of large floodgates, lock gates and similar structures. The VE study goal is to identify possible measures to improve the design approach, and to both minimize maintenance costs and increase the time period between required major maintenance cycles.

In August 2004, a Value Engineering Study Report was published entitled *Improving Life Cycle Costs of Construction/Operation/Maintenance of Gate Structures, Value Engineering Report, GeoVal, Inc. and U.S. Army Corps of Engineers, New Orleans District.* The objective of that VE study was to identify viable alternatives to improve the life cycle performance of lock gates through reduced maintenance, improved corrosion resistance, and reduced frequency and duration of maintenance cycles and lock closures. Such improvement generally looks to improving function, improving quality, incorporating life cycle costs, and reducing and/or increasing cost/performance as appropriate to improve the project value.

Since publishing this report, the U.S. Army Corps of Engineers has assessed the recommendations contained in the report, implementing some, rejecting others and delaying decisions on some as a result of the need for further analysis or a lack of available funding. This VE study reexamined the findings of the 2004 study along with the decisions (made or pending) instituted by the Corps, and developed additional recommendations based on the latest available knowledge and documents relative to the design and maintenance of gate structures.

SUMMARY OF RESULTS

Major Findings

Significant findings of the VE workshop include:

Recognition that a 20-year major maintenance cycle is both reasonable and attainable and that such a 20-year maintenance cycle design criterion should be established – Current 'preferred' major maintenance cycle frequency for major steel structures is 10 to 12 years; due to budget constraints, actual cycle is 14 to 15 years unless a significant problem arises that requires immediate attention. What is apparent is that a 14 to 15 year cycle has not been particularly problematic, and more important, only several specific critical items that drive the maintenance cycle, can be improved **with relatively small investment**, to attain even longer maintenance cycle frequency. It is believed that these components can be upgraded to 20-year service life and that this should be adopted as an official design criterion. It is worth noting that Louisville District has not pulled gates on locks in the Ohio River for such a 20-year period. **While such improvements will slightly increase construction and/or major maintenance costs, increasing maintenance cycle to 20 years will certainly be cost-effective just based on life-cycle maintenance costs and will produce significant navigation cost savings in locations where high impact to navigation is associated with major maintenance activity.**

The following summary lists the critical factors (may not limited to only these) that could be addressed to achieve 20-year maintenance cycle duration:

- Corrosion protection systems – The addition of anodes **for all** submerged steel structures, **including those in freshwater**, plus more stringent paint application specifications and field control, and the use of tubular structural members to reduce convex connections can increase corrosion protection systems to 20-year practical life.

- Lubrication of pintles and hinges – Improvements to performance and longevity of lubrication systems is an important factor in extending maintenance cycle. Premium grease delivery components and/or the addition of redundant lines, etc. should be considered.

- Seals – The design and material selection for seals can be improved to gain additional service duration.

- Pintle bushing material – Use of a more expensive steel/lead alloy would provide longer service life to the pintle bushing particularly if lubrication systems do not fully perform as this material is self lubricating to some extent.

- Impact fender systems – All gates are subject to both major and minor impacts – the latter with relative high frequency. The addition of impact fender systems on gate frontage can add to the overall maintenance cycle life.

Changes in gate design that would help facilitate maintenance – There are several design considerations that may significantly reduce future maintenance time and cost. Such modifications may include:

- Designing for in-place maintenance of new, large gates; it is possible to oversize the gate holding structure and include amenities that would permit jacking up the gate in place and performing all necessary maintenance. This has recently been implemented and constructed for the West Closure Complex. Temporary de-watering gates must be designed/included such that marine traffic is not disrupted during gate maintenance.

- It may also be possible to design 'sectional' gates (miter gates only) that would provide a modular approach to gate fabrication and maintenance. For example, one gate could be comprised of three modules while another of equal length could be made of only two, such as Louisville District for the Green River Locks 1 and 2.

- The standardization of as many structural and mechanical components would allow some level of spare part storage that would be available for use for numerous locations.

- Consideration should be made to using alternate gate construction materials that would eliminate or greatly reduce corrosion. Various options of a concrete gate appear to warrant further evaluation.

Implementation of measures to address risk management challenges – Optimizing and planning major maintenance action is becoming increasingly difficult given aging facilities and probable reduction of funding. It is therefore recommended that the following actions be accomplished:

- Development of an asset/risk management system; The Corps' Risk Management Center (RMC) has been working to establish asset management systems for Corps Districts, and the first basic condition assessment has already been accomplished for all locks nationwide. The Engineering Research and Development Center (ERDC) has created asset management software, but at this point the level of detail to be tracked is not to the finer component level proposed herein. The RMC eventually hopes to allow regional, if not national, prioritization for major repairs or replacement of lock and dam components. A District asset management system can be used to prioritize repairs and establish a plan for major capital expenditures, such as replacement miter gates, replacement sector gates, etc.

- Preparation of a risk report that demonstrate potential loss associated with loss of a facility and/or closure (navigation and/or flood damage risk); given reduced maintenance funding, prioritization of major maintenance needs will be required. A major consideration in selecting which gate gets maintained versus not is the consequential risk of failure of the facility. It is, therefore, highly recommended that Operations requests Project Management – Economics Branch to prepare a brief document quantifying flood damage and/or navigation impact risk consequence associated with failure or closure of all gated structures. This information is critical in prioritization of maintenance needs under probable upcoming significant to severe budget restraints.
- Prioritization of major maintenance actions; the adoption of a highly detailed and cost balanced O&M priority system has the great potential to extend the length of each maintenance cycle and could shorten the period or frequency of closures over what is currently being experienced. This process can be both integral and supplemental to the above discussed asset risk/management.

VE Alternatives and Maintenance/Design Suggestions

Three specific VE alternatives that could directly lower long-term life-cycle costs were identified and developed and are listed in the following table. Full documentation of these recommendations can be found in the next section of the report. Explanation of costs and navigation benefits are also discussed below.

Summary of VE Alternatives

Alt Number	Alternative Title	Initial Cost Savings	Total Estimated Present Worth of LCC Savings Without Potential Benefits to Navigation	Total Estimated Present Worth of LCC Savings With Potential Benefits to Navigation
1a	Develop and implement improved corrosion protection systems for gates – sacrificial anodes in fresh water	($223,000)	$300,000	$2,493,000
1b	Develop and implement improved corrosion protection systems for gates – sacrificial anodes in salt water	($100,000)	$501,000	$5,330,000
2	Use tubular members where possible	$111,000	$775,000	$5,727,000
3a	Build sector gates out of concrete – steel reinforcing	($393,000)	($234,000)	$4,718,000
3b	Build sector gates out of concrete – FRP reinforcing	($577,000)	($418,000)	$4,354,000

Cost savings is based on individual lock facility. In addition to the above individual alternatives that directly address life cycle cost the VE team also developed a series of related suggestions as follows:

Design Suggestions	
Number	**Description**
Changes to Maintenance Procedures:	
1	Recognize that a 20-year major maintenance cycle is both reasonable and attainable; establish 20-year maintenance cycle design criterion
2	Perform a critical path analysis of past dewatering operations
3	Develop an asset/risk management system to prioritize repairs
4	Prioritize O&M to reflect shrinking funds
5	Prepare a risk report that demonstrate potential loss associated with loss of a facility and/or closure

Design Suggestions	
Number	**Description**
6	Summarize critical items that are pertinent to a maintenance cycle
7	Locate critical mechanical equipment above the 500 year flood elevation; and/or design the critical components to be submerged; and/or provide critical spare equipment
8	Analyze dewatering levels to extend the maintenance window
9	Streamline miter gate diagonal prestress procedure
10	Use best value procurement for painting
11	Repair cracks in walls before rebar can corrode
12	Use rapid set concrete or epoxies for concrete repair
13	Assess section loss for structural steel members using non-destructive testing techniques; Investigate sensors to assess level of deterioration below the waterline or where direct visual inspection is prevented
14	Conduct more aggressive inspections with ROV or divers
15	Have spare operating machinery at each structure
16	Provide alternate means to operate gates while the operating machinery is out of service
17	Use more hand preparation/grinding for paint preparation (follow NACE RP0178 standard)
18	Take gates 5 and 6 out at IHNC and store on land
19	Provide maintenance facilities
20	Develop action plan for implementing VE recommendations
Changes to Design	
21	Provide spare gates at all projects
22	Design gates for new structures to be maintained in place
23	Standardize gate design (e.g. modular units, ancillary components, etc.) where appropriate
24	Modify existing gates to eliminate high corrosion locations
25	Use leaded bronze for all bushings including pintle bushings
26	Design a sectional gate that can fit multiple locations
27	Design a modular/replaceable check post system
28	Put fenders on the skin plate side of the sector gates to protect from minor

Design Suggestions	
Number	**Description**
	impacts, where space is available for existing gates, and on new gates; Use "safer barrier" design for fenders
29	Use fiber reinforced concrete; Use stainless reinforcing steel; Use FRP reinforcement in lieu of steel reinforcement
30	Develop systems to monitor lubrication and design greasing system for ease of use by maintenance personnel
31	Develop automatic lubrication system for rack and pinion systems
32	Assess additive compound for seals to extend their life
33	Investigate alternate types (use floating seals instead of J-bulb seals (see WCC)
34	Develop a modular accessible seal for ease of replacement
35	Ensure that seal locations (including stoplogs) are readily accessible to diver
36	Add a second nut to reduce the need to continually tighten nuts on the strut
37	Supplement facility and navigation lighting
38	Consider broader application of a plow blade/sweeper plate on the leading edge of the gates
39	Use sacrificial steel where you have known potential for wear
40	Modify horizontal girder for needle dewatering system
41	Incorporate roller bearings on gates
42	Extend fenders at Algiers Lock to close gaps in lock wall
43	Use paint coating paint systems that can be easily repaired in the field
44	Build fiber reinforced polymer (FRP), or other synthetic sector gates

SIGNIFICANT PROJECT FACTORS

Gate Design

Using the Inner Harbor Navigation Canal (IHNC) Lock and Old River locks as examples of a typical miter gate system, and Calcasieu and Algiers locks as examples of typical sector gate systems, the figures and photographs presented below provide a visual representation of these structures.

Critical components of either a sector or miter gate include, but are not limited to the following:

- Gate structural frame and skin plates
- Movement mechanism, power source and mechanical components

- Connecting and bearing components – top hinge assembly and bottom pintle bearing and socket bushing
- Lubrication system
- Gate seals – bottom and sides
- Impact protection fender system

Figure 2: Front of miter gate, IHNC Lock

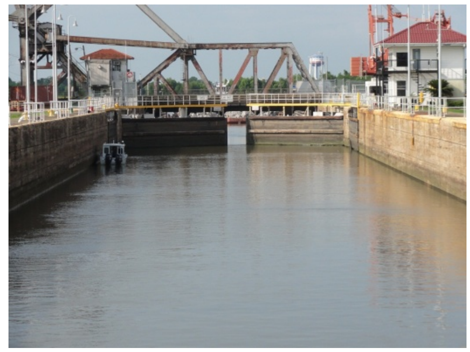

Figure 3: Back of miter gate, IHNC Lock

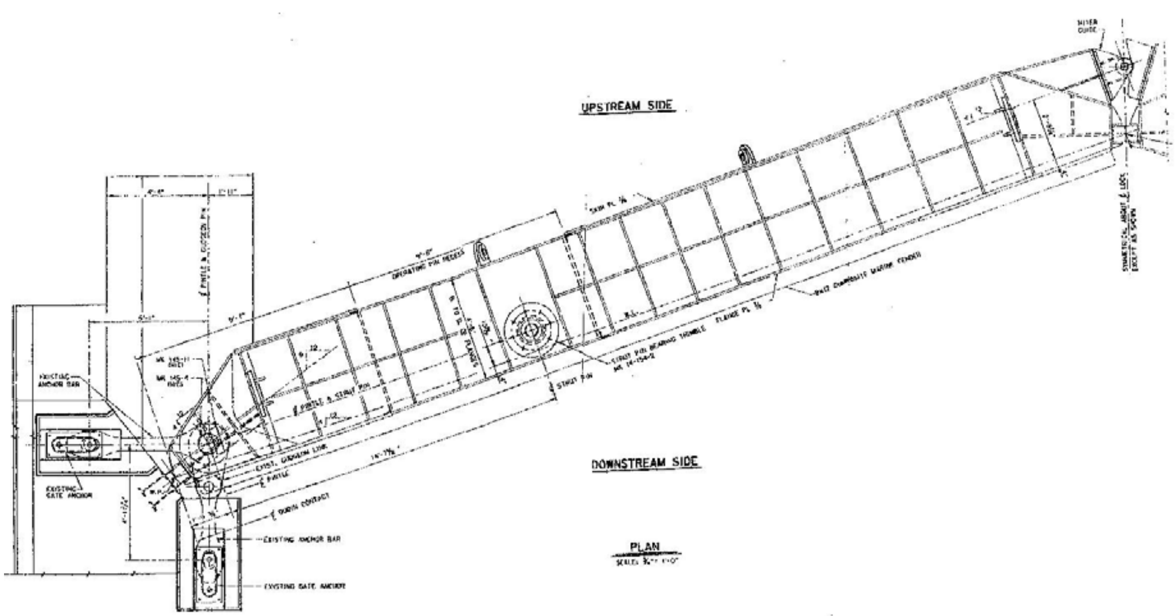

Figure 4: Plan view of miter gate details (typical), Old River Lock

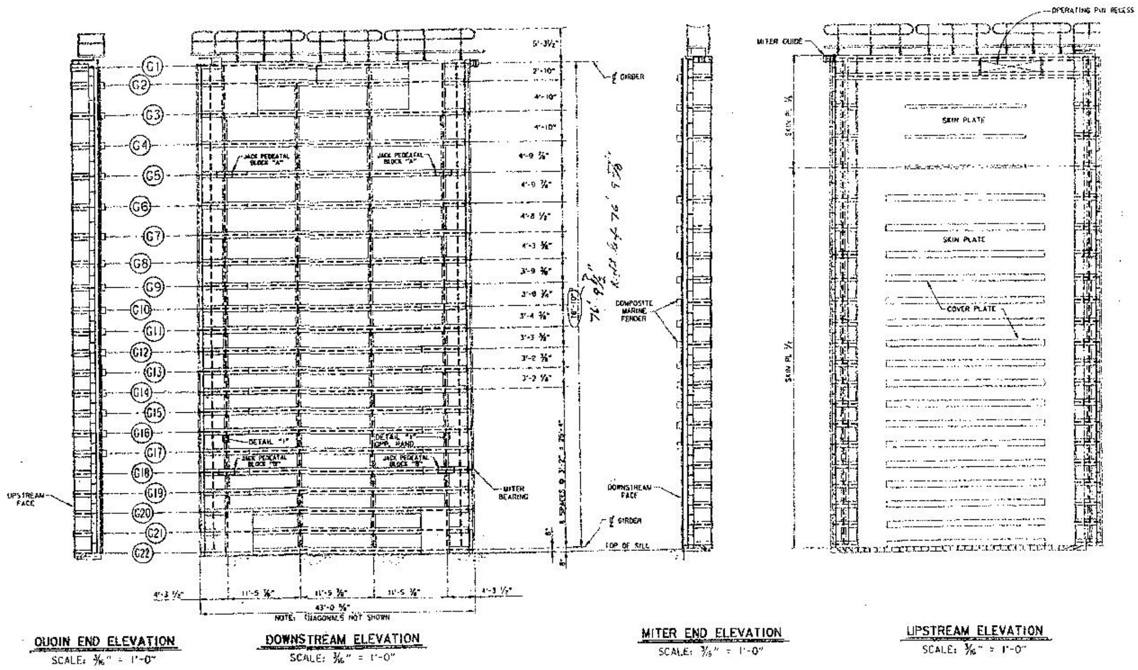

Figure 5: Elevation view of miter gate details (typical), Old River Lock

Figure 6: *Top and back of sector gate, Algiers Lock* *Figure 7: Front of sector gate, Algiers Lock*

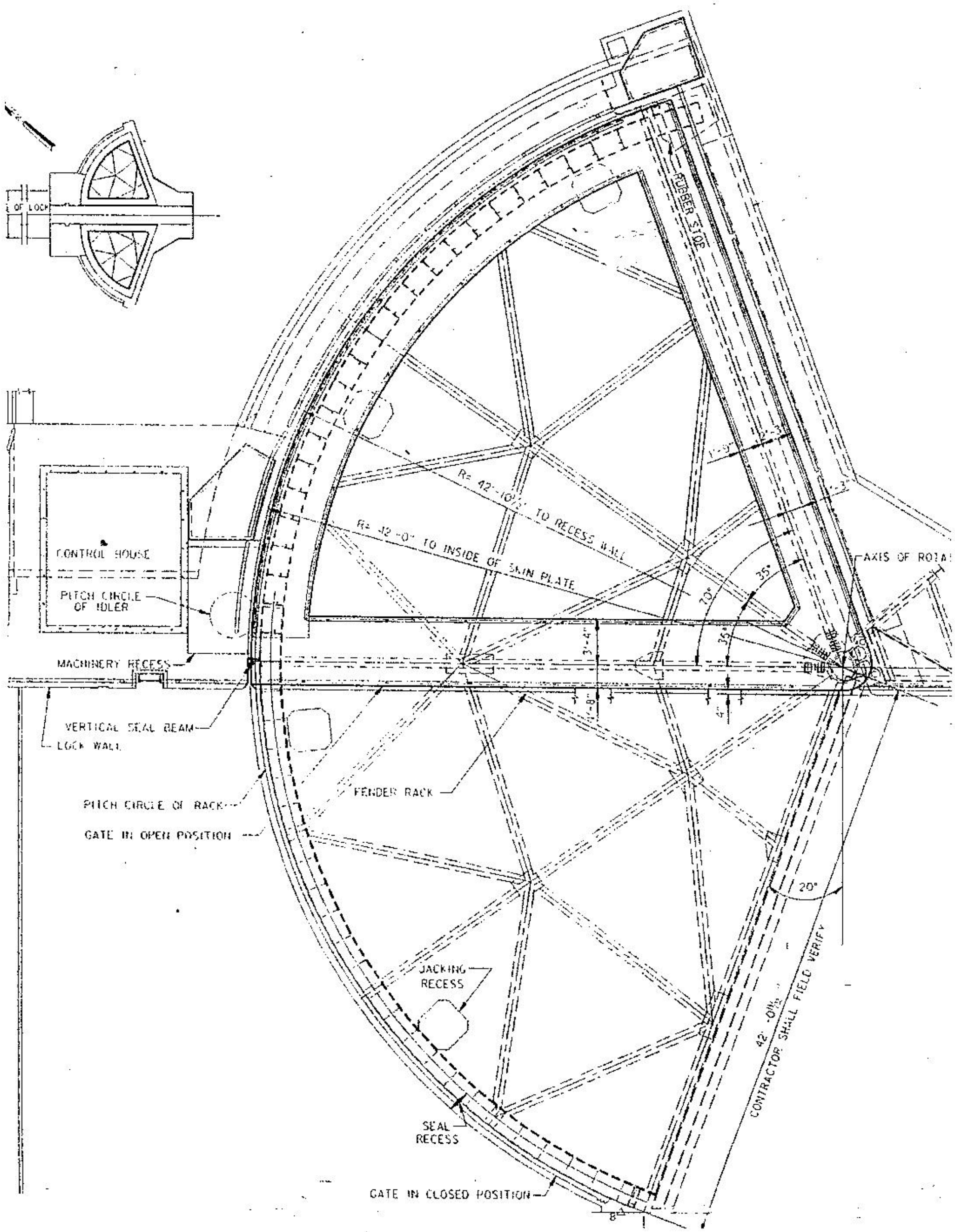

Figure 8: Plan view of sector gate details (typical), Calcasieu Lock

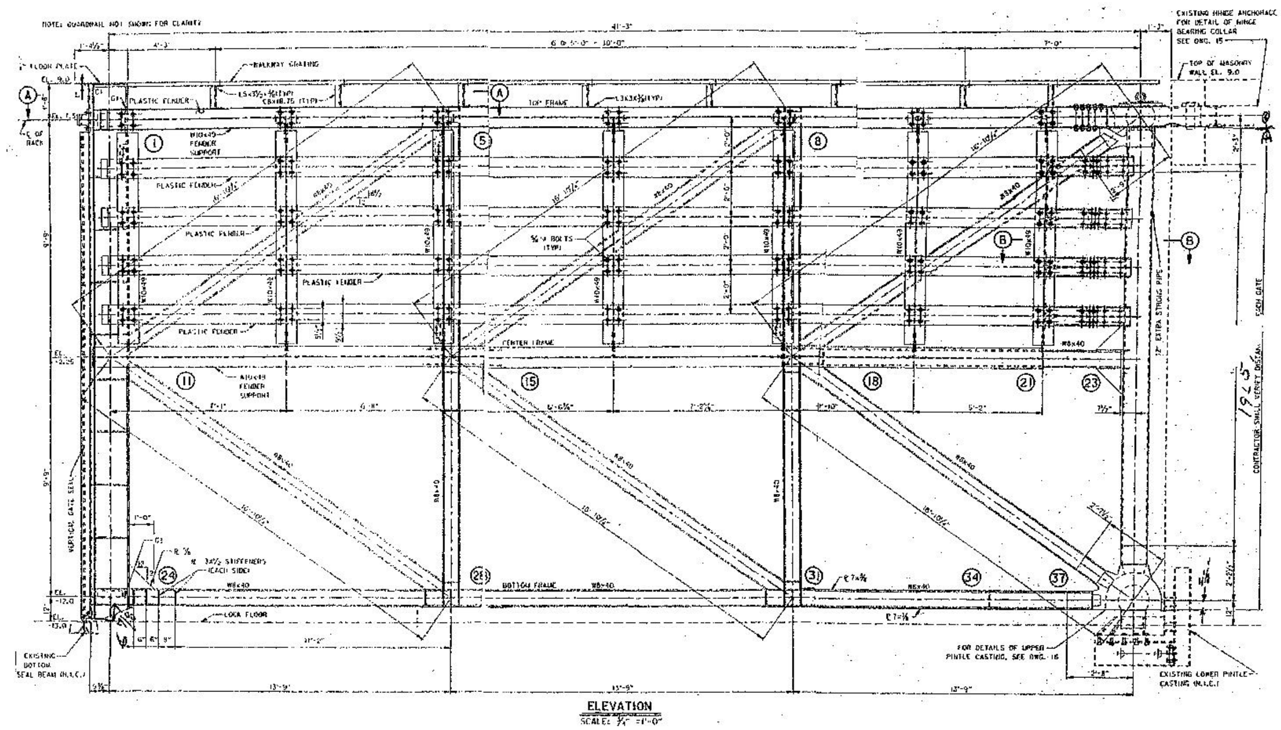

Figure 9: Elevation view of sector gate details (typical), Calcasieu Lock

Appendix C to this report contains numerous photographs taken of the miter gates at IHNC Lock, and the sector gates at Algiers Lock and the West Closure Complex (WCC) floodgates during the VE team site visit of July 26th. The photographs present the type, operation, construction and condition of these gates, exhibiting the typical maintenance-related damage that the USACE must resolve.

Issues

In order to fully analyze and evaluate current maintenance and design as well as new ideas, the VE Team first participated in an exercise whereby they identified critical issues they saw to be important to the design and maintenance of gate structures. In doing so, the team members were able to focus on these items and develop alternatives relevant to the critical issues in addition to the project functions.

Two lists were developed. The first identified critical issues the VE team felt were still open where additional information would eventually be needed for a complete assessment. **Appendix D** - *Performance Attributes, Project Constraints, Critical Issues and Site Visit Observations* contains the complete list. The items listed below are the key drivers, constraints, or issues being addressed by the project and considered during this VE study to identify possible improvements:

- Frequency and duration of maintenance events
- Deferred maintenance due to a lack of available funding
- Bearing surfaces wear (hinge, pintle, bushings, anchorage, etc.)

- Painting including sand blasting that occupies a significant portion of the maintenance cycle
- Rusting/pitting corrosion
- Reduction in operations and maintenance (O&M) funding

The team also identified two project constraints listed below:

- Gate operations cannot be impaired
- Must maintain "adequate" structural integrity and/or factor of safety

Major Maintenance

The VE process generally requires that the alternative costs be developed and compared to the 'Status Quo' where appropriate. For this study, the VE team lacked a detailed cost breakdown for the maintenance and refurbishment of miter and sector gates. It was further recognized by the team that each structure has unique requirements that are involved in the cost of maintenance, such as installation of cofferdams, etc., which could not be quantified for this study. In order to address this difficulty, the VE team developed representative costs associated with the "Status Quo" to serve as the baseline cost to which the costs associated with the alternatives could be compared.

Since most gates within the system of control structures in Louisiana are sector gates, the VE team selected **Calcasieu Lock** as the example of sector gates to use in analyses in the study

The below table illustrates estimated cost items for a major maintenance event at a facility such as Calcasieu Lock. The cost shown **($939,000)** covers a single event where only one pair of gates are removed, re-furbished and replaced. Note that it is assumed in later cost comparisons that a second equal event would be performed the following year on the remaining set of gates.

Maintenance and construction costs that were developed in the 2004 report were indexed to 2011 levels (27%) via indices from EM 1110-2-134 - Lock Construction. For other construction items shown in various cost comparisons below a composite index factor of 1.40 (40%) was calculated by combining materials and general construction, as weighted by percentage of labor versus materials.

INITIAL COSTS *Gate and Lock Maintenance and Design Considerations*							VMS
TITLE Current Maintenance Costs to Refurbish One Set of Sector Gates							NUMBER Status Quo
CONSTRUCTION ELEMENT		ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Quantity	Cost/Unit	Total	Quantity	Cost/Unit	Total
				$0			$0
Pull Sector Gate Set for Repairs	Day	6	$18,000	$108,000			$0
Based on 15 person mixed crew &				$0			$0
equipment which includes 130 Ton				$0			$0
Crane, also need Tugboat & Barge for				$0			$0
1/2 the time.				$0			$0
				$0			$0
Minor Surface Prep & Repair Welding	Day	15	$7,700	$115,500			$0
Based on SP-6 surface prep of areas				$0			$0
that need welding repair work with 8				$0			$0
person crew that Includes the welders.				$0			$0
				$0			$0
Operational Coating System for Gate	Day	20	$6,250	$125,000			$0
Based on SP-5 surface preparation,				$0			$0
and day by day base primer coating and				$0			$0
then three cost system for main coating				$0			$0
				$0			$0
Reset Repaired Sector Gates	Day	20	$19,500	$390,000			$0
Based on Mixed Crew of 15 People &				$0			$0
Equipment which includes 130 Ton				$0			$0
Crane, also need two sets of Tugboat				$0			$0
and Barge for full time.				$0			$0
				$0			$0
Note: Day costs include materials costs				$0			$0
for the coatings systems per info from				$0			$0
Lynn Tinto. Minor allowance also has				$0			$0
been included for welding rods and				$0			$0
make-up replacement steel pieces.				$0			$0
				$0			$0
				$0			$0
				$0			$0
SUB-TOTAL:				$738,500			$0
27% cost index from 2004 to 2011	27%			$200,872			$0
TOTAL:				$939,000			$0
					FIRST COST SAVINGS		$939,000

*Markups is 0% because costs above include General Contractor Markup = GC% (Field Office = FO%, Home Office = HO%, Profit = PR%, Bond = BD%, Mob/Demob = MOB%); Escalation = ESC%; Contingencies = CNT%; Supervision, Inspection & Overhead = SIOH%; Ops & Maint. = O&M%

Monetary Impact to Navigation

When major maintenance is performed and gates are removed, the lock or floodgate must be closed to navigation for a period of time. This closure can vary depending on whether or not the lock can be left open and/or whether or not spare or temporary gates are immediately installed upon removal of the set to be re-furbished.

As part of the 2004 evaluation, it was determined that an 8-day closure to navigation would be a reasonable estimate for cost evaluation. Depending on the location, closure either requires re-routing of vessels through an alternate route, or, where there is no such reasonably close route, complete stoppage. For closures lasting far in excess of 8-days, alternate transportation would be arranged via rail or other vessel type/routes.

Cost to navigation (commerce) for a delay is significant and is dependent on the location. The most impact is encountered at Calcasieu Lock where there is no alternative route and there is a high volume of traffic. With the recent closure of the Mississippi River Gulf Outlet (MRGO) the Inner Harbor Navigation Canal (IHNC) Lock also has no practical alternate route when closed.

Commerce data from MVN Economics Branch was applied to 8-day closures for both Calcasieu and IHNC and are tabulated below. There is an estimated $0.08 per ton per hour or $701 per ton per day of loss per navigation stoppage on the Intercoastal Waterway of which both Calcasieu and IHNC serve. Given reported annual tonnage figures (37 million for Calcasieu and 16.4 million for IHNC) an 8-day navigation stoppage would result in an average commerce loss of $7 and $3.1 million respectively for each lock.

These are very significant costs that can be reduced with the reduction of duration and/or frequency of major maintenance events.

For the general purpose of the comparative cost evaluation performed for the VE Alternatives identified in this workshop, navigation impact costs for Calcasieu Lock were used as basis for ‘saltwater’ facilities and IHNC for ‘freshwater’.

Estimated Monetary Impact to Navigation for a Single Major Maintenance Lock Closure of 8-Day Duration for:

CALCASIEU			
			701 $/TN/Day
	37,000,000	TN/Year	0.08 $/TN/Hr
	101,370	TN/Day	
Day	Cum. Days	Cum. Cost	
0			
1	8	1,557,041	
2	7	1,362,411	
3	6	1,167,781	
4	5	973,151	
5	4	778,521	
6	3	583,890	
7	2	389,260	
8	1	194,630	
Day Cum. Cost		7,006,685	
		($7 million rounded)	

IHNC			
			701 $/TN/Day
	16,400,000	TN/Year	0.08 $/TN/Hr
	44,932	TN/Day	
Day	Cum. Days	Cum. Cost	
0			
1	8	690,148	
2	7	603,879	
3	6	517,611	
4	5	431,342	
5	4	345,074	
6	3	258,805	
7	2	172,537	
8	1	86,268	
Day Cum. Cost		3,105,666	
		($3.1 million rounded)	

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APPENDIX F – SUPPORTING INFORMATION

SELECTED PROPOSALS AND DESIGN COMMENTS FROM "VALUE ENGINEERING STUDY ON CALCASIEU LOCK, FEBRURARY 2003" (AMENDED AND ABRIDGED)

Construct a 110' Wide Sector Gate as a Pass-thru Structure

ORIGINAL DESIGN:

A 75' X 1200' foot second lock structure or 75' foot drainage gate will be constructed to pass shipping and flood flows.

PROPOSED DESIGN:

Construct a 110 foot wide sector gate to serve as a saltwater barrier and passage for large barge traffic. This sector gate can also be used to pass tows of any length up to 110 foot wide during low head conditions or when salt-water intrusion is not an issue. The gate can be installed on all current plans, however it may not require a bridge relocation if placed on the south alignment.

ADVANTAGES:

1. Reduces the construction complexity to one gated barrier structure.
2. Wider structure allows passage of larger flows.
3. No limitation on length of tows with single gate structure.
4. Structure can be left open during low head periods to pass large traffic.
5. Eliminates need for second lock.
6. Maintenance on existing lock can be scheduled during favorable operation period for sector gate operation as traffic passage.
7. May capture significant portion of total project benefits.
8. Can be easily expanded later by addition of another 110 foot wide sector gate to provide function of a lock structure, should future navigation needs warrant.
9. Wider gate could be closed intermittently to eliminate navigation cross currents but would compensate (equivalent to a 75' foot gate) allowing greater flow when open.

DISADVANTAGES:

Potential cross currents on south alignment need to be modeled and mitigated if necessary.

JUSTIFICATION:

A single sector gate will serve the function of high flow water passage structure and salt water barrier. A 110 foot wide structure serves as a traffic passage structure for tows of any length, and as a bypass structure to be used during periods of maintenance on the existing lock. A larger 110' foot gate would allow for intermittent closing if navigation cross currents are problematic (open time equivalent to full time open 75' foot gate.

Consider the LDOTD Plan for Barge (Pontoon) Bridge Replacement: The existing barge bridge located on the east approach to the existing lock will likely be replaced in the not too distant future. For lock and pass-through gate options south of the existing lock, location of the new bridge may be critical. An eastward re-alignment would be advantageous while a westward one could be unacceptable for safe long barge maneuvering. It is therefore important that such re-alignment be coordinated (and adjusted if need be) with LDOTD.

Perform Model Study Now to Solve the Issue of Cross Currents: Detailed modeling of potential cross-currents induced by a proposed channel project would normally be performed post-authorization during Pre-construction Engineering and Design (PED). In this project, however, the potential realization that cross-currents (just east of the existing lock caused by may be unacceptable to navigation would have significant plan formulation/NED/ environmental analysis, etc., effects. The non-suitability of the 'south alignment' would require alternate location of any proposed lock or gate and would certainly require the addition of a major bridge relocation cost that otherwise would not be included in NED calculation. Both time and money would best be invested 'up-front' to identify plan viability.

Move South Alignment South and/or West to Better Align with Existing Bridge: It may be determined that potential cross-currents induced by a slightly off-set and intersecting south channel may be unacceptable. Consideration should then be made to adjusting the location of the south-aligned lock or gate southward and/or westward to counteract or reduce expected cross-currents to acceptable levels.

Use 110' Flood Gate and Synchronize Lockages: As stated above the proposed south channel may induce unacceptable cross-currents just east of the existing lock. Given the relatively low head situation and the utilization of sector gates, fast opening and closing (3 minutes to open or close) it would appear that a simple, synchronized, short closing of the drainage gate (or existing lock gate) as a large tow passes the critical reach east of the lock could be utilized as a means to alleviate potential cross-currents. This appears to be most viable as part of the above proposed plan for a 110 ft. wide pass-through gate on the south alignment since higher drainage flow via a 110 ft. vs. 75 ft. opening would offset intermittent closures.

Widen Channel Between Bridge and Existing Structure: The current plan does not include channel widening over and above that required for two-way navigation. It is suggested that the channel East of the proposed lock be over widened to accommodate the cross currents that may occur.

Account for Possible Un-Reported Delays, Pass-Through Tonnage, Drainage Event Delays and Traffic Variations: The Calcasieu's Lock traffic monitor, Performance Monitoring System Utilization, may apparently only report traffic delays during each locking of a vessel. The report may fall short in recording other delays when the locks are closed and then reopened without locking-in any vessels. For example, the locks are closed to vessel traffic during storm events that produce high water velocities from leaving the gates open to drain the Mermentau Basin. Also, lock closures due to power failures or routine maintenance produces hours of delays. These delays are apparently not recorded when the locks are then reopened and vessels are allowed to pass through the locks without locking-in (gates left in open position). These vessels result in large amounts of unreported delays. In addition, these delays also contribute to a large amount of tonnage cargo not being reported. Therefore, the average "Delays per Tow" and "Tonnage per Year" data would need to include delays when the gates are left open and the vessels are not locked-in. This would produce a more accurate average between delays and tonnage per year, and accounting of potential project benefits. A sensitivity analysis on barge traffic will be conducted as part of the feasibility study. Such an analysis could possibly include consideration of the above issues as well as general variations in past recorded and anticipated future navigation traffic.

Quantify Safety Risk / Benefits: In comparing the economics of various lock widths, consideration to the risks and potential consequences of navigation accidents should be considered. It appears possible to quantify safety-risk-loss potentials associated with various lock widths. This may be significant given the type of cargo carried by many barges coming through this area (chemicals and petroleum products).

Operate the Bridge from the Lock

ORIGINAL DESIGN:

- The location of a new lock near the present lock will leave the bridge within about ½ mile of the lock. See Figures 1 & 2
- Control houses at the lock are continuously manned
- Control house for the bridge is continuously manned
- Both the lock and the bridge result in related delays to navigation.
- Operation of the bridge must be coordinated with lock operation to minimize delays
- An electronic (logic) control system with video monitoring should is being suggested for the new lock

PROPOSED DESIGN:

- Provide controls with video monitoring within the lock control houses for bridge operation.
- Install the necessary compatible equipment and cameras on the bridge.
- Coordinate approval and operation of the system with the State DOT.

ADVANTAGES:

1. Significant cost reduction over the long term by removing a full time bridge operator
2. Simplified coordination and minimization of the associated bridge & lock delays to navigation
3. The bridge appears to be outdated and will likely be renovated or replaced in the near future. The replacement could be accelerated in order to have the necessary equipment installed in coordination with the construction of the new lock systems.
4. Cameras on the bridge could also be used to monitoring the waiting tows and the alignment of tows approaching and leaving the east end of the lock.
5. Immediate operation of the bridge may be a safety benefit in the event of and emergency situation in the channel or at the lock.

DISADVANTAGES:

1. Cost of new control and monitoring equipment.
2. Approval of funding may be an obstacle.

3. Approval from LDOTD may be an obstacle.
4. Additional tasks & responsibilities for the lock operators should be evaluated.
5. Complexities of different owner operator arrangement.

JUSTIFICATION:

Significant reduction for the cost for bridge operation and increased coordination between the bridge and lock operations may be achieved if operations are consolidated.

Integrate Lock Approach with the Bridge Approach; Move South Alignment East and Integrate with New Bridge

ORIGINAL DESIGN:

The existing lock is located approximately 2,000 feet northwest of an existing movable pontoon bridge. The present design maintains this separation between the new lock and the bridge.

PROPOSED DESIGN:

The proposed design would locate the new lock next to the bridge site and continue the guide walls under the bridge.

ADVANTAGES:

Co-locating the new lock and bridge would eliminate the need for fendering under the bridge since the guide walls would serve this function.

DISADVANTAGES:

More complicated construction, since site features are closer together.

JUSTIFICATION:

The 2000 foot separation between the bridge and existing lock site provides a minimum amount of maneuvering room for tows. Co locating the bridge eliminates the need to navigate between the bridge and lock approach and thus creates a safer condition. Cost savings results from shared use of the guide walls under the bridge, thus eliminating the need for bridge fendering.

Reduce Clear Span of Bridge from 200' to Range of Width Between 125'-200': The current preliminary plans indicate a 200 ft.-plus bridge channel clear span for alternatives that require a new bridge. While this may be the minimum acceptable Coast Guard clearance, it should be noted that other bridges in the area maintain only a 125 ft. clearance. Also, if new guide walls come close to the bridge (and its guide walls), their integration may be both economic and improve safety. Such a continuous 75 or 110 ft. plus channel restriction would negate the need for a 200 ft. wide clear span.

Elevate Critical Controls and Equipment Above Storm Surge (Old Lock Also): The current design is based on navigation and saltwater barrier need and does no take into consideration a storm surge from a tropical storm. It is suggested that design take into consideration the possibility of such a surge and elevate all critical equipment if possible.

Integrate Back Up Power Systems for Old Lock, New Gate, or New Lock: If we are to have two adjacent lock structures one generator (or generator set) should serve both structures. The emergency generator should provide enough power output to operate the entire facility simultaneously (except lock gates, where only one set may be powered at a time) at night, with EPA-compliant fuel storage for 500 gallons of diesel fuel. This generator should be enclosed in a building, elevated well enough that it will not flood, with as much ventilation as can be built in. Most of our existing generator houses are designed so that the house must have its doors opened to provide sufficient airflow for engine aspiration and cooling. Recently, at Calcasieu River Saltwater Barrier, we built an elevated generator house that includes a roof ridge vent and vents at baseboard elevation on the two long sides in place of soffit vents. This allows natural air flow all the way from floor level to roof level when the generator is not running; if the generator must cut on automatically, both the baseboard vents and the roof ridge vent allow air in (to be blown out through the louvered radiator vents) until someone can open the doors to increase airflow even more. Depending on the minimum electrical load, it may actually be more advantageous to use two small generators than one large one, with one kicking on automatically when municipal power is lost, and the other kicking on when the first approaches maximum load. With one large generator, the minimum power condition may be too low for efficient operation of the generator.

Revisit Criteria for Exterior and Interior Guide Walls: A single guide wall design is planned to be used. Forces on the guide wall would be expected to be greater outside the lock chamber, where tows are traveling at higher speed and are more likely to come in contact. Separate designs should be considered for exterior and interior guide walls.

Eliminate the Piles and Pile Cap under Fill in Dolphin and Replenish the Fill Periodically

ORIGINAL DESIGN:

The present design calls for constructing a timber pile supported slab within the sheet pile cell and a 5'-8" thick concrete wall behind the sheet pile, then filling the pile supported concrete "container" with lightweight fill material.

PROPOSED DESIGN:

The proposed design would eliminate the timber piles and the concrete within the sheet pile cell. Unclassified fill material would be placed within the sheet pile cell and would be replenished periodically as it settles to "top off" the dolphin.

ADVANTAGES:

Eliminates need to drive timber piles, place tremie concrete, and form and pour a concrete wall within the sheet pile cell, thus saving construction time and cost.

DISADVANTAGES:

Requires periodic maintenance to top off fill material

JUSTIFICATION:
Substantial savings can be realized by eliminating the pile support under the dolphin fill. Periodic topping off of the fill material will not be required often and is a simple and inexpensive operation to undertake.

Use Stainless Steel or Aluminum Railings on Guide Wall in Lieu of Painted Steel: Using a corrosion resistant metal for the railings will have a higher first cost, but will require less maintenance. The life cycle cost using a corrosion resistant metal may be less than painted steel railings. Field maintenance personnel prefer corrosion resistant railings.

Use Fiberglass Deck Grating in Lieu of Steel: Fiberglass deck grating is strong, lightweight, and does not corrode. The lighter weight deck grating will result in less structural support framing and easier construction. There will be less maintenance required since the fiberglass does not corrode.

Value Management Strategies, Inc.

Offices in Escondido and Sacramento, California; Grand Junction, Colorado; Kansas City, Kansas; Almont, Michigan
Great Falls, Montana; Las Vegas, NV; Portland, Oregon and Seattle, Washington

APPENDIX H

Value Management Strategies, Inc.

Final Value Engineering Study Report

Calcasieu Lock Replacement Feasibility Study

U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT

August 2012

Value Management Strategies, Inc.

Final Value Engineering Study Report

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APPENDIX H

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX I

MITIGATION PLAN

CALCASIEU LOCK LOUISIANA
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FIGURES

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX I

MITIGATION PLAN

I. MITIGATION PLANNING

A. Introduction. This appendix describes the mitigation planning process and resulting mitigation plan developed for the Calcasieu Lock Tentatively Selected Plan (TSP, Alternative 1, New Channel with Gate). Alternative 1 would provide a new channel through which freshwater flows stemming from rainfall events over the Mermentau Basin to the east would be diverted around the existing Calcasieu Lock. Construction of this channel would result in unavoidable direct impacts to two types of habitat within the Project area, aquatic and terrestrial, that require mitigation. The Project area, located in Calcasieu Parish, southwestern Louisiana, is within the state's designated coastal zone (figure I-1).

There are three main types of habitat in the Project area (figure I-2). Coastal marsh, the predominant type, is represented by brackish marsh to the west of Louisiana Highway 384 (Big Lake Rd) and intermediate marsh to the east. These marshes consist of emergent vegetation interspersed with and bordered by shallow open water. Deeper areas of open water distinct from marsh are represented by the GIWW, Black Bayou, and smaller contiguous water bodies. All these habitats are aquatic. Lastly, a small component of terrestrial habitat occurs along the south side of the GIWW in the vicinity of the existing lock. This upland habitat consists of a linear forested spoil bank. It was created about 60 years ago during construction of the lock when dredged material was deposited and eventually colonized by volunteer plant species. The higher elevations of the spoil bank are forested (about half the area), whereas the lower elevations which border the trees consist of scrub-shrub vegetation.

The potential for all project alternatives to adversely affect any of these habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Natural Resources Conservation Service, and the Corps.

With regard to the project alternatives as a whole, there would be unavoidable impacts to brackish marsh, intermediate marsh, and forested spoil bank that were considered by the HET to be permanent and for which compensatory mitigation would be required to offset such losses. In contrast, potential impacts to deeper open water habitats like Black Bayou were not regarded as permanent by the HET and did not warrant any such mitigation.

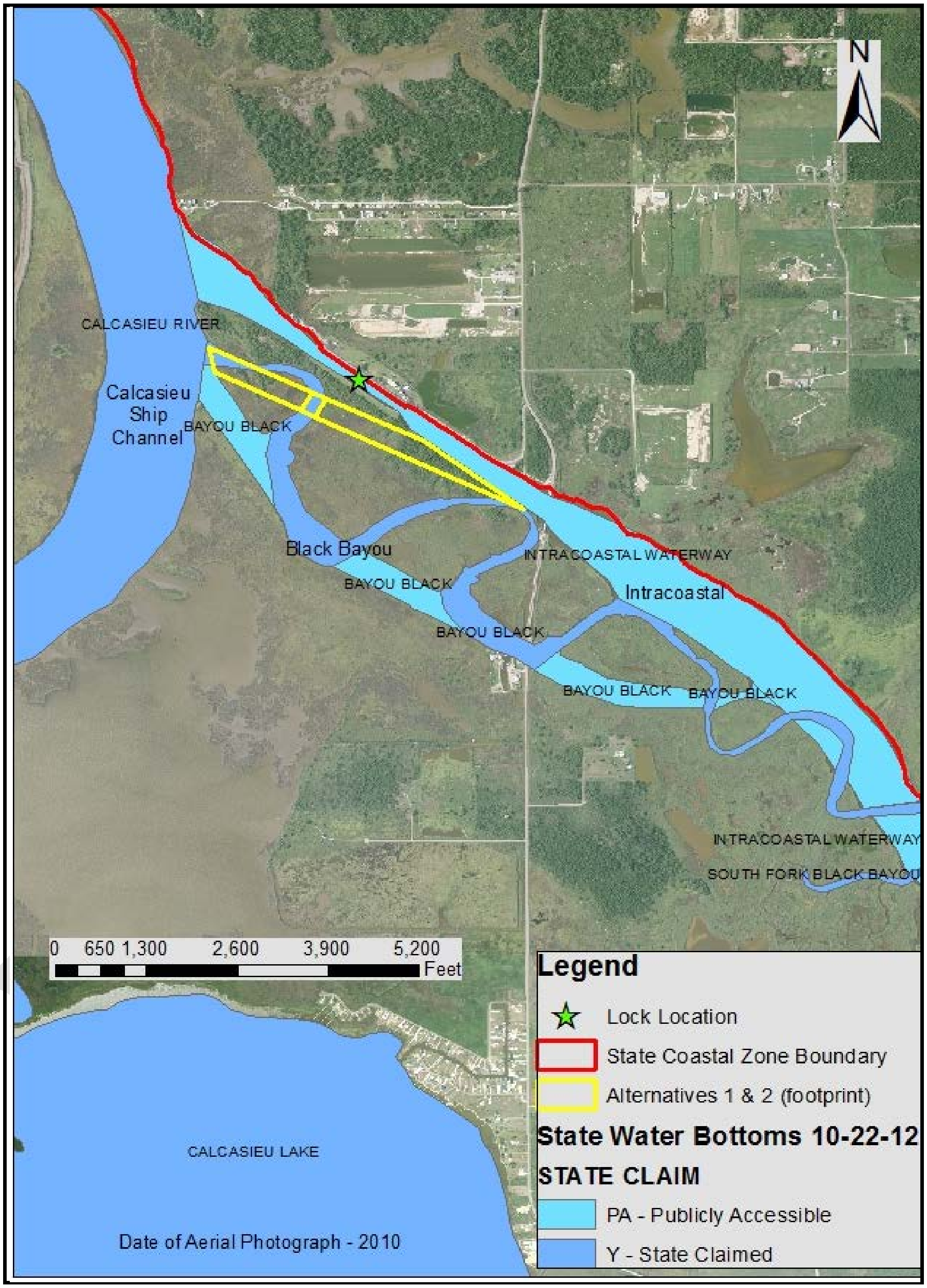

Figure I-1. Alternative 1 (TSP) Located Within Project Area, Calcasieu Lock, Calcasieu Parish, Southwestern Louisiana

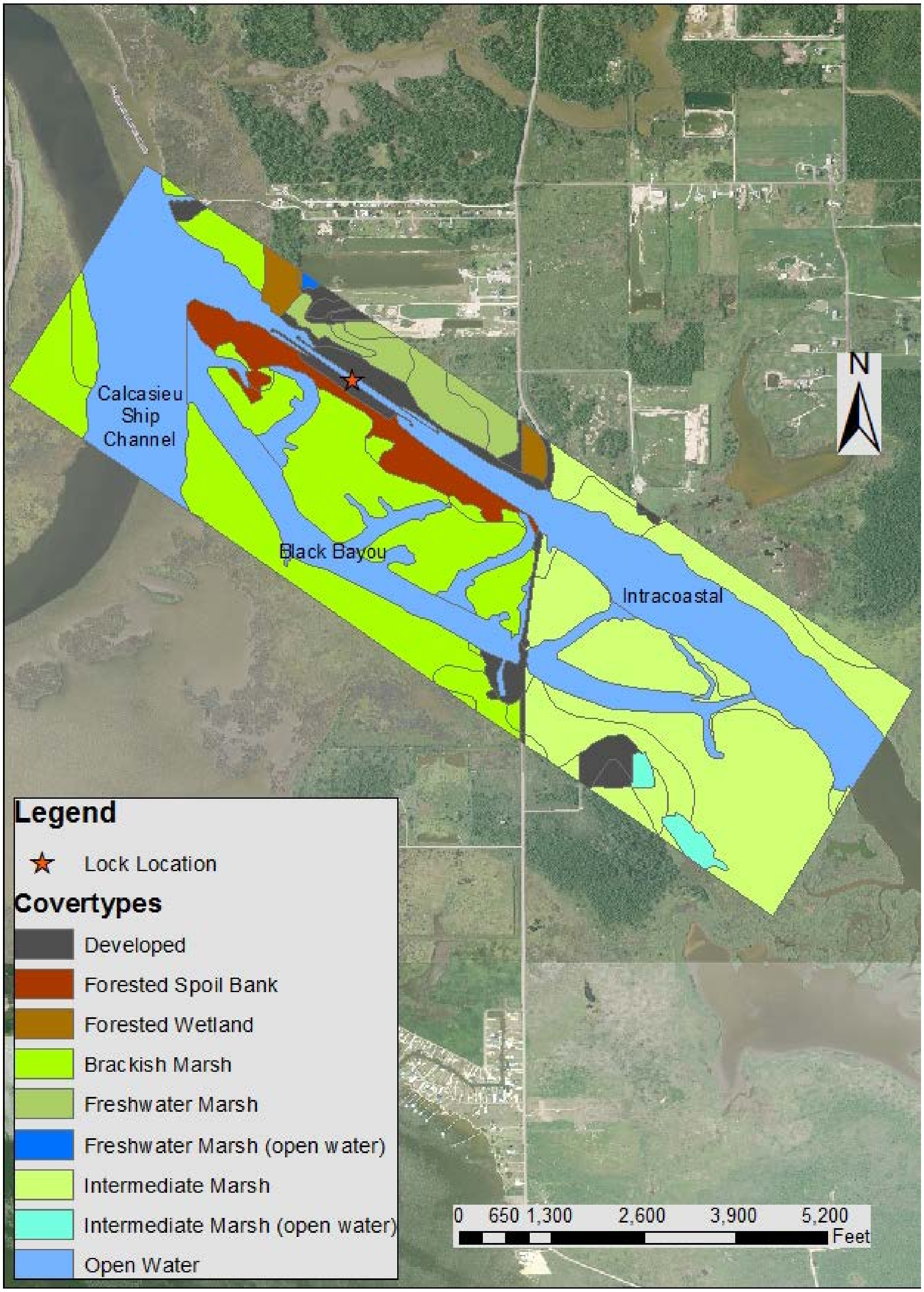

Figure I-2. Habitat Types Within Project Area

The Water Resources Development Act (WRDA) of 2007 details mitigation requirements for fish and wildlife and wetland losses caused by water resources projects. An excerpt from Title VIII, Section 2036 of WRDA 2007 states:

> *(3) MITIGATION REQUIREMENTS.—*
>
> *(A) IN GENERAL.—To mitigate losses to flood damage reduction capabilities and fish and wildlife resulting from a water resources project, the Secretary shall ensure that the mitigation plan for each water resources project complies with the mitigation standards and policies established pursuant to the regulatory programs administered by the Secretary.*

For the TSP, about 11 acres of forested spoil bank and 14 acres of brackish marsh would be directly impacted by constructible elements (table I-1), as based on Geographic Information System analysis. These same unavoidable losses are expressed in terms of Average Annual Habitat Units (AAHUs), which were derived from the application of three Wetland Value Assessment (WVA) models (see Appendix P, Wetland Value Assessment). The WVA methodology assesses expected changes to habitat functions and values over time. As indicated in table I-1, these models predicted that approximately 3.8 AAHUs would be lost due to direct impacts to existing brackish marsh habitat, while approximately 7.2 AAHUs would be lost due to direct impacts to existing forested spoil bank habitat, over the course of the 50-year period of analysis. In terms of replacement acres needed to produce these amounts of AAHUs, the models forecast that 7.9 acres of brackish marsh mitigation would be required, and 14.6 acres of forested spoil bank mitigation would be necessary (see Section G,. *Evaluation of Alternatives Considered in Detail*). The WVA methodology and models used in this analysis have been approved for use as planning tools for habitat impact assessment of water resource projects in coastal Louisiana that are proposed by the Corps (USACE, undated).

B. Mitigation Planning Objectives. The primary objective of mitigation planning for Alternative 1 (TSP) is to restore in acres the equivalent of -7.2 AAHUs of forested spoil bank and -3.8 AAHUs of brackish marsh, with "in-kind" mitigation. To meet the requirement of "in-kind" mitigation, the HET desired that marsh restoration developed for Alternative 1 take the form of brackish marsh restoration.

With regard to impacts to forested spoil bank, because this is a man-made habitat, there is no "in-kind" equivalent natural habitat that directly corresponds. Functionally, this habitat is similar to natural coastal levee or chenier forests. It is also similar to coastal bottomland hardwood forests. (The HET chose to use the WVA's chenier/ridge model rather than that method's bottomland hardwood forest model to assess forested spoil bank habitat impacts because the former was developed for forested spoil bank habitat assessment, whereas the latter was not.) Consequently the HET decided that mitigation planning strategies for forested spoil bank habitat would consist of either improvement of existing forested spoil bank habitat, or restoration or creation of natural levee or chenier habitat. Therefore, to meet the "in-kind" requirement for forested spoil bank habitat, mitigation would take the form of one or more of these approaches.

Table I-1. Unavoidable Direct Impacts (Acre) by Habitat Type for Alternative 1, New Channel with Gate (TSP)

	Upland Forested Ridge Habitat-Existing Spoil Disposal Areas	Brackish Marsh-Emergent Vegetated & Assoc. Water	Brackish Marsh-Open Water Within Marsh (Bayous, Ponds)	Intermediate Marsh-Emergent & Open Water	Deeper Open Water-Not a WVA Calculation (GIWW, Black Bayou)	Total
Impacts (acres)	11	9.7	4.3	0	0	25
Impacts (AAHUs)	-7.2	-3.78		0	0	-10.98
Req'd Mitigation (acres)	14.6	7.8		0	0	22.4

C. Opportunities and Constraints. The HET conducted the mitigation planning and potential site identification process according to the following opportunities and constraints:

- Hydraulically dredged material obtained during construction of the new channel could be used in a beneficial use manner by converting open water areas to marsh. For Alternative 1, there would be an estimated total of 170,000 cys that would need to be disposed of somewhere.

- The same material could be used to create levee or ridge habitat, or to restore degraded natural levee or chenier habitat.

- Mitigation would be located within Louisiana's coastal zone.

- Mitigation would preferably be located within the same watershed (impact HUC 8080206, Lower Calcasieu).

- On-site mitigation is preferred over off-site opportunities.

- Areas not classified as state water bottoms are preferred over sites that are.

- Areas designated as oyster seed grounds or for oyster harvest would be avoided.

- Areas mapped by the Natural Resources Conservation Service as prime farmland would be avoided as much as possible.

- Mitigation would not be located in areas causing impacts that in turn would require mitigation (for example, wetlands or bottomland hardwood forest).

- For each of the proposed project alternatives, including the TSP (Alternative 1), it is desirable from an engineering perspective to maximize hydraulic efficiency of freshwater flows passing from east to west around the Calcasieu lock and into the Calcasieu River, whether through a new channel or along Black Bayou. To maximize hydraulic efficiency, it is desirable to eliminate those places along the pathway where flow could be diverted or delayed from reaching the Calcasieu River. These points occur at several natural water features that are connected to the pathway, and these features are meander remnants of the historic Black Bayou. For Alternatives 3, 4, and 5, there would be three such meander remnants on the west side of Highway 384 and one to the east. For Alternatives 1 (TSP) and 2, there would be only one, the western-most meander remnant that lies south of the lock's west gate. The desired engineering solution for eliminating such points of hydraulic inefficiency would be to replace the open water feature with 'land' (i.e., marsh). (An historic topographic map of the Project area displaying Black Bayou is included in Appendix M, *Hazardous, Toxic, and Radioactive Waste.)*

- Dredged material generated by the Calcasieu Lock project cannot be placed at any disposal site that is part of the approved Dredged Material Management Plan (DMMP) for the "Calcasieu River and Pass, Louisiana" project. The closest DMMP disposal site is less than one mile to the west of Calcasieu Lock. If such placement were to occur, it would reduce the storage capacity for planned dredged material placement for this other project.

D. Alternative Development and Preliminary Screening Criteria. Under Section 2036(c)(1) of the WRDA of 2007, the Corps is obligated to consider the use of a mitigation bank to fulfill compensatory mitigation requirements for Federal projects. In addition to this mandated alternative, the following range of potential alternatives was formulated by the HET.

- Marsh Mitigation
  - Acquire credits from an approved In-Lieu Fee (ILF) program.
  - Place hydraulically dredged material into open water areas to convert them to brackish marsh.

- Forested Spoil Bank Mitigation
  - Acquire credits from an approved ILF program.
  - Enhance remaining forested spoil bank habitat by implementing tree stand improvements, including control of invasive plant species.
  - Create ridge or chenier habitat.
  - Restore degraded natural ridge or chenier habitat.

- Development of a mitigation plan from these potential alternatives would address the following planning objectives recommended by the USFWS in its Planning Aid Letter for this project (Appendix B, USFWS Coordination Letter and Support):
  - "Fully compensate, in-kind, for any unavoidable losses of wetland habitat values caused by project features."
  1) "Beneficially use any dredged material, not necessary for project construction, for wetland construction."

E. Preliminary Screening. For the potential range of alternatives described above, a preliminary screening was conducted to identify alternatives that would proceed to further analysis (table I-2). The criteria used for preliminary screening included: engineering effectiveness, economic efficiency, and environmental and social acceptability. The alternatives that did not meet these criteria were considered infeasible and were eliminated from further study.

Table I-2. Preliminary Alternative Screening Results

Mitigation Alternative	Eliminated	Carried Forward
Marsh		
Acquire credits from approved ILF program	X	
Acquire credits from mitigation bank	X	
Convert open water to marsh with dredged material placement		X
Forested Spoil Bank		
Acquire credits from approved ILF program	X	
Acquire credits from mitigation bank		X
Enhance remaining habitat by implementing tree stand improvements		X
Create ridge or chenier habitat	X	
Restore degraded ridge or chenier habitat	X	

F. Alternatives Eliminated from Consideration. A number of alternatives were considered but eliminated from detailed consideration for various reasons. A description of these alternatives and the rationale for their elimination follows.

Marsh: Acquire credits from approved ILF program. Although Louisiana currently operates an ILF program, it is not an available mitigation alternative for this project. A draft ILF instrument and corresponding program documents have been developed in order to fulfill the requirements of the Apr 10, 2008 Federal Regulations “Compensatory Mitigation for Losses of Aquatic Resources” (33 CFR Parts 325 and 332). These documents have been reviewed by an interagency team, and an issue concerning perpetual easements has been raised. Once this issue is addressed and agreement is reached, this ILF program is expected to be implemented and made available to Federal projects sponsored by the Corps. In the future, this ILF program could be reconsidered.

Marsh: Acquire credits from mitigation bank. The cost of mitigation at brackish marsh banks in Louisiana is estimated to be $80,000 per acre (LDNR, undated). Assuming this, the estimated cost of brackish marsh mitigation for Alternative 1 and 2 would be about $624,000. The current planning-level cost estimate for Alternative 1 includes about $4.4 M for hydraulic excavation of dredged material associated with construction of the new channel and disposal of this material within the Project area. If disposal were not to take advantage of any on-site or nearby opportunities to beneficially use dredged material to convert open water into marsh, then acquiring credits at a bank would add unnecessary cost to the project.

Forested Spoil Bank: Acquire credits from approved ILF program. This option was eliminated for the same reason as presented above for *Marsh: Acquire credits from approved ILF program.*

Forested Spoil Bank: Create ridge or chenier habitat. At the outset the HET acknowledged that natural ridge or chenier habitat does not occur as far north in the coastal zone as Calcasieu Lock, but rather at least 15 miles to the south. The following paragraph, *Forested Spoil Bank: Restore degraded ridge or chenier habitat*, provides further details. In contrast, man-made spoil banks are found all across coastal Louisiana. The HET searched for potentially suitable sites for creating replacement habitat in the vicinity of the project, and used the following criteria to define suitability: inside the coastal zone, not wetland, not forested, not water, and not developed. Using these criteria, potential opportunities north of the GIWW in the vicinity of the lock would be outside the coastal zone and therefore excluded from consideration. A potential opportunity within the coastal zone on the immediate south side of the lock was identified and rejected (enlarge the existing forested spoil bank by planting trees in a landscaped area on existing Corps property; this would provide less than one acre of additional forest and require a utility relocation). To the south of the lock within the coastal zone, a search for creation opportunities within several miles of the lock was conducted using various digital datasets in the Geographic Information System, including the soil surveys for Calcasieu and Cameron Parishes, National Wetland Inventory mapping, and land use information. Potentially suitable sites may occur 1 or more miles further to the south and east of the lock. Such sites consist of areas mapped as upland or non-hydric soils (Midland silty clay loam, Mowata-Vidrine silt loam, Morey loam). However, these soils are considered prime farmland. In addition, according to recent aerial photography, at least some of these areas currently support woody vegetation. Therefore this option was not given further consideration. Lastly, the option of creating low ridges in existing marsh was identified, but not given further consideration because the idea was raised near the end of the mitigation planning process. Meanwhile, the USFWS expressed more interest in restoring degraded natural ridge or chenier habitat. Because of these factors, this alternative was not considered further.

Forested Spoil Bank: Restore degraded ridge or chenier habitat. As noted above, natural coastal ridge or chenier habitat occurs in southwest Louisiana at least 15 miles to the south of Calcasieu Lock.

> *Southwest Louisiana is characterized by extensive coastal marshland interrupted by numerous forests atop relict beach ridges, or chenier ridges, and natural ridges or levees. The cheniers of southwest Louisiana and the natural ridges of southeast Louisiana are unique geological features that are critical components of the ecology of these areas. They support a diversity of wildlife and, because of their location along important migration pathways, are especially significant for migrating birds, as well as providing natural protection against storm surge and flooding.* LDNR (2009:1)
>
> *The remnant forests present on cheniers – coastal live oak-hackberry forest – are ranked by the Louisiana Natural Heritage Program as imperiled or critically imperiled because of the factors making them vulnerable to extirpation…. Cheniers have been greatly impacted because these features are slightly above the level of the surrounding marsh and are the only inhabitable land for the people of these areas. As a result, many of the cheniers have been cleared of vegetation for home sites, linear transportation projects, and commercial properties or have been drastically altered by livestock grazing or commercial mining operations….*LDNR (2009:16)

In southwest Louisiana, this habitat is mainly found in Cameron Parish to the southwest, south and southeast of Calcasieu Lake, but also further east in Vermilion Parish (LDNR 2009: Figure 1). Opportunities for restoring degraded habitat would vary in complexity from replacing native vegetation on disturbed sites where the natural ridge is still intact, to replacing both native vegetation as well as ridge material for sites that have been drastically altered. The cost of restoring native vegetation only would be considerably less on a per acre basis than restoring both vegetation and ridge substrate. Because opportunities for extensive restoration are too distant from Calcasieu Lock to consider using dredged material obtained from the project in a cost effective manner, such opportunities would be eliminated from further consideration. No potential locations for cost effective restoration (such as vegetation only) were identified because the option of ridge restoration was raised within the HET for consideration near the end of the mitigation planning effort.

G. Evaluation of Alternatives Considered in Detail. The mitigation alternatives considered in detail for all five project alternatives including Alternative 1 include:

Marsh. use dredged material in a beneficial use manner by converting open water to brackish marsh

Forested Spoil Bank. 1) enhance remaining habitat by implementing tree stand improvements, and 2) acquire credits from mitigation bank. These alternatives were further developed and evaluated in order to develop a proposed mitigation plan that would fully compensate for lost resource values, be cost effective, and meet as many of the opportunities and constraints identified above as possible.

Marsh. use dredged material in a beneficial use manner by converting open water to brackish marsh. The WVA evaluation assessed the mitigation potential for on-site beneficial use of dredged material. This assessment was grounded in the opportunity/constraint identified above, namely the hydraulic engineering requirement that open water meander remnants of Black Bayou be filled and made into marsh to maximize efficiency of Mermentau Basin freshwater flows passing through either the proposed new channel (Alternatives 1 and 2) or Black Bayou (Alternatives 3, 4, and-5). By placing dredged material in such locations, not only would hydraulic efficiency be attained, but perhaps enough marsh would be restored to offset each alternative's marsh mitigation requirement.

The WVA assessment of mitigation potential assumed the placement of dredged material into all meander remnants of Black Bayou on both sides of Highway 386 to restore marsh. The restoration potentials for brackish and intermediate marsh were evaluated separately. For the three meander remnants on the west side of the highway where 30.9 acres of brackish marsh was assumed to be restored, 14.8 AAHUs would be generated. Given this information, then to attain the 3.8 AAHUs lost from construction of the new channel for Alternatives 1 (TSP) and 2, a total of 7.9 acres of brackish marsh would need to be restored. A comparison of this acreage requirement with the 9.7-acre western-most meander remnant (the one south of the west lock gate, which is the specific water feature that should be made into marsh for hydraulic efficiency purposes), shows that this meander remnant is large enough to accommodate the mitigation requirement.

If the 170,000 cys of hydraulically dredged material from construction of the new channel were to be placed in all 35.2 acres of meander remnants on both sides of the highway, this would result in about 4,800 cys per acre (assuming the existing substrate elevation of these placement locations is -2.0 MLG and they would be filled with an initial slurry elevation of +3.5 and final target elevation for marsh at +1.5). Based on this, then the quantity of dredged material that would be placed in the western-most meander remnant would be about 46,560 cys. (The remaining 123,440 cys would need to be disposed of elsewhere; assuming such a site was also open water of similar depth, then about 25 additional acres of marsh could be restored, as an incidental benefit to the project.)

The western-most meander remnant is a desirable location for marsh restoration, but it should be noted that this area is considered to be a state water body because it is a natural feature. Further, it and the other meander remnants within the Project area support shallow water habitat. To minimize disposal effects to state water bodies and areas of shallow water habitat, it is desirable to place the remaining dredged material not required for mitigation at a site which is not a state water body and which supports proportionally less shallow water habitat. A potential opportunity meeting these conditions is located southwest of the lock less than a mile away

Forested Spoil Bank. Enhance remaining habitat by implementing tree stand improvements. There are about 40 acres of existing forested spoil bank habitat in the Project area, and based on examination of recent aerial photography, about half this area is forested whereas the remainder consists of scrub-shrub. Construction of a new channel under Alternatives 1 (TSP) and 2 would result in the loss of about 11 acres of this habitat, with about 29 acres remaining. The remaining forested area, estimated at about 15 acres, would be enhanced by implementing tree stand improvements. The intent of such improvements is to increase native tree and shrub species diversity by either adding desirable species that are not present, or increasing abundance of desirable species that are present but under abundant. Implementation measures include planting of desirable seedlings and removal or culling of undesirable species. At the same time, invasive plant species can be removed or controlled by accepted mechanical or chemical methods to make way for more desirable vegetation. The invasive Chinese tallow tree is present within this habitat and can be treated. All these efforts are expected to benefit wildlife using this habitat.

The HET evaluated this alternative of enhancing 15 acres of remaining forested spoil bank habitat using the WVA method, and the results indicate that 3.1 AAHUs would be gained. In comparison, the loss of 11 acres of this habitat to construct the new channel is 7.2 AAHUs. If a mitigation plan were to include this enhancement option, then a total of 4.1 AAHUs of compensatory mitigation would still be needed.

The cost of implementing these improvements on 15 acres is estimated to be about $3,500 per acre, or about $53,000 total. (This assumes $1,500 per acre for tree planting; $1,200 per acre for selective clearing or culling; $125 per acre for chemical tallow control; and $10,000 for mobilization and demobilization.) This cost can be considered the cost of “construction” for this alternative.

Forested Spoil Bank. acquire credits from mitigation bank. Choosing which kind of mitigation bank is most appropriate as “in-kind” mitigation for forested spoil bank losses is somewhat problematic. There are no banks established to compensate for losses to ridge or chenier forest (or forested spoil bank habitat). Because of the similarity of forested spoil bank habitat to bottomland hardwood forest habitat, the choice appears to be limited to bottomland hardwood banks.

As mentioned on page I-6, the impact watershed is HUC 8080206, Lower Calcasieu. This watershed is also regarded as the service area. Mitigation banks within this service area that currently have available bottomland hardwood credits are being considered. In addition, any new banks that would be approved in the future and have applicable credits available, if and when a decision is made to acquire mitigation credits from a bank, would be considered. Table I-3 lists the currently available banks and the amount of available bottomland hardwood credits in each. As new applicable banks are approved, they may be considered for potential use.

Table I-3. Bottomland Hardwood Mitigation Banks Applicable to Service Area HUC 8080206. [1]

Bank Name	Available Credits	Notes
Cow Bayou	20.30	Secondary service area is 8080206
Nabours “No Hope” Farms	179.7	Secondary service area is 8080206
Petit Bois	74.50	Primary service area is 8080206

[1] Credits available as of June 2013

Based on the WVA analysis of forested spoil bank impacts, 7.2 AAHUs of mitigation benefits would be needed to offset the 11 acres lost. The WVA analysis also determined that the acre equivalent of this amount of AAHU loss would be 14.6 acres, based on an assumed restoration of degraded ridge habitat with no native vegetation present.

The cost of acquiring mitigation credits from approved bottomland hardwood mitigation banks located in southwestern Louisiana is estimated to range from $35,000 to $50,000 per acre (personal communication, Martin Mayer, Regulatory Branch, MVN). Assuming a cost of $50,000 per acre, then the total cost of acquiring mitigation credits for 11 acres of forest spoil bank losses is estimated to be $550,000. If enhancement were considered as a first option, then the estimated cost for acquiring the balance of required credits (4.1 AAHUs or 8.2 acres) at a bank is about $410,000.

This proposed plan represents the least cost solution for compensating for marsh and forested spoil bank losses. The overall construction cost for mitigation is estimated to be about $463,000 (including $410,000 for bottomland hardwood mitigation credits and $53,000 for tree stand improvements). Costs for marsh mitigation are already accounted for in the project cost estimates, since hydraulic dredging and disposal are required whether beneficial use occurs or not. The planning level or rough-order-of-magnitude estimate for mitigation that was developed prior to the availability of WVA results was $550,000.

II. PROPOSED MITIGATION PLAN

Based on the preceding evaluation of mitigation alternatives, the proposed mitigation plan for Alternative 1 consists of the following:

> ***Forested Spoil Bank Mitigation.*** 1) enhance 15 acres of remaining forested habitat by implementing tree stand improvements (figure I-3), and 2) acquire 8.2 acres of credits from an approved bottomland hardwood mitigation bank located in the project's service area.
>
> ***Brackish Marsh Mitigation.*** Use dredged material in a beneficial use manner by converting 9.7 acres of open water at the western-most meander remnant of Black Bayou to brackish marsh (figure I-3).

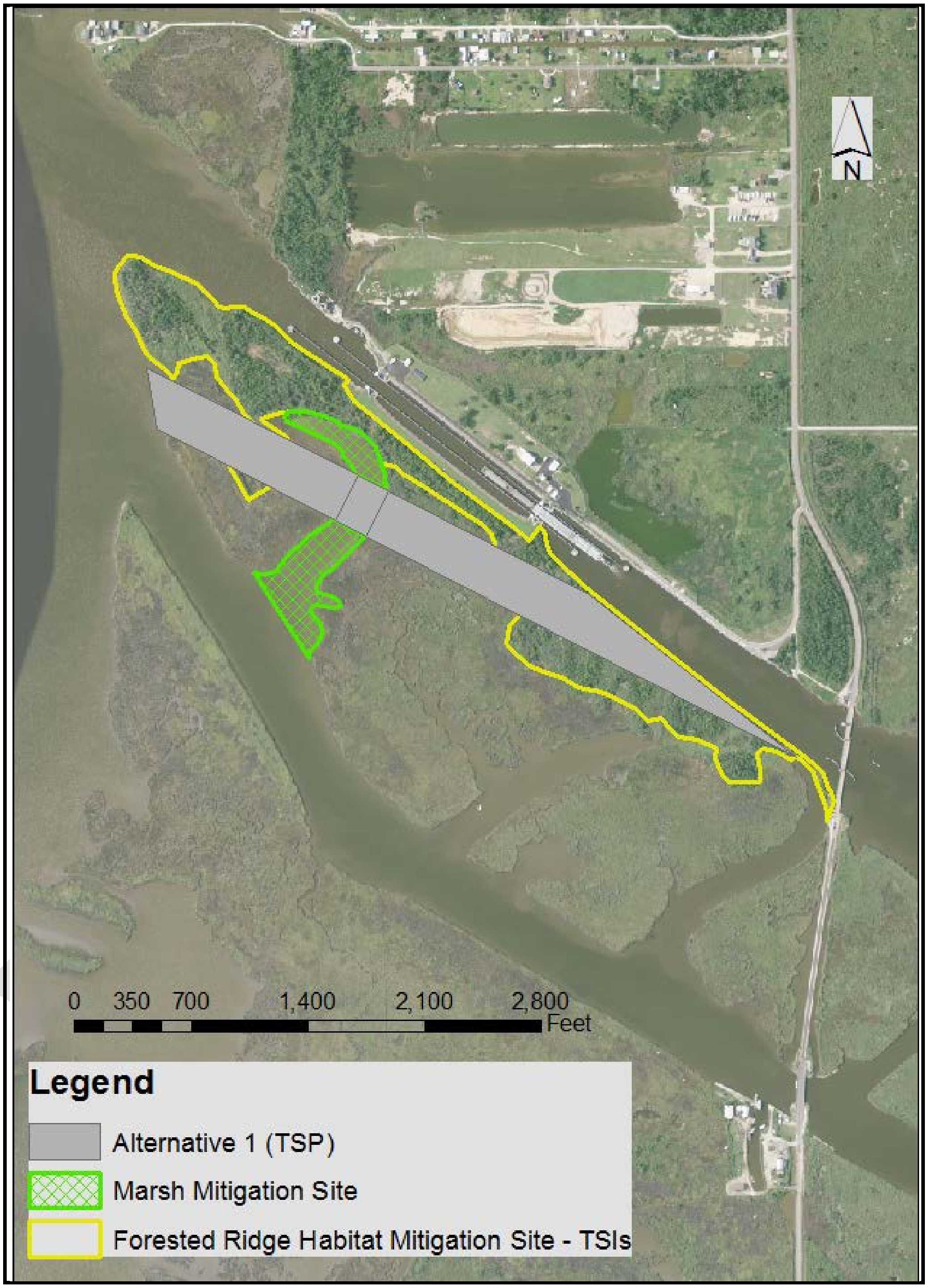

Figure I-3. Proposed Mitigation Sites

The WRDA of 2007 details mitigation requirements for fish and wildlife and wetland losses caused by water resources projects. An excerpt from Title VIII, Section 2036 of WRDA 2007 states:

(3) MITIGATION REQUIREMENTS.—

(B) INCLUSIONS.—A specific mitigation plan for a water resources project under paragraph (1) shall include, at a minimum—

(i) a plan for monitoring the implementation and ecological success of each mitigation measure, including the cost and duration of any monitoring, and, to the extent practicable, a designation of the entities that will be responsible for the monitoring;

(ii) the criteria for ecological success by which the mitigation will be evaluated and determined to be successful based on replacement of lost functions and values of the habitat, including hydrologic and vegetative characteristics;

(iii) a description of the land and interests in land to be acquired for the mitigation plan and the basis for a determination that the land and interests are available for acquisition;

(iv) a description of—

(I) the types and amount of restoration activities to be conducted;

(II) the physical action to be undertaken to achieve the mitigation objectives within the watershed in which such losses occur and, in any case in which the mitigation will occur outside the watershed, a detailed explanation for undertaking the mitigation outside the watershed; and

(III) the functions and values that will result from the mitigation plan; and

(v) a contingency plan for taking corrective actions in cases in which monitoring demonstrates that mitigation measures are not achieving ecological success in accordance with criteria under clause (ii).

(C) RESPONSIBILITY FOR MONITORING.—In any case in which it is not practicable to identify in a mitigation plan for a water resources project the entity responsible for monitoring at the time of a final report of the Chief of Engineers or other final decision document for the project, such entity shall be identified in the partnership agreement entered into with the non-Federal interest under section 221 of Flood Control Act of 1970 (42 U.S.C. 1962d–5b).

(4) DETERMINATION OF SUCCESS.—

(A) IN GENERAL.—A mitigation plan under this subsection shall be considered to be successful at the time at which the criteria under paragraph (3)(B)(ii) are achieved under the plan, as determined by monitoring under paragraph (3)(B)(i).

(B) CONSULTATION.—In determining whether a mitigation plan is successful under subparagraph (A), the Secretary shall consult annually with appropriate Federal agencies and each State in which the applicable project is located on at least the following:

(i) The ecological success of the mitigation as of the date on which the report is submitted.

> *(ii) The likelihood that the mitigation will achieve ecological success, as defined in the mitigation plan.*
> *(iii) The projected timeline for achieving that success.*
> *(iv) Any recommendations for improving the likelihood of success.*

(5) MONITORING.—Mitigation monitoring shall continue until it has been demonstrated that the mitigation has met the ecological success criteria.

Paragraphs A through L outline these mitigation requirements as they apply to the proposed mitigation for Alternative 1, Calcasieu Lock project.

A. Objectives. The objective of this Mitigation Plan is to fully compensate for unavoidable losses of important fish and wildlife resources, by providing in-kind mitigation at locations that are on-site to the maximum extent practicable. For Alternative 1, the direct losses of important resources include 11 acres of forested spoil bank (that functions as forested ridge habitat) and 14 acres of brackish marsh. Based on the WVA assessment conducted for this feasibility phase of the project, the required mitigation consists of 7.2 AAHUs of forested ridge habitat and 3.78 AAHUs of brackish marsh. In the later Preliminary Engineering and Design (PED) Phase, unavoidable losses would be re-examined in light of further developments in project planning to determine if impacts to important resources might change with regard to resource type and quantity. The WVA assessment would also be revisited to determine its adequacy. The Corps would coordinate such activities with USFWS, Louisiana Department of Wildlife and Fisheries (LDWF), the NMFS, and other natural resource agencies.

B. Site Selection. Proposed mitigation sites are located on-site for the most part. The marsh mitigation site consists of a shallow open water area in the immediate vicinity of the footprint of Alternative 1. This site is a remnant of the historic meandering Black Bayou, and is located on the west side of Louisiana Hwy 384 and south of the lock's west gate. This 10-acre site would be bisected by construction of the new channel. Placement of hydraulically dredged material would convert this area to marsh. This open water site was selected over other open water sites, including additional historic Black Bayou remnants located on either side of the highway, because converting it to marsh would fulfill a second purpose. For Alternative 1, this particular remnant is the only area of open water that would need to be filled to maximize hydraulic efficiency of the new bypass channel.

The forested spoil bank mitigation site consists of the remaining forested habitat located along the south side of Calcasieu Lock on relatively high ground. An estimated 15 acres of trees represents this site. Tree stand improvements would be implemented here. Because not enough AAHUs would be generated by this measure, the remaining required forested spoil bank mitigation would be located at an approved bottomland hardwood mitigation bank within the project's service area (HUC 8080206), where credits would be acquired.

Properties required could be privately owned or owned by a government agency. For areas that are owned by a government agency, the non-Federal Sponsor (Sponsor) will sign an interagency agreement that will allow the Corps to construct the mitigation features. Areas that are privately owned will be acquired in accordance with the requirements of Public Law 91-646. Each property to be acquired will be appraised and the owner will be offered the market value of his/her property. The owner will be given an opportunity to negotiate the sale price of the property. If the Sponsor and the owner are unable to come to an amicable agreement as to price or if the title of the property is not clear, the acquisition will be completed through eminent domain.

C. Site Protection Instrument. The proposed 10-acre marsh mitigation site is designated as a state water bottom, whereas the 15-acre forested spoil bank site is privately owned. The non-Federal Sponsor will be required to provide all lands, easements, rights-of-way, relocations and disposal areas (LERRDs) necessary for the project, including mitigation sites. The non-Federal Sponsor will obtain a Grant of Particular Use from the state of Louisiana for the use of the lands that are located within state water bottoms. The non-Federal Sponsor will acquire fee interest in the private lands as a mitigation site. The non-Federal Sponsor will ensure all operation, maintenance, repair, replacement and rehabilitation (OMRR&R) associated with the mitigation sites in perpetuity. A standard temporary work area easement will be acquired by the Sponsor for any mitigation construction access or staging areas that are geographically distinct from the mitigation sites.

D. Baseline Information.

Impact Sites. During the environmental impact analysis of the Project area, four different habitats were identified: upland forested spoil bank, brackish and intermediate marshes (with emergent and open water components), and deeper open water. Impacts to these habitats were documented during the WVA that was coordinated with the USFWS and NMFS. Table I-1 displays the impacted habitat acres, resulting average annual habitat unit (AAHU) loss, and the required mitigation acres to compensate the losses.

Mitigation Sites. Based on the WVA assessment, table I-4 displays the mitigation acres and AAHUs expected to be obtained from the proposed mitigation features.

Table I-4. Proposed Mitigation for Upland Forested Ridge Habitat and Brackish Marsh Impacts

Proposed Mitigation	Mitigation Acres	Mitigation AAHUs	AAHUs Required
Upland Forested Ridge Habitat - tree stand improvements	15	3.1	7.2
Upland Forested Ridge Habitat - mitigation bank (credits)	8.25	4.1	
Brackish Marsh - convert open water to marsh	9.7	4.66	3.78

The proposed marsh mitigation site is a shallow open water area mapped as a state water bottom. It is a remnant of the historic Black Bayou that meandered through the Project area. The site is immediately surrounded by natural brackish marsh to the east and west, Black Bayou to the south, and forested spoil bank habitat to the north. Average water depth is about 1-2 feet, and submerged aquatic vegetation appears to be uncommon.

The proposed forested ridge habitat mitigation site is located in an area of forested spoil bank located along the south side of Calcasieu Lock. This linear upland habitat was created about 60 years ago during construction of the lock when dredged material was deposited along the facility's south side and eventually colonized by volunteer plant species. It is immediately bordered by the GIWW to the north and brackish marsh to the south.

The higher elevations of the roughly 40-acre spoil bank are located closer to the lock and are generally forested (about half the area), whereas the lower elevations that border the trees often consist of scrub-shrub vegetation. Ridge elevations of the spoil bank vary, and extent up to about +10 feet MLG and probably a few feet higher. Dominant native tree and shrub species include sugarberry (*Celtis laevigata* and live oak (*Quercus virginiana),* and yaupon (*Ilex vomitoria*) and saltbush (*Atriplex* sp.).

Scattered pine trees (*Pinus* sp.) occur in the overstory. The invasive nonnative Chinese tallow-tree (*Sapium sebiferum)* is a common woody component of the scrub-shrub vegetation. Herbaceous ground cover is likely dominated by saltmeadow cordgrass (*Spartina patens*), great ragweed (*Ambrosia trifida*), and saltgrass (*Distichlis spicata*).

In appearance the spoil bank is patchy in terms of tree and shrub coverage. Most trees are less than 40 feet tall and do not form a closed canopy. The midstory and ground cover layers of vegetation are relatively dense.

These habitat descriptions are based on a qualitative survey of the Project area in December 2012. No indications or signs of previous habitat management or fire were observed. Prescriptions for enhancing the habitat quality of the spoil bank area were not developed based on this site visit and will need to be conducted during the PED phase. The tree stand improvements that make up this forested ridge habitat mitigation measure are based on best professional judgment.

E. Determination of Credits. For USACE Civil Works projects such as Calcasieu Lock, project-induced impacts to natural resources are quantified using accepted resource assessment methods (including the WVA, which was employed for this project). Impacts are expressed in terms of average annual habitat units, or AAHUs. Each AAHU represents the quality and quantity of the habitat at a given point in time. The AAHUs are calculated using the acres of impacted habitat multiplied by the Habitat Suitability Index to produce habitat units (HU). The HU is then averaged over the project life (50 years for this project) to determine AAHU loss. Through multiagency coordination, a mitigation potential (HU value for each acre restored) is established for each habitat. This value is divided by the lost AAHUs to compute the total mitigation acres needed to fully offset the impacts from construction.

For this project, credits for forested ridge habitat mitigation were determined by subtracting the AHHUs generated from implementing tree stand improvements (3.1 AAHUs, table I-4) from the mitigation requirement (7.2 AAHUs) and considering the balance (4.1 AAHUs) to come from a mitigation bank. To determine how many acres of mitigation would be required at a bottomland hardwood forest bank (for developing mitigation cost estimates), a mitigation potential was developed using the WVA based on an assumed mitigation alternative of restoring degraded natural forested ridge habitat. Restoration of an assumed 16 acres of such habitat without any natural woody vegetation gave a gain of 7.9 AAHUs, or about 0.49 AAHU per acre. To obtain the AAHU balance, 8.25 acres of such restoration would be required. This value of 8.25 acres was assumed to represent the number of credits to be acquired from an approved bank. Implementation of the proposed tree stand improvements and acquisition of such credits are expected to fully compensate for forested ridge habitat functions and values lost due to construction.

Similarly, credits for brackish marsh mitigation were determined by using the WVA based on an assumed mitigation alternative of converting to marsh the three open water remnants of historic Black Bayou on the west side of Highway 384, which total about 30.9 acres. Restoration of these sites gave a gain of 14.78 AAHUs, or about 0.48 AAHU per acre. To obtain the AAHU requirement, about 7.9 acres would be needed for conversion. Because the proposed site is about 9.7 acres and larger than the requirement in acres, use of this site is expected to fully compensate for marsh functions and values lost due to construction.

F. Mitigation Work Plan

1. Brackish Marsh Mitigation

a. Dredged Material Placement. A hydraulic dredge would be used to discharge slurry into shallow water areas and degraded marsh areas. Material would be obtained from construction of the new bypass channel. Slurry would be discharged to an elevation conducive to the development of wetlands habitat following dewatering and compaction. It is anticipated that the final result of this dredge material placement would be a combination of wetlands, mud flat, and shallow water habitat within the placement site. Following compaction and dewatering, the area would be planted with marsh vegetation appropriate for the site. For marsh restoration, it was assumed that existing elevations of proposed disposal sites average -2.0 feet MLG, and that adjacent marsh is about +1.5 feet MLG. Maximum slurry elevation would be +3.5 feet. The final target grade elevation for marsh would be +1.5 feet. Necessary adjustments to these elevations would be determined during the PED phase.

The pipelines used to carry material from the new channel to the marsh restoration features could be routed: as submerged pipelines (laid along existing water bottoms; trenching used where needed to not impede navigation or recreational uses); as pontoon lines (pipelines suspended near surface of water by pontoons, with safety marker signs installed every 150 linear feet of pipeline); by running pipelines along existing shoreline/canal bank; using a combination of these approaches.

b. Earthen Dikes and Weirs. Retention closures and weirs will be constructed around the entire disposal areas. Closures will be constructed from adjacent borrow and will be at +5.0 feet with a 5-foot crown width and 1 vertical on 4 horizontal side slopes. Weirs will also be built from adjacent borrow to an elevation of +3.5 feet with a 5-foot crown width and 1 vertical on 4 horizontal side slopes.
During the PED phase, it may be determined that one or more retention (containment) dike segments may need to be constructed as armored earthen dikes or as rock dikes.

Earthen dikes/closures would be allowed to degrade naturally. If earthen dikes/closures do not sufficiently degrade to provide fisheries and tidal ingress/egress following appropriate settlement of dredge material placed within the disposal area, earthen dikes/closures would be mechanically breached and/or degraded as necessary.

Interior low-level earthen weirs may be constructed within the marsh restoration areas to facilitate sediment deposition to enhance wetlands development. Borrow material for weir construction would be taken from within the restoration area. Earthen dikes/closures would be allowed to degrade naturally. If earthen dikes/closures do not sufficiently degrade to provide fisheries ingress/egress and tidal exchange after settlement of dredge material, earthen dikes/closures would be mechanically breached and/or degraded as necessary.

c. Temporary Flotation Access Corridors. Flotation access corridors (channels) may be excavated as needed in shallow open water areas to allow construction equipment to access the mitigation feature and disposal sites. If necessary, flotation access channels would be excavated by a mechanical dredge to maximum dimensions of approximately 80 feet wide and 10 feet deep. Flotation access channel material would be used in dike/closure construction or refurbishment, to backfill flotation access channels, or be placed adjacent to and behind the containment dikes and closures in shallow open water to an elevation conducive to wetlands development following consolidation of the material. Flotation access channel material used to backfill the flotation access channels following completion of disposal work would be temporarily stockpiled on water bottoms adjacent to the flotation access channels.

Temporary board roads may be constructed along access corridor alignments and staging areas wherever emergent marsh exists. Board roads would be removed when work is completed. Fill material may be deposited where the board road would be located to offset damage to the underlying marsh caused by soil compression. Board road fill material may be degraded to adjacent marsh elevations following completion of disposal activities either by placing excess material into nearby shallow open water to elevations conducive to wetlands development, by placing material on existing uplands, or by removing material from the project vicinity.

Details of borrow sites, construction access corridors, flotation access corridors, and construction staging areas will be developed during the PED phase.

d. Planting Plan. Once the dredged material has settled to the final target grade, the mitigation site would be planted with native marsh plant species as soon as feasible. The CWPPRA estimate for vegetative planting of brackish marsh is 875 plants/acre planted on 7-foot centers on rows 7 feet apart. Some plant species are available commercially and can be propagated. Plant species usually dominant in a brackish marsh are: marsh-hay cordgrass (*Spartina patens),* saltgrass (*Distichlis spicata),* American bulrush (*Schoenoplectus americanus),* black needle rush (*Juncus roemerianus),* seashore paspalum (*Paspalum vaginatum*), and switchgrass (*Panicum virgatum*).

Plants will be obtained from a registered licensed regional nursery/grower and of a regional eco-type species properly stored and handled to ensure viability. The plants will typically be installed during the period from March 15 through June 15.

2. Forested Ridge Habitat Mitigation. The objective of tree stand improvements will be to increase the quality of remaining forest habitat in the Project area by selective tree and shrub plantings, selective thinning or cutting, and eradication of invasive and nonnative species.

a. Selective Clearing and Planting Plan. To enhance the ecological value of the site, thinning of the existing canopy and/or midstory strata will occur prior to plantings to remove nonnative species, to create openings for the release of shade-tolerant native species such as oaks, or reduce abundance of less desirable species.

Selective plantings will consist of native hardwood tree and shrub species that are not present, or that are present but under abundant. Once mature, these hardwood species, including hard and soft mast-bearing species, will provide food resources for multiple migratory and resident species and increase overall habitat diversity. Hardwoods tree species will be planted on the upper sides of the ridge slopes and ridge tops. Hardwoods such as live oak (*Quercus virginiana)*, sugarberry (*Celtis laevigata*), dwarf palmetto (*Sabal minor*), and red cedar (*Thuja occidentalis*) will likely be suitable for ridge planting. Side slopes of the ridge not affected by the tides as well as the ridge top are suitable for midstory/shrub-scrub species such as wax myrtle (*Myrica cerifera*), groundsel bush (*Baccharis* *halimifolia*), marsh elder (*Iva frutescens*), and yaupon (*Ilex vomitoria*). These will provide habitat for neo-tropical migrants. Other woody species such as red mulberry (*Morus rubra*), hackberry/sugarberry (*Celtis laevigata*), California desert-thorn (*Lycium carolinianum*), and green ash (*Fraxinus pennsylvanica*) could also be used on the high side slopes.

Tree and shrub seedlings will be planted in existing or newly-created forest openings. Native species of 1-year-old bare-root seedlings will be planted in clearings at an average density of about 50 trees/acre (30-foot spacing) and 150 shrubs /acre (15-foot spacing); for sites of Chinese tallow-tree eradication (see below), planting densities would be about 435 trees per acre (10-foot spacing).

b. Eradication of Invasive and Nuisance Species. Existing stands of Chinese tallow-tree will be removed or controlled by accepted mechanical or chemical methods to make way for more desirable vegetation. Heavy colonization with Chinese tallow-tree must be mechanically cleared prior to the application of any chemical. Chemically treating Chinese tallow-tree stands via broad-scale aerial application of selective chemicals, prior to mechanical clearing, may prove largely unsuccessful due to the relatively uneven canopy structure, which would result in an uneven chemical application, leaving many midstory and understory stems completely untreated.

In order to increase the success of the proposed Chinese tallow-tree eradication, the following sequence of actions will be required (they are listed in chronological order):

i. For heavy colonized areas, mechanically clear the site with a hydro-axe or similar equipment. Felled woody plants may be chipped on-site and left as a thin layer, which may aid in the control of Chinese tallow-tree regeneration. Woody debris may also be burned on-site or removed from the site and disposed at an approved/licensed facility.

ii. Allow a minimum of 2 months (during the growing season) for root resprouting to occur.

iii. Use a tractor with boom-sprayer, or a similarly effective method, to apply chemicals to the Chinese tallow-tree resprouts, or to areas of tallow-tree that are not heavily colonized. Chemical treatment must occur in the late summer or fall, when plant resources are being transported to the roots; this increases the likelihood of a complete "root-kill." The acceptable chemical treatment period is June 1 through October 15, with the optimum period occurring September 1 through October 15. To ensure effectiveness, the treatment must occur before the leaves begin to change color for the autumn season.

iv. Allow adequate time for seed germination/sprouting to occur (i.e., a second growing season). Most seeds that did not germinate during the first year of site preparation, should germinate during the second growing season. Chemically treat the site as described in "iii" above.

v. Plant bare-root seedlings during the following dormant season (Dec 15 – Mar 15). This would allow a minimum of 2 months between the second chemical treatment and the planting of seedlings.

The Corps will be responsible for conducting the invasive plant eradication events until such time that the performance standards listed in Section G. Costs associated with these events (e.g. those that are the responsibility of the Corps will be cost-shared with the Sponsor.)

G. Performance Standards. The ecological success (performance) standards applicable to the proposed mitigation are described as follows. The year numbers cited are based on the initiation of mitigation construction activities beginning in Year 1.

1. Brackish Marsh Mitigation. In order for the brackish marsh mitigation to be considered acceptable for mitigating wetland impacts, the site vegetation, soils, and hydrology will be restored such that the site meets wetland criteria as described in the Corps 1987 Wetland Delineation Manual. Additionally, the following criteria are applicable:

- Initial Success Criteria
    - Initial placement of dredged material is completed and at least 80 percent of site is within "as-built" or initial construction elevation range (+1.5 feet MLG).
- Year Three Success Criteria
    - After at least 2 full years following construction, no less than 90 percent of the marsh creation site is within the "functional marsh" elevation range (e.g., +1.0 feet to + 1.5 feet MLG).
    - At least 80 percent of the dredge material disposal area should be vegetated.
    - Containment dikes breached and any resulting tidal creeks constructed and functioning.
    - At least 80 percent of the vegetative cover consists of plant species classified as Facultative (FAC) or wetter, as verified by monitoring reports and verified by an interagency team if necessary.
- Year Five Success Criteria
    - 5 years after construction, at least 75 percent of the created marsh remains within the "functional marsh" target elevation range.
    - Demonstrated use of the created marsh area by estuarine-dependent marine fishery species (not just forage species) typical of that marsh type as shown by sampling on a quarterly basis during years four and five using cast nets and/or seines in open water within the Project area.
    - Observed use of created marsh by wildlife species typically found in natural marsh habitats of similar salinity regime.

2. Forested Ridge Habitat Mitigation. The mitigation site will be considered to meet ecological success, if after 10 years, there is 80 percent survivorship and a positive relative growth rate of planted trees and shrubs.

The initial eradication of invasive plant species will be completed within 1 year of completion of final mitigation construction activities. Maintain the site free from invasive plant species immediately following a given maintenance event and such that the total average vegetative cover accounted for by invasive species constitutes less than 5 percent of the total average plant cover during periods between maintenance events. These criteria must be satisfied throughout the duration of the overall monitoring period.

H. Monitoring Requirements

1. As-Built Reports. The Corps/Sponsor will submit an As-Built Report to LDWF, NMFS, EPA, the Service, and the Louisiana Department of Coastal Management (CMD), for the marsh and forested ridge mitigation features within 1 year following completion of the work. For the marsh mitigation, the As-Built Report shall contain a survey providing the areal extent of the dredge disposal area and the settled grade of the dredged material and adjacent marsh areas. For the forested ridge mitigation, the As-Built report shall contain a survey displaying the areas of woody clearings, tree and shrub plantings, and Chinese tallow-tree eradication.

2. Monitoring Provisions. The Corps/Sponsor agrees to perform all necessary work to monitor the Calcasieu Lock mitigation project to demonstrate compliance with the success criteria established in this monitoring plan. The monitoring program shall follow these guidelines:

a. Visual Description., Visual descriptions shall be provided with each monitoring report by one of the following means:

- Photographs of each vegetation plot and hydrology monitoring station [permanent markers shall be established to ensure that the same locations (and view directions) are monitored in each monitoring period], or
- One color aerial photograph (8 by 10 inches or larger) depicting the entire site. An aerial photograph should be taken once the site has been constructed, stabilized and planted (preferably in Year 3 or Year 5 following completion of initial work).

b. Hydrology (for marsh mitigation only). Tidal influence shall be discussed using indicators of high and low tides referenced to a known datum. The condition of the any constructed tidal channels and ponds noting general flow characteristics, noting excessive scouring and/or silting in of channels.

c. Vegetation (for marsh mitigation)

i. The Corps/Sponsor shall establish survey plots along systematically spaced linear transects at the time of construction, and shall conduct a survey of each tract at or near the end of the first growing season. Surveys shall be conducted in accordance with an accepted academic or industrial sampling methodology (e.g. Steyer et. al. 1995). The Corps/Sponsor shall establish one-hundredth-acre permanent continuous monitoring plots that account for at least 2 percent of the total created marsh area. The Corps/Sponsor shall document the species and percentage coverage by species within each plot. The Corps/Sponsor will begin monitoring the continuous monitoring plots and submit monitoring reports to LDWF, NMFS, EPA, the Service, and CMD at required intervals.

ii. The Corps/Sponsor shall provide a written report to LDWF, NMFS, EPA, the Service, and CMD that describes the developing vegetative communities developing within the marsh by determining:

- dominant vegetation species;

- a coverage assessment;
- the number and species rated FAC or wetter (excluding FAC-) growing in wetlands (total and #/acre);
- the percentage of dominant species FAC or wetter (excluding FAC-); and
- an invasive/noxious species assessment.

iii. The report shall describe the general condition of the vegetation, and discuss likely causes for any observed mortality.

d. Vegetation (for forested ridge habitat)

i. The Corps/Sponsor shall establish survey plots in the forested ridge habitat mitigation site to determine the survival rate and growth rate of planted trees and shrubs, and to determine the success of eradicating Chinese tallow-tree. For the tree and shrub plantings, in Year 1, five points will be randomly selected within the reforested section of the mitigation area. Each of these points will form the center of a permanent square 1/5th acre vegetation sampling plot. If plots overlap or extend beyond the mitigation site boundaries, additional random points shall be selected until five suitable plots are found. The GPS coordinate for the center of each plot will be recorded to allow for relocation of the plot in subsequent years. All planted trees within the subplot shall be tagged with an aluminum label indicating species and month and year of planting. Tags shall be permanently placed on or adjacent to planted trees using a method that will not impair tree growth. All planted seedlings within the five plots will be monitored annually and species, state (alive/dead), height, and basal diameter recorded.

For areas of Chinese tallow-tree eradication, the Corps/Sponsor shall establish survey plots in these treated areas to document the species and percentage coverage by species within each plot. The plots will be one-hundredth-acre permanent continuous monitoring plots that account for at least 2 percent of the treated area. The Corps/Sponsor will begin monitoring the continuous monitoring plots and submit monitoring reports to LDWF, NMFS, EPA, the Service, and CMD at required intervals.

ii. The Corps/Sponsor shall provide a written report to LDWF, NMFS, EPA, the Service, and CMD that describes the developing vegetative communities developing within the marsh by determining:

- dominant vegetation species;
- a coverage assessment;
- an invasive/noxious species assessment.

iii. The report shall describe the general condition of the vegetation, and discuss likely causes for any observed mortality.

e. Site Elevation. The Corps/Sponsor shall provide a topographic survey with elevations shot along the transect lines established for determining vegetation cover and species composition. Surveys should be included in monitoring reports for years 1, 3, 5, 10, 20, 30, 40, and 50.

f. Timing

i. Monitoring shall be conducted during the growing season following Years 1, 3, 5, 10 and every 10 years thereafter for 50 years.

ii. Monitoring for the first year or any year following construction shall take place between August and October;

3. Monitoring Reports

a. Upon achievement of the initial success criteria, the Corps/Sponsor shall document the results of his monitoring in a report submitted to LDWF, NMFS, EPA, the Service, and CMD. Additional reports will be submitted following years 3, 5, 10, 20, 30, 40 and 50.

b. The reports shall contain a description of the conditions of the mitigation project relating those conditions to the success criteria and shall contain the following;

i. An aerial photograph (only in report submitted after Year 3 or 5) taken during the growing season, depicting a completed tract of the mitigation project with the photo date and approximate scale noted:

ii. Ground level photographs;

iii. A detailed narrative summarizing the condition of the mitigation project and all regular maintenance activities;

iv. A drawing based upon the site plan that depicts topography, sampling plots and permanent photo stations;

v. Results of tidal monitoring, including mean high and low water elevations:

vi. Results of vegetation survey including visual estimates of percentage (%) overall cover and % cover by each species, % exotic vegetation, total % facultative" and total % "upland" species in each vegetation layer, survival rate of planted vegetation (if planted), an estimate of natural revegetation, and a qualitative estimate of plant vigor as measured by evidence of reproduction; and

vii. if Year 1 success criteria is obtained, but all performance criteria have not been met in Year 3, a monitoring report shall be required for each consecutive year until two annual sequential reports indicate that all criteria have been successfully satisfied (i.e., that corrective actions were successful).

c. Reports will be submitted by December 31 of each monitoring year:

d. Monitoring reports shall be provided to LDWF, NMFS, EPA, the Service, and CMD and made available to other members of the natural resource agencies upon request.

Table I-5 displays the currently anticipated monitoring report schedule and the party responsible for conducting the monitoring and preparing the report.

I. Long-Term Management Plan. The mitigation features will remain in the ownership of the non-Federal Sponsor, who will also be responsible for all operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of these features. In order for the mitigation features to sustain the restoration goals outlined in this Mitigation Plan document, the annual appropriations and management responsibilities will be outlined in the OMRR&R manual that will be prepared for this project by the Corps and provided to the Sponsor.

J. Adaptive Management Plan. If site conditions are unsuccessful or successful criteria has not been met due to unavoidable or natural disaster, the Corps and cooperating agencies will reassess the project location and determine if alternative methods are necessary to meet successful criteria.

For the marsh mitigation, in the event monitoring reveals that initial success criteria have not been met, the Corps/Sponsor shall take measures to achieve those criteria in accordance with the following plan:

1. Fill Material Elevations and Area

a. Should the initial placement of dredged material for marsh mitigation not meet the 80 percent target construction elevation or areal coverage, the Corps/Sponsor shall either deposit additional dredged material or redistribute existing material as necessary to achieve the target percentage and areal coverage.

b. At Year 5, if less than 75 percent of the marsh creation area contains emergent vegetation (at least 50 percent of which have an FAC or wetter designation), then the Sponsor may be required, at the discretion of the natural resource agencies, to deposit and plant (according to their specifications) additional dredged material. Should the agencies decide that such measures are necessary, the location and extent of fill placement and vegetative plantings will be determined in consultation with, and with their approval.

c. From Years 6 through 20, if less than 50 percent of the marsh creation area contains emergent vegetation (at least 50 percent of which have an FAC or wetter designation), then the Sponsor may be required, at the discretion of the natural resource agencies, to deposit additional material and plant these areas (according to their specifications) so that the extent of marsh coverage is at minimum 50 percent at Year 20. Should the agencies decide that such measures are necessary, the location and extent of fill placement and vegetative plantings will be determined in consultation with, and with their approval.

Table I-5. Standard Mitigation Monitoring Report Schedule and Monitoring Responsibility

Year	Monitoring Report Number	Party Responsible for Monitoring and Reporting
1 (begin & complete initial construction activities; completion near end of year)	N/A	N/A
2 (begin & complete final construction activities; filled areas settle to final target grades near end of year)	1 (Time Zero Report)	USACE
3 (complete initial plantings early in year; complete initial invasive/nuisance plant eradication)	2	USACE
4 (1 year after initial plantings; 2 years after completion of final construction activities)	3	USACE
5 (Re-planting if necessary; 3 years after completion of final construction activities)	4	USACE if replanting necessary; NFS if replanting not necessary
6 (1 year after re-planting if re-planting needed)	5A*	USACE if replanting necessary in Year 5; No report needed if replanting not necessary in Year 5
7 (2 years after re-planting if re-planting needed; 5 years after initial plantings)	5B	USACE if replanting necessary in Year 5; NFS if replanting not necessary in Year 5
12	6	NFS
17	7	NFS
22	8	NFS
27	9	NFS
32	10	NFS

2. Vegetative Plantings

a. If vegetative plantings survival is less than 50 percent per acre as determined by sampling or by observing high mortality at any location within the planted tract, the Sponsor shall take appropriate actions, as recommended by the natural resource agencies, to address the causes of mortality and shall replace all dead plantings during the following planting season. Replanting and monitoring and reporting, shall occur as needed to achieve and document the required 1-year survival rate. If the survival criterion is not met after a second unsuccessful attempt, the Corps/Sponsor will convene a meeting to decide if replanting should continue. Should the natural resource agencies determine that achieving the required survival rate would not be likely, the Sponsor shall be required to provide replacement mitigation for the increment of value that did not accrue within the unsuccessful tracts within 1 year of this decision. In addition, the natural resource agencies will reassess the created marsh to determine if a new management potential should be calculated incorporating the new conditions.

b. Year 5 monitoring shall verify vegetation composition and survivorship goals. The Sponsor shall implement remedial action, as deemed necessary by the natural resource agencies, to ensure attainment of Year 5 survivorship and composition criteria.

For the forested ridge mitigation, in the event monitoring reveals that initial success criteria have not been met, the Corps/Sponsor shall take measures to achieve those criteria in accordance with the following plan:

If survival of tree and shrub plantings falls below 80 percent during any year following project completion, additional plantings would be needed. Supplemental plantings would continue until ecological success is met. If tree mortality is caused by invasive species (e.g., kudzu, Japanese hops, etc.) then invasive species management (hand cutting and herbicide treatment) should be implemented and trees species replanted using the species list in Section F.2.a. If tree mortality is caused by disease/insect infestation, then the effectiveness of pesticide application versus replanting of resistant trees should be evaluated and one of these measures implemented.

No adaptive management is expected to be needed as maintenance of invasive species is part of the O&M for the project. If a large amount of invasive species are removed through O&M efforts, potential Adaptive Management actions include replanting of the areas previously covered by invasive species. Additional thresholds/triggers will be developed during PED.

K. Financial Assurances. Financial assurances are required to ensure that the compensatory mitigation project would be successful. In this case, PPA between the Sponsor and the Federal Government provides the required financial assurance for this mitigation project. In the event that the Sponsor fails to perform, the Corps has the right to complete, operate, maintain, repair, rehabilitate or replace any project feature, including mitigation features, but such action would not relieve the Sponsor of its responsibility to meet its obligations and would not preclude the Corps from pursuing any remedy at law or equity to ensure the Sponsor's performance.

L. Cost. The total cost of mitigation monitoring and reporting activities addressed herein is currently estimated to be approximately $121,000. This assumes that annual monitoring will be conducted a total of 12 times over the 50-year project life (at an assumed cost of $6,750 per year), and monitoring reports will be prepared a total of 10 times (at an assumed cost of $4,000 per report).

The total cost of adaptive management is currently estimated to be approximately $137,500. This assumes that 50 percent of the marsh plantings and forested ridge habitat tree and shrub plantings do not survive and will need to be replanted once ($17,500 for marsh replanting, $7,500 for tree and shrub replanting), and multiple herbicide treatments will be needed to control Chinese tallow-tree ($12,500 total, assuming annual applications for each of the first 5 years). In addition to replanting, it is assumed that initial placement of dredged material for marsh mitigation will not meet the 80 percent target construction elevation or areal coverage, and that restoration or renourishment actions will be required (assumed cost of $100,000). No further topographic alterations following completion of the final mitigation construction activities are assumed.

All mitigation monitoring and adaptive management costs occurring during the first five years after initial construction will be cost shared with the non-Federal Sponsor, whereas monitoring costs and any adaptive management costs occurring after the first five years will be 100 percent non-Federal costs.

III. LITERATURE CITED

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX J

REAL ESTATE PLAN

APPENDIX J
REAL ESTATE PLAN

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APPENDIX J
REAL ESTATE PLAN

I. PURPOSE OF THE REAL ESTATE PLAN AND PROJECT DESCRIPTION

This Real Estate Plan (REP) presents the real estate req uirements and costs for the Feasibility Report for the Calcasieu Lock Louisiana Feasibility Study. The information contained herein is tentative in nature for planning purposes only. At the time the REP was prepared, the Project Delivery Team (PDT) had reached the TSP milestone, and feasibility level analysis was just beginning. Footprint maps which identify locations of all project features were not available. The information contained within this REP is based on assumptions made by the PDT, and estimated acreages of project features. This REP does not fully conform to the requirements of Chapter 12 (ER 405-1-12). Once feasibility level analysis is complete, the REP will be revised to conform with Chapter 12.

The Calcasieu Study addresses navigation improvement planning for the Gulf Intracoastal Waterway (GIWW) at and in the vicinity of Calcasieu Lock, Cameron Parish, LA. This Study was developed from the results of the GIWW Locks, Louisiana reconnaissance report, completed in May 1992. This comprehensive Study involved a systems analysis of the GIWW locks west of the Mississippi River. The report documented the need for replacements or improvements at Bayou Sorrel, Calcasieu, and Port Allen locks. This resulted in a 905(b) Reconnaissance report specifically for the Lock that was completed in 2001 and which found justification and Federal interest in further feasibility level study of the navigation delays and potential solutions at Calcasieu Lock.

The principal problem to be addressed is the delay to navigation induced through operation of the Calcasieu Lock for drainage of the Mermentau River Basin as part of its authorized purpose. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of Calcasieu Lock as a salinity barrier for the Mermentau Basin is also critical.

Opportunities exist to increase navigation efficiency through improved operational routines and potential modification of the existing structure to accommodate existing and future traffic. Further opportunities exist to reduce or eliminate navigation delays due to drainage. A drainage event occurs when a rainfall or storm surge event within the Mermentau Basin results in a 3-foot reading at the Calcasieu East gage. This causes operations at Calcasieu Lock to switch from a locking operation with sector gates closed; preventing salinity intrusion, to a drainage operation with sector gates open forcing tows to wait to transit the lock until the gage moves below 3ft. Altering the existing lock structure to decrease the impacts of drainage events on transiting tows will result in shorter lockage times and delays for tows staging at either segment of the GIWW (east or west). Fewer barge reconfigurations to allow for transit during drainage events will increase cycling times of tows through the lock. An additional or wider lock chamber would allow for passing of flows through the old lock or through a new wider lock that can accommodate drainage events and lockages. Redirecting completely or partially drainage flows away from the existing lock will reduce or eliminate the delays that result.

II. PROJECT LOCATION

Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Cameron Parish, LA, approximately 10 miles south of Lake Charles, LA. The lock is located at mile 238 of the GIWW. Calcasieu Lock is a critical component of the Louisiana portion of the GIWW, along with its location in the junction of the Mermentau and Calcasieu River Basins. It also provides flood risk management benefits when used to drain the Mermentau Basin after storm events. It operates in conjunction with Leland Bowman Lock and Catfish Point and Schooner Bayou control structures. Figure J-1 shows a map of the Calcasieu Lock study area, and Figure and J-2 shows the location of the Calcasieu Lock on the GIWW.

Figure J-.1. Calcasieu Lock Study Area

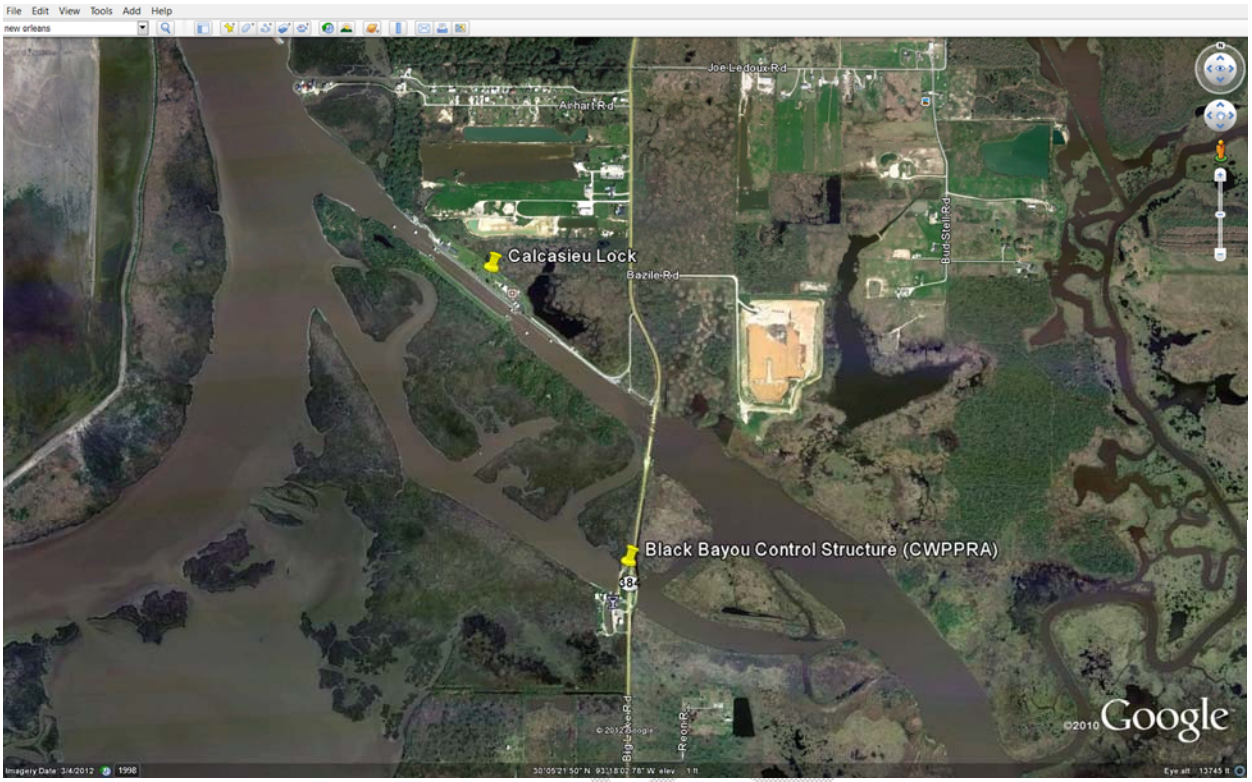


Figure J-.2. Location of Calcasieu Lock on the GIWW

III. PROJECT FEATURES

The project features identified within this section are not presented to a feasibility level design. This information is based on assumptions made during alternatives analysis.

Figure J-3 shows the location of various project features. The hatched areas on the map are potential disposal areas, but only portions of these areas will be utilized. This map will be refined after feasibility level design.

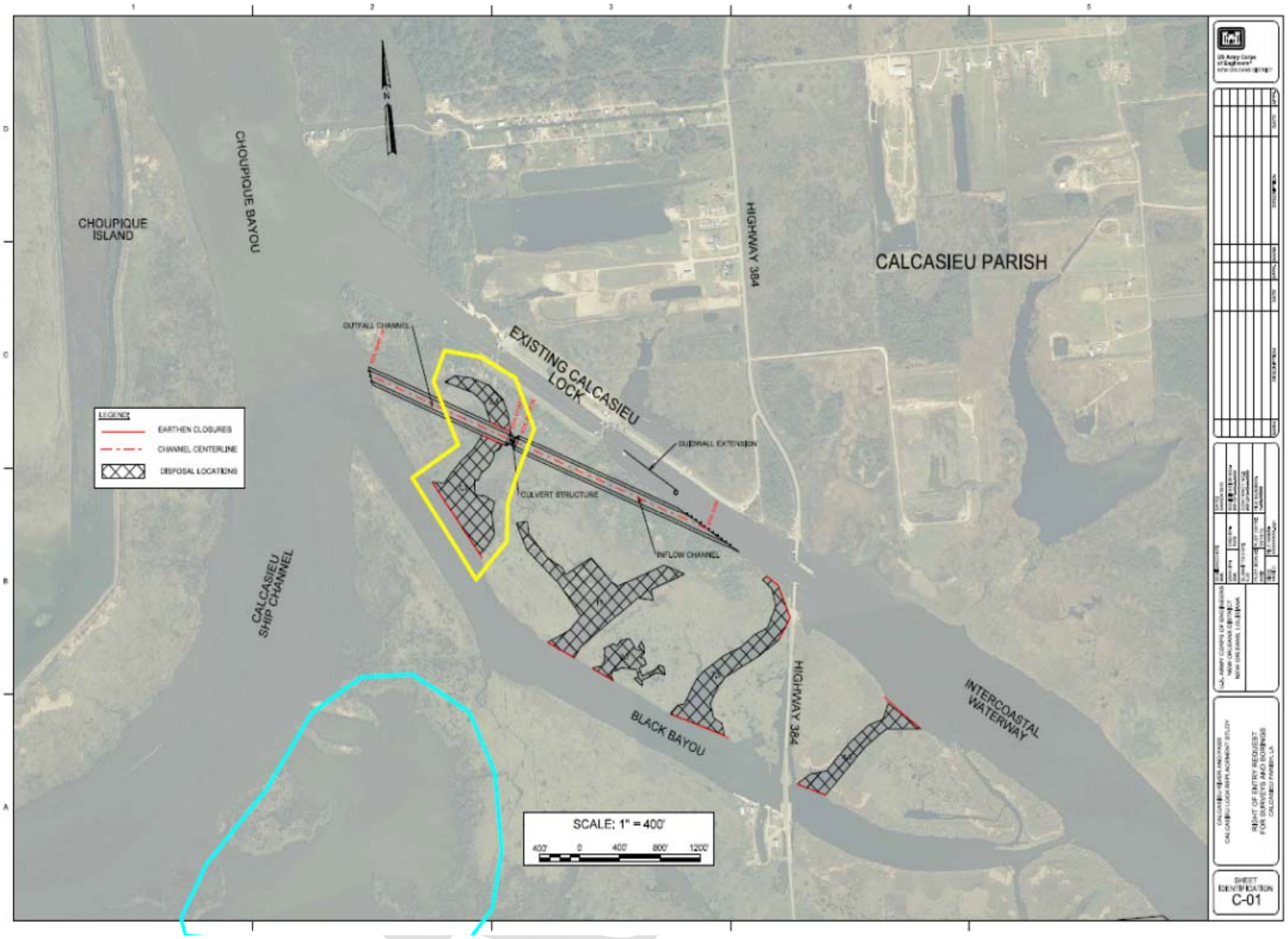


Figure J-3. Calcasieu Lock Project Features

A. <u>Culvert Structure.</u> The culvert structure consists of five openings (9' x 14' each) that will allow for the passage of the additional flow. The structure is pile-founded, reinforced concrete with cast iron sluice gates that can be closed when salinity levels in the ship channel are too high. The structure is 82-ft wide and 100-ft long. The invert of the structure is (-) 6.0, with the top of the structure at (+) 14.0. The top of the culvert is at (+) 5.0, which is higher than the anticipated flow line thru the area, so water cannot overtop the structure. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this phase.

Preliminary assumptions of pile sizes, spacing, and pile tip elevations were based on the design of similar structures found in the vicinity. Verification of the pile assumptions, along with any adjustments, was accomplished with the use of pile capacity curves that were developed for similar soils. A more accurate determination of soil properties was not possible due to the absence of reliable borings; therefore, pile tip elevations may be adjusted in the next stage of design.

The structure can be dewatered for maintenance purposes with the use of steel bulkheads on either side of the sluice gates.

The operation of the gates can be done remotely, with hydraulic motors. Therefore, there is no requirement to man the structure during events in which the structure is opened. Power was assumed to be provided from the Calcasieu Lock area.

B. Culvert Structure Dredging. Approximately 3,650 linear feet of dredging for the inflow and outflow channels will be required to tie the Intercoastal Waterway to Bayou Choupique. The channel will be dredged to elevation (-) 12.0 MLG and have an 80-foot bottom width (approx. 170,000 cubic yards). Approximately 300 feet of riprap with a 3-foot thickness will be placed on either side of the structure. All material from the channel dredging will be placed in the open water areas in the potential disposal sites identified below. The material will be contained by earthen weirs and closures.

C. Pipeline to Disposal Site. For disposal of dredged materials, a pipeline will be routed through the existing open water using floating or submerged pipeline. The pipeline would traverse the Calcasieu Ship Channel, a state water body.

D. Disposal Area. The above referenced maps show hatched lines which identify potential disposal sites. The area outlined in blue also represents a potential disposal site. Approximately 25 acres will be required for disposal area, and the disposal site will be identified following feasibility level design.

E. Mitigation. The project will require both marsh mitigation and forested spoil bank mitigation. The mitigation area is depicted on the above referenced map in the hatched area outlined in yellow. Approximately 10 acres will be required for marsh mitigation. For spoil bank mitigation, approximately 15 acres will be required, and a second mitigation component consists of purchasing an additional 10 credits at a mitigation bank for bottomland hardwoods.

F. Access/Staging. Construction access to the site for Alternative 1 will be via barge. In addition, a permanent access road will be constructed from the lock to the culvert structure for use by the lock personnel. Tentatively, staging for Alternative 1 will be adjacent to the site between the lock and culvert structure. There will be no impact to utilities in proposed location.

IV. PROJECT AUTHORIZATION

Authorization for the GIWW originally occurred in 1925 and has been modified and supplemented numerous times since then. The Calcasieu Lock was authorized as part of the *Mermentau River, Louisiana Flood Control, Irrigation and Navigation Project* (Mermentau Project) in the River and Harbor Act of 24 July 1946, Public Law No. 525, 79th Congress, 2nd Session, in accordance with the plan outlined in Senate Document No. 231. This document recommended modification of the existing project for the GIWW to provide for a salt water guard lock in the waterway. The document included other closely related improvements for flood control, navigation and salt water intrusion in the Mermentau River and Basin. The plan of improvement pertaining to the GIWW as contained in the project document is as follows:

> "Gulf Intracoastal Waterway. An earth-chambered salt water guard lock, 425 by 75 by 12 feet, at or near Grand Lake Ridge, Mile 231 west of Harvey Lock."

The Calcasieu Lock, Louisiana Feasibility Study (Study) is being performed by the US Army Corps of Engineers (Corps), New Orleans District (MVN), under the authority of the following resolutions:

> A resolution at the request of Senators Long and Edwards of Louisiana, adopted by the Committee on Public Works of the United States Senate on September 29, 1972, that the "Board of Engineers for Rivers and Harbors, be, and is hereby, requested to review the reports on the Gulf Intracoastal Waterway (Louisiana-Texas Section, including the Morgan City-Port Allen Route) submitted in House Document 556, 87th Congress, Second Session, and subsequent reports, with a view to determining the advisability of modifying the existing project in any way at this time, particularly with regard to widening and deepening the existing and/or authorized channel."

> A resolution at the request of Congressman Jack Brooks of Texas, adopted by the Committee on Public Works of the United States House of Representatives on October 12, 1972, that the "Board of Engineers for Rivers and Harbors, be, and is hereby, requested to review the reports on the Gulf Intracoastal Waterway (Louisiana-Texas Section, including the Morgan City-Port Allen Route) submitted in House Document 556, 87th Congress, second session, and subsequent reports, with a view to determining the advisability of modifying the existing project in any way at this time, particularly with regard to widening and deepening the existing and/or authorized channel."

V. NON-FEDERAL SPONSOR

Since the Calcasieu Lock feasibility study is being developed as a single purpose study to address inland navigation efficiency, the project cost will be 100% Federal during the feasibility phase (as stated in ER-1105-2-100, Sec 2-8 (3)). The project will be cost shared at 50%/50% for construction. The Non-Federal Sponsor (NFS) will be required to provide all Lands, Easement, Rights-of-Way,Relocation of Utilities or Other Existing Structures & Disposal Areas (LERRDs) necessary for the project, and should receive credit towards its cost share for LERRDs acquired. At the time of this draft report, an NFS has not been identified, and a Project Partnership Agreement (PPA) has not been created. In addition, a *Non-Federal Sponsor Real Estate Acquisition Capability Assessment* has not been prepared. This assessment will be prepared and included within the Real Estate Plan prior to submission of the final report.

VI. LANDS, EASEMENTS & RIGHTS-OF-WAY (LER)

The project primarily impacts wetlands. It is estimated that a total of five private landowners could be affected by the project. The Federal Government holds existing perpetual easements within the project area, which could be utilized for the channel creation and/or disposal sites, and this information will be reviewed by MVN's Office of Counsel during feasibility level design. However, for the purposes of this draft report, it is assumed that new rights of way (ROW) will be acquired for the project.

A non-material deviation will be made to the standard road easement to revise the rights necessary for any required privately owned waterway access routes. This estate is further discussed in Section VIII, *Estates*, “Road Easement.”

The area in which the dredged material pipeline will be placed, access areas, and some of the area proposed for disposal, is located within state water bottoms. The State of Louisiana is prohibited by Constitutional mandate from granting easements over its property or selling the property in fee interest. The Grant of Particular Use is the instrument executed by the State which allows the Federal Government to enter its property and construct the project (in Federal terms, this would be called Right-of-Entry). The document discusses the work to be performed on the land and the duration of occupancy. The state will issue a Grant of Particular Use for the project area which lies within state owned water bottoms. The rights delineated in the Grant of Particular Use issued by the State will be similar to the language in the standard temporary work area easement.

With the exception of the dredged material pipeline, access areas, and potential disposal site, all project features lie within privately-owned lands. Table J-1 demonstrates the project feature acreages, as well as the estimated number of landowners affected and the proposed estate:

Table J-1. Project Features and Estates Required

Project Feature	# Acres	# Tracts/ Ownerships	Proposed Estate
Inflow Channel	11	3	Perpetual Channel Improvement Easement
Culvert Structure	.31	1	Fee, Excluding Minerals (With Restriction on Use of Surface)
Permanent Access Road	3	1	Perpetual Road Easement
Disposal Area	25	5	Temporary Work Area Easement / Grant of Particular Use (State Water Bottoms)
Dredged Material Pipeline	10	1	Grant of Particular Use (State Water Bottoms)
Mitigation Area	25	2	Fee, Excluding Minerals (With Restriction on Use of Surface)
Access (Temporary)	10	1	Grant of Particular Use (State Water Bottoms)
Staging	1	1	Temporary Work Area Easement

VII. NON-FEDERAL SPONSOR OWNED LANDS, EASEMENT, RIGHTS-OF-WAY,

An NFS has not been identified for the project. However, none of the lands required for the project are owned by any government entity, with the exception of state water bottoms. This information will be revised after feasibility level analysis is complete.

VIII. ESTATES

The following standard estates will be required for the project:

FEE EXCLUDING MINERALS (With Restriction on Use of the Surface)

The fee simple title to the land, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the for the purpose of exploration, development, production and removal therefrom of said (coal) (oil and gas).

CHANNEL IMPROVEMENT EASEMENT

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_______________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

ROAD EASEMENT

A (perpetual [exclusive] [non-exclusive] and assignable) (temporary) easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed

> *___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

The language and approval of the Temporary Access Easement (Non-Material Deviation from Standard Estate) is attached as **Exhibit A**.

IX. NON-STANDARD ESTATES

There are no non-standard estates proposed for the project.

X. EXISTING FEDERAL PROJECTS WITHIN THE LER REQUIRED FOR THE PROJECT

The GIWW is often referred to as the most remarkable artery of transportation in America. The GIWW extends westward to Brownsville, Texas, at the Mexican border, and eastward to Apalachicola, Florida. There are numerous open-water and wetland areas located along the ship channel which are productive fish and wildlife habitats. This vital inland waterway was constructed from the 1920s to 1949. The Louisiana segment stretches for 302.4 miles from the Texas-Louisiana state line in the west to the Louisiana-Mississippi state line in the east. The GIWW Alternate Route from Port Allen to Morgan City adds another 64 miles to its length for a total of 366.4 miles.

In Louisiana, the MVN operates and maintains the GIWW and its six locks for both navigation and agricultural purposes. The Corps maintains channel dimensions in the GIWW to 12 feet deep and 125 feet wide from the Mississippi River west, and 12 feet deep and 150 feet wide from the Inner Harbor Navigation Canal to the Rigolets. Channel enhancements and additions continue to this day.

XI. FEDERALLY OWNED LANDS WITHIN THE LER FOR THE PROJECT

The Federal Government owns 18 acres in fee at the existing Calcasieu Lock. In addition, the Federal Government holds a total of 23,705 acres of perpetual dredging and disposal easements along the GIWW, including the proposed ROW for this project.

Portions of the required ROW are encumbered by perpetual dredging and perpetual spoil disposal easements acquired by the Federal Government in 1928 for the Calcasieu Lock project and Mermentau Basin project, as part of the GIWW. It has not yet been determined whether these easements would be applicable for this project. During feasibility level analysis, MVN's Office of Counsel will make a determination regarding these existing easements.

Any additional project features which require acquisition of fee (excluding minerals) or channel easements will be acquired from the private landowner(s).

XII. NAVIGATION SERVITUDE

The navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution to use, control and regulate the navigable waters of the United States and submerged lands thereunder for various commerce-related purposes. Commerce-related purposes currently recognized by the courts include navigation and flood control.

The existing channel is a man made waterway and is used in the aid of commerce. Comprehensive easements acquired for the project extend beyond the waterway. These easements include both the right to construct, operate and maintain a channel and the right to deposit dredged material on the part not cut away. Further, the authorizing legislation for this project included the provision that the waterway would become part of the waters of the United States. Accordingly, besides being able to assert the rights acquired through the easements, the waterway is also subject to navigational servitude. In either case, sufficient rights exist in the waterway for those portions of the project that are located therein.

Therefore, it is assumed that the Navigational Servitude could be invoked for any portion of the work that is performed below the ordinary high water mark.

XIII. INDUCED FLOODING

There will be no induced flooding as a result of the project.

XIV. BASELINE COST ESTIMATES/CHART OF ACCOUNTS (COAs)

The estimated cost of real estate required for the project is $107,000. These costs include administrative costs associated with acquisition activities, including potential condemnations. This estimate also includes a 25% contingency. A Baseline COA is attached as **Exhibit B.** This cost estimate will be revised following feasibility level analysis.

XV. UNIFORM RELOCATION ASSISTANCE (PL 91-646, Title II as amended)

There will be no displaced persons, farms or businesses as a result of the project.

XVI. TIMBER/MINERAL/ROW CROP ACTIVITY

There are no active oil and gas wells located within the project study area. There are no crops affected by the project. The NFS, when identified, will not be asked to acquire mineral rights for any required LERRDs.

XVII. OYSTER LEASES

There are no oyster leases located within the project study area.

XVIII. NON-FEDERAL SPONSOR CAPABILITY ASSESSMENT

As mentioned in Sections V, and VII, an NFS has not yet been identified for the project. A *Non-Federal Sponsor Real Estate Acquisition Capability Assessment* will be prepared during the feasibility level analysis period, once the NFS is identified.

XIX. ZONING IN LIEU OF ACQUISITION

There will be no application or enactment of zoning ordinances in lieu of, or to facilitate, acquisition in connection with this project.

XX. ACQUISITION SCHEDULE

The following acquisition schedule is based on the premise that the project will impact approximately 5 landowners and that no condemnation will be required. A deviation from this assumption will affect the schedule.

1)	TOD, Mapping	30 days
2)	Obtain Title	60 days
3)	Obtain Appraisal (concurrent with Title)	30 days
4)	Negotiations	90 days
5)	Closing	60 days

In the event that condemnation becomes necessary, the schedule will require an additional 6 months before construction can begin.

XXI. FACILITY/UTILITY RELOCATIONS

The construction of project features for the Calcasieu Lock project can be conducted with minimal to no impact of nearby utilities. There will be no required facility/utility relocations for the project.

XXII. HAZARDOUS, TOXIC AND RADIOACTIVE WASTE (HTRW)

A Phase I Environmental Site Assessment was conducted in June, 2013 on behalf of the Corps for the project. No HTRW materials or Recognized Environmental conditions were observed or discovered. The probability of encountering HTRW in the course of the project would be low, and direct significant adverse impacts would not be anticipated.

XXIII. LANDOWNER CONCERNS

LERRDs required for the project (in addition to existing easements) are expected to be minimal. The project has received support from the community; however, the attitudes of the landowners who will be directly affected by the project is not known. It is anticipated that landowner support will be high, and the NFS will be able to acquire the additional LER required for the project.

XXIII. NOTIFICATION OF RISK

Once an NFS is identified, they will be notified in writing of the risks of acquiring LER before execution of the PPA.

Prepared by:

Karen E. Vance
Realty Specialist
Real Estate Region South Division
July 12, 2013

Recommended for Approval By:

Judith Y. Gutierrez
Chief, Appraisal & Planning Branch
Real Estate Region South Division
July 12, 2013

EXHIBIT A

NON-MATERIAL DEVIATION FROM
STANDARD ESTATE

TEMPORARY ACCESS EASEMENT

TEMPORARY ACCESS EASEMENT

A non-exclusive and assignable temporary easement for a period not to exceed _____years beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as an access route and/or right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way, reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired, including the right to cross over the right-of-way as access to their adjoining land; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

In accordance with paragraph 12-9 c. of ER 405-1-12, the District Chief of Real Estate may approve a non-standard estate if it serves the intended project purpose, substantially conforms with and does not materially deviate from a corresponding standard estate, and does not increase the costs or potential liability of the Government. The foregoing estate complies with those requirements as it achieves the project purpose in as narrow a manner as practical, and is a minor modification of the standard Road Easement, adding language for a temporary term and replacing the word "road" with the words "access route and/or right of way.

Reviewed by:

Marco Rosamano
Assistant District Counsel
New Orleans District

Approved by:

Linda Labure
Chief, Real Estate Division
New Orleans District

EXHIBIT B

BASELINE COST ESTIMATES/
CHARTS OF ACCOUNTS

CALCASIEU LOCK REPLACEMENT STUDY
BASELINE CHART OF ACCOUNTS
TENTATIVELY SELECTED PLAN

					AMOUNT	CONTINGENCY	PROJECT COST
						ROUNDED	107,000
	TOTAL PROJECT COSTS				82,000	25,000	107,000
01	**LANDS AND DAMAGES**		CONTINGENCY	PROJECT COST	82,000	25,000	107,000
01B	**ACQUISITIONS**						
01B10	BY GOVERNMENT	34,000	8,500	42,500			
01B20	BY NON-FEDERAL SPONSOR (NFS)	0	0	0			
01B30	BY GOVT ON BEHALF OF LS	0	0	0			
01B40	REVIEW OF LS	0	0	0			
01C	**CONDEMNATIONS**						
01C10	BY GOVERNMENT	10,000	2,500	12,500			
01C20	BY LS	0	0	0			
01C30	BY GOVT ON BEHALF OF LS	0	0	0			
01C40	REVIEW OF LS	0	0	0			
01E	**APPRAISAL**						
01E10	BY GOVT (IN HOUSE)	20,000	5,000	25,000			
01E20	BY GOVT (CONTRACT)	0	0	0			
01E30	BY LS	0	0	0			
01E40	BY GOVT ON BEHALF OF LS	0	0	0			
01E50	REVIEW OF LS	0	0	0			
01F	**PL 91-646 ASSISTANCE**						
01F10	BY GOVERNMENT	0	0	0			
01F20	BY LS	0	0	0			
01F30	BY GOVT ON BEHALF OF LS	0	0	0			
01F40	REVIEW OF LS	0	0	0			
01R	**REAL ESTATE PAYMENTS**						
01R1	**LAND PAYMENTS**						
01R1A	BY GOVERNMENT	18,000	9,000	27,000			
01R1B	BY LS	0	0	0			
01R1C	BY GOVT ON BEHALF OF LS	0	0	0			
01R1D	REVIEW OF LS	0	0	0			
01R2	**PL 91-646 ASSISTANCE PAYMENTS**						
01R2A	BY GOVERNMENT	0	0	0			
01R2B	BY LS	0	0	0			
01R2C	BY GOVT ON BEHALF OF LS	0	0	0			
01R2D	REVIEW OF LS	0	0	0			

CALCASIEU LOCK LOUISIANA FEASIBILITY STUDY

APPENDIX K

ECONOMICS

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX K

ECONOMICS

FIGURES

TABLES

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX K

ECONOMICS

I. DESCRIPTION OF PROJECT SETTING

Calcasieu Lock is located on the GIWW, just east of the Calcasieu River, in Cameron Parish, LA, approximately 10 miles south of Lake Charles, LA (figure K-1). Calcasieu Lock is a critical component of the Louisiana portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins. Therefore the primary Study area is the Lock and immediate vicinity; however a broader approach was taken in assessing environmental, economic and hydraulic conditions and potential impacts. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast was evaluated. Hydraulically, potential impacts are local and regional in nature as the operation of the Lock is done in conjunction with other structures in the Mermentau Basin. Therefore, the Mermentau Basin and certain adjacent drainage areas were evaluated. Finally, the economic evaluation area includes the entire Louisiana portion of the GIWW.

A. Mermentau Basin. The Calcasieu Lock is an inland navigation project located in Louisiana on the GIWW near the TX border. The navigation project has several distinct purposes. These purposes are: preventing salt water intrusion from the Gulf of Mexico into the Mermentau River Basin, providing a route for inland navigation, and serving as a floodway for draining flood waters from the Mermentau River Basin. These purposes are accomplished by two interconnected systems: The Mermentau River Basin flood control system and the GIWW.

The Mermentau basin encompasses a total area of about 4.2 million acres and contains highly productive agricultural lands interwoven into a variety of intrinsically valuable natural environments. Located between the Teche-Vermilion and Calcasieu basins, the Mermentau river basin is a controlled waterway system. Control exists for the drainage of the Mermentau River and its tributaries. Maintaining optimal water levels helps secure a freshwater reservoir for agricultural use while preserving the basin‘s sensitive environments which are kept from the detrimental effects of saltwater intrusion from the Gulf. Catfish Point, Schooner Bayou Control Structures, the Calcasieu, the Freshwater Bayou, and Leland Bowman Locks are all features which control the impoundment of winter runoff for irrigation use in the summertime. The target water level inside the basin is 2.0 feet above the mean low gulf (MLG). These five features are operated in unison to achieve this target level.

The principal agro/aqua cultural products of the Mermentau Basin are rice and crawfish. There are approximately 300,000 acres of rice farming, as well as 35,000 acres devoted to crawfish farming. The average annual economic values of the rice and crawfish production equates to $160 million dollars. The rice and crawfish farming both require ample supplies of fresh water, as well as similar terrain. Also dependent upon the fresh water supply is the surrounding natural ecosystem. The basin provides a home to upwards of a half a million ducks and well over 300 species of birds as well as large commercial sport fishing use. It is crucial for these reasons for the basin to have adequate freshwater. While quantity is important, the quality of the water is of equal importance.

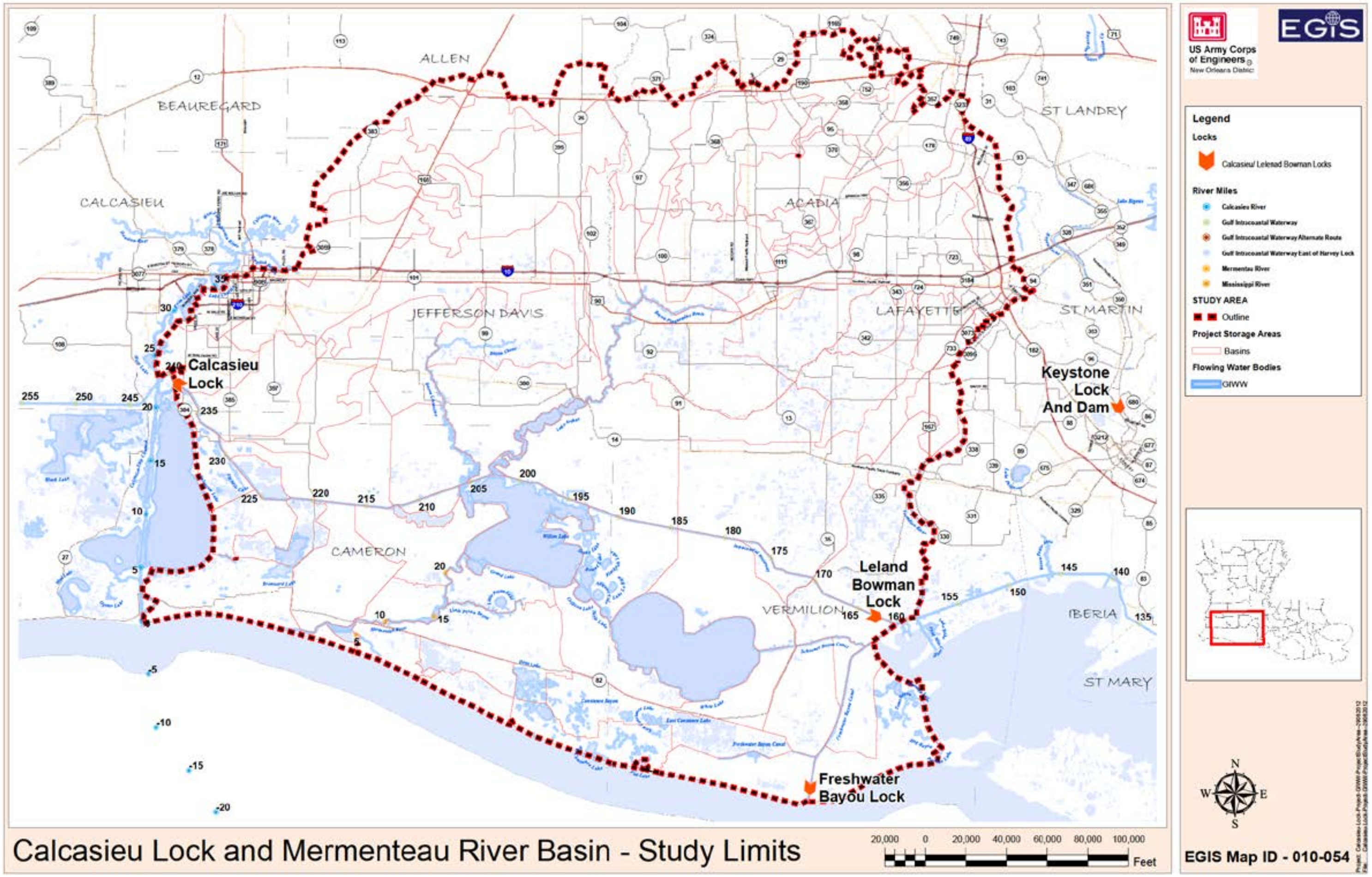


Figure K-1. Calcasieu Lock Study Area

B. Gulf Intracoastal Waterway. The GIWW traces the U.S. coast along the Gulf of Mexico from Appalachia Bay near St. Marks, FL, to the Mexican border at Brownsville, TX. Mile 0.0 of the GIWW intersects the Mississippi River at mile 98.2 above Head of Passes (AHP), the location of Harvey lock, and extends eastwardly for approximately 376 miles and westward for approximately 690 miles. In addition to the mainstem, the GIWW includes a major alternate channel, 64 miles long, which connects Morgan City, LA to Port Allen, LA at Mississippi River mile 227.6 AHP, and a parallel mainstem channel, 9.0 miles long, which joins the Mississippi River at mile 88.0 AHP, the location of Algiers lock, to the mainstem at GIWW West mile 6.2. Project dimensions for the mainstem channel and the alternate route are 12 feet deep and 125 feet wide, except for the 150 foot width between the Mississippi River and Mobile Bay portion of the GIWW East. Numerous side channels and tributaries intersect both the eastern and western mainstem channels providing access to inland areas and coastal harbors.

Within the study area, there are nine primary navigation locks. On the GIWW mainstem west: Algiers, Harvey, Bayou Boeuf, Leland Bowman, and Calcasieu, with Port Allen and Bayou Sorrel on the GIWW Morgan City - Port Allen Alternate Route. On the Inner Harbor Navigation Canal (IHNC), which intersects the Mississippi River at mile 93 AHP there is the IHNC lock, connecting the eastern and western sections of the GIWW. On Old River, there is the Old River lock near mile 304 AHP on the Mississippi River, which links the Atchafalaya and Mississippi Rivers. West of Calcasieu lock, the westernmost lock identified above, there are four additional navigation structures. These include the East and West Brazos River Floodgates located at GIWW West mile 404.1, and the East and West Colorado River locks located at GIWW West mile 444.8. There are no navigation structures on the GIWW east of the IHNC lock. Table K-1 describes the physical characteristics and locations of the nine primary locks, and figure K-2 maps the area that includes these locks.

The GIWW is a middle-aged system compared to other inland waterway segments within the United States. As shown in table K-1, with the exception of Leland Bowman, most of the primary locks are over 50 years old. However, the GIWW continues to be a critical part of our nation's infrastructure and confers wide-ranging benefits on national and state economies. The waterway is important not only to American commerce, but it supports a variety of other public purposes, including flood control, waterside commercial development, and water-based recreational activities, as well.

Table K-1. System Physical Description of Locks

Waterway/Lock	GIWW Mile	Mississippi R. Mile	Length (ft)	Width (ft)	Depth (ft)	Lift (ft)	Year Opened
GIWW East							
IHNC	0	92.6	640	75	31.5	17	1923
GIWW West							
Algiers	0	88	760	75	13	18	1956
Harvey	0	98.2	425	75	12	20	1935
Bayou Boeuf	93.3	NA	1156	75	13	11	1954
Leland Bowman	162.7	NA	1200	110	15	5	1985
Calcasieu	238.9	NA	1206	75	13	4	1950
GIWW Alt. Route Morgan City - Port Allen							
Port Allen	64.1	227.6	1202	84	14	45	1961
Bayou Sorrel	36.7	NA	797	56	14	21	1952
Atchafalaya-Mississippi R. Link (Old River)							
Old River	n/a	304	1200	75	11	35	1963

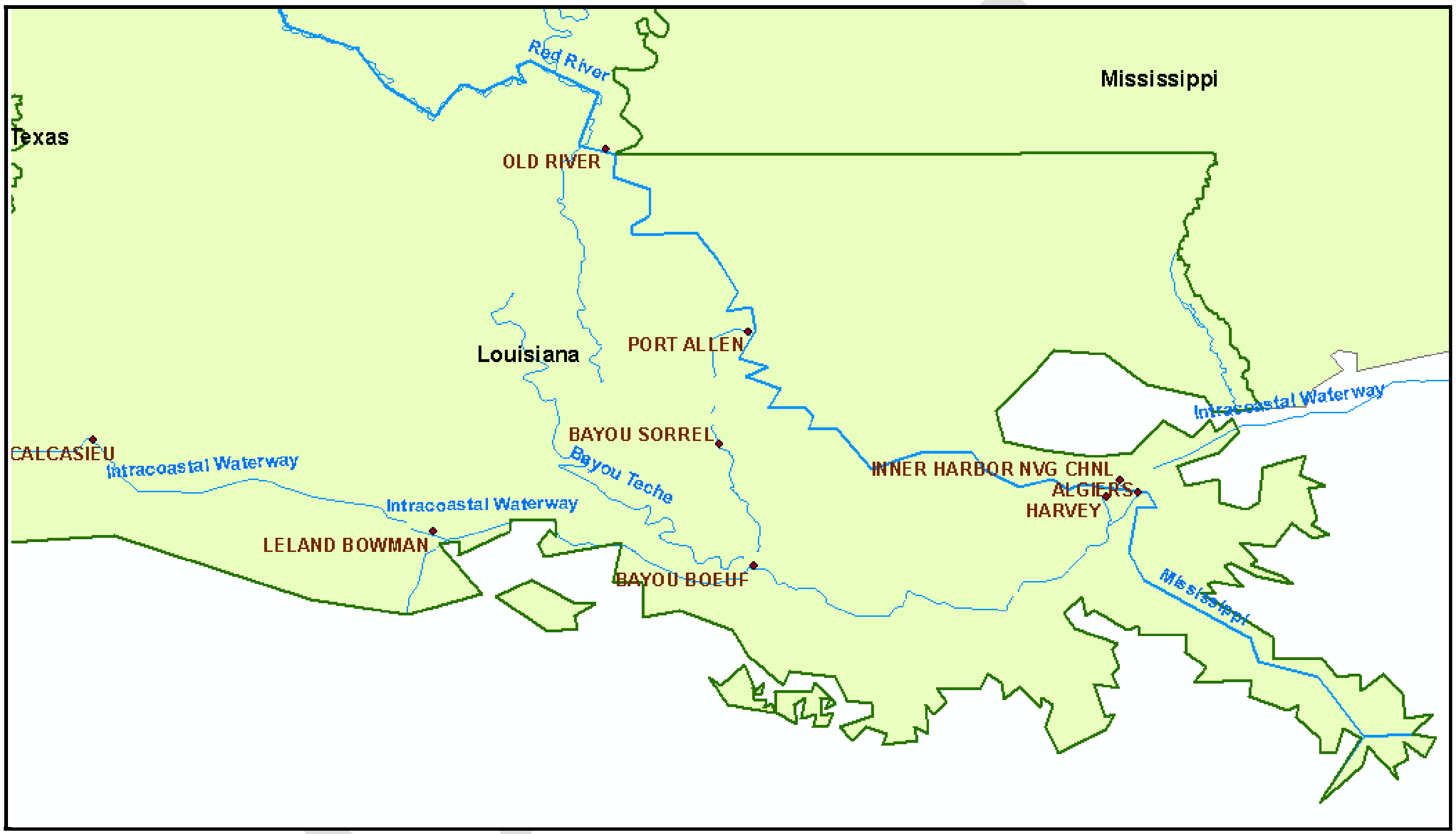


Figure K-2. Location of Nine Primary Locks

II. EXISTING, HISTORICAL AND PROJECTED TRAFFIC

A. Existing and Historical Traffic. This section presents the Waterborne Commerce Statistics Center (WCSC) data for the three waterway system segments that are germane to Calcasieu Lock (figure K-3):

GIWW Mississippi River, LA to Sabine River, TX
GIWW Louisiana Portion
GIWW Morgan City-Port Allen, LA

The emphasis is on the historical trends of vessel trips and cargo tons.

Figure K--3. Total GIWW Navigation System

1. Segment 1 – GIWW Mississippi River, LA to Sabine River, TX. Table K-2 contains the total annual vessel trips by direction (up and down) for the GIWW Mississippi River, LA to Sabine River, TX, for the period 1990 through 2011. Total trips upbound and total trips downbound in 2008 are nearly the same as 1990. The total trips (up and down) increased from about 60,000 each way in 1991 to about 82,000 each way in 1996, and thereafter declined to fewer than 60,000 trips each way in 2002. The total annual trips each way increased to about 73,000 in 2004 and then began to decline through 2011.

Table K-2. GIWW from Mississippi River, LA to Sabine River, TX:
Annual Total Vessel Trips (Up + Down) 1990 to 2011

Year	Total Upbound Vessel Trips	Total Downbound Vessel Trips
1990	62,158	62,168
1991	60,552	60,569
1992	67,320	66,977
1993	73,841	73,822
1994	74,500	74,516
1995	81,237	81,369
1996	81,808	81,705
1997	76,267	76,284
1999	63,374	62,664
2002	59,898	58,830
2003	65,945	64,791
2004	73,083	73,093
2005	70,230	70,165
2006	66,368	66,106
2007	67,084	67,408
2008	63,056	63,058
2009	59,737	60,634
2010	57,510	57,254
2011	51,590	52,470

Source: Waterborne Commerce Statistics Center

Table K-3 contains the total annual cargo tons for the GIWW Mississippi River, LA to Sabine River, TX for the period 1990 through 2011. For the period 1990 through 2008, total annual cargo tons remained nearly the same at about 67 million. Total annual cargo tons increased to 68 million by 1995/1996 and then declined to 59 million by 2002, thereafter increasing to the mid to upper 60 million ton range. Recently, the total annual cargo tons declined from 70 million in 2006 to nearly 63 million in 2011. Overall, there has been little if any sustained growth in total annual cargo tons for the GIWW segment between the Mississippi River, LA and the Sabine River, TX.

Table K-4 displays the major cargo trends for the GIWW between the Mississippi River, LA, and Sabine River, TX, for the period 1990 through 2011. The three largest commodity groups in terms of annual tons are petroleum and petroleum products, chemicals, and crude materials. Petroleum-related total annual tons were nearly 40 million in 1990, generally declining to about 33 million in 2008. Similarly, total chemical tons declined from about 13 million in 1990 to about 10 million in 2008 with a small rise through 2011. However, crude materials total annual tons increased from about 10 million in 1990 to nearly 16 million in 2008 thereafter a small downturn through 2011. There is a long-term slide in petroleum-related annual tons, while chemicals are nearly constant at about 12 million annual tons until declining in 2008 through 2011. Crude materials tons increased to 16 million in 2006 with a slight decline to 13 million tons in 2011.

Table K-3. GIWW Mississippi River, LA to Sabine River, TX: Annual Total Commodity Tons (1,000s), 1990 to 2011

Year	Total Tons
1990	67,758
1991	65,949
1992	66,178
1993	65,241
1994	67,688
1995	68,203
1996	68,665
1997	66,739
1999	60,979
2002	58,933
2003	64,851
2004	69,458
2005	65,970
2006	70,104
2007	69,663
2008	66,731
2009	62,862
2010	64,556
2011	63,384

Source: Waterborne Commerce Statistics Center

Table K-4. GIWW Mississippi River, LA to Sabine River, TX: Major Commodity Annual Tons (1,000s), 1990 to 2011

Year	Petroleum and Petroleum Products	Chemicals	Crude Materials
1990	39,935	12,629	10,433
1991	37,908	11,982	11,161
1992	40,312	12,070	9,306
1993	36,929	12,543	10,695
1994	36,108	12,765	13,545
1995	34,539	13,209	12,134
1996	33,063	12,979	13,696
1997	31,149	13,325	14,981
1999	28,449	14,464	14,001
2002	30,077	11,619	11,665
2003	31,266	12,485	14,395
2004	33,710	12,916	16,148
2005	32,442	12,153	14,956
2006	35,952	12,272	14,825
2007	36,495	12,042	14,315
2008	33,542	10,450	15,568
2009	35,345	9,514	12,031
2010	35,653	10,256	12,536
2011	34,140	10,340	13,452

Source: Waterborne Commerce Statistics Center

2. Segment 2 – GIWW Louisiana Portion. Table K-5 contains the total annual vessel trips by direction (up and down) for the GIWW Louisiana portion for the period 1997 through 2011. Total annual vessel trips have declined from about 89,000 in 1997 to just under 60 million tons in 2011. The total trips (up and down) decreased from about 88,000 each way in 1997 to about 68,000 each way in 2002 and thereafter increased to about 82,000 each way in 2004. After 2004, total annual vessel trips decreased to 73,000 and 74,000 in 2006 and 2007, respectively, and then declined to slightly fewer than 60,000 in 2011.

Table K-5. GIWW Louisiana Portion:
Annual Total Vessel Trips (Up + Down), 1997 to 2011

Year	Total Upbound Vessel Trips	Total Downbound Vessel Trips
1997	88,852	88,934
1999	76,507	76,736
2002	68,987	67,637
2003	74,274	72,792
2004	82,486	81,983
2005	77,730	77,664
2006	73,370	73,431
2007	74,160	74,433
2008	69,993	69,718
2009	65,936	66,627
2010	64,466	64,490
2011	58,717	59,216

Source: Waterborne Commerce Statistics Center

Table K-6 shows the total annual cargo tons for the GIWW Louisiana Portion for the period 1997 through 2011. Total annual tons declined from 83 million in 1997 to 71 million in 2002 and then increased to 82 million in 2004 and 2006 but then declined to nearly 74 million tons in 2011.

Table K-6. GIWW Louisiana Portion:
Annual Total Commodity Tons (1,000s), 1997 to 2011

Year	Total Tons
1997	83,399
1999	75,123
2002	71,509
2003	76,751
2004	82,368
2005	77,855
2006	82,322
2007	80,674
2008	76,680
2009	72,177
2010	76,177
2011	73,734

Source: Waterborne Commerce Statistics Center

Table K-7 displays the major cargo trends for the GIWW Louisiana Portion for the period 1997 through 2011. The three largest commodity groups in terms of annual tons are shown for petroleum and petroleum products, chemicals, and crude materials. Petroleum-related total annual tons were nearly 36 million in 1997, exhibiting some increase to about 40 million tons in 2006 and 2007 and then declining to about 38 million tons in 2011. Total chemical tons declined from nearly 16 million in 1997 to about 14 million in 2005, 2006, and 2007 then declining to 12 million tons by 12 million tons in 2011. Crude materials tons remained nearly constant at about 17 million in 1997 and 2011.

Table K-7. GIWW Louisiana Portion:
Annual Commodity Annual Tons (1,000s), 1997 to 2011

Year	Petroleum and Petroleum Products	Chemicals	Crude Materials
1997	35,627	16,148	18,417
1999	31,837	15,032	17,632
2002	33,708	14,178	14,445
2003	35,759	15,179	16,562
2004	38,359	15,454	19,035
2005	37,091	14,545	17,614
2006	40,586	14,426	17,918
2007	40,565	14,411	17,104
2008	36,714	12,158	18,461
2009	38,379	11,039	15,064
2010	39,571	12,738	15,616
2011	37,553	12,373	16,333

Source: Waterborne Commerce Statistics Center

3. Segment 3 – GIWW Morgan City to Port Allen, LA. Table K-8 contains the total annual vessel trips by direction (up and down) for the GIWW Morgan City-Port Allen, LA, for the period 1990 through 2011. Total annual vessel trips remained relatively steady in the range of 15,000 to 16,000 for the period 1990 through 1999, with a slight decline thereafter. The total trips for this segment (up and down) have fluctuated, but generally declined slightly over the period 1990 through 2011.

Table K-9 shows the total annual cargo tons for the GIWW Morgan City-Port Allen, L, for the period 1990 through 2011. As shown, total annual cargo tons declined from 29 million in 1990 to only 17 million tons in 2011. In 2011 the decline was mainly due to the waterway being closed due to flooding.

Table K-8. GIWW Morgan City-Port Allen, LA:
Annual Total Vessel Trips (Up + Down), 1990 to 2011

Year	Total Upbound Vessel Trips	Total Downbound Vessel Trips
1990	16,580	16,861
1991	15,157	15,139
1992	15,081	15,179
1993	16,715	16,727
1994	15,512	15,476
1995	15,945	15,948
1996	14,779	14,770
1997	16,449	16,433
1999	14,894	14,917
2002	14,246	14,247
2003	15,414	15,401
2004	14,575	14,575
2005	15,032	15,035
2006	13,575	13,599
2007	15,800	14,286
2008	14,801	13,339
2009	11,193	9,758
2010	12,843	11,795
2011	10,237	8,958

Source: Waterborne Commerce Statistics Center

Table K-9. GIWW Morgan City-Port Allen, LA:
Annual Total Commodity Tons (1,000s), 1990 to 2011

Year	Total Tons
1990	29,287
1991	24,532
1992	23,606
1993	27,097
1994	24,461
1995	25,416
1996	25,056
1997	26,428
1999	23,187
2002	20,798
2003	24,253
2004	24,313
2005	23,584
2006	22,494
2007	22,830
2008	23,289
2009	16,402
2010	20,502
2011	16,985

Source: Waterborne Commerce Statistics Center

Table K-10 displays the major cargo trends for the GIWW Morgan City-Port Allen, LA, for the period 1990 through 2011. The three largest commodity groups in terms of annual tons are petroleum and petroleum products, chemicals, and crude materials. Petroleum-related total annual tons were nearly 10 million in 1990, exhibiting a slight decline to 9 million tons in 1997 and thereafter declining to about 5.5 million tons in 2011. Chemicals have similarly declined, from 9 million tons in 1990 to about 6 million tons in 2011. Crude materials have fluctuated from 8 million tons in 1990 to nearly 5 million tons in 2002 and then rose to more than 8 million tons in 2008 and then declined to only 4 million tons in 2011.

Table K-10. GIWW Morgan City-Port Allen, LA
Major Commodity Annual Tons (1,000s), 1990 to 2011

Year	Petroleum and Petroleum Products	Chemicals	Crude Materials
1990	9,744	9,019	8,163
1991	9,295	7,441	5,612
1992	8,529	6,585	6,438
1993	9,357	8,837	6,567
1994	7,616	8,319	6,710
1995	8,658	8,677	6,075
1996	7,387	8,347	6,181
1997	9,210	8,302	6,658
1999	7,175	7,622	6,537
2002	7,122	6,606	4,965
2003	7,074	7,838	6,824
2004	7,335	7,422	7,270
2005	7,122	7,293	6,960
2006	6,107	7,099	6,895
2007	6,884	6,688	6,438
2008	5,750	6,071	8,367
2009	5,066	4,151	6,051
2010	6,535	5,724	6,193
2011	5,486	5,234	4,160

Source: Waterborne Commerce Statistics Center

4. Lock Statistics. This section focuses on lock statistics and trends for the different locks that constitute the bulk of the GIWW traffic that also influences the Calcasieu Lock, which includes Calcasieu, Leland Bowman, Bayou Sorrel, Bayou Boeuf, Brazos East/West, Colorado East/West, Port Allen, Old River, Harvey, Algiers, and Inner Harbor.

a. Calcasieu Lock. Table K-11 contains the statistics for total lockages and total vessels transiting the Calcasieu Lock annually from 1999 through 2011. Total lockages rose slightly from a 1999 level of nearly 12,000 to nearly 13,000 by 2004 and then declined to fewer than 12,000 from 2009 through 2011. Total vessels reflected a similar pattern, hovering around 15,000 annually until 2004 and then declining to about 14,000 and 13,000 in 2008 and remained there through 2011.

Table K-11. Calcasieu Lock Statistics, 1999 to 2011

Year	Total Lockages	Total Vessels
1999	11,954	15,090
2000	12,348	15,288
2001	13,592	16,210
2002	12,986	15,231
2003	12,546	15,730
2004	13,030	15,260
2005	11,744	14,431
2006	11,871	14,609
2007	12,984	15,378
2008	12,189	14,229
2009	11,379	12,969
2010	11,259	13,314
2011	11,139	13,598

Source: Waterborne Commerce Statistics Center

Figure K-4 depicts the trends of lockages and vessels for Calcasieu Lock during the period 1999 through 2011. Total annual lockages were nearly constant during most of the period and then slight declined between 2007 and 2011.

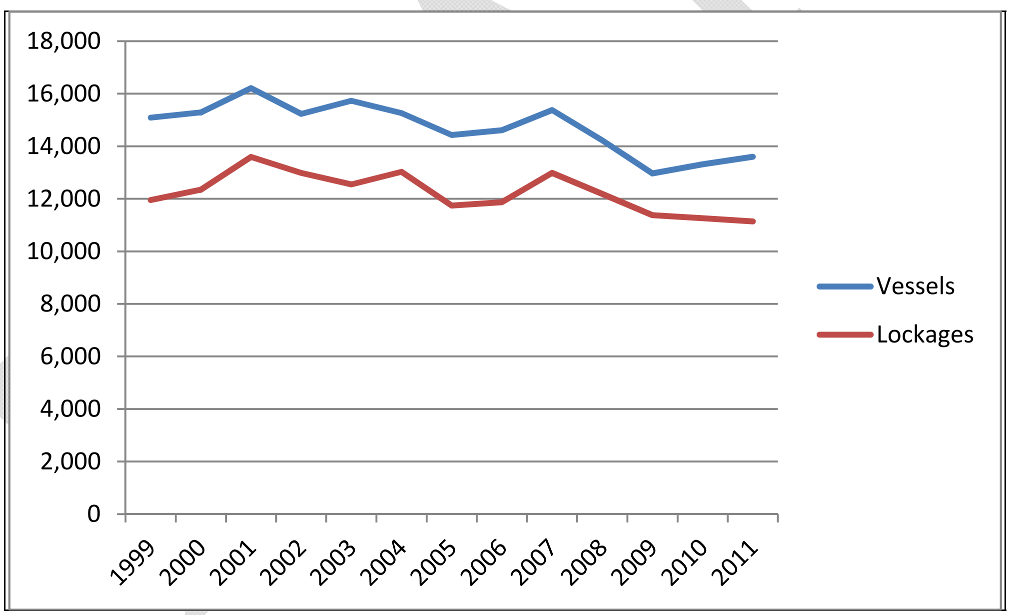


Figure K-4. Calcasieu Lock Statistics, 1999 to 2011

Table K-12 depicts the annual cargo tons for Calcasieu Lock for the period 2000 through 2011. The total annual tons were around 38 million from 2000 through 2003 and then increased in 2004 to 42 million. Total tons averaged about 40 million from 2004 through 2008 and declined to about 33 million in 2009 and rises to 37 million tons in 2011. Figure K-5 shows the pattern of Calcasieu Lock total annual commodity tons, which increased from 2000 to a relative high in

2004, and then gradually declined to 2007 followed by a more sustained decline to 2009 with a small rise in 2010 followed by a leveling off.

Table K-12. Calcasieu Lock Annual Commodity Tons, 2000 to 2011

Year	All Commodities
2000	38,820,484
2001	36,990,131
2002	37,127,096
2003	38,414,676
2004	41,995,766
2005	38,723,550
2006	39,997,909
2007	40,999,329
2008	37,839,539
2009	33,646,375
2010	37,033,000
2011	36,781,000

Source: Waterborne Commerce Statistics Center

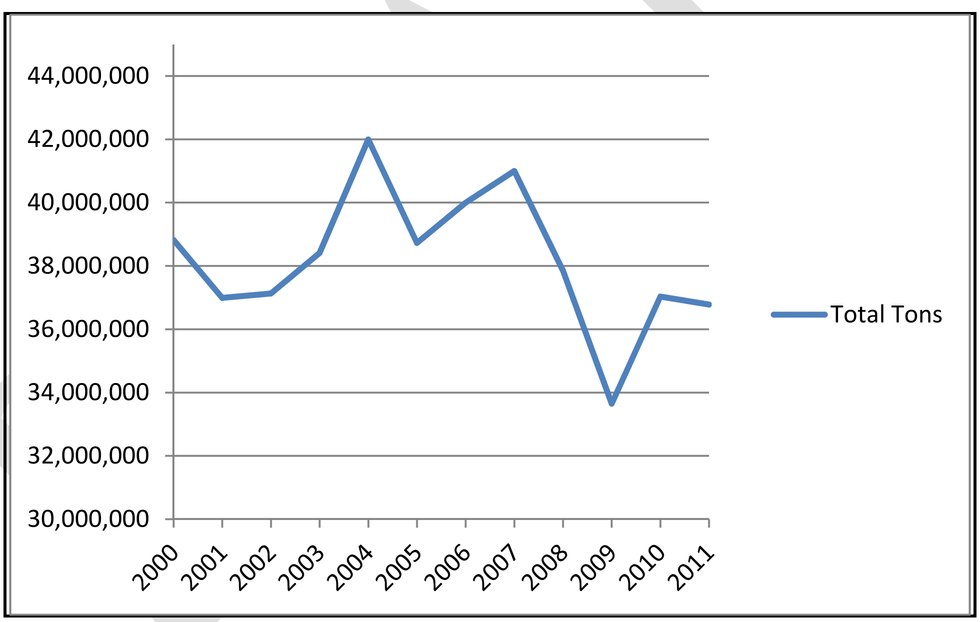


Figure K-5. Calcasieu Lock Annual Commodity Total Tons, 2000 to 2011

Table K-13 depicts the total annual cargo tons for the major commodity groups using the Calcasieu Lock for the period 1999 through 2011. Petroleum products tonnages increased from 16 million in 1999 to 18 million in 2011, whereas chemical tons declined from about 14 million in 1999 to almost 11 million in 2011. Crude materials tons stayed close to 4 million annually between 1999 and 2008, but then declined to 2 million in 2009 and then recovered to 3 million in 2011. Figure K-6 depicts the trends for petroleum products (increase), chemicals (decline), and crude materials (steady until 2009).

Table K-13. Calcasieu Lock Major Commodity Annual Tons, 1999 to 2011

Year	All Petroleum and Petroleum Products	All Chemical and Related Products	All Crude Materials, Inedible, Except Fuels
1999	15,981,031	14,332,140	3,898,023
2000	15,254,098	15,124,568	4,162,057
2001	16,877,435	12,957,479	3,116,901
2002	17,865,894	13,111,917	3,169,700
2003	17,862,737	12,532,958	3,911,881
2004	19,410,913	13,657,477	4,744,011
2005	18,022,263	13,251,363	4,446,624
2006	17,667,478	13,205,641	4,228,632
2007	17,716,245	13,528,668	4,617,683
2008	16,940,739	11,696,169	4,080,045
2009	18,424,144	9,715,203	1,915,734
2010	19,074,600	10,733,200	2,935,700
2011	18,331,600	10,866,300	3,028,600

Source: Lock Performance Monitoring System

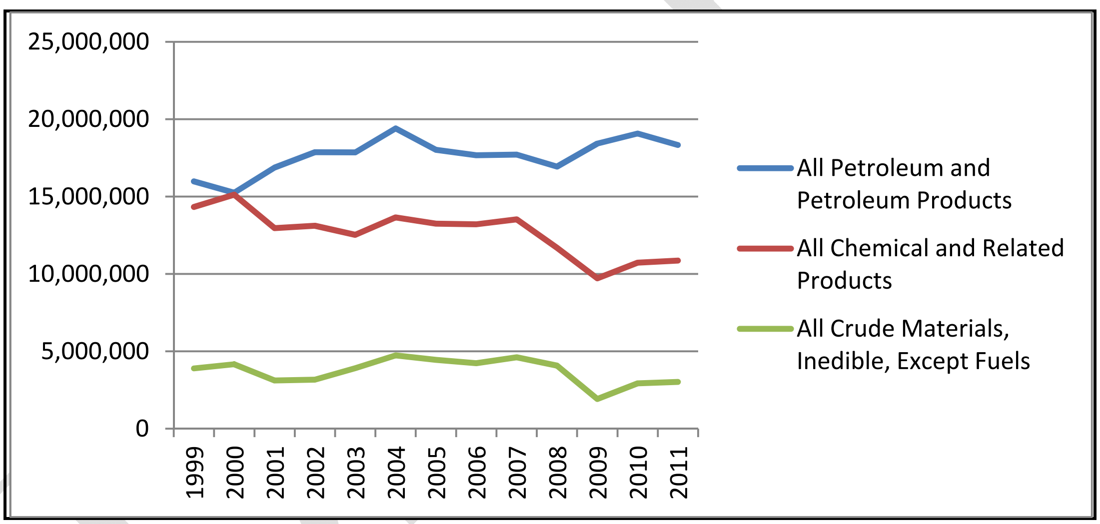


Figure K-6. Calcasieu Lock Annual Commodity Tons, 1999 to 2011

b. Other GIWW Lock Statistics. Table K-14 shows the annual lock tonnages for Calcasieu Lock and the GIWW locks that are contiguous to the east: Leland Bowman, Bayou Sorrel, and Bayou Boeuf (figure K-7). Calcasieu and Leland Bowman tonnages move together and exhibit the same decline after 2007. Similarly, but to a lesser degree, Bayou Sorrel and Bayou Boeuf lock tonnages move together and exhibit a decline after 2008. Figure K-8 shows the annual lock tonnages for the GIWW system locks at Port Allen and Old River. The tonnages are relatively stable until 2008, when Port Allen declines. Figure K-9 depicts the annual lock tonnages for the GIWW system locks at Harvey, Algiers, and Inner Harbor. The lock tonnages are different from the main stem GIWW. Algiers tonnages rose during the period 2000 to 2009, Harvey had a very slight decline in 2009 but rebounded thereafter, and Inner Harbor declined in 2008 and increased slightly in 2010 to 16 million tons, but declined again in 2011.

Table K-14. Calcasieu Lock Waterway System Locks Total Commodity Tons (1,000s), 2000 to 2011

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Calcasieu Lock	40,146	38,675	39,260	40,121	44,078	41,999	41,375	41,778	38,446	33,070	37,033	36,718
Leland Bowman	41,181	39,121	39,166	40,247	43,821	42,115	41,338	41,879	38,092	32,537	36,284	36,380
Bayou Sorrel	22,048	22,617	19,439	23,479	23,686	24,367	23,987	24,017	22,916	15,909	19,909	15,739
Bayou Boeuf	24,179	19,822	23,701	24,731	27,466	25,530	25,950	26,245	25,595	25,461	13,353	13,943
Brazos East	21,307	19,565	17,825	19,709	21,415	20,640	20,443	20,673	17,745	16,285	18,573	18,997
Brazos West	21,156	19,430	17,786	19,651	21,322	20,647	20,458	20,240	17,672	16,189	18,643	18,994
Colorado East	20,818	19,305	17,368	19,070	20,682	20,089	19,945	19,808	17,249	16,032	18,390	18,672
Colorado West	20,446	19,056	16,989	18,715	20,267	19,481	19,403	19,161	16,756	15,497	17,632	17,515
Port Allen	24,106	24,073	20,460	24,492	25,294	25,364	25,146	25,133	24,168	16,900	20,819	17,035
Old River	9,154	8,027	7,929	7,377	7,124	7,378	9,161	7,773	6,253	7,729	7,092	7,007
Harvey	2,162	2,087	2,296	1,762	2,310	2,674	852	1,825	2,850	2,362	2,028	3,063
Algiers	20,001	22,884	23,521	24,182	26,839	24,078	26,543	25,356	24,832	25,291	24,013	26,429
Inner Harbor	17,066	16,624	17,571	17,290	18,663	16,308	16,681	17,412	12,791	14,210	16,350	15,150

Source: Lock Performance Monitoring System

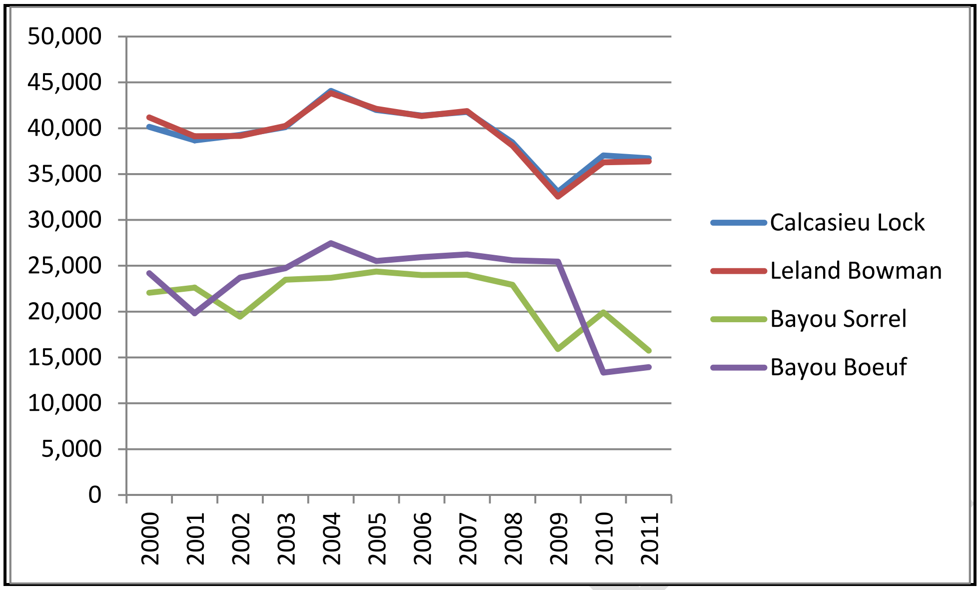


Figure K-7. Lock Annual Total Commodity Tons:
Calcasieu, Leland Bowman, Bayou Sorrel, Bayou Boeuf, 2000 to 2011

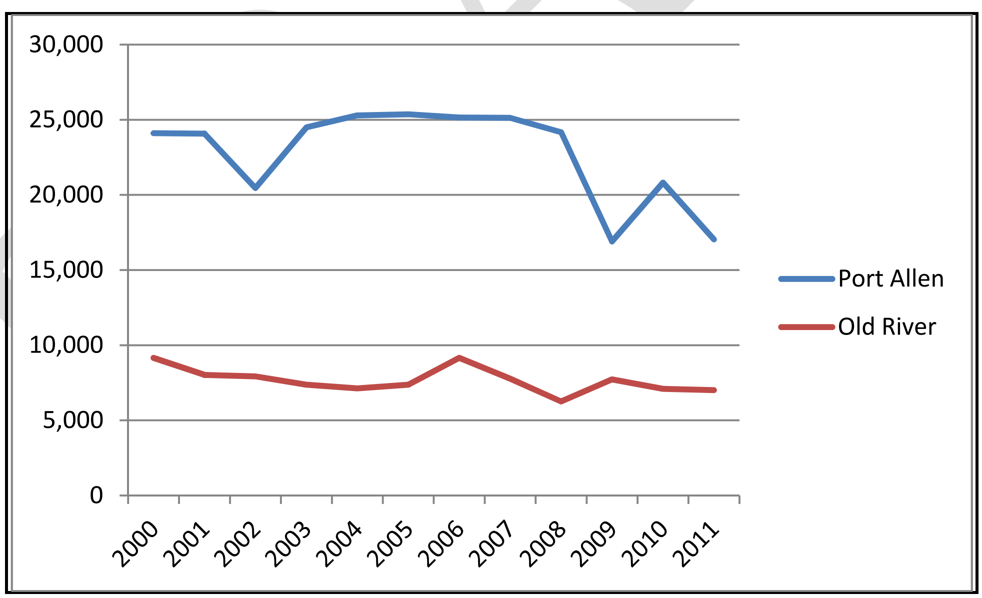


Figure K-8. Lock Annual Total Commodity Tons: Port Allen and Old River, 2000 to 2011

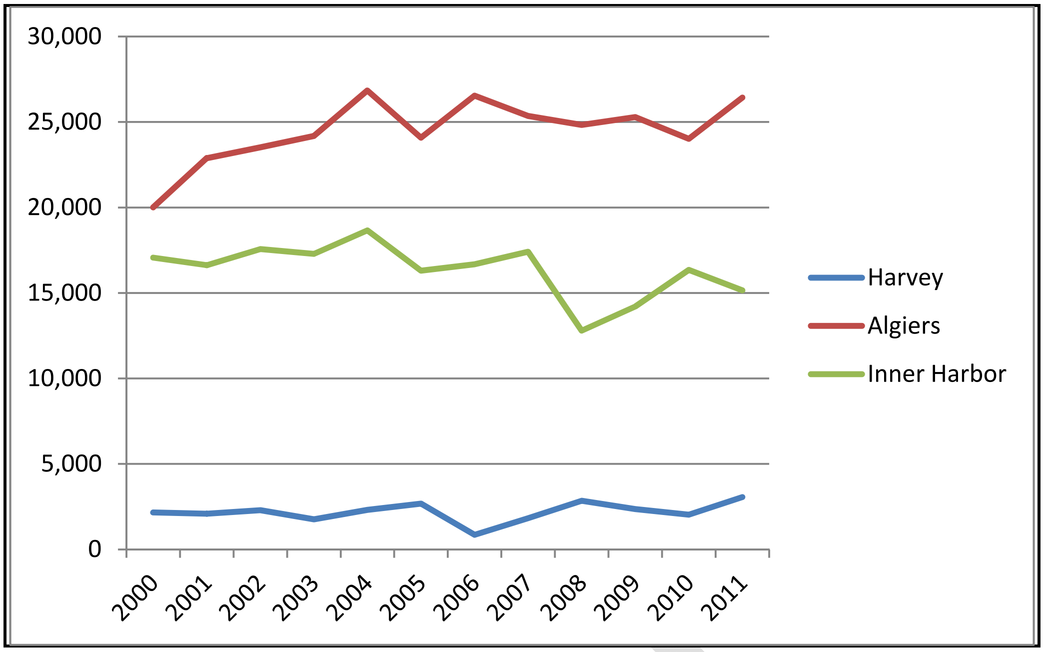


Figure K-9. Lock Annual Total Commodity Tons: Harvey, Algiers, and Inner Harbor, 2000 to 2011

5. Calcasieu Lock Major Shippers, Commodities and Tons. It is crucial for future estimation of vessel traffic to gain an understanding of what commodities are being shipped on the waterway and, to a lesser extent, who is shipping these goods. The demand for a particular commodity is what will drive the estimation for waterborne transportation. Tables K-15 and K-16 and figures K-10 though K-16 provide analyses of historical traffic broken down by major shipper, commodities shipped, and tonnage.

Table K-15 contains the major commodity group tonnages transiting the Calcasieu Lock by the top 10 shippers for the period 2004 through 2008. 2008 is the most current year for this type of information, but the trends and relationships displayed still hold today. The top 10 shippers account for nearly 40 percent of total annual lock tonnages during this period, ranging from 17.6 million tons in 2004 to 13.6 million tons in 2008. The major commodity groups of the top 10 shippers are petroleum products and chemicals. Petroleum products tonnages from the top 10 were relatively stable during the 2004 to 2008 period, close to about 10.5 million tons annually. Chemical tons were steady during the 2004 to 2008 period and then dropped substantially from about 4.6 million tons in 2007 to 3.0 million tons in 2008. Figure K-10 depicts the ton trends for petroleum products and chemicals for the top 10 Calcasieu Lock shippers.

Table K-15. Calcasieu Lock Top 10 Shippers Annual Commodity Tons, 2004 to 2008

Commodity	2004 Tons	2005 Tons	2006 Tons	2007 Tons	2008 Tons	Total
Aggregates	1,033,424	1,153,072	695,805	310,101	494,253	3,686,655
Chemicals	4,762,105	4,909,239	4,664,195	4,537,084	3,056,480	21,929,103
Coal	38,151	20,502	83,741	40,875	20,135	203,404
Crude Petroleum	1,042,392	498,670	647,404	245,643	206,037	2,640,146
Iron Ore and Iron & Steel Products	7,852				12,524	20,379
Non-Metallic Iron and Ores	7,142					7,142
Others	202			14,951	16,734	31,887
Petroleum Products	10,736,345	9,296,954	9,966,485	10,468,543	9,801,929	50,270,256
Total	**17,627,613**	**15,878,437**	**16,057,630**	**15,617,197**	**13,608,092**	**78,788,972**
Percent of All Commodities	**41.91%**	**35.94%**	**35.94%**	**38.07%**	**35.94%**	**39.45%**

Source: WCSC and G.E.C., Inc

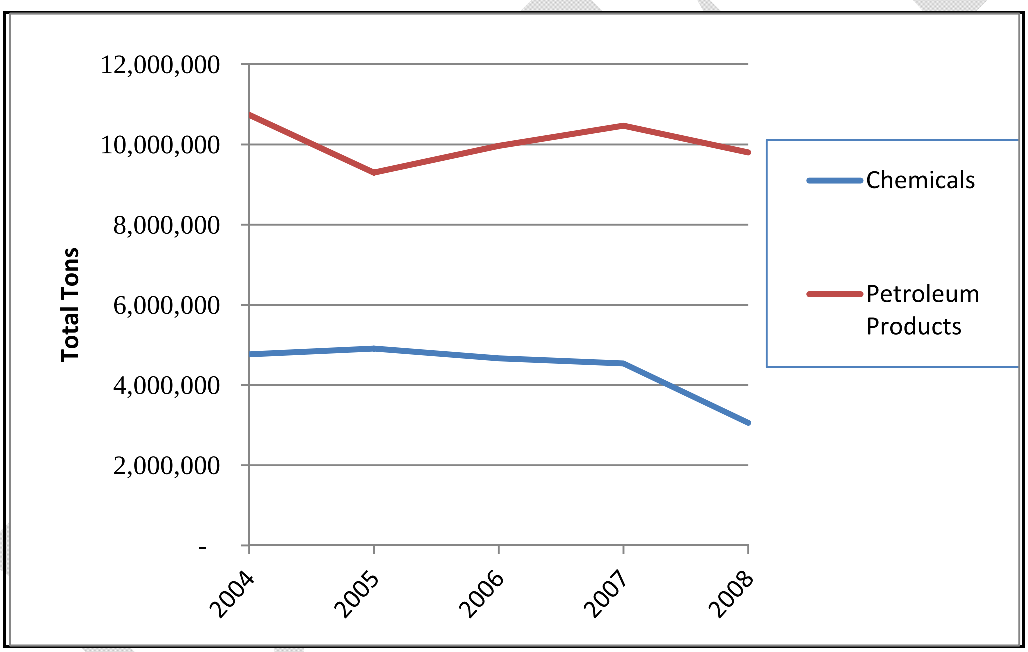


Figure K-10. Calcasieu Lock Top 10 Shippers Commodity Tons, 2004 to 2008

Table K-16 identifies the top 10 Calcasieu Lock shippers during the period 2004 through 2008 and the major commodity groups that constitute their volumes. Of the total volume of 78.8 million tons for the 5-year period 2004 to 2008, the majority is petroleum products at 50 million tons and chemicals at 22 million tons. The largest shippers during the five-year period 2004 to 2008 identified from dock records are ExxonMobil (16.2 million tons), ConocoPhillips (12.6 million tons), and Valero (10.8 million tons). These are also the largest petroleum products shippers. The largest chemical shippers identified from dock records during the 5-year period 2004 to 2008 are Dow (5.2 million tons), LyondellBasell (4.2 million tons), and Citgo (2.9 million tons).

Table K-16. Calcasieu Lock Top 10 Shippers Commodity Tons, 2004 to 2008

	Aggregates	Chemicals	Coal	Crude Petroleum	Petroleum Products	Others	Non-metallic Iron and Ores	Iron Ore and Iron &Steel Products	Total
Chevron		581,328		815,772	3,090,719	217			4,488,036
Citgo		2,947,491	3,195	240,930	4,167,705				7,359,321
ConocoPhillips		529,722	157,227	657,077					2,640,220
Dow		5,206,367			804,929	1,689			6,012,985
ExxonMobil		3,093,375	26,604	253,812	12,851,138			9,332	
LyondellBasell		4,273,791			398,461				4,672,252
Motiva		2,778,504		58,963	6,184,874		7,142		9,029,483
Shell		1,469,433	3,437	451,269	1,893,666	200			3,818,005
Valero		1,049,092	11,306	162,323	9,582,570				
Martin Marrietta	3,686,655		1,635			29,781		11,047	3,729,118
Total	**3,686,655**	**21,929,103**	**203,404**	**2,640,146**	**50,270,256**	**31,887**	**7,142**	**20,379**	**78,788,972**

Source: WCSC and G.E.C., Inc

There is a wide array of chemical products compared to fewer groupings for other more homogeneous commodity groups for Calcasieu Lock for the period 2000 to 2008. Figure K-11 depicts the trends for aggregates, rising from about 1.5 million tons in 2000 to about 2.2 million tons in 2007 before declining to about 1.9 million tons in 2008.

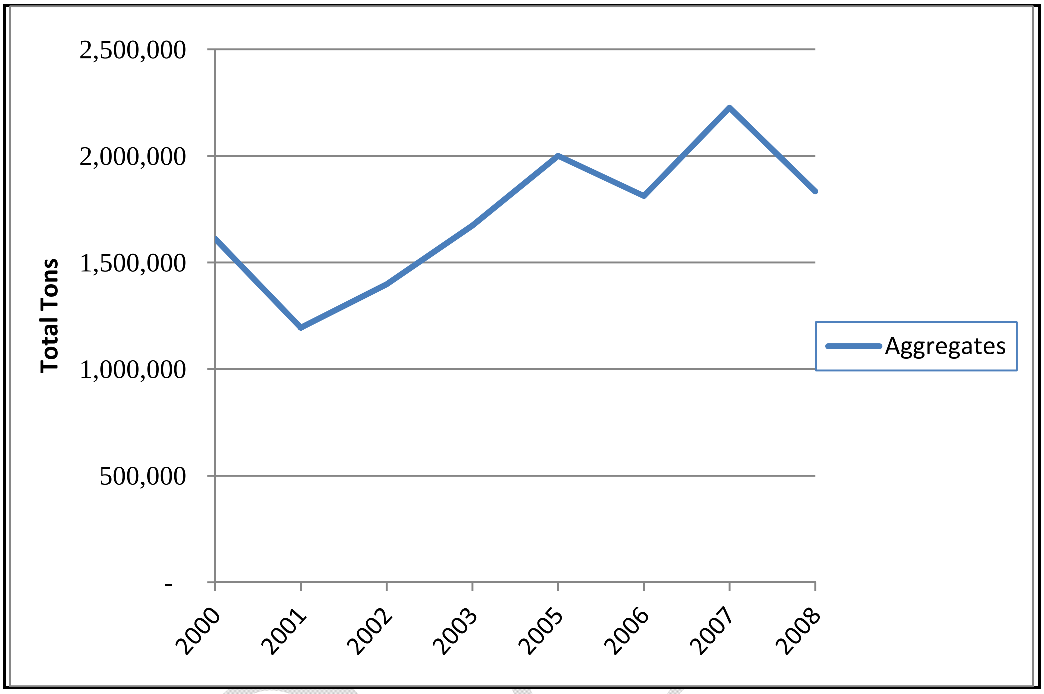


Figure K-11. Calcasieu Lock Aggregates Annual Tons, 2000 to 2008

Figure K-12 depicts the chemicals lockage trends, with a steady to slight decline in the period 2000 to 2007 and then declining from about 11 million tons in 2007 to about 9 million tons in 2008. The major chemicals in terms of annual volume transiting Calcasieu Lock are shown in figure K-13 for benzene, cumene, sodium hydroxide, styrene, and xylenes. Some of these basic chemicals (as opposed to specialty chemicals) have declined substantially, such as styrene from about 1.6 million tons in 2000 to about 0.8 million tons in 2008. Others such as sodium hydroxide have declined less substantially, from 1.0 million tons in 2000 to fewer than 0.6 million tons in 2008. Others have declined less, such as benzene, cumene, and xylene. However, even this latter group has exhibited declines in annual tons over the recent business cycle, coinciding with the period 2006-2007.

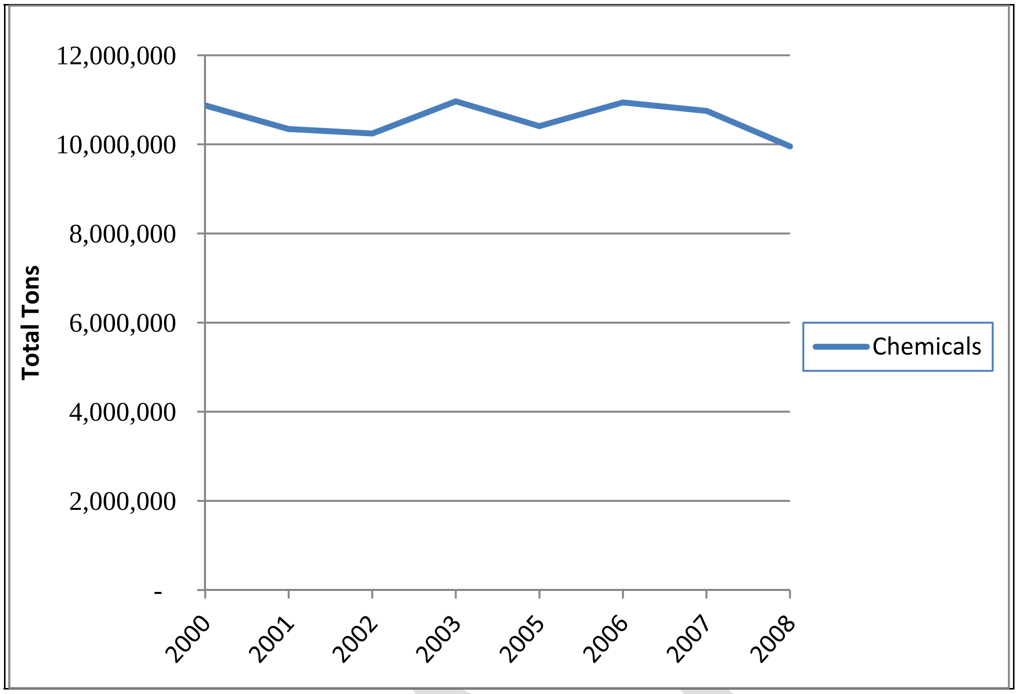


Figure K-12. Calcasieu Lock Chemicals Annual Tons, 2000 to 2008

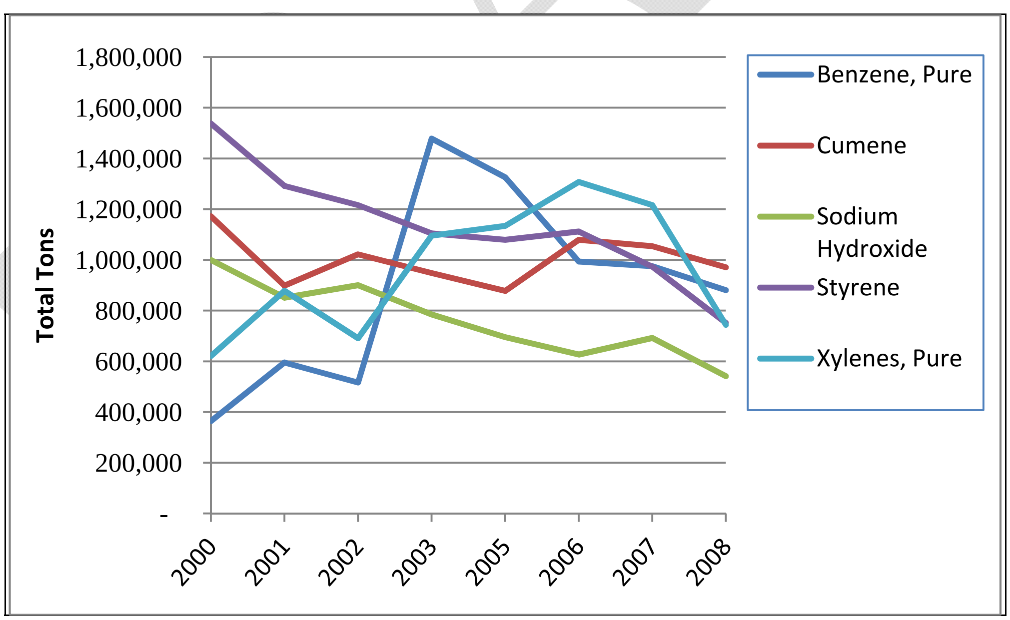


Figure K-13. Calcasieu Lock Major Chemicals Tons, 2000 to 2008

Figure K-14 depicts the annual tons of crude petroleum products transiting Calcasieu Lock during the period 2000 through 2008. Crude petroleum tons have generally declined (although slightly), from about 3.5 million tons in 2000 to about 3.0 million tons in 2008.

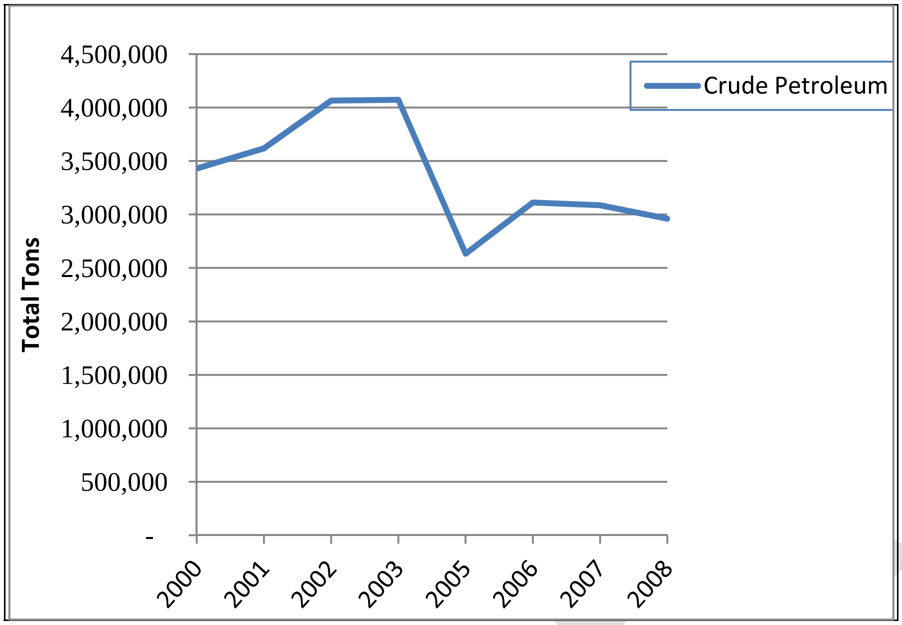


Figure K-14. Calcasieu Lock Crude Petroleum Annual Tons, 2000 to 2008

Figure K-15 indicates that tonnages of petroleum (refined) products increased from about 14 million tons in 2000 to about 18 million tons in 2007 before declining to about 16.4 million tons in 2008. The major petroleum products are depicted in figure K-16, including fuel oils, gas oils, gasoline, and lubricating petroleum oils. Fuel oils and lubricating oils have been relatively stable, whereas gasoline has declined and gas oils have increased, nearly (but not quite) offsetting each other.

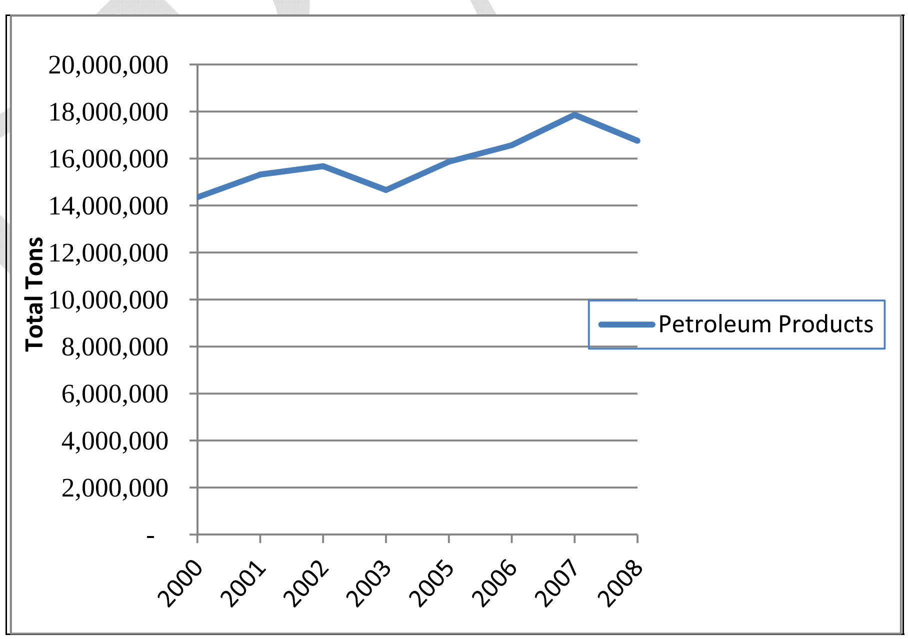


Figure K-15. Calcasieu Lock Petroleum Products Annual Tons, 2000 to 2008

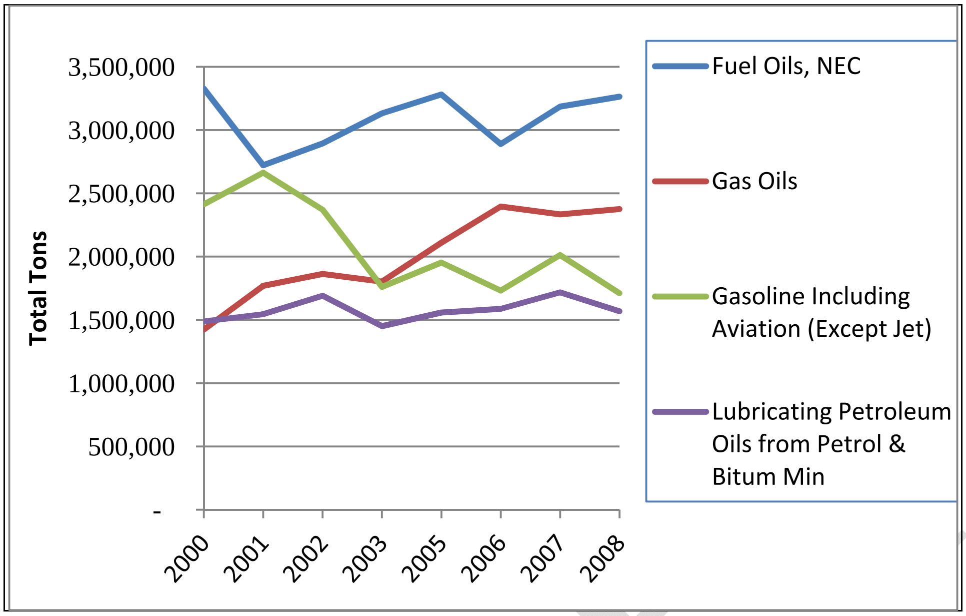


Figure K-16. Calcasieu Lock Major Petroleum Products Annual Tons, 2000 to 2008

6. Calcasieu Lock and Related System Traffic. Table K-17 shows the compilation of the Calcasieu Lock annual commodity tons and the related movements of these tons through the other GIWW system locks relevant to the Calcasieu Lock. The Leland Bowman Lock handles nearly all of the Calcasieu Lock tonnages during this period, whereas Bayou Sorrel and Bayou Boeuf handle about one-half of this volume. The major GIWW system locks for Calcasieu Lock tons are Leland Bowman, Port Allen, Bayou Sorrel, Bayou Boeuf, and Algiers. The other locks, Brazos and Colorado to the west and Harvey and Old River to the extreme east, handle comparatively little volume.

Table K-18 shows the compilation of the Calcasieu Lock annual vessel trips and the related movements through other GIWW system locks that are relevant to the Calcasieu Lock.

Table K-19 shows the percentages of the Calcasieu Lock annual commodity tons of the total annual tons passing through the other GIWW system locks that are relevant to the Calcasieu Lock for the years 2006, 2007, and 2008. The Calcasieu Lock annual tons account for a high percentage (greater or equal to 60 percent) of total annual lock tonnages at Leland Bowman, Port Allen, Bayou Sorrel, Bayou Boeuf, Harvey, and Algiers. The Calcasieu Lock annual tons account for a much smaller percentage of total annual lock tons (about 20 percent or less) for the other locks such as Inner Harbor and Brazos and Colorado to the west, with a very small percentage of total tons through the Old River Lock.

Table K-20 shows the percentages of the Calcasieu Lock annual vessel trips of the total annual vessel trips passing through the other GIWW system locks that are relevant to the Calcasieu Lock for the years 2006, 2007, and 2008. The Calcasieu Lock annual vessel trips account for a high percentage (greater or equal to 60 percent) of total annual vessel trips at Leland Bowman, Port Allen, Bayou Sorrel, and Harvey and slightly less dominant (about 50 percent) for Bayou Boeuf and Algiers. The Calcasieu Lock accounts for a much smaller percentage of total annual vessel trips (about 20 percent or less) for the other locks such as Inner Harbor, Brazos, and Colorado to the west, with a very small percentage of total annual trips through Old River Lock.

Table K-17. Calcasieu Lock System Tons (1000s), 2006 to 2008

	Calcasieu	Leland Bowman	Port Allen	Bayou Sorrel	Bayou Boeuf	Harvey	Algiers	Old River	Inner Harbor	Brazos East and West	Colorado East	Colorado West
2006	39,970	38,859	16,731	16,731	17,212	471	15,966	431	4,052	7,074	4,029	4,000
2007	40,945	39,772	17,055	17,055	17,298	826	15,602	316	4,479	3,949	3,794	3,786
2008	37,801	36,817	15,601	15,601	16,955	1,360	15,153	276	4,324	3,778	3,778	3,705

Source: WCSC and G.E.C., Inc.

Table K-18. Calcasieu Lock System Trips, 2006 to 2008

	Calcasieu	Leland Bowman	Port Allen	Bayou Sorrel	Bayou Boeuf	Harvey	Algiers	Old River	Inner Harbor	Brazos East and West	Colorado East	Colorado West
2006	19,608	19,044	8,721	8,721	7,812	232	6,775	234	1,635	2,102	2,086	2,065
2007	19,344	18,805	8,816	8,816	7,213	426	6,108	194	1,810	1,940	1,890	1,884
2008	17,818	17,346	8,180	8,180	6,889	517	5,877	168	1,833	1,891	1,891	1,857

Source: WCSC and G.E.C., Inc.

Table K-19. Calcasieu Lock System Total Tons Percentage, 2006 to 2008

	Calcasieu	Leland Bowman	Port Allen	Bayou Sorrel	Bayou Boeuf	Harvey	Algiers	Old River	Inner Harbor	Brazos East and West	Colorado East	Colorado West
2006	100.00%	97.22%	41.86%	41.86%	43.06%	1.18%	39.95%	1.08%	10.14%	10.19%	10.08%	10.01%
2007	100.00%	97.13%	41.65%	41.65%	42.25%	2.02%	38.11%	0.77%	10.94%	9.64%	9.27%	9.25%
2008	100.00%	97.39%	41.27%	41.27%	44.85%	3.60%	40.09%	0.73%	11.44%	9.99%	9.99%	9.80%

Source: WCSC and G.E.C., Inc.

Table K-20. Calcasieu Lock System Total Trips Percentages, 2006 to 2008

	Calcasieu	Leland Bowman	Port Allen	Bayou Sorrel	Bayou Boeuf	Harvey	Algiers	Old River	Inner Harbor	Brazos East and West	Colorado East	Colorado West
2006	100.00%	97.12%	44.48%	44.48%	39.84%	1.18%	34.55%	1.19%	8.34%	10.72%	10.64%	10.53%
2007	100.00%	97.21%	45.57%	45.57%	37.29%	2.20%	31.58%	1.00%	9.36%	10.03%	9.77%	9.74%
2008	100.00%	97.35%	45.91%	45.91%	38.66%	2.90%	32.98%	0.94%	10.29%	10.61%	10.61%	10.42%

Source: WCSC and G.E.C., Inc.

B. Projected Traffic. This section summarizes the long-term forecasts of unconstrained commercial traffic expected to transit Calcasieu Lock annually for the period 2009 through 2060. The forecast data presented here was prepared by Gulf Engineers and Consultants (GEC) under contract with the Corps. For a more thorough discussion see Attachment 1, *Updated Vessel Traffic Forecast for the GIWW as It Relates to Calcasieu Lock.*

In this context, *unconstrained* means unconstrained by increases in future water congestion associated with increased levels of waterway traffic. Therefore, unconstrained traffic levels can also be viewed as levels of possible demand for waterway transportation on a particular waterway system, such as GIWW.

The majority of the commercial cargo tons transiting Calcasieu Lock are related to the petrochemical industrial base that is contiguous to the lock and the adjacent waterway network. Petroleum products, chemicals, and crude oil constitute over 75 percent of the total annual lock tonnage. A wide array of other dry bulk commodities constitute the remainder of the lock cargo tonnages, primarily iron and steel products and aggregates.

The annual volumes of bulk liquids have been relatively stable for the last decade until declining in 2007 and 2008. The decline in liquid cargoes particularly characterizes bulk chemicals and to a lesser degree petroleum products. Dry bulk cargo volumes have fluctuated with no clear trends.

In 2010, the US Department of Energy, Energy Information Administration (EIA), issued the 25-year energy forecasts. These were used for forecasts of Calcasieu Lock tonnages related to liquid cargo and aggregates based on correlations between historical production/consumption estimates and lock tonnages. The EIA projections currently extend out to 2035. Moreover, the EIA most-likely expected energy forecasts are accompanied by low and high forecasts that are an important component for sensitivity analyses.

Calcasieu Lock projections for dry bulk commodities other than aggregates were based on average tonnages during the period 2000 to 2008. The dry bulks (other than aggregates) were not correlated to the energy related forecasts that corresponded with the other lock commodity tons (liquids and aggregates). The dry bulk categories displayed fluctuating and relatively low volumes of tons typically dominated by one or two specific commodities within each group such as iron and steel nonmetallic minerals (aluminum ores), coal (petroleum coke), grains (rice), and others (cement and waste water). The average tonnages of each dry bulk cargo were calculated from the period 2000 to 2008 and used to reflect annual values for the period 2009 to 2060.

Figure K-17 depicts the total annual projected commodity tons for Calcasieu Lock for the period 2009 to 2060 for the major categories of liquid bulk, aggregates, and other dry bulks. Liquid bulk tonnages (petroleum products, chemicals, and crude petroleum) are projected to decline further from 2008 (29.167 million tons) to 2009 (27.042 million tons) and then rise to 29.510 million tons (2015) and thereafter remain at or near 29 million tons until 2034. Total liquid bulk tons are projected to decline from 28.945 million tons in 2034 to 26.351 million tons in 2060. Total lock tonnage is projected to closely follow the slow to no growth pattern of liquid bulk cargo tons. Total lock tonnage is projected to decline from 37.639 million tons in 2008 to 35.631 million tons in 2009 and then rise to 38.614 million tons in 2020 and remain less than 39 million tons until 2028. Total annual lock tonnage will remain at or near 39 million tons until 2042, decreasing very slowly thereafter to 38.614 million tons by 2060.

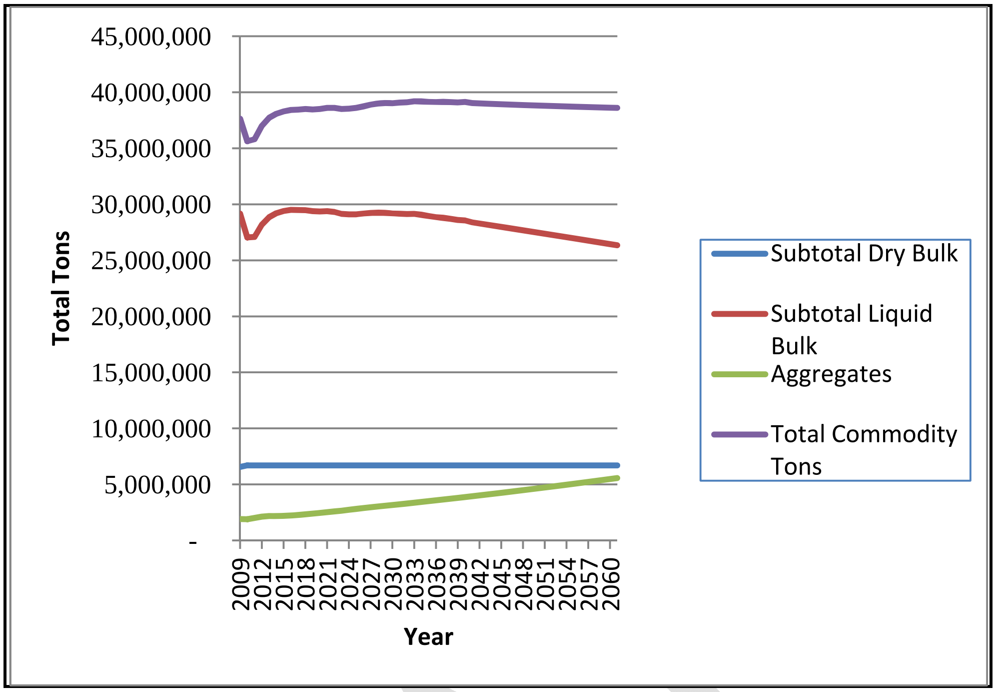


Figure K-17. Annual Commodity Tons Projected for Calcasieu Lock, 2009 to 2060

The EIA forecasts used for most of the lock tonnages (liquids and aggregates) are provided for a reference case and for high and low values of major inputs such as world oil prices and economic growth. The EIA alternative forecasts provide insight into the robustness of the reference case with respect to changes in major inputs. Usually, the reference case falls between the high and low values reflected in the alternative forecasts which allows for a measure of potential variability in the forecasts.

The EIA energy projections extend out 25 years, currently to 2035. Beyond 2035, the EIA projections have to be extrapolated based on trends in the out years. The EIA projections were extrapolated past 2035 for trends in the forecasts except for petroleum products, which displayed no clear trends among the individual product components. Consequently, petroleum product forecasts were fixed at the EIA 2035 ending year. Other forecasts for chemicals, crude oil, and aggregates were extrapolated out to 2060.

Overall, until at least 2035, the 2010 EIA outlook had conservative projections for U.S. energy use. Beginning in 2014 and extending through 2035, the EIA expects flat production of oil in the Gulf of Mexico, which constitutes a major input to Calcasieu Lock tonnage for crude, chemicals, and petroleum products. This, in effect, has made total traffic projections at Calcasieu Lock rather conservative as well. As shown in figure K-18 and table K-21, using the most likely traffic forecast based on 2010 EIA projections, tonnage moving through Calcasieu Lock is expected to grow by only about 8 percent over the next 50 years.

Table K-21. Calcasieu Lock Most Likely Traffic Forecasts (Total Tons)

Year	Tons
2010	35,801,187
2015	38,429,408
2020	38,614,962
2025	38,743,972
2030	39,087,124
2035	39,122,936
2040	39,034,922
2045	38,907,360
2050	38,794,394
2055	38,696,580
2060	38,614,495

1. Updated Traffic Forecast. The 2010 EIA projections, described in the previous section, were updated with the 2012 EIA projections to update vessel traffic forecast as it relates to the GIWW and Calcasieu Lock. The reason for using this update in our analysis is because the 2010 AEO was based primarily on energy trends and developments prior to that year. Significantly, the very recent developments in natural gas extraction (fracking) had not been fully implemented in the vast new onshore domestic gas fields and reflected in the AEO projections. Table K-22 contains the projected natural gas prices from the 2010 and 2012 AEO. The 2010 AEO shows continually rising natural gas prices based on 2010 index value (2010 = 100) increasing to 1.39 (2015), 1.48 (2020), 1.55 (2025), 1.79 (2030) and 1.97 (2035). Subsequently, the 2012 AEO projects substantially lower gas prices that display little or no increase between 2010 and 2020 and thereafter are projected at levels substantially less than projected in 2010 AEO such as 1.28 (2025), 1.43 (2030) and 1.68 (2035).

Table K-22. Natural Gas Prices and Production Forecast

Prices (2010 dollars per million Btu)	2010	2015	2020	2025	2030	2035
2010 Energy Outlook	$4.50	$6.27	$6.64	$6.99	$8.05	$8.88
2012 Energy Outlook	$4.39	4.29	4.58	$5.63	$6.29	$7.37
2010 Outlook Growth Indices (2010=100)	1.00	1.39	1.48	1.55	1.79	1.97
2012 Outlook Growth Indices (2010=100)	1.00	0.98	1.04	1.28	1.43	1.68

Dry Production (Trillion cubic feet)	2010	2015	2020	2025	2030	2035
United States Total 2010 Energy Outlook	20.01	19.29	19.98	21.31	22.38	23.27
Lower 48 Onshore 2010 Energy Outlook	17.01	16.09	16.23	15.96	16.59	17.07
United States Total 2012 Energy Outlook	21.58	23.65	25.09	26.28	26.94	27.93
Lower 48 Onshore 2012 Energy Outlook	18.66	21.48	22.48	23.64	24.11	24.97
United States 2010 Outlook Growth Indices (2010=100)	1.00	0.96	1.00	1.07	1.12	1.16
Lower 48 Onshore 2010 Outlook Growth Indices (2010=100)	1.00	0.95	0.95	0.94	0.98	1.00
United States 2012 Outlook Growth Indices (2010=100)	1.00	1.10	1.16	1.22	1.25	1.29
Lower 48 Onshore 2012 Outlook Growth Indices (2010=100)	1.00	1.15	1.20	1.27	1.29	1.34

Source: Table 14 Oil and Gas Supply from 2010 and 2012 Annual Energy Outlook.

The distinctly lower natural gas prices are a result of a substantial increase in domestic production from advances in extraction (fracking) technology. Table K-21 compares the AEO natural gas production forecasts from 2010 and 2012 releases. The 2010 AEO shows relatively constant domestic onshore production or slightly declining onshore domestic production compared to 2010 index value (2010 = 100) decreasing to 0.95 in 2015 and 2020, 0.94 in 2025, 0.98 in 2030 and 1.00 in 2035. Comparatively, the 2012 AEO shows continually rising onshore domestic natural gas production compared to 2010 index value (2010 = 100) rising to 1.15 in 2015, 1.20 in 2020, 1.27 in 2025, 1.29 and 2030 and 1.34 in 2035.

It is evident that there has been a significant paradigm shift akin to a “game changer” for domestic natural gas in terms of significantly increased production (upward) and decreased prices (downward) when the 2010 and 2012 AEO forecasts are compared. Why this may be important for our own analysis is because the changes in natural gas markets can have significant spill-over impacts on the major commodity sectors (e.g., petro chemicals which are heavily dependent upon natural gas as feedstock for production of basic chemicals) that use the GIWW and transiting Calcasieu Lock.

The previous 2010 EIA forecast indicated that the commodity group chemicals started at 9.450 million tons (2008), peaked at 9.471 million tons at 2021, and subsequently steadily declined to 8.564 million tons by the end of the EIA projections at 2035. Extrapolating the EIA downward trend line forward to 2060, the chemical tonnages decline to 6.469 million tons. The updated 2012 forecast indicates that the commodity group chemicals at Calcasieu Lock start at 9.302 million tons (2011), peak at 11.495 million tons at 2029, and subsequently decline to 11.404 million tons by the end of the EIA projections at 2035.

However, the relatively more robust forecast of real growth for chemicals as updated (2012), versus secular decline from the previous forecast (2010), did not transpose to the petrochemicals commodity group as expected when comparing the 2012 versus 2010 EIA forecasts. The 2012 forecasted commodity tonnages for the petrochemicals group are very similar to 2010 forecasted tonnages based on EIA forecasts in 2012 and 2010, respectively. Petrochemicals tonnages transiting Calcasieu Lock were 16.755 million tons in 2008 and projected to grow to 16.576 million tons in 2035 at the end of the EIA forecast (2010). As updated by the EIA 2012 forecast petrochemicals tonnages transiting Calcasieu Lock were 16.229 million tons in 2011 projected to increase to 16.893 million tons by 2035at the end of the EIA forecast (2012).

Accordingly, the increased growth of the chemicals commodity group in the updated forecast has not been accompanied by a similar resurgence in the petrochemicals sector. Consequently, for the biggest single commodity group, petrochemicals, defined by total annual tons transiting Calcasieu Lock (and the GIWW), there is nearly “no growth” since petrochemical tonnages increase only 0.664 million by 2035 compared to 2011 (16.893 – 16.229 = 0.664). For the second largest commodity group transiting Calcasieu Lock, chemicals, there is modest positive growth which is relatively significant growth when compared to the absolute decline in tonnage projected in 2011 based on EIA 2010 forecasts and trends extrapolated beyond 2035.

Nearly half of the forecasted growth in Calcasieu total lock tonnage between 2011 and 2061, 4.507 million tons (42.490 – 37.983 = 4.507), comes from growth in chemicals (2.102 million tons). Petrochemical total tonnages increase 0.664 million tons from 2011 to 2061. Total annual tonnages of aggregates increase 1.891 million tons (4.309 – 2.418 = 1.891) from 2011 to 2061. Total growth in these three commodity groups accounts for 4.657 million tons (2.102 + 0.664 +1.891 = 4.657) which is offset by forecasted decline in crude petroleum between 2011 (4.035 million tons) and 2061 (3.885 million tons). Crude petroleum is projected to grow in the early stages of the forecast, peaking at 5.002 million tons in 2020. The overall decline in crude petroleum between 2011 and 2061 is 0.150 million tons (4.035 – 3.885 = 0.150). The net increase of total annual Calcasieu Lock commodity tonnage (with rounding) of 4.507 million tons represents the net growth in chemicals, petrochemicals and aggregates, 4.657 million tons, less the decrease in crude petroleum, 0.150 million tons (4.507 = 4.657 – 0.150).

Figure K-18 compares the total annual tonnages forecasted for Calcasieu Lock for the period 2011–2061 as updated (2012) with the forecasted total annual lock tonnages from the previous (2010) forecast. The 2010 forecast exhibits a modest increase in total tonnage from 37.000 million in 2011 to 39.122 million by 2035 and then declining to 38.614 million by 2060. The updated (2013) forecast exhibits a slightly more but still modest increase in total tonnage from 37.983 million tons in 2011 to 42.123 million tons in 2035 and then very slow growth thereafter to 42.490 million tons in 2061. The slow growth for the updated forecast after 2035 is attributable to constant values for the two largest commodity groups, petrochemicals and chemicals, after 2035 while there is a slight decline in crude oil tons projected after 2035.

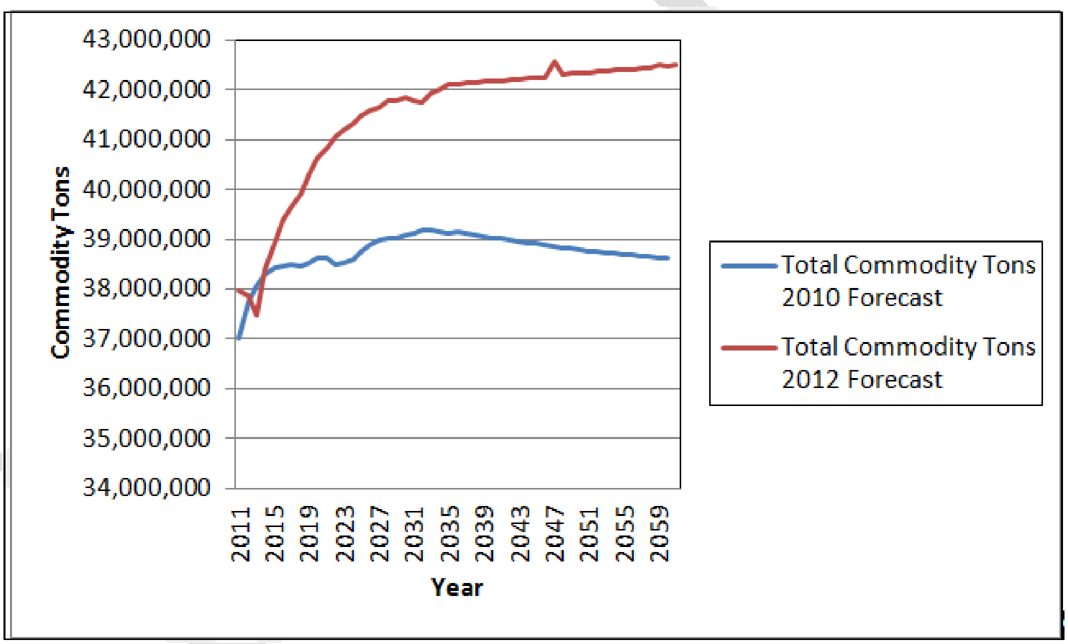


Figure K-18. 2010 and 2012 Total Annual Forecasted Commodity Tons Transiting Calcasieu Lock, 2011 to 2061

2. Traffic Forecast Sensitivity. Sensitivity of the traffic forecasts will be addressed quantitatively through the EIA alternative forecasts to the reference case forecasts that underlie the majority of the forecasted lock annual tonnage comprising liquid bulk and aggregates.

The EIA reference case (most likely) forecasts have been used for petrochemicals (petroleum products), chemicals, crude petroleum, and aggregates. The EIA reference case forecasts typically are accompanied by alternative forecasts for measures of higher and lower forecasts as a result of assumptions about major inputs such as world oil prices and level of economic growth. The alternative energy forecasts developed by EIA are used for petrochemicals, chemicals, crude oil, and aggregates to develop alternative sensitivity projections. As mentioned previously, in the absence of any meaningful correlations of the annual Calcasieu Lock tonnages of dry bulk commodities with other indices of economic activity, the average of the time series was used for forecasting. Plus or minus one standard deviation was used for high and low cases. Table K-23 displays total tonnage for each scenario.

Table K-23. Calcasieu Lock Updated Traffic Forecast (Total Tons)

Year	Most Likely	Low	High
2011	37,983,139	30,068,875	40,839,196
2015	39,376,852	36,328,911	43,075,425
2020	40,838,366	38,541,550	45,125,220
2025	41,576,265	39,257,497	46,011,851
2030	41,779,000	39,458,565	46,641,104
2035	42,123,340	39,844,071	47,437,840
2040	42,190,857	40,185,596	47,676,298
2045	42,258,374	40,531,885	47,923,496
2050	42,355,614	40,878,174	48,170,695
2055	42,423,131	41,224,463	48,417,893
2060	42,490,648	41,570,752	48,665,091

III. FUTURE WITHOUT-PROJECT CONDITION

Identification of the most likely condition expected to exist in the future in the absence of any improvements to the existing navigation system is a fundamental first step in the evaluation of potential improvements. The Future Without Project (FWOP) Condition serves as a baseline against which alternative improvements are evaluated. The increment of change between an alternative plan and the FWOP condition provides the basis for evaluating the beneficial or adverse economic, environmental, and social effects of the considered plan. The definition of the FWOP condition is presented below. The forecast of the FWOP Condition reflects the conditions expected during the period of analysis.

The FWOP Condition identified for use in this Study includes the following analytical assumptions:

1. Operation and maintenance of all system locks will be continued through the period of economic analysis to ensure continued navigability.

2. All existing waterway projects or those under construction are to be considered in place and will be operated and maintained through the period of analysis.

3. Replacement of the IHNC Lock and Bayou Sorrel Lock was not assumed.

4. All system locks are using the most efficient locking policies.

5. Alternative non-system transportation means (rail and non-system water) are assumed to have sufficient capacity to move diverted system traffic at current costs over the period of analysis.

6. The capacities of system locks are as presented in Section 4 of this appendix.

7. Traffic demands on the system will grow at the mid (most likely) growth rates.

8. The Calcasieu Lock was constructed as a saltwater barrier, and will continue to be operated to keep salt water from moving west to east into the Mermentau Basin.

9. The existing Black Bayou diversion structure, located east of the Calcasieu lock at the junction of Black Bayou and the GIWW, will continue to be maintained by the Natural Resources Conservative Service (NRCS).

10. The existing Calcasieu Lock will continue to serve three purposes: a.) to pass waterway traffic as a navigation lock on the GIWW; b.) to prevent saltwater intrusion from the Gulf of Mexico in the Mermentau River Basin; and c.) to serve as a flood way during high water in the Mermentau River Basin. The ability of the gates to operate under differential water levels facilitates the capability of Calcasieu to serve as a flood-way. Operational rules at Calcasieu dictate that if the east gage exceeds 2.0 feet and the west gage is less than the east, then the Mermentau River Basin is "drained" by opening the sector gates on both ends of the lock. This allows water to flow from east to west through the lock chamber. This unrestricted flow of water has the potential to hinder or completely halt navigation due to excessive current speeds through the chamber.

Operational policy dictates that when the east gage reads between 2.0 and 2.5, eastbound tows can be accommodated by operating the lock gates if the tows have insufficient power to "push the current". In this case, the sector gates are closed, stopping the flow of water through the lock, and allowing the tows to pass using standard locking techniques.

At east gage readings above 2.5 feet and west gage readings lower than the east, the lock operates with a policy where the flood-way has priority over navigation. For purposes of this document, this operating condition is referred to as "full open pass". In full open pass, a vessel must have sufficient power to push the current. If they do not, they must do one of two things:

- reconfigure, or
- wait for better current conditions

Either of these activities can cause significant delays to navigation attempting to traverse the Calcasieu Lock and it is these delays which this feasibility study will address via the with-project alternatives discussed in Section VII of this appendix.

IV. EVALUATION PROCEDURE

A. Introduction. The purpose of a Corps' planning analysis is to estimate changes in national economic development that occur as a result of differences in project outputs with a plan, as opposed to national economic development without a plan. This is accomplished through a federally-mandated National Economic Development (NED) analysis which is generally defined as an economic cost benefit analysis for plan formulation, evaluation, and selection that is used to evaluate the federal interest in pursuing a prospective project plan. NED benefits are defined as increases in the net value of the national output of goods and services, expressed in monetary units.

B. Inland Navigation Analysis. For a navigation project investment, NED benefits are composed primarily of the reductions in transportation costs attributable to the improved waterway system. The reduction in transportation costs are achieved through increased efficiency of existing waterway movements, shifts of waterway and overland traffic to more efficient modes and / or routes, and / or shifts to more efficient origin-destination combinations. Further benefits accrue from induced (new output / production) traffic that is transported only because of the lower transportation cost deriving from an improved project, and from creating or enhancing the potential for other productive uses of the waterway, such as the generation of hydropower. But, the conceptual basis for the basic economic benefit of a navigation project is the reduction in the value of resources required to transport commodities.

Traditionally, this primary benefit for barge transportation is calculated as the cost savings for barge shipment over the long-run least-cost all-overland alternative routing. This benefit estimation is referred to as the waterway transportation rate-savings, and it also accounts for any difference in transportation costs arising from loading, unloading, trans-loading, demurrage, and other activities involved in the ultimate point - to - point transportation of goods. A newer way to estimate this primary benefit is to define the movement willingness-to-pay for barge transportation with a demand curve (instead of the long-run least-costly all-overland rate) and then calculate a transportation surplus (consumer surplus). Either way, the primary benefit for federal investment in commercially navigable waterways (benefits with a plan as opposed to benefits without a plan) ends up as a transportation cost reduction. The primary guidance document that sets out principles and procedures for evaluating federal interest is the *Economic and Environmental Principles and Guidelines for Water and Related Implementation Studies Principles and Guidelines,* (P&G, 1983). Corps guidance for implementing P&G is found in the *Planning Guidance Notebook, ER 1105-2-100 (2000)* with additional discussions of NED analysis documented in the *National Economics Development Procedures Overview Manual (2009)*. For inland navigation analysis, the focus is on the evaluation and comparison of the existing waterway system with three basic alternative measures: 1) increase capacity (decrease transit times, thereby reducing delay costs); 2) increase reliability (replace or rehabilitate aging structures, thereby reducing the probability of structural failure and its consequences); and/or reduce demand (e.g., congestion fees). The P&G provides general guidance for doing this benefit assessment, but leaves open opportunities to improve the analytical tools used as new data and computational capabilities become available.

C. System Analysis. The inland waterway system is a network of locks and open channel reaches. As a result, no navigation project stands in isolation from other projects in the system. The study area must extend to areas that would be directly, indirectly or cumulatively, be affected by the alternative plans. An improvement at one node (e.g., lock) in the system affects traffic levels past that node, and since that traffic can also transit other system nodes, the performance at these other nodes possibly affect traffic levels unique to those nodes, and so on. The evaluation of inland navigation system equilibrium is a substantial computational problem given the mix of commodity flows, each transiting different locks and each having its own set of economic properties. Since the 1960s the Corps has been performing inland waterway cost-benefit analysis with a system level evaluation. Through the Corps' Planning Center of Expertise for Inland Navigation (PCX-IN) located in the Navigation Planning Center in the Huntington District (CELRH-NC), the Corps' Great Lakes and

Ohio River Division has adopted and continues to maintain a set of computerized analytical models for estimating the NED benefits of proposed improvements to the inland navigation system. The primary modeling suite is the Ohio River Navigation Investment Model (ORNIM) which has since been modified for this analysis to incorporate the GIWW system and is now simply called the Navigation Investment Model (NIM). Section D. provides a brief history of the Corps' inland navigation transportation modeling is given below.

D. History of Corps Waterway System Modeling. The decentralized nature of Corps program execution resulted in the early development of several system models. The first model was developed by the North Central Division for the Illinois Waterway in the 1960s. In the early 1970s, with more complex studies on the horizon, a centralized research and development program was initiated within the Office of the Chief of Engineers called the Inland Navigation Systems Analysis (INSA) Coordination Group. In the mid-1970s the Waterway Analysis Model (WAM) and the Flotilla Model were developed. The WAM is a tow-level discrete-event simulation model used to estimate lock performance under a given operating condition, with a defined fleet and for a specific traffic level. WAM was capable of modeling single, or multiple, navigation projects each with multiple lock chambers and was also modified in 1993 into a deep-draft version. The Flotilla Model was developed to calculate with and without-project economic impacts.

In 1977 the Transportation Systems Center of the U.S. Department of Transportation sponsored the expansion of the Flotilla Model into the Resource Requirements Model and a Post-Processor program. Additional modifications were made from 1979-80 under the direction of the CELRH-NC, and a third program, the Marginal Economic Analysis Model, was added. Collectively, these three programs (Resource Requirements Model, Post-Processor and the Marginal Economic Analysis Model) were known as the Tow Cost Model (TCM). Further modifications led to the development of the Equilibrium (EQ) Model in the mid-1980s, and the Marginal Economic Analysis Model was dropped. Collectively, the TCM and EQ Model were known as the Tow Cost / Equilibrium (TC/EQ) Models.

In the early-1990s structural reliability analytical techniques advanced, allowing for a more quantitative assessment of project maintenance requirements and the probability of unscheduled project closures. In the mid-1990s the TC/EQ Model suite was supplemented with the inclusion of the Life Cycle Lock Model (LCLM), which was developed to estimate the expected transportation impacts of unscheduled closures under both the without- and with-project conditions external to the TC/EQ. During this time period the WAM was also modified to capture re-scheduling effects observed during historic long-duration closure events.

In the mid to late-1990s, modernization and expansion of TC/EQ into the ORNIM began as engineering reliability data multiplied and the need to dynamically link the reliability analysis (LCLM) with a simultaneous investment optimization algorithm. ORNIM was built by Oak Ridge National Laboratory (ORNL) in collaboration with CELRH-NC / PCX-IN.

From 2005-2009, under the Corps'Institute of Water Resources Navigation Economic Technologies program, empirically derived demand elasticities were developed and ORNIM was expanded to equilibrate using a downward sloping movement-level demand curves.

E. Navigation Investment Model (NIM). As are its predecessors, ORNIM is an annual model which can be described as a spatially detailed partial equilibrium model designed to estimate the NED benefits of proposed improvements to the inland navigation system and then to compare the benefits to the costs. While it is not really designed to estimate the total benefits of a river system, or the benefits the nation would lose if the river system no longer existed (something like a computable general equilibrium model would be needed), it is appropriate to estimate the benefits of incremental improvements to river systems.

ORNIM has also been described as a standard transportation planning model. Freight transportation supply and demand is part of a simultaneous decision process by multiple economic agents, with spatial and time dimensions. While the Four-Step Transportation Planning Model includes: 1) trip generation; 2) trip distribution; 3) mode choice; and 4) route assignment, ORNIM focuses on mode choice, or more specifically modal diversion from water shipment.

ORNIM has been certified as a planning tool for Corps studies. As a result of ORNIM's success the PCXIN now is tasked with modifying the ORNIM for specific characteristics of other waterways for analysis of proposed improvements. This modified model is simply known as the Navigation Investment Model (NIM). The NIM was used to evaluate the proposed improvements to the Calcasieu Lock. As explained above a systems approach was taken that included the entire Louisiana portion of GIWW system. The NIM focuses on the mode choice, or more specifically, the diversion of water shipments to alternative modes (rail or truck). Trip generation and distribution are handled exogenously to NIM through inputs (i.e., waterway traffic demand forecast scenarios and alternate mode rate analysis). Waterway route assignment is handled within the model.

F. Model Development and Structure. Simulation models fall into two basic categories: event-based and period-based. In an event- based model, a set of events that the model is concerned with are defined, and time moves forward in jumps, as each event takes place. Period-based models divide time into discrete periods of known length (e.g. years). All calculations are made for a given period, and then time is advanced to the next period. Both types of approaches have their advantages and disadvantages. In general, period-based models are easier to formulate and contain simpler calculations, but the assumptions required about averaging of data may be limiting. The NIM is classified as a period-based model running on yearly time increments.

The NIM System is composed of three primary modules: a.) the Lock Risk Model (LRM); b.) the Waterway Supply and Demand Model (WSDM); and c.) the Optimal Investment Module (Optimization). The general linkage of the model modules are shown in figure K-19.

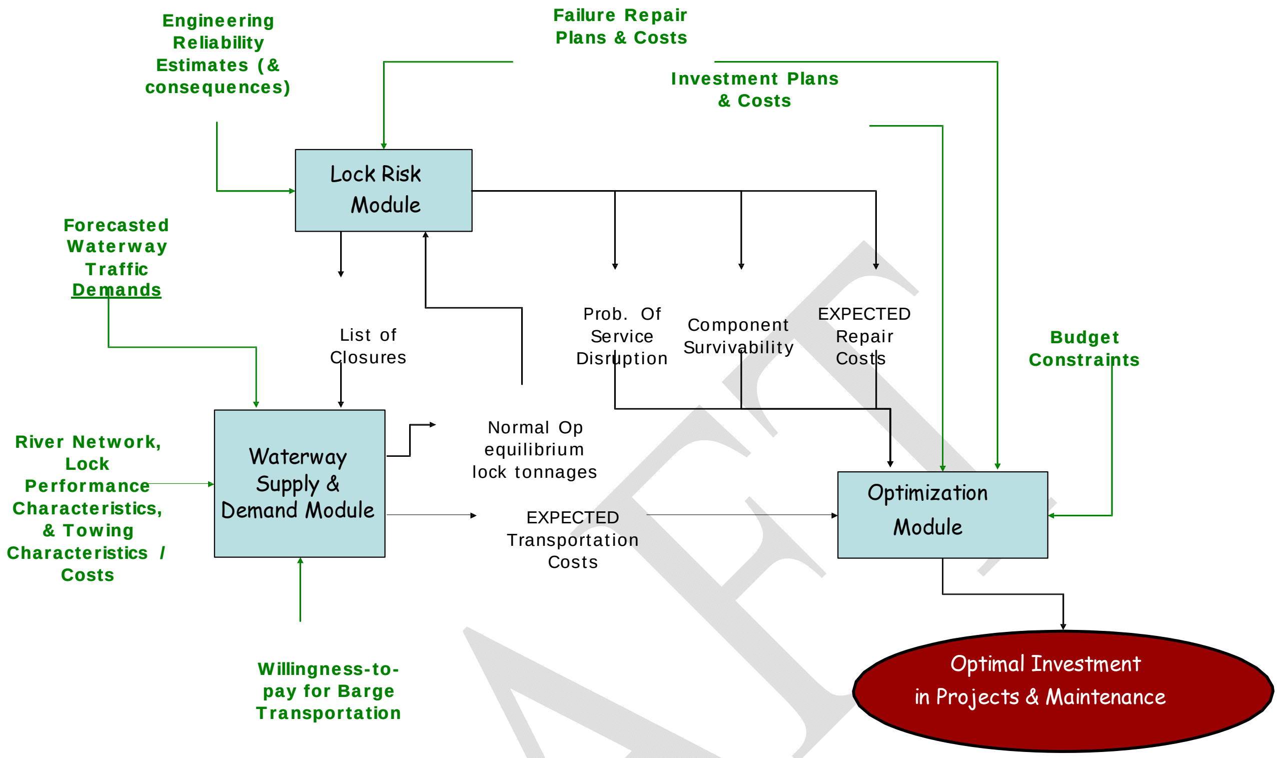


Figure K-19. Navigation Investment Model Primary Modules

The LRM Module forecasts structural performance by simulating component-level engineering reliability data (hazard functions and event-trees) to determine life-cycle repair costs and service disruptions. The LRM summarizes the probabilities of reliability driven service disruptions (typically lock closures) for each lock for each component for each year, which are then used by the WSDM and Optimization modules to estimate expected transportation impacts resulting from the service disruptions.

The WSDM Module estimates equilibrium waterway traffic levels and transportation costs given a traffic demand forecast, movement willingness-to-pay, and waterway system performance characteristics. NIM's major economic assumptions are embedded within WSDM.

The Optimization Module organizes and analyzes the investment life-cycle benefit and cost streams and recommends optimally timed investments (what and when).

While there are three primary modules, the model is much more complex. For a more thorough description of NIM see Attachment 2, *Gulf Intracoastal Waterway Navigation Investment Model*

V. NAVIGATION INVESTMENT MODEL INPUTS

Several inputs to the NIM need to be calculated exogenously to the model. The major inputs include

- Waterway Traffic Demand Forecast Scenarios
- Willingness-To-Pay For Barge Transportation Estimates
- Reliability Analysis
- Lock Capacity Calculations

The Waterway Traffic Demand Forecast Scenarios were discussed in Section II of this appendix. The remaining three model inputs, Willingness To Pay; Reliability Analysis, and Lock Capacity Analysis, are described as follows.

A. Willingness To Pay for Barge Transportation. Willingness-to-pay (WTP) for barge transportation is needed to determine the equilibrium traffic level and to calculate the transportation surplus representing the benefits of barge transportation. The willingness-to-pay can be defined as either "*fixed quantity*" or "*price responsive*", and NIM allows either specification on a movement to movement basis.

1. Inelastic Demand for Barge Transportation. In the "fixed quantity" (a.k.a. inelastic demand for barge transportation) equilibrium assumption, a WTP point estimate is used. Under this assumption suppose a movement moves on water at $8/ton and the least-costly all-overland rate is $12/ton. The WTP for barge transportation is then $12/ton and the consumer or transportation surplus is $4/ton times the tonnage being moved which is also often referred to as the movement's rate-savings. In the future, as system congestion increases and/or system reliability decreases, water transportation costs increase. Under this inelastic demand case, this movement will continue to transport the same amount of cargo as long as the water price remains below the $12.00/ton estimate. Once the water price exceeds this level then this entire movement is removed from the waterway to the least costly overland mode of transportation.

Transportation Rate Study. Under the inelastic demand assumption for barge transportation, determining the willingness to pay (and ultimately benefits to barge transportation) relies on an accurate representation of transportation cost estimates via water (barge) transportation and the next least costly overland alternative (typically rail) for those movements within the study area.

This analysis was conducted by the TX Transportation Institute (TTI) under contract with the Nick J. Rahall, II Appalachian Transportation Institute at Marshall University for the Corps. The objective of this research was to facilitate the calculations of the National Economic Development (NED) benefits attributable to navigation through the Calcasieu Lock. To accomplish this objective, the study developed a full range of transportation routings, rates, and supplemental costs for a sampling of 150 movements routed through the Calcasieu Lock and contained in the 2008 WCSC commodity movement data.

Freight rates for each sample movement were developed based on the actual water- inclusive routing, any alternative water-inclusive routing indicated in the dataset, and for a competing (least-cost) all-overland alternative. All rates and fees were stated in 4th Quarter 2010 U.S. dollars.

Waterborne Movement Sample. The initial dataset consisted of 10,381 lock-flagged waterborne movements routed over the GIWW in 2008. 5,189 movements which involved passenger vessels, deep water, or non-Calcasieu Lock routings were removed, resulting in a population of 5,192 movements. These movements represented annual flows for the specific origin-destination-commodity (ODC) triplet and not individual trip tonnages. A sample of 150 movements were then selected for inclusion in the sample to mirror the entire population as accurately as possible, i.e., such that the distribution of tonnage by WCSC commodity group in the sample mirrored the distribution of tonnage by commodity group in the WCSC population of movements that utilized the Calcasieu Lock in 2008 (tables K-24a and 24b). The sample of 150 movements corresponded to approximately 3 percent of movements and 10 percent of tonnage of the population.

Table K-24a. Distribution of Movements and Tonnage by Commodity Group in Population

	WCSC Commodity Group	**Movements**	**%**	**Tons (000's)**	**%**
1	Coal	61	1	402	1
2	Petroleum Products	2,129	41	16,692	44
3	Crude Petroleum	209	4	2,958	8
4	Aggregates	100	2	1,907	5
5	Grain & Grain Products	43	1	152	0
6	Chemicals	1,592	31	9,451	25
7	Non-metallic Ores & Minerals	150	3	902	2
8	Iron Ore and Iron & Steel Products	642	12	3,125	8
9	Others	266	5	2,082	6
	TOTAL	**5,192**	**100%**	**37,671**	**100%**

Note: 5,189 movements were removed from a total of 10,381 movements contained in the original dataset of all GIWW lock-flagged movements (passenger vessels, deep water, non-Calcasieu)

Table K-24b. Distribution of Movements and Tonnage by Commodity Group in Sample

	WCSC Commodity Group	**Movements**	**%**	**Tons (000's)**	**%**
1	Coal	2	1	25	1
2	Petroleum Products	62	41	1,615	44
3	Crude Petroleum	6	4	303	8
4	Aggregates	3	2	169	5
5	Grain & Grain Products	1	1	2	0
6	Chemicals	46	31	922	25
7	Non-metallic Ores & Minerals	4	3	56	2
8	Iron Ore and Iron & Steel Products	18	12	341	9
9	Others	8	5	258	7
	TOTAL	**150**	**100%**	**3,692**	**100%**
	Sample as % of Population	**3%**		**10%**	

Existing Water Routing Methodology. During the course of the research, it was discovered that off-river origins and/or destinations were either nonexistent or unknown in almost all the movements in the sample. It was found that origin and destination docks are privately owned and operated by industrial facilities, and in many instances serve as "holding docks" for adjoining or nearby facilities. Hence, it was concluded that there was no land movement per se between a facility and the port/dock as is generally observed in the national WCSC population. Loading/unloading of barges is typically performed via pump, conveyor belt, crane with clamshell, and the like, directly from/to the port/dock. Therefore, the water origin/destination was assumed to also be the "off-river" origin/destination.

Water line haul cost, time, and distance, loading/unloading cost and time, as well as any supplemental costs and times were calculated through the Barge Costing Model (BCM). The fuel price was adjusted within the model by using the Energy Information Administration's (EIA) latest published price for Low Sulfur Diesel Fuel. All costs output by the model were in 2006 dollars and were subsequently adjusted to 4th Quarter 2010 dollars through the *All-Inclusive Index Less Fuel (All-LF)*, published by the Association of American Railroads (AAR). The index provides a parallel measure of the *Rail Cost Adjustment Factor* (RCAF) without the influence of the fuel cost component. Further details on the BCM and the RCAF are provided below.

All water routing-related calculations were performed using the BCM which was originally developed by the Tennessee Valley Authority (TVA) over 20 years ago and has been updated and used continuously, extensively, and successfully for the Corps's study and analysis purposes; thus it can be described as a "legacy model." The BCM is designed to provide cost information on the movement of commodities between points on the Inland Waterway System. Additionally, the model calculates transfer costs to and from barge, i.e., shipper/receiver costs for loading to and unloading from barge for the routing being analyzed. The model utilizes information obtained from a variety of sources:

- the Corps's LPMS and WCSC databases
- the *Inland River Record* (barge and towboat characteristics)
- *Shallow Draft Vessel Costs* (fixed and variable cost data)
- shippers and receivers
- the towing industry

The latest update of the model was in 2006; hence the cost output was in 2006 dollars and required adjustment as described above.

Least–Cost All-Overland Routing Methodology. A close examination of each origin/destination via online photography and satellite images, the 2010 National Transportation Atlas Database and the Corps's *Port Series Reports*, showed that the majority of facilities had direct access to/from a rail line. Given the bulk nature of the commodities involved, the least-cost line haul alternative would undoubtedly be rail. In cases where either or both the origin and/or destination facility did not have direct access to a rail line, the nearest railhead was identified. Without direct rail access to the nearest railhead, a short truck haul, estimated 15 miles on average, would be required between each facility and the nearest railhead.

Rail mileage and costs (revenue per net ton) were obtained from the Surface Transportation Board's Carload Waybill Samples 2008 (latest available when this analysis was conducted). Each Waybill was analyzed for movements of similar ODC triples at two geographic levels, the county Federal Information Processing Standard level and the Business Economic Area level. Mileage and rates for ODC triples not contained in the Waybill Sample at either geographic level were obtained from websites of Class I railroads. Differences between the WCSC commodity classification system and the Standard Transportation Commodity Code (STCC) system used by railroads sometimes only permitted matching the 5-digit WCSC code to the 2-digit STCC code. Absence of waybills for ODC triples identical or similar to the waterborne movements is not surprising since waterborne transportation competes effectively with rail, especially for the movements included in this sample. Costs obtained from the Waybill Samples were then adjusted to 4th Quarter 2010 dollars via the AAR's *Rail Cost Adjustment Factor*, which measures the rate of inflation in all seven railroad inputs: labor, fuel, materials and supplies, equipment rents, depreciation, interest, and other expenses.

The Waybill-reported railroad revenues were all-inclusive while railroad websites reported line haul carload rates, fuel surcharges, and switching charges separately. Switching charges were determined given individual movement OD routings and applicable agreements regarding any track rights and reciprocal switching charges between railroads at a given location. Total cost in dollars per net ton was calculated assuming a carload weight of 112 tons.

Based on the researchers' experience, the reported system average speed of 26.7 mph for Union Pacific Railroad, the governing railroad in this geographic area was reduced to 21 mph in order to reflect en-route terminal dwell times and was used to calculate the mainline rail trip time in days. Two days were added to origins and destinations with direct rail line access to account for the travel time and terminal dwell time required by non-mainline local rail service between facilities and line haul railheads.

Only one movement was found to require a truck-only line haul due to the extremely short distance between origin and destination (50 miles). This hypothesis was supported by the fact that no waybills with even remotely similar combinations of ODC triples or even distance- commodity doubles were found in either Waybill Sample.

Short truck hauls between facilities without direct rail access and the nearest railhead were estimated to be 15 miles on average at an average speed of 30 mph. Truck trip times--either for line haul or short haul to the nearest railhead--were calculated in days, to enable comparison with rail and water. Truck rates per net ton were obtained from national interstate and local motor carriers. The rates consisted of a base rate and a fuel surcharge expressed in dollars per pound, gallon, or day. A truckload net cargo weight of 25 tons (50,000 lbs), densities of individual commodities, and trip distances and durations were taken into consideration in order to calculate a truck cost in dollars per net ton.

All calculations included requisite loading/unloading and transfer costs. Loading/unloading costs between facilities and rail or truck, as well as transfer costs directly between rail and truck, in terms of dollars per net ton were assumed to be equal to the loading/unloading costs included in the BCM for the water routing. However, loading/unloading times involving rail or truck were likely to be different than barge but it was not possible to estimate them without knowing the size of individual shipments. Furthermore, the logistics involved in a theoretical modal shift from barge to rail or truck are likely to be prohibitive considering the capacity advantage of barges: one dry cargo barge is equivalent to 16 railcars or 70 trucks while one tank barge is equivalent to 46 railcars or 144 trucks.

Research Results. The methodology applied in selecting the 150-movement sample from the movement population was based on tonnage distribution by WCSC commodity group and was non-statistically significant. However, the rates in dollars per net ton-mile obtained for the movements in each commodity group in the sample can serve as a valid proxy for extrapolation to the rates associated with all movements of the same commodity group in the population of 5,192 movements. The rates in dollars per net ton-mile obtained for the existing water routing, the least-cost overland routing, and the ratio of least-cost overland routing miles to existing water routing miles obtained for each movement were averaged by commodity group (table K-25). Clearly, barge shipment is by far the least-cost transportation alternative for every commodity group.

Table K-25. Transportation Rates per Net Ton-Mile by Commodity Group

	Avg Transportation Rate ($/net ton-mile)		
WCSC Commodity Group	**Existing Water Route**	**Least-Cost All Overland Route**	**Average Ratio Land/Water Miles**
Coal	$0.03	$0.07	1.73
Petroleum Products	$0.05	$0.12	0.99
Crude Petroleum	$0.06	$0.11	1.38
Aggregates	$0.01	$0.06	0.78
Grain & Grain Products	$0.02	$0.11	0.74
Chemicals	$0.06	$0.12	0.89
Non-Metallic Ores & Minerals	$0.02	$0.09	1.01
Iron Ore and Iron & Steel Products	$0.02	$0.10	0.89
Others	$0.04	$0.13	0.74

The actual transportation rates obtained from the research were applied to the 150 sampled movements. The transportation rates and ratio of land miles to water miles were applied to each un-sampled movement in the population (5,042 movements) according to commodity group in order to calculate the total existing water routing cost and the total least-cost all-overland routing cost. The following equations were applied to each movement in the population:

Total Cost of Existing Water Routing = average transportation rate of existing water routing ($/net ton-mile) x existing water routing miles x annual tons

Total Cost of Least-Cost All-Overland Routing = average transportation rate of least- cost all-overland routing ($/net ton-mile) x existing water routing miles x average ratio land/water miles x annual tons

2. Elastic Demand for Barge Transportation. In the "price responsive" a.k.a. elastic equilibrium assumption, a WTP curve is used. This curve defines how an *n*% increase in water price results in an *x*% decrease in tonnage being transported by barge. In the future, as system congestion increases and/or system reliability decreases, water transportation costs increase. For this movement, when the water price increases (regardless of the amount of increase), part of the movement tonnage is removed from the waterway (based on location on the demand curve). As water price increases, parts of all movements are removed.

Under the elastic demand assumption for barge transportation, in order to determine how increases in water costs affect barge transportation NIM uses the water rate developed from the transportation rate study described previously. As an example, suppose the base water rate for a particular movement is $8.00/ton. In the future, as system congestion increases and/or system reliability decreases, NIM calculates a new water transportation cost. Let's assume it is now $9.50/ton. NIM then calculates the movemen''s cost increase of $1.50 ($9.50 - $8.00).

For the inelastic equilibrium assumption NIM calculates the new water rate as $9.50 (base rate of $8/ton plus $1.50). The movement's rate is less than its WTP (i.e., $12/ton) so it stays on the water. Its rate-savings is reduced from $4/ton to $2.50/ton. Its consumer surplus a.k.a. rate-savings is $2.50 times the tonnage.

Under the elastic equilibrium assumption NIM calculates that the water price has increased 18.8 percent (1 - $9.50/$8). The percent of quantity is looked up on the movement's demand curve and the tonnage calculated. This quantity of tonnage is something less than its total demand and less than in the inelastic example immediately above. Its consumer surplus is an integration under the elastic demand curve to this new water price.

As noted above as system congestion increases and/or system reliability decreases, NIM calculates a new higher water transportation cost. To estimate this increase in cost NIM first needs to know the cost characteristics of each movement. The WCSC provides data on barge types, loadings, and historic tonnage moving on the waterway. The LPMS provides data on tow-sizes and tow characteristics for all movements passing through the locks. From these inputs NIM defines a tow-size and towboat type for each movement which is validated against LPMS and WCSC estimates. Operating costs based on these tow-sizes and towboat types were then assessed based on the Institute of Water Resources' latest shallow draft vessel operating costs estimates *(EGM05-06 FY 2004 Shallow Draft Vessel Costs).* Representing 2004 price levels these estimates were then updated for this analysis to 2013 price levels using the BLS CPI Inflation Calculator.

Determining Demand Elasticity. Willingness-to-pay for barge transportation is needed to determine the equilibrium traffic level and to calculate the waterway transportation surplus (benefit). The willingness-to-pay for a transportation service may include not only the rate but also the user's valuation of other characteristics specific to the mode such as its reliability or transit time. The concept of the price of waterway shipping in NIM is the rate the carrier charges (as computed from modeled shipping costs) plus the cost incurred due to a delay which reflects the value of time to the shipper. Willingness-to-pay can be specified as inelastic of elastic. Elasticity, in this case, is simply the probability of a shipper switching to another mode, to/from another location or shutdown divided by the percent change in price. The more responsive a shipment is to a change in price the more elastic that shipment is considered to be.

The NIM allows for specifying an elasticity estimate on a movement by movement basis. For this analysis, all movements modeled were assigned demand curves based on a study of demand curve elasticity for the study area. The overriding purpose of the study was to develop estimates of shippers to changes in the attributes central to their decisions. A survey instrument, from a previous study, was adapted for this study. Over 2,200 were contacted, by telephone, mail and email.

The survey instrument was designed for a choice framework. The mode and location (i.e., origin or destination) along with the attributes of the movement (rate, transit times, and reliability measures) were solicited for the shipment made and alternative shipments that could have been made. The survey also contained information on the access shippers have to modes, size of firm, etc. that can influence decisions. In addition, information was also solicited on the sensitivity of choices to changes on rates, transit times, and reliability. These data are commonly called stated preference data. Various models were estimated using both sets of data separately and together.

The results, based on the survey data, provided evidence that shippers do respond to rates, however, there was little evidence to support that transit times or reliability matter. The findings about rates were translated to elasticities as a measure of responsiveness and while elasticities varied across the range of the data, the overall results tended to support relatively inelastic demands for barge transportation. Additional detail on the development of these elasticities can be found in Attachment 3, *Gulf Intracoastal Waterway Willingness-To-Pay for Barge Transportation.*

For the Calcasieu Lock analysis, all movements in the model were assigned a demand curve based on this study of demand elasticity in the GIWW system. Whether defined as fixed quantity or with a price responsive demand curve, the willingness-to-pay defines the relationship between the quantity shippers are willing to ship as the waterway price (rate) charges, while holding the rates of alternative modes constant. Additional detail on the development of the price responsive movement demand curves can be found in Attachment 2, *Addendum C Demand Curve Inputs*.

B. Reliability Analysis. The reliability of the structures is determined by performing a reliability analysis or review on all the major mechanical and structural components to determine the likelihood of extended closures due to lock failure. Life-cycle maintenance assumptions, and in particular the lock service disruptions they can create, are often critical in the analysis of lock investment decisions. Not only are scheduled maintenance needs applicable, but also service disruption risk from unscheduled repairs.

In the case of the Calcasieu Lock study, while requiring regular maintenance, the lock's structural, electrical, and mechanical systems have either been determined reliable, or to have insignificant consequence to navigation service if a failure is experienced. In short, unscheduled failures and repairs are not expected and not included in this Calcasieu Lock analysis. In the gulf region, however, hurricane events can impact Calcasieu Lock performance. As a result, unscheduled lock closure resulting from hurricane events have been included in this analysis.

1. Without-Project Scheduled Maintenance. The scheduled maintenance data included the following maintenance cost categories, maintenance work items, and lock service disruption type. Of those that generate navigation impacts, a tonnage-transit curve has been developed for each of these service disruptions which will be discussed in the lock capacity analysis section of this appendix. Navigation Investment Model incorporates these scheduled events with a frequency defined by Corps engineers.

- No Impact to Navigation Work Items
    - Security Maintenance
    - ED Instrumentation
    - Routine Maintenance
    - Periodic Inspection
    - A/E Instrumentation

- Annual Fair Wear and Tear/Reimbursable Repairs (13-day 12 open/12 closed disruption)

- Minor Closures
    - SE Guide Wall Face (7-day 12/12 disruption)
    - SW Guide Wall Face (5-day 12/12 disruption)
    - NW Guide Wall Face (7-day 12/12 disruption)
    - NE Guide Wall Face (5-day 12/12 disruption)
    - W Chamber Wall Rehabilitation (69-day 12/12 & 9-day 12/12 disruption)
    - E Chamber Wall Rehabilitation (69-day 12/12 & 9-day 12/12 disruption)

- Major Closures
    - SW Guide Wall and Dolphin Rehab (69-day 12/12 disruption)
    - SE Guide Wall and Dolphin Rehab (61-day 12/12 disruption)
    - NE Guide Wall and Dolphin Rehab (69-day 12/12 disruption)
    - NW Guide Wall and Dolphin Rehab (61-day 12/12 disruption)
    - Dewatering & Monitoring/Major Gate Repair (3-day 24 15-day 12/12 disruption)

2. Unscheduled Service Disruption Events. Lock service disruption events not only occur from scheduled maintenance events, but can also occur from probabilistically driven events (risk). These unscheduled service disruption events are typically generated by unreliable lock components, and as such the NIM tables and field names are biased toward modeling lock parts. The structure for modeling of unreliable components, however, is applicable for any probabilistic event. In the case of the Calcasieu Lock study, the lock's structural, electrical, and mechanical systems have either been determined reliable, or to have insignificant consequence to navigation service if a failure is experienced. In the gulf region, however, hurricane events can impact Calcasieu Lock performance. The hurricane probability and its lock service disruption consequence can be loaded and modeled in NIM.

In the model, unscheduled service disruptions are defined probabilistically. As a result, the adjustment of equilibrium traffic levels, transportation costs, and waterway transportation surplus for unscheduled service disruptions is different than for scheduled service disruptions. Probabilistic events are described through a probability of unsatisfactory performance (PUP) and event-tree. While PUPs and event-trees can change through time from continued degradation and from failure and repair reliability adjustment, in the case of a hurricane event a flat PUP and a single branch event-tree was used. The expected service disruption from a hurricane event occurrence has been estimated to occur approximately 20 percent for each year.

For a more thorough discussion of the reliability analysis and how it has been used in NIM along with a description of the with-project maintenance costs, see Attachment 4, *Maintenance, Construction, and Unscheduled Event Input.*

C. Lock Capacity Analysis. One of the major constraints imposed on vessel traffic passing through locks on a waterway is the capacity of the locks. The capacity of a lock is the volume of traffic a lock can physically pass in a given amount of time. The volume of traffic is measured in tons. As the tons needing to pass through the lock increases and begins to reach the lock capacity, transit times necessarily increase exponentially. This tonnage delay relationship (also known as transit or capacity curves) was developed for each of the nine major locks in the study area (including the Calcasieu Lock) which was ultimately used by the NIM to estimate the potential delay cost to existing and future traffic levels on GIWW system. For this analysis, these capacity curves were estimated by using the WAM. The WAM is a discrete event simulation model that has been used and improved by the Corps' Planning Center of Expertise since the mid-1980s. In February 2011 a memorandum certifying the WAM for use for 3.5 years was circulated in Corps Headquarters. For the Calcasieu Lock Study the WAM was modified to incorporate the effects on navigation whenever the lock is used to drain the Mermentau basin as discussed in Section 3 of this appendix.

In order to properly model navigation traffic through Calcasieu, it first became necessary to understand the lock operation and navigating processes involved. This understanding was obtained through numerous conversations and a face-to-face meeting with towing industry representatives, the lock master, and several experienced lock operators. The information gleaned from these communications served as the foundation for the assumptions and modeling techniques used in this analysis.

1. Lock Operation – Water Level Interplay. Table K-26 contains a matrix representation of the lock operation rules used in the WAM.

Table K-26. Lock Operations – Water Level Rules

East Gage	West Gage	Standard Locking	Open Pass Locking
Less Than West	Greater Than East	X	
Between 2.0 and 2.5	Less Than East	X	
Greater Than 2.5	Less Than East		X

A review of the hourly east and west gage readings from the lock revealed there were only 3 years of valid data available 2007, 2008, and 2009. This data, and data from the Corps' LPMS database, served as the basis for determining the periods when the lock was in standard locking or full open pass mode.

2. Water Level – Navigation Impacts Interplay. The face-to-face meeting referenced above primarily focused on how full open pass locking conditions affect navigation. This is when the lock gates are left fully open primarily to allow excess levels of water to drain from the Mermentau basin. Conversations during the meeting revealed that the interplay of four factors determines whether, and to what degree, a tow is impacted by full open pass conditions at the lock. Each of the four factor is addressed asfollows:

a. Direction of Travel. It was concluded that west bound tows are rarely affected by currents thru the lock. When current speed exceeds 6 mph and an approaching tow is 70 feet wide, it must reconfigure so it is only 35 feet wide for safety reasons. Also, current speeds in excess of 8 mph cause all west bound traffic to wait until current speed decreases to less than 8 mph.

Eastbound traffic is affected much more often during full open pass locking. The degree of effect, if any, is a complex interplay between current speed, tow configuration, and towboat horsepower. This interplay is described in greater detail in the next three subsections.

b. Current Speeds. The participants at the face-to-face meeting were more comfortable discussing potential navigation impacts based on current speed through the lock rather than gage readings at the lock. Since the Corps had historic gage readings, not velocities, it became necessary to convert the gage readings into current speeds. The following levels of impacts based on current speeds were developed for the WAM.

Level 0 – Current speed below 2 mph
Level 1 – Current speed equal to or above 2 mph and below 4 mph
Level 2 – Current speed equal to or above 4 mph and below 6 mph
Level 3 – Current speed equal to or above 6 mph and below 8 mph
Level 4 – Current speed equal to or above 8 mph

c. Tow Configuration. Tow configuration plays a major role in deciding whether a tow is affected by various current speeds. Loaded tows block a larger percentage of the cross-sectional area at the gate monoliths than empty tows. Likewise, wide barges block a larger percentage of the cross- sectional area than narrow barges. As the percentage of cross-sectional area blocked increases, it takes more power to "push the current". Therefore, at any given current speed, it takes more horsepower to push a loaded 54-foot wide tow through the lock than an empty 35-foot wide tow.

d. Towboat Horsepower. Towboat horsepower is another important factor in determining whether a tow is impacted by current speeds. Tables K-27a, 27b, and 27c summarize the rules that were developed. These rules apply to eastbound loaded tows.

Table K-27a. Eastbound 54 Foot Wide Loaded Tow
1 barge wide, 2 barges long

Current Speed (mph)	Minimum HP To Push Through Current
2	1400-1500
4	2000-2400
6	3000-3200
8	Tows will not attempt to push an 8 mph current regardless of HP

Table K-27b. Eastbound 35 Foot Wide Loaded Tow
1 barge wide, 2 barges long

Current Speed (mph)	Minimum HP To Push Through Current
2	800
4	1200-1500
6	1600-1800
8	Tows will not attempt to push an 8 mph current regardless of HP

Table 27c. Eastbound 70 Foot Wide Loaded Tow
2 barge wide, 1 or 2 barges long

Current Speed (mph)	Minimum HP To Push Through Current
2	1200-1500
4	2800-3000; 75% will reconfigure to only one barge wide
6	All will reconfigure to only one barge wide
8	Tows will not attempt to push an 8 mph current regardless of HP

3. Calcasieu Results. This section presents the results of running the Calcasieu version of the WAM under various assumed conditions.

a. Full Operation Condition. Full operation condition is defined as the lock is open and able to pass traffic the entire year, other than minor lock closures due to weather, minor maintenance, and other minor closure events.

Figure K-20 shows the tonnage transit-time curves (commonly referred to as capacity curves) for Calcasieu Lock, Existing Condition, Full Operation scenario, using the 2007 fleet and open pass schedule. One curve assumes there are full open pass drainage impacts during the simulation; the other assumes the historic 2007 full open pass drainage impacts. These two curves are shown together to illustrate the effect full open pass drainage events have on lock operations.

In addition, figure K-20 shows the relevant range of traffic demand. This is the approximate range of tonnage projected to use Calcasieu during the study period. The NIM uses this portion of the curve when modeling traffic at Calcasieu.

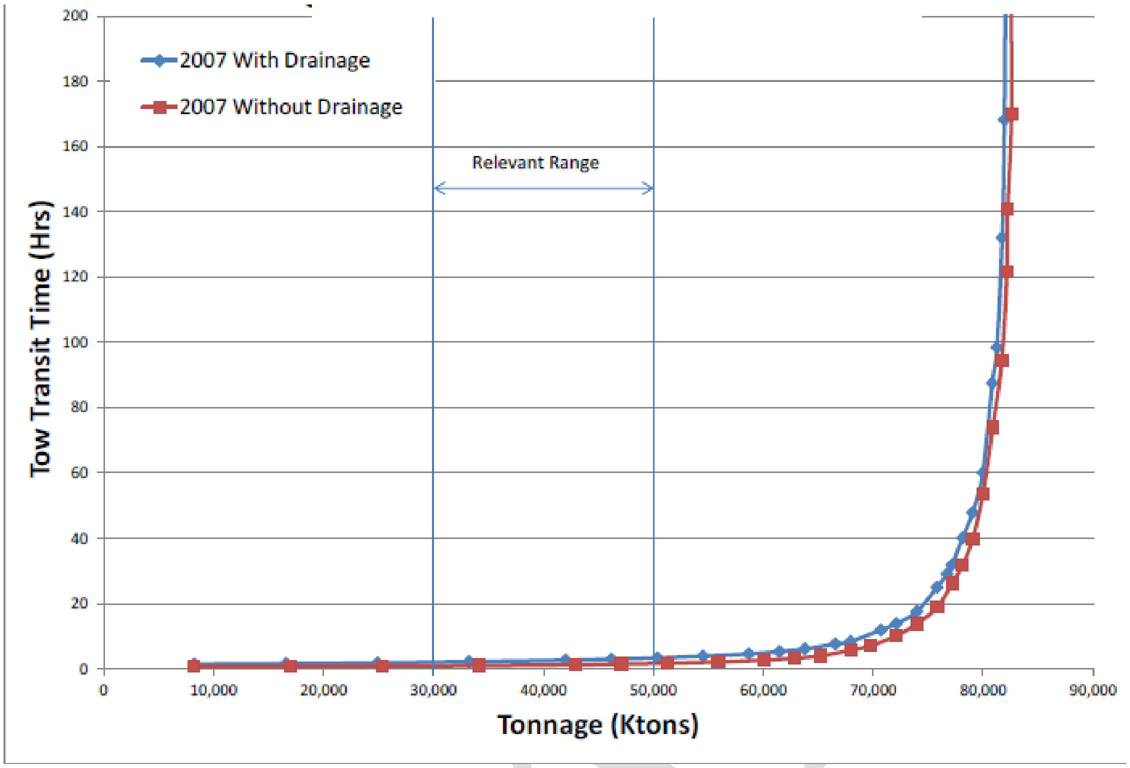


Figure K-20. 2007 Existing Condition Full Operation Capacity Curves With and Without Drainage

In order to more clearly show the effect of full open pass drainage events at Calcasieu, figure K-21 shows the same data as figure K-20, but focuses only on the relevant range of the curves. One can see from this more focused view that drainage events, as they occurred in 2007, nearly double the transit time.

Figures K-22 and K-23 show full operation capacity curves using the 2008 and 2009 fleets and open pass schedules with and without drainage impacts. Figure K-24 shows the averages of the 2007, 2008, and 2009 curves. The NIM economic model uses the data in figure K-24 as input.. Only the relevant ranges are shown in these charts so the reader can focus on the range of traffic used by the NIM economic model.

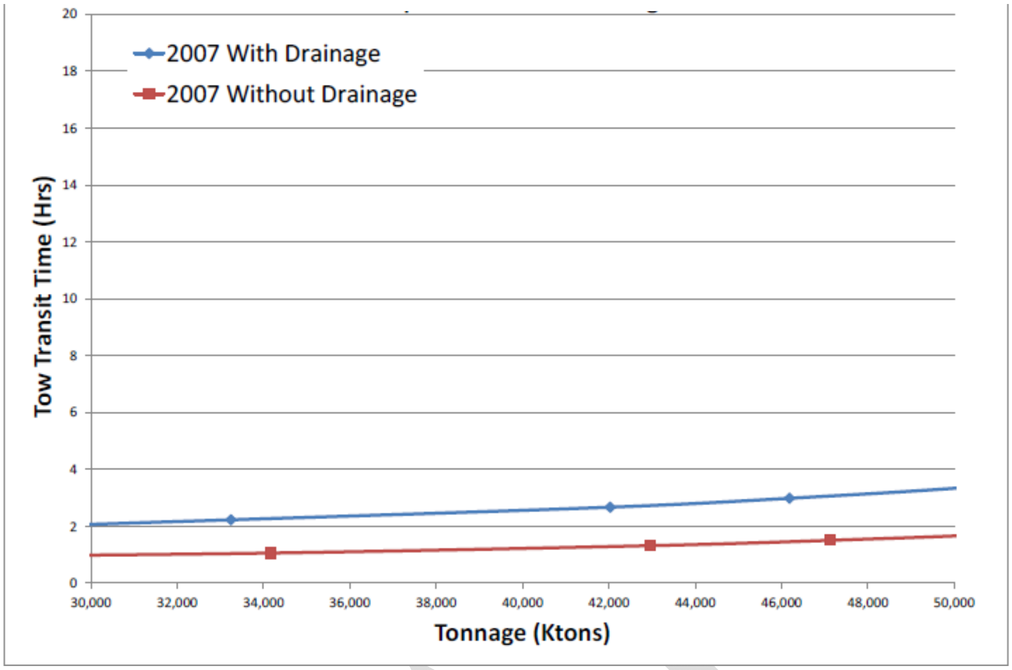


Figure K-21. 2007 Curves With and Without Drainage
Full Operation Relevant Range

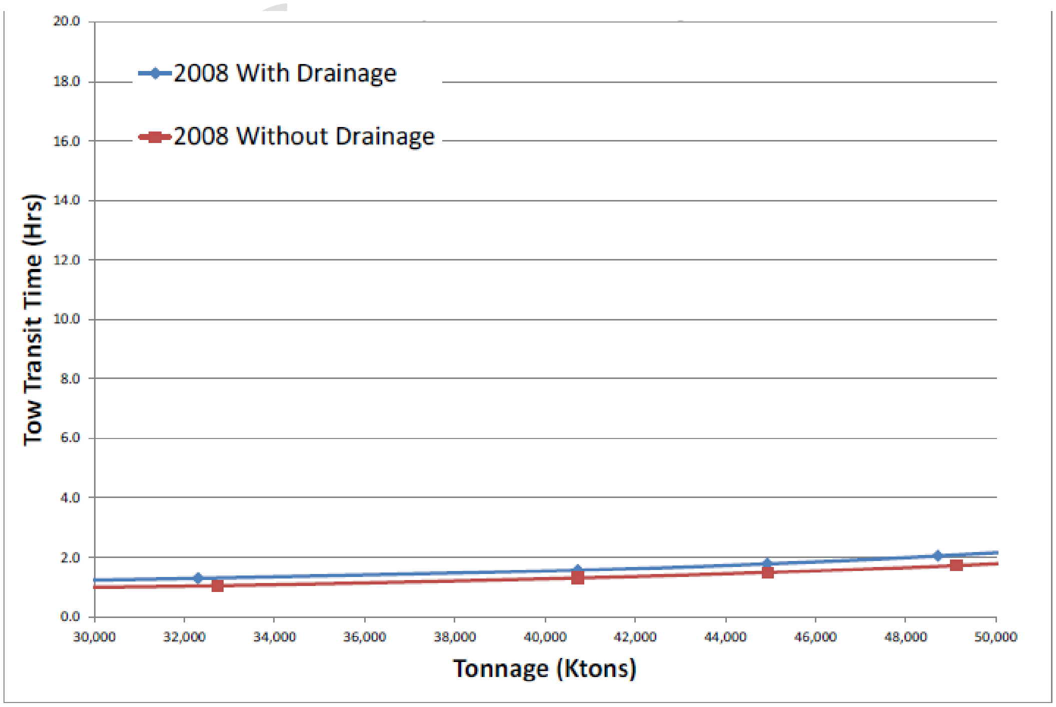


Figure K-22. 2008 Curves With and Without Drainage
Full Operation Relevant Range

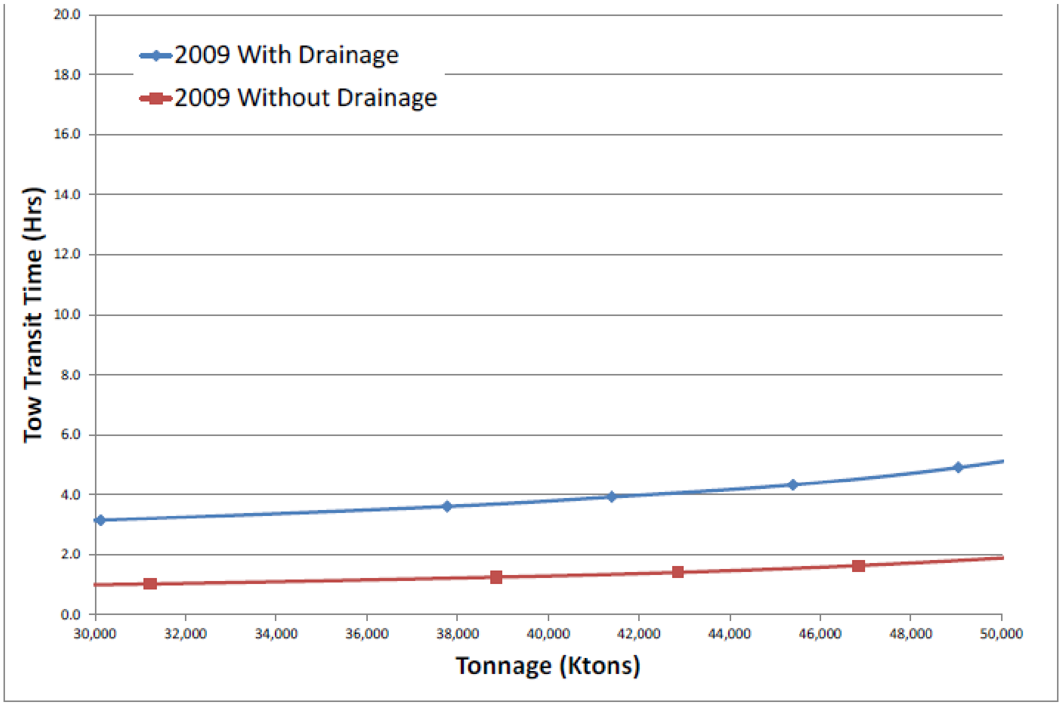


Figure K-23. 2009 Curves With and Without Drainage
Full Operation Relevant Range

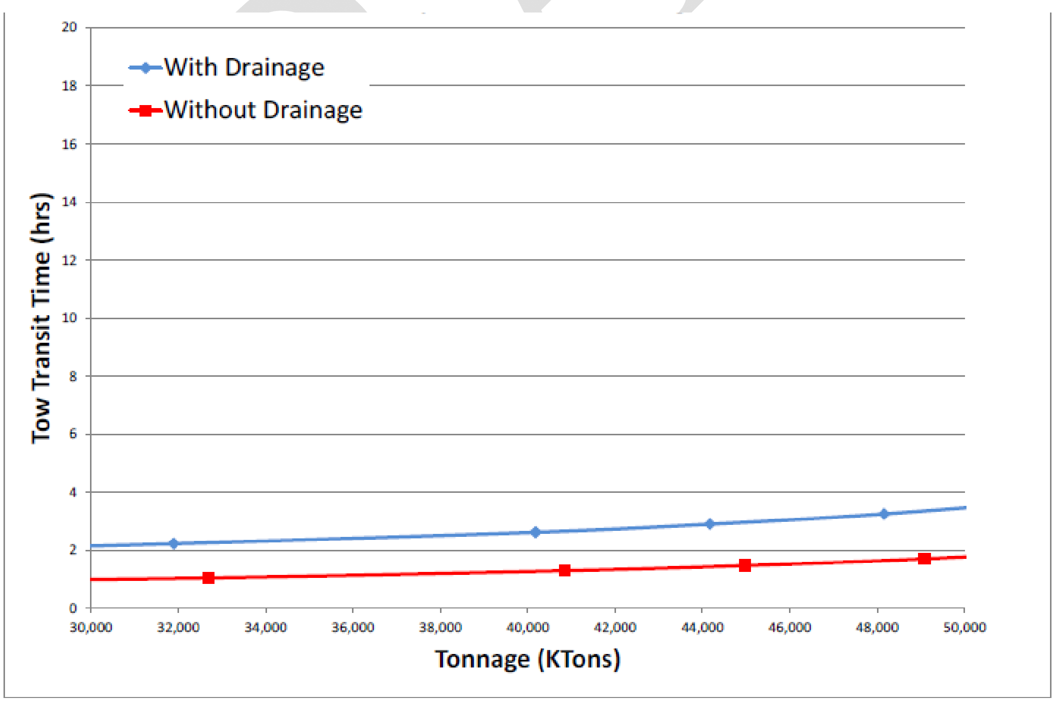


Figure K-24. 3-Year Combined GULFNIM INPUT Curves
Full Operation Relevant Range

With respect to the difference between the “with” and “without” drainage curves for the 3 years shown in figures K-21, K-22, and K-23, at the low end of the relevant range there is about a 1.2 hour difference in 2007, a 0.3 hour difference in 2008, and a 2.1 hour difference in 2009. This substantial difference in drainage effects are explainable by comparing the proportion of time spent at each drainage impact level in those years.

Table K-28 shows the percent of time spent at each drainage impact level. Level 0 means no drainage impact and all tows are able to pass through Calcasieu during full open pass without being impacted. As the drainage impact level increases, the number of tows impacted also increases until at Level 4 essentially all traffic is stopped.

Table K-28. Drainage Impact Level Analysis

Drainage Impact Level	2007 Days Duration	2008 Days Duration	2009 Days Duration
0	81.4%	89.8%	73.7%
1	4.0%	3.4%	4.5%
2	10.0%	4.2%	15.2%
3	4.3%	2.0%	6.5%
4	0.3%	0.6%	0.2%

Table K-28 supports the differences in drainage effects reflected in Figure K-21, Figure K-22, and Figure K-23. That is, the very small drainage effect shown in 2008 is supported by the fact that almost 90 percent of the time the drainage level is at 0. Conversely the large drainage impact shown in 2009 is supported by the fact that the impact level is at 0 only about 74 percent of the time and is at level 2 or 3 almost 22 percent of the time. The conclusion of these observations is that the substantial difference in modeled drainage effects is plausible and explainable.

b. With Drainage Family of Curves. Major maintenance events as well as hurricanes can close the chamber at Calcasieu for extended periods of time. These major closure events must be accounted for in our economic analysis. New Orleans District Operations personnel developed a list of the major closure events that are likely to occur during the planning period of analysis. Table K-29 shows these events.

In order for the NIM model to determine the economic impact of these major closure events, it was necessary to create curves for each of these events. Figure K-24 shows each of the curves developed for the major closure events as well as the Full Operation curve. This grouping of curves, and the data behind them, is known as a Family of Curves. It is this Family of Curves that is used by the NIM to model the Calcasieu Existing condition.

Table K-29. Calcasieu Major Closure Events Analyzed

File Name Code	Work Item	Closure Time (hrs)	Closure Time (days)	Closure Breakouts	Start Month
69Day12-12	Rehabilitation of X Chamber Guidewall (W & E)	828	69	12-hr shifts	Jan
69Day12-12	Rehabilitation of XX Guidewall and Dolphin (SW & NE)	828	69	12-hr shifts	Jan
61Day12-12	Rehabilitation of XX Guidewall and Dolphin (SE & NW)	732	61	12-hr shifts	Jan
10Day24	Hurricane Closure	156	10	24-hr shifts	Aug
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 1st Gate	252	18	24/12-hr shifts	Feb
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 2nd Gate	252	18	24/12-hr shifts	Apr
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 3rd Gate	252	18	24/12-hr shifts	Feb
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 4th Gate	252	18	24/12-hr shifts	Apr
15Day12-12	Rewiring &Machinery Rehabilitation	180	15	12-hr shifts	Apr
13Day12-12	Maintenance by Hired Labor Units	156	13	12-hr shifts	Mar
9Day12-12	Rehabilitation of Face Timber X Chamber Guidewall (W & E)	108	9	12-hr shifts	Jan
7Day12-12	Rehabilitation of Face Timber XX Guidewall (SE & NW)	84	7	12-hr shifts	Jan
5Day12-12	Rehabilitation of Face Timber XX Guidewall (SW & NE)	60	5	12-hr shifts	Jan

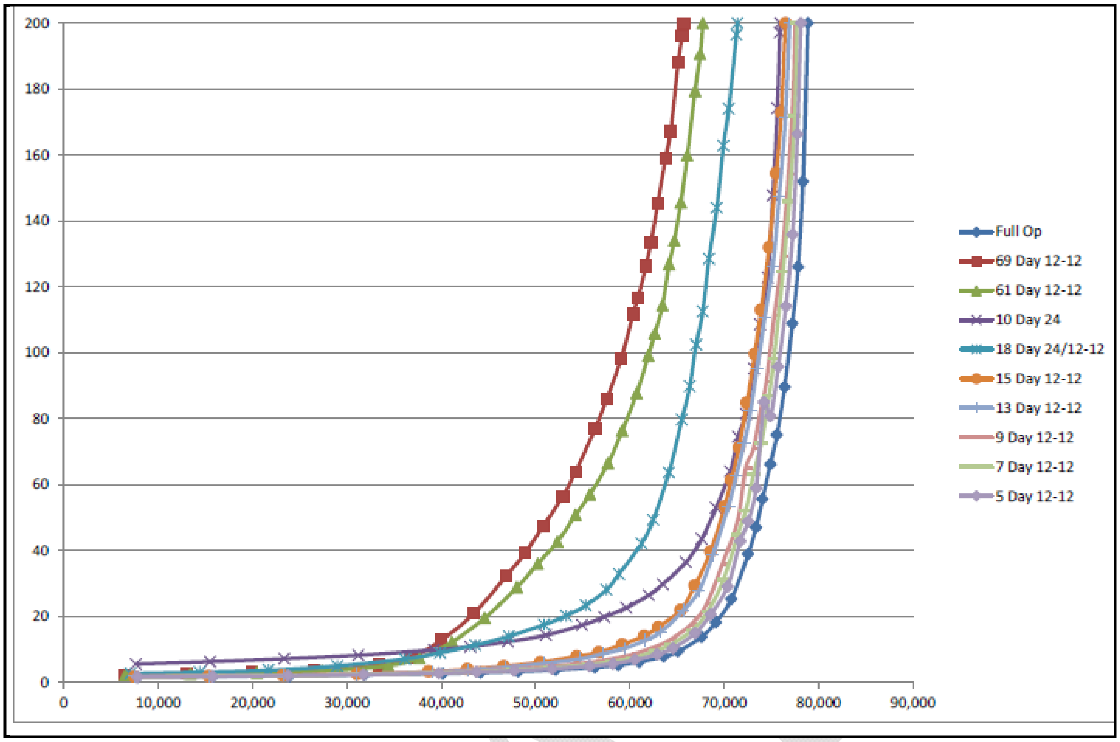


Figure K-25. Existing Condition With Drainage Family of Curves

The curves shown above show the full range of tonnage to transit time relationships for the full operation condition as well as all other conditions required by the NIM economic model. Another way of looking at these conditions is to consider the capacities of each condition. Although lock capacity is not as informative as the tonnage transit-time relationship, the Corps has traditionally published capacity numbers. A project's capacity is defined as the tonnage accommodated by the project when average tow transit time reaches 200 hours per tow. Table K-30 shows the capacities for each with drainage condition analyzed for Calcasieu Lock.

Table K-30. Calcasieu Existing Condition With Drainage Capacities

Condition Code	With Drainage Capacity (Mtons)
Full Operation	78.9
5 Day 12-12	78.1
7 Day 12-12	77.7
9 Day 12-12	77.5
10 Day 24	75.9
13 Day 12-12	76.9
15 Day 12-12	76.5
18 Day 24 12-12	71.4
61 Day 12-12	67.7
69 Day 12-12	65.7

c. Without Drainage Family of Curves. In order to provide a quick means for gauging the economic impact of drainage on navigation at Calcasieu, an additional family of curves was developed assuming no drainage impacts. This family of curves, shown in figure K-26 when compared to the With Drainage family, can provide insight into the possible benefits to be gained from a project that eliminates drainage impacts. Table K-31 shows the capacities for the without drainage conditions analyzed for Calcasieu Lock.

Table K-31. Calcasieu Existing Condition Without Drainage Capacities

Condition Code	With Drainage Capacity (Mtons)
Full Operation	79.9
5 Day 12-12	79.5
7 Day 12-12	78.8
9 Day 12-12	78.5
10 Day 24	76.9
13 Day 12-12	78.4
15 Day 12-12	78.1
18 Day 24 12-12	72.3
61 Day 12-12	68.7
69 Day 12-12	67.3

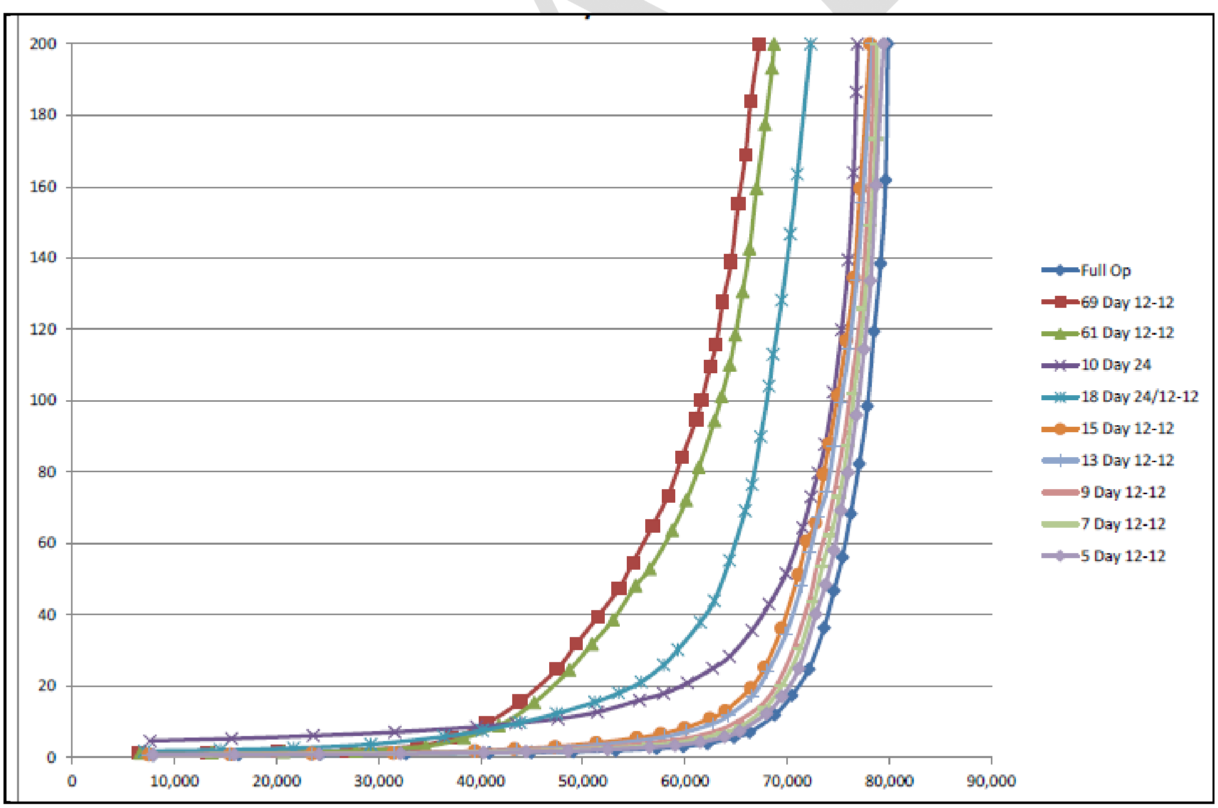


Figure K-26. Existing Condition Without Drainage QLimit Family of Curves

4. Sea Level Rise Implications. Engineering Circular 1165-2-212 provides the Corps guidance for incorporating the direct and indirect physical effects of projected future sea-level change across the project life cycle in planning Corps projects.

In the vicinity of the Calcasieu Lock it has been determined that significant increases in sea levels could occur over the 50 year period of analysis and that these impacts would only be felt on the west side of the lock where the lock is open to Gulf of Mexico influences.

Table K-32 shows the expected sea level rises for the relevant years during the period of analysis by the three sea level rise scenarios. Tables K-33a. 33b, and 33c display resulting impacts to the percent of open pass lockages expected at Calcasieu Lock for the gage years 2007, 2008, and 2009, respectively.

Table K-32. Expected Sea Level Rise by Year and Scenario (Feet)

Year	Low	Medium	High
2017	0.08	0.17	0.29
2042	0.28	0.68	1.32
2067	0.49	1.30	2.82

Table K-33a. Percent of Year Lock is in Open Pass Mode, 2007 Gages

Year	non-SLR	Low SLR	Medium SLR	High SLR
2017	66.0%	60.4%	54.6%	42.2%
2042	66.0%	43.2%	14.7%	2.0%
2067	66.0%	24.4%	2.1%	0.0%

Table K-33b. Percent of Year Lock is in Open Pass Mode, 2008 Gages

Year	non-SLR	Low SLR	Medium SLR	High SLR
2017	60.9%	55.6%	48.8%	37.3%
2042	60.9%	38.0%	15.3%	2.8%
2067	60.9%	23.9%	3.1%	0.0%

Table K-33c. Percent of Year Lock is in Open Pass Mode 2009 Gages

Year	non-SLR	Low SLR	Medium SLR	High SLR
2017	81.0%	76.6%	70.4%	60.6%
2042	81.0%	61.6%	23.0%	3.4%
2067	81.0%	40.8%	3.5%	0.0%

As is shown in tables K-32 and K-33a,33b, and 33c, a sea level rise of 1.30 feet that is expected to occur in the year 2067 causes the percent of open pass lockages to drop to almost zero. This is true not only for the gage year of 2007 but for 2008 and 2009 as well.

This loss of open pass lockages is significant in that if there are no open pass lockages, there can be no drainage impacts to navigation which means the justification for building a project to alleviate drainage impacts no longer exists in the year 2067.

Figure K-27shows the tonnage transit time curves which were developed earlier and the curve for the No Open Pass Lockages condition. The red and green lines were developed earlier and do not include SLR. The blue line represents the No Open Pass Lockages condition.

The difference between the red and green line represents the benefit of building a project that eliminates drainage impacts without regard to sea level rise. If sea levels were to rise by 1.30 feet, the red and green lines would both move into the position of the blue line. The difference between with and without drainage effects would be zero, thereby eliminating the benefit of building a project to reduce drainage effects.

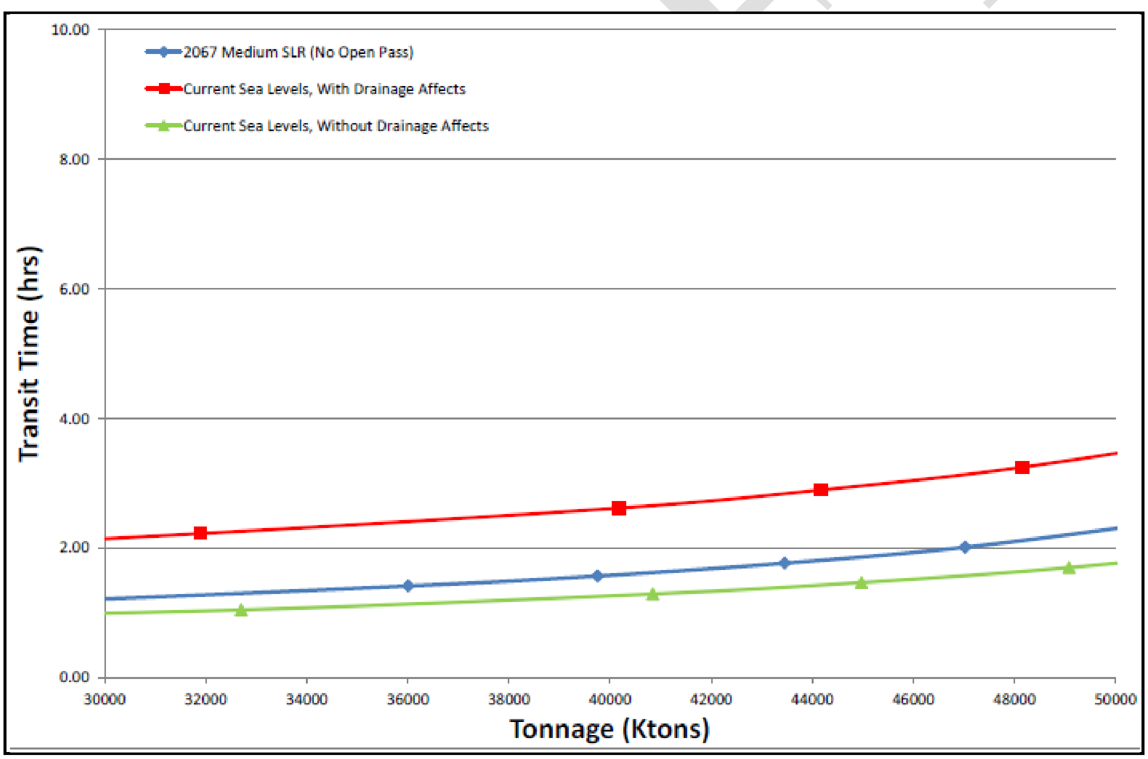


Figure K-27. Comparison of 2067 Sea Level Rise and Drainage Effects Assumptions, 2007-2009 Average

Based on the results of the 2067 sea rise analysis, which indicated there would be essentially zero open pass lockages, the decision was made to look at sea level rises in the middle of the study period, 2042. This way we could gauge how rapidly project benefits would decline as sea levels rise throughout the study period.

The estimated sea level rise for the medium sea level rise scenario is 0.68 feet. The sea level rise impacts were recalculated by adding 0.68 feet to the west gage instead of the 1.30 feet used for 2067. It was found that at a sea level rise of 0.68 feet, the lock would be in open pass mode about 7 percent of the time.

The WAM was rerun for a condition where the lock would be in open pass mode 7 percent of the time. Curves were developed for both the with- and without-drainage impacts conditions. Figure K-28 shows the results.

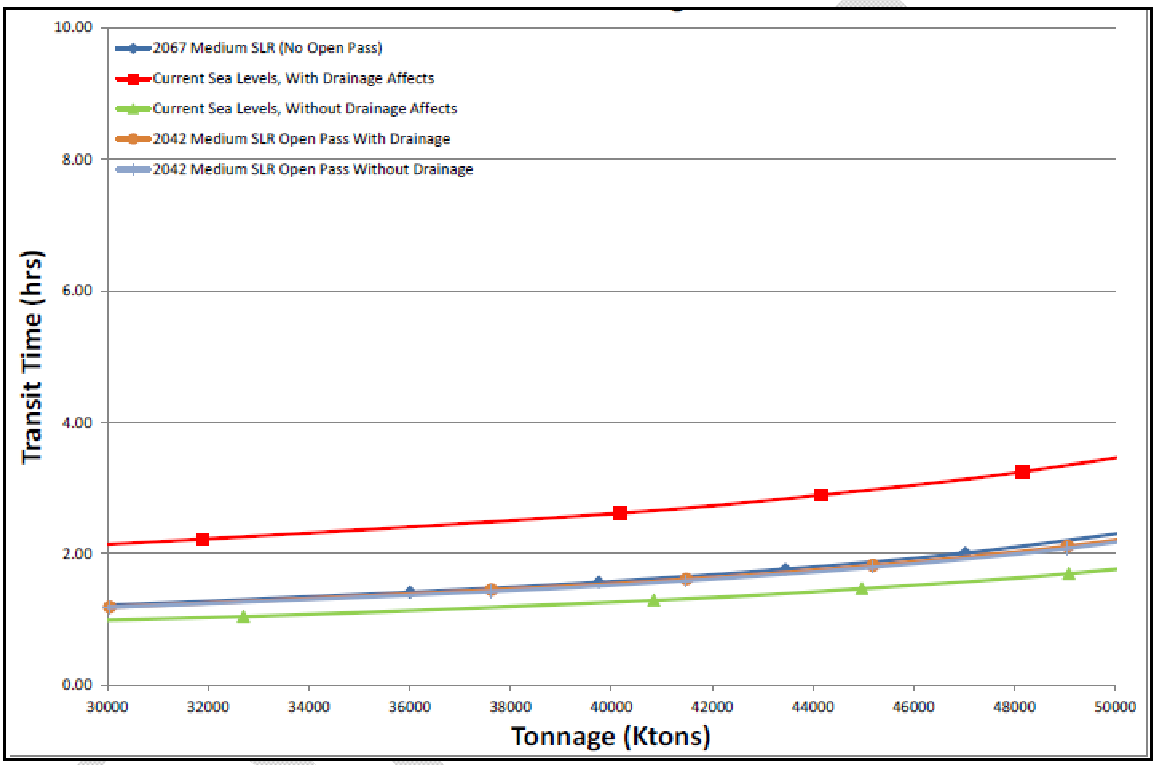


Figure K-28. Comparison of 2042 and 2067 Sea Level Rise and Drainage Effects Assumptions, 2007-2009 Average

At 7 percent open pass, the tonnage transit time curves lie very close to the no open pass curves. This means that by the middle of the study period, most of the benefit of building a project to alleviate drainage impacts would be gone. The results of all the WAM runs for all the different sea level rise assumptions were eventually used as inputs to the NIM.

5. Other Lock Capacities. The previous discussion primarily focuses on Calcasieu Lock but capacity analysis was also performed for the eight other major locks in the GIWW and its alternate route systems. Table K-34 shows the capacities and other information produced for the eight other locks in the system. For a more detailed discussion on how these estimates were developed see Attachment 5, *Calcasieu Lock Feasibility Study Capacity Attachment*.

Table K-34. Other Lock Information and Capacities

Lock Name	Dimensions (feet)	Capacity (Mtons)	Processing Time (min/tow)
Leland Bowman	1200 x 110	86.3	18.8
Bayou Boeuf	1156 x 75	58.5	21.7
Harvey	425 x 75	13.6	38.7
Inner Harbor	640 x 75	25.5	46.1
Algiers	760 x 75	35.2	45.2
Old River	1200 x 75	46.8	43.3
Port Allen	1202 x 84	38.1	76.7
Bayou Sorrel	797 x 56	32.5	60.0

VI. SYSTEM ANALYSIS RESULTS

A. Overview. Given the relatively high traffic capacity of the existing Calcasieu Lock when compared to expected future traffic levels, navigation delays due to insufficient capacity at Calcasieu Lock will not likely be a problem. Therefore, the goal of this study is to determine what alternatives will reduce or eliminate delay cost to navigation at Calcasieu Lock due to the current authorized use of the lock to drain the Mermentau Basin as a result of heavy rains. With that said, NIM was run to estimate the total transportation costs (NED costs) attributable to the Calcasieu lock when used for drainage purposes. These costs to navigation will in turn represent potential NED benefits if alternatives can be found that could eliminate them.

B. NIM Results. Table K-35 displays the average annual cost of operating the Calcasieu Lock for the period 2018 to 2068 assuming no sea-level rise and using the updated low, reference, and high traffic demand forecasts. As shown, costs are divided into Federal costs, the cost of maintaining and repairing the lock, and the cost to commercial transportation. With respect to the cost to commercial transportation, the disruptions due to scheduled maintenance services and unscheduled repair services are isolated and shown separately. As table K-35 shows, assuming the most likely (mid) traffic forecast, drainage events cost the commercial navigation about $3.9 million on an average annual basis. Eliminating these costs would represent a savings to the navigation industry of the same amount.

Table K-35. Existing/Without-Project Condition Costs and Impacts
(Average Annual Estimates, 3.75% discount rate, 2018 base year, FY2013 dollars)

Cost Category	Most-Likely /Expected (Reference)	Forecast Sensitivity Minimum (low traffic forecast)	Forecast Sensitivity Maximum (high traffic forecast)
Federal Costs (Calcasieu Lock only)			
Normal Operations and Maintenance	$303,840	*na*	*na*
Major Maintenance Repairs (scheduled)	$1,558,163	*na*	*na*
Unscheduled Repairs (i.e., hurricane)	$281,898	*na*	*na*
Sub-Total	**$2,143,901**		
Commercial Transportation Costs			
Transit Time Cost (no service disruptions) - At Calcasieu	$6,140,538	$5,376,955	$7,500,795
Transit Time Cost (no service disruptions) - Other Locks	$19,346,722	$12,505,238	$63,772,072
Major Maintenance Service Disruptions (scheduled) [1]	$6,608,370	$4,294,007	$8,525,535
Unscheduled Service Disruptions (i.e., hurricane) [1]	$3,180,312	$2,771,446	$3,905,903
Drainage Event Service Disruptions [2]	**$3,871,895**	**$3,146,730**	**$3,885,398**
Sub-Total	**$39,147,835**	**$28,094,376**	**$87,589,701**
GRAND TOTAL	**$41,291,737**	**$30,238,277**	**$89,733,603**

[1] Includes transit cost changes at all locks in the system and lost barge transportation consumer surplus from diverted tonnage.

[2] Impacts of disruption are from year 2015. Note, all these impacts are not recoverable given construction/implementation time.

Incorporation of Sea Level Rise . Engineering Circular 1165-2-212 provides the Corps guidance for incorporating the direct and indirect physical effects of projected future sea-level change across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining Corps projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. As a result, impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

For this study, as has been discussed in Section 5 of this appendix, the WAM analysis of the sea level rise scenarios indicate significant reduction in Calcasieu Lock open pass and open pass drainage events over the period of analysis. With a reduction in the drainage events, potential benefits from a structural elimination of the drainage event will also erode overtime.

The most accurate way to model the sea level rise effect would be to develop tonnage-transit curves for each annual Calcasieu west gage level and have NIM switch out the tonnage-transit curves each year to the appropriate curves given the sea level rise scenario (low, medium, and high). However, this would require development and loading of hundreds of curves and was judged to be impractical. The method chosen consisted of externally adjusting the latest NIM results (table K-36). In the current Calcasieu analysis, the planning horizon is analyzed assuming the existing open pass drainage events and analyzed assuming elimination of the drainage events but maintaining existing open pass frequencies. The difference between these two scenarios quantifies the impacts of the drainage events and estimates the potential benefits from eliminating drainage events from the project. With sea level rise these benefits will diminish through time. Given that the west gage estimates indicate that open pass will be eliminated from Calcasieu by year 2090 under the low sea level rise scenario, by year 2042 under the medium sea level rise scenario, and by year 2028 under the high sea level rise scenario, the cash flow stream of potential benefits can be linearly reduced through time.

Table K-36 displays the average annual cost of operating the Calcasieu lock for the period 2011 to 2068 assuming the existing sea level remains constant over time and the expected low, medium and high sea level rise forecasts. All estimates were calculated using the most likely (medium) traffic forecast. As shown, the cost of drainage events decrease significantly when sea level rise forecast are included in the analysis. Assuming existing sea levels remain constant over the period of analysis the cost to commercial navigation from drainage events is about $3.9 million on an average annual basis. Assuming sea levels will rise overtime, the cost to commercial navigation on an average annual basis from drainage events decreases to about $2.7 million using the slow (low) sea level rise forecast, $1.2 million for the moderate (mid) level sea level rise forecast and $0.4 million for the rapid (high) sea level rise forecast.

Table K-36. Existing/Future Without-Project Condition Costs and Impacts
Reference Demand Scenario – Sea Level Rise Sensitivity Test
(Average Annual Estimates, 3.75% discount rate, 2018 base year, FY2013 dollars)

		Sea-Level Rise Sensitivity [2]		
Cost Category	**Existing Sea Level**	**Slow**	**Moderate**	**Rapid**
Federal Costs (Calcasieu Lock only)	$303,840	$303,840	$303,840	$303,840
Normal Operations and Maintenance	$1,558,163	$1,558,163	$1,558,163	$1,558,163
Major Maintenance Repairs (scheduled)	$281,898	$281,898	$281,898	$281,898
Unscheduled Repairs (i.e., hurricane)				
Sub-Total	**$2,143,901**	**$2,143,901**	**$2,143,901**	**$2,143,901**
Commercial Transportation Costs				
Transit Time Cost (no service disruptions) - At Calcasieu [3]	$6,140,538	$6,140,538	6,140,538	$6,140,538
Transit Time Cost (no service disruptions) - Other Locks	$19,346,722	$19,346,722	$19,346,722	$19,346,722
Major Maintenance Service Disruptions (scheduled) [1]	$6,608,370	$6,608,370	$6,608,370	$6,608,370
Unscheduled Service Disruptions (i.e., hurricane) [1]	$3,180,312	$3,180,312	$3,180,312	$3,180,312
Drainage Event Service Disruptions [4]	**$3,871,895**	**$2,655,866**	**$1,170,577**	**$ 424,372**
Sub-Total	**$39,147,835**	**$37,931,806**	**$36,446,518**	**$35,700,313**
GRAND TOTAL	**$41,291,737**	**$40,075,708**	**$38,590,419**	**$37,844,214**

[1] Includes transit cost changes at all locks in the system and lost barge transportation consumer surplus from diverted tonnage.

[2] NIM was not exercised for this sensitivity analysis. Drainage event disruption costs were reduced based on a linear reduction of the open pass drainage event cost to zero based on the estimated open pass extinction year.

[3] Transit time costs at Calcasieu Lock will most-likely change as sea level rises. Sea level rise decreases the drainage event gage differential, benefiting vessel transit; however, overall open pass reduction increases transit as more vessels are required to lock.

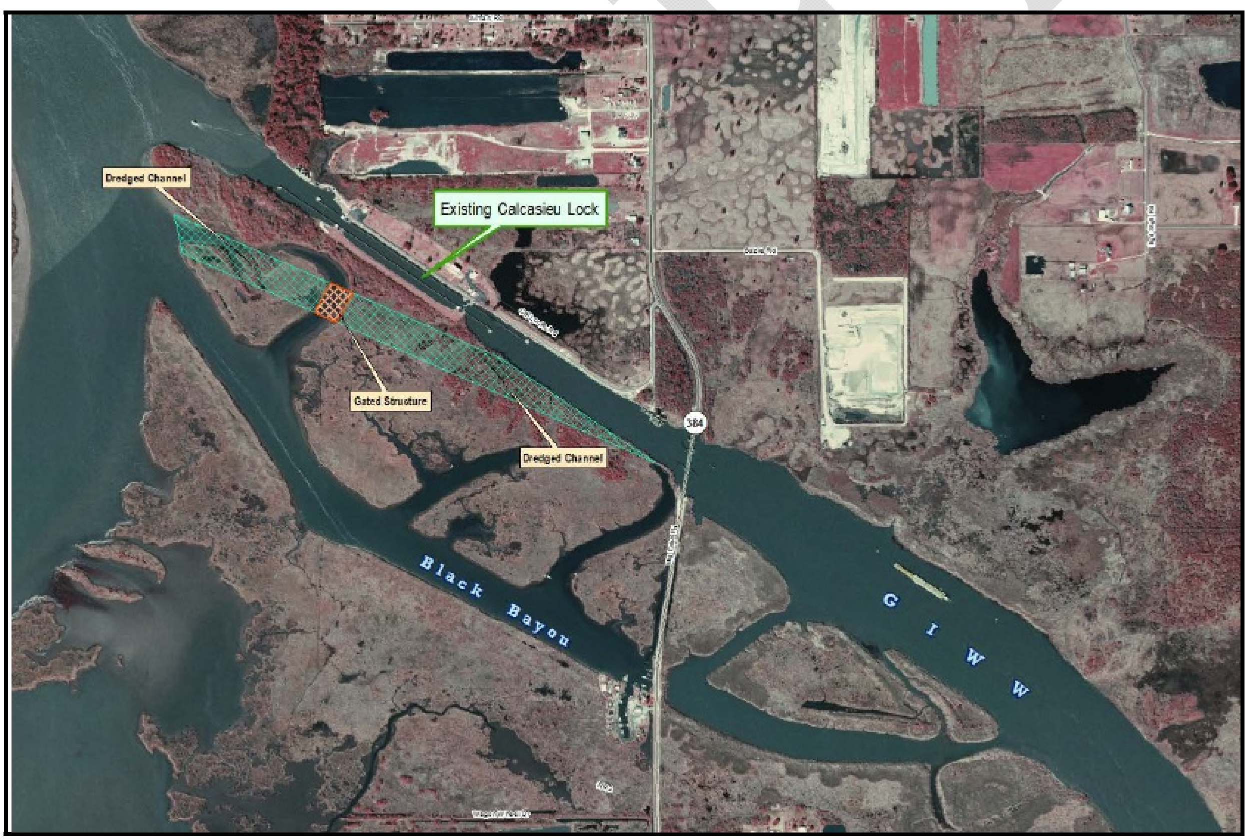
[4] Impacts of disruption are from year 2015. Note, all these impacts are not recoverable given construction/implementation time.

VII. WITH PROJECT COST AND ECONOMIC JUSTIFICATION

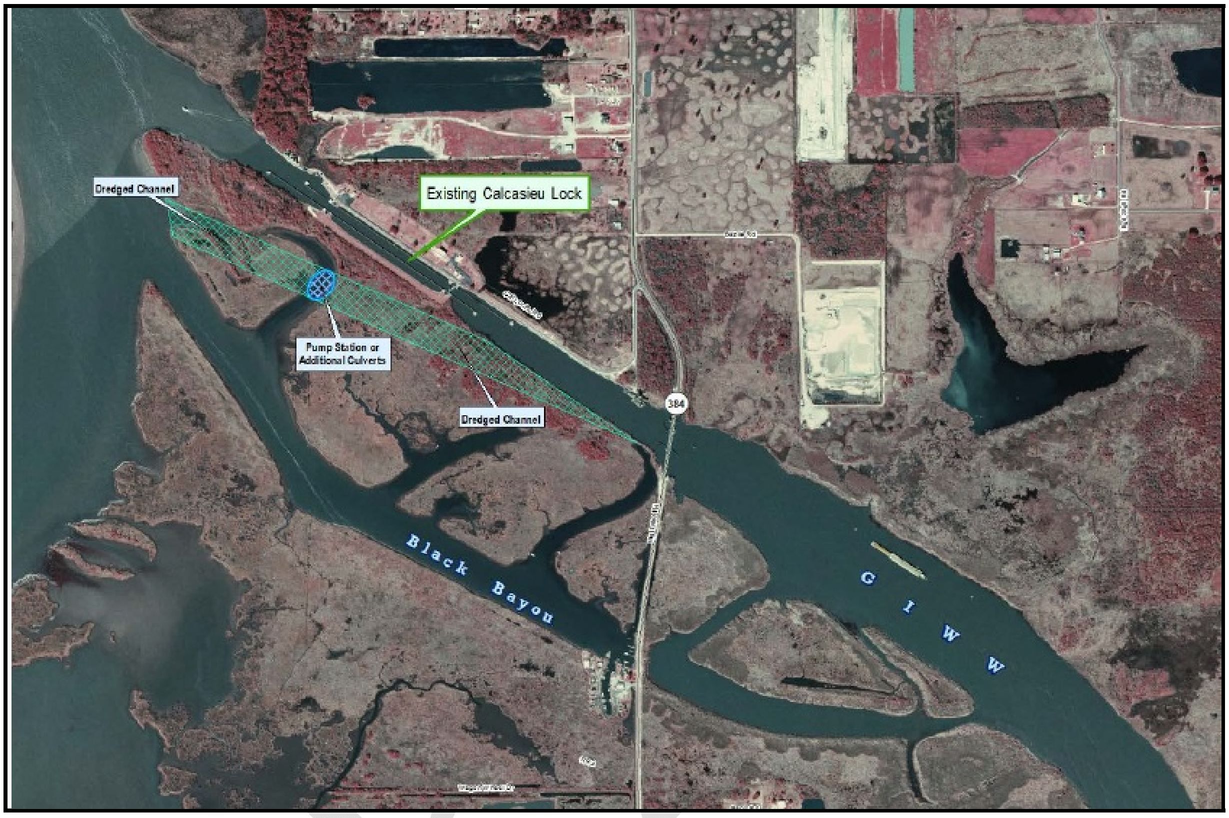
Given the relatively high traffic capacity of the existing Calcasieu Lock when compared to expected future traffic levels, navigation delays due to insufficient capacity at Calcasieu Lock will not likely be a problem. Therefore, the goal of this study is to determine what alternatives will reduce or eliminate delay cost to navigation at Calcasieu Lock due to the current authorized use of the lock to drain the Mermentau Basin as a result of heavy rains. The with-project alternatives selected for this analysis are designed to shift the drainage function away from the existing lock to another structure or location thereby eliminating the impacts to navigation whenever drainage occurs. A description of each alternative follows.

A. With-Project Alternatives

1. Alternative 1. A 75-foot sluice gate located south of the existing lock. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated.



2. Alternative 2. A 3,700 CFS pumping station located south of the existing lock. For safety, a guidewall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated.



3. Alternative 3. Supplemental Culverts would be added to the Black Bayou NRCS structure to increase its capacity. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG. Black Bayou Dredging to the east and west of the NRCS structure will also occur.

4. Alternative 4. A 2,000 CFS Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative will operate in conjunction with the Black Bayou structure.

5. Alternative 5. A 3,700 CFS Pumping Station would be constructed adjacent to and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative will operate independent of the Black Bayou Structure.

B. Project Costs. Construction expenditures by year in 2013 dollars are displayed in table K-37 for each with-project alternative. As shown in table K-37, total costs for the alternatives range from $8.6 million for alternative 3 (Black Bayou Culverts) to $91.4 million for alternative 2 (South 3,700 CFS Pump Station).

Annual Normal Operations, Maintenance and Replacement costs are shown in table K-38, and cyclical maintenance costs are shown in table K-39.

During the construction phase for each alternative, supervisory/administrative and engineering and design work were each estimated to cost 8 percent of the total construction cost. Real estate costs of $86,380 for Alternatives 1 and 2 and $89,380 for Alternatives 3, 4, and 5 were also included in the total project cost along with mitigation costs for forested impacts of $550,000 for alternatives 1 and 2. In addition, it was determined that for alternatives 3 and 4 rehabilitating the existing Black Bayou culverts at a cost of $7,043,000 would also be necessary. All of these costs were spread over the construction period reflecting the distribution of the construction expenditures for each alternative.

Table K-37. Calcasieu Lock Alternative Construction Costs

Year	Alt. 1 – South 75' Gate	Alt. 2 – South 3,700 cfs Pump	Alt. 3 – Black Bayou Culverts	Alt. 4 – Black Bayou 2,000 cfs Pump	Alt. 5 – Black Bayou 3,700 cfs Pump
2015		$27,419,363		$14,758,682	$25,914,197
2016	$8,998,282	$45,698,939	$5,472,334	$24,597,804	$43,190,328
2017	$4,677,862	$18,279,575	$3,137,781	$9,889,121	$17,326,131
TOTAL	$13,676,144	$91,397,877	$8,610,115	$49,245,607	$86,430,656

Table K-38. Calcasieu Lock Alternative Normal O&M Costs

Structure	Alt. 1 – South 75' Gate	Alt. 2 – South 3,700 CFS Pump	Alt. 3 – Black Bayou Culverts	Alt. 4 – Black Bayou 2,000 CFS Pump	Alt. 5 – Black Bayou 3,700 CFS Pump
Lock	$300,000	$300,000	$300,000	$300,000	$300,000
South Gate	$50,000	na	na	na	na
Pump	na	$250,000	na	$250,000	$250,000
Black Bayou	na	na	$20,000	na	na
TOTAL	$350,000	$550,000	$320,000	$550,000	$550,000

Table K-39. Cyclical Maintenance Cost by Alternative

	Without-Project Condition	Alt. 1 South 75' Gate		Alt. 2 South 3,700 CFS Pump		Alt. 3 Black Bayou Culverts		Alt. 4 Black Bayou 2,000 CFS Pump		Alt. 5 Black Bayou 3,700 CFS Pump	
Year	Lock	Lock	South Gate	Lock	Pump	Lock	Black Bayou	Lock	Pump	Lock	Pump
2018	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2019	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2020	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2021	$1,000,000	$1,000,000	$0	$1,000,000	$675,000	$1,000,000	$0	$1,000,000	$675,000	$1,000,000	$675,000
2022	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2023	$825,000	$825,000	$310,000	$825,000	$60,000	$825,000	$310,000	$825,000	$60,000	$825,000	$60,000
2024	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2025	$1,975,000	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0
2026	$6,700,000	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0
2027	$730,000	$730,000	$0	$730,000	$675,000	$730,000	$0	$730,000	$675,000	$730,000	$675,000
2028	$675,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$60,000
2029	$825,000	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0
2030	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2031	$5,700,000	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0
2032	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2033	$975,000	$975,000	$310,000	$975,000	$735,000	$975,000	$310,000	$975,000	$735,000	$975,000	$735,000
2034	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2035	$1,825,000	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0
2036	$1,700,000	$1,700,000	$0	$1,700,000	$675,000	$1,700,000	$0	$1,700,000	$675,000	$1,700,000	$675,000
2037	$1,030,000	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0
2038	$1,275,000	$1,275,000	$1,410,000	$1,275,000	$60,000	$1,275,000	$2,310,000	$1,275,000	$60,000	$1,275,000	$60,000
2039	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2040	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2041	$700,000	$700,000	$0	$700,000	$0	$700,000	$0	$700,000	$0	$700,000	$0
2042	$880,000	$880,000	$0	$880,000	$675,000	$880,000	$0	$880,000	$675,000	$880,000	$675,000
2043	$1,275,000	$1,275,000	$3,310,000	$1,275,000	$60,000	$1,275,000	$310,000	$1,275,000	$60,000	$1,275,000	$60,000
2044	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2045	$5,975,000	$5,975,000	$0	$5,975,000	$675,000	$5,975,000	$0	$5,975,000	$675,000	$5,975,000	$675,000
2046	$5,700,000	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0
2047	$880,000	$880,000	$0	$880,000	$0	$880,000	$0	$880,000	$0	$880,000	$0
2048	$6,675,000	$6,675,000	$1,310,000	$6,675,000	$6,485,000	$6,675,000	$1,310,000	$6,675,000	$6,485,000	$6,675,000	$6,485,000
2049	$975,000	$975,000	$0	$975,000	$0	$975,000	$0	$975,000	$0	$975,000	$0
2050	$1,275,000	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0
2051	$700,000	$700,000	$0	$700,000	$675,000	$700,000	$0	$700,000	$675,000	$700,000	$675,000
2052	$6,730,000	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0
2053	$675,000	$675,000	$310,000	$675,000	$60,000	$675,000	$310,000	$675,000	$60,000	$675,000	$60,000
2054	$825,000	$825,000	$0	$825,000	$675,000	$825,000	$0	$825,000	$675,000	$825,000	$675,000
2055	$2,275,000	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0
2056	$1,700,000	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0
2057	$730,000	$730,000	$0	$730,000	$675,000	$730,000	$0	$730,000	$675,000	$730,000	$675,000
2058	$975,000	$975,000	$1,410,000	$975,000	$60,000	$975,000	$2,310,000	$975,000	$60,000	$975,000	$60,000
2059	$825,000	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0
2060	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2061	$1,000,000	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0
2062	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2063	$675,000	$675,000	$310,000	$675,000	$735,000	$675,000	$310,000	$675,000	$735,000	$675,000	$735,000
2064	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2065	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2066	$700,000	$700,000	$0	$700,000	$675,000	$700,000	$0	$700,000	$675,000	$700,000	$675,000
2067	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2068	$675,000	$675,000	$4,310,000	$675,000	$60,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$60,000

C. Economic Justification. Table K-40 summarizes the annual costs, annual benefits, net benefits, and BCR for each alternative assuming the most likely scenario. In this analysis, the most likely scenario is defined as the reference (mid) traffic forecast with the moderate (mid) sea-level rise assumption. Note that since the total O&M costs for the existing lock are the same in both the without-project and with-project scenarios, these costs effectively cancel each other out when computing the difference and therefore are not shown in the BCR summary tables.

Net benefits represent the difference between total annual benefits and total annual costs. Maximum net benefits define the NED plan.

As table K-40 shows, assuming the most likely scenario, only two of the five with-project alternatives are economically justified. While Alternative 3, *Black Bayou Culverts*, produces $0.16 million in net benefits, net benefits are maximized at $0.19 million with Alternative 1, *South 75' Gate*, producing a BCR of 1.05 to 1.

Table K-40. Average Annual Benefit - Cost Summary
MOST LIKELY SCENARIO - Mid Traffic Forecast and Mid Sea-Level Rise
(Millions of FY2013 dollars, 3.75% discount/amortization rate, 2015-2068 with 2018 base year)

	Alt 1 – South 75' Gate	**Alt 2 - South 3,700 CFS Pump**	**Alt 3 - Black Bayou Culverts**	**Alt 4 - Black Bayou 2,000 CFS Pump**	**Alt 5 - Black Bayou 3,700 CFS Pump**
Construction	$0.625	$4.244	$0.393	$2.286	$ 4.013
Engineering & Design (E&D)	$0.050	$0.340	$0.031	$0.183	$ 0.321
Supervisory/Administration (S&A)	$0.050	$0.340	$0.031	$0.183	$ 0.321
Mitigation	$0.025	$0.026	$-	$ -	$ -
Real Estate	$0.004	$0.004	$0.004	$0.004	$0.004
O&M	$0.232	$0.548	$0.228	$0.597	$0.552
Rehab Existing Black Bayou Structure	NA	NA	$0.321	$0.327	NA
Total Cost	$0.986	$5.500	$1.009	$3.580	$5.211
Total Benefits	$1.171	$1.171	$1.171	$1.171	$1.171
Net Benefits	$0.185	$(4.329)	$0.162	$(2.409)	$(4.040)
Benefit-Cost Ratio (BCR)	1.19	0.21	1.16	0.33	0.22

VIII. SENSITIVITY ANALYSIS

Given the nature and complexity of the benefit measurement procedures, an unavoidable component of uncertainty is implicit in the estimates of project benefits. A single change to any number of parameter values or assumptions holds the potential for significantly affecting benefit estimates and ultimately, in turn, project formulation. The role of sensitivity analysis is to identify those parameters and assumptions with the greatest potential for project formulation impact and to evaluate the magnitude of those impacts for discrete changes in the key parameters. The parameters identified as potentially significant, and consequently incorporated into the sensitivity analysis, include traffic projections, sea-level rise assumptions and the discount rate. In the following paragraphs of this section, the low and high impacts on project benefits and plan formulation resulting from alternative parameter values and assumptions are presented.

A. Low Scenario. For this analysis, the low scenario is defined as the low traffic forecast with the high sea-level rise assumption. As shown in table K-41, both assumptions have a significant impact on the with-project benefits for each of our alternatives. Average annual benefits decreased from $1.17 million in the most likely scenario to $0.36 million in the low scenario causing none of the alternatives to be economically justified.

B. High Scenario. The high scenario is defined as the high traffic forecast with a no sea-level rise assumption. As shown in table K-42, both assumptions also have a significant impact on the with-project benefits for each of our alternatives. Average annual benefits increased from $1.17 million in the most likely scenario to $3.89 million in the high scenario causing now three of the five alternatives to be economically justified with Alternative 1 still producing the highest net benefits.

C. Alternative Discount Rate – 7.0%. Throughout this study the current federal discount rate of 3.75 percent was used in determining average annual costs and benefits. In order to explore the implications on alternative interest rates on NED plan selection, the Office of Management and Budget (OMB) prescribed interest rate of 7.0 percent was applied and the results are presented in table K-43. As shown, under the most likely scenario, Alternatives 1 and 3 are economically justified with net benefits of $0.05 million and $0.02 million, respectively.

Table K-41. Average Annual Benefit - Cost Summary
Low Scenario - Low Traffic Forecast and High Sea-Level Rise
(Millions of FY2013 dollars, 3.75% discount/amortization rate, 2015-2068 with 2018 base year)

	Alt 1 – South 75' Gate	**Alt 2 - South 3,700 CFS Pump**	**Alt 3 - Black Bayou Culverts**	**Alt 4 - Black Bayou 2,000 CFS Pump**	**Alt 5 - Black Bayou 3,700 CFS Pump**
Construction	$0.625	$4.244	$0.393	$2.286	$4.013
Engineering & Design (E&D)	$0.050	$0.340	$0.031	$0.183	$0.321
Supervisory/Administration (S&A)	$0.050	$0.340	$0.031	$0.183	$0.321
Mitigation	$0.025	$0.026	$-	$ -	$ -
Real Estate	$0.004	$0.004	$0.004	$0.004	$0.004
O&M	$0.232	$0.548	$0.228	$0.597	$0.552
Rehab Existing Black Bayou Structure	NA	NA	$0.321	$0.327	NA
Total Cost	**$0.986**	**$5.500**	**$1.009**	**$3.580**	**$5.211**
Total Benefits	**$0.357**	**$0.357**	**$0.357**	**$0.357**	**$0.357**
Net Benefits	**$(0.629)**	**$(5.143)**	**$(0.652)**	**$(3.223)**	**$(4.854)**
Benefit-Cost Ratio (BCR)	**0.36**	**0.06**	**0.35**	**0.10**	**0.07**

Table K-42. Average Annual Benefit - Cost Summary
High Scenario - High Traffic Forecast and No Sea-Level Rise
(Millions of FY2013 dollars, 3.75% discount/amortization rate, 2015-2068 with 2018 base year)

	Alt 1 – South 75' Gate	Alt 2 - South 3,700 CFS Pump	Alt 3 - Black Bayou Culverts	Alt 4 - Black Bayou 2,000 CFS Pump	Alt 5 - Black Bayou 3,700 CFS Pump
Construction	$0.625	$4.244	$0.393	$2.286	$4.013
Engineering & Design (E&D)	$0.050	$0.340	$0.031	$0.183	$0.321
Supervisory/Administration (S&A)	$0.050	$0.340	$0.031	$0.183	$0.321
Mitigation	$0.025	$0.026	$-	$ -	$ -
Real Estate	$0.004	$0.004	$0.004	$0.004	$ 0.004
O&M	$0.232	$0.548	$0.228	$0.597	$ 0.552
Rehab Existing Black Bayou Structure	NA	NA	$0.321	$0.327	NA
Total Cost	**$0.986**	**$5.500**	**$1.009**	**$3.580**	**$5.211**
Total Benefits	**$3.885**	**$3.885**	**$3.885**	**$3.885**	**$3.885**
Net Benefits	**$2.899**	**$(1.615)**	**$2.876**	**$0.305**	**$(1.326)**
Benefit-Cost Ratio (BCR)	**3.94**	**0.71**	**3.85**	**1.09**	**0.75**

Table K-43. Average Annual Benefit - Cost Summary
MOST LIKELY SCENARIO - Mid Traffic Forecast and Mid Sea-Level Rise
(Millions of FY2013 dollars, 7.00% discount/amortization rate, 2015-2068 with 2018 base year)

	Alt 1 – South 75' Gate	**Alt 2 - South 3,700 CFS Pump**	**Alt 3 - Black Bayou Culverts**	**Alt 4 - Black Bayou 2,000 CFS Pump**	**Alt 5 - Black Bayou 3,700 CFS Pump**
Construction	$1.037	$7.142	$0.652	$3.848	$6.754
Engineering & Design (E&D)	$0.083	$0.571	$0.052	$0.308	$0.540
Supervisory/Administration (S&A)	$0.083	$0.571	$0.052	$0.308	$0.540
Mitigation	$0.042	$0.043	$-	$ -	$-
Real Estate	$0.007	$0.007	$0.007	$0.007	$0.007
O&M	$0.205	$0.506	$0.193	$0.542	$0.509
Rehab Existing Black Bayou Structure	NA	NA	$0.533	$0.550	NA
Total Cost	**$1.456**	**$8.841**	**$1.489**	**$5.563**	**$8.351**
Total Benefits	**$1.509**	**$1.509**	**$1.509**	**$1.509**	**$1.509**
Net Benefits	**$0.053**	**$(7.332)**	**$0.020**	**$(4.054)**	**$(6.842)**
Benefit-Cost Ratio (BCR)	**1.04**	**0.17**	**1.01**	**0.27**	**0.18**

April 2013

ATTACHMENT 1

UPDATED VESSEL TRAFFIC FORECAST FOR THE GIWW AS IT RELATES TO THE CALCASIEU LOCK

US Army Corps of Engineers
New Orleans District
New Orleans, Louisiana

Final Report

UPDATED VESSEL TRAFFIC FORECAST FOR THE GIWW AS IT RELATES TO THE CALCASIEU LOCK

JESCO-N.O. Contract No. W912P8-10-D-0016
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U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

April 2013

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report updates the previous report from January 2011 very long term forecast of vessel traffic for the GIWW as it relates to the Calcasieu Lock. Nearly all of the tables and figures from the January 2011 report have been updated to include more recent historical data now available for calendar years 2009, 2010 and 2011. The forecast period which extended from 2009 to 2060, using year 2008 as the baseline in the January 2011report now extends from 2012 to 2061 using year 2011 as the baseline. Two new tables have been created (tables 3-9 and 3-10) to display the low and high forecasted tonnages for the Calcasieu Lock based on high world oil prices and low other dry bulk (Table 3-9) and low world oil prices and high other dry bulk (Table 3-10). The two interim reports that pertain to historical data and trends for waterborne commercial traffic and shippers using Calcasieu Lock (June 2010) and industry supply-demand issues affecting the production and consumption for commodities relevant to Calcasieu Lock (October 2010) that served as inputs to the January 2011 forecast have not been updated except for contents which were explicitly used in the January 2011 forecast.

The most current U.S. Energy Information Administration (EIA) long term annual energy forecasts, "Annual Energy Outlook, 2012", (released in the latter part of 2012 for 2011-2035) are an expression of how the natural gas revolution, characterized by proliferation in increased exploration and production, has thus far to date affected the annual EIA projections (2010 versus 2012). The current EIA 2012 forecasts show a distinctly different rate of real growth for chemicals compared to the stagnation and decline of this sector in the earlier 2010 forecast.

The previous report (January 2011) that is updated here forecasted commodity tonnages at Calcasieu Lock. The prior forecast indicated that the commodity group chemicals started at 9.450 million tons (2008) peaked at 9.471 million tons at 2021 and subsequently steadily declined to 8.564 million tons by the end of the EIA projections at 2035. Extrapolating the EIA downward trend line forward to 2060 the chemical tonnages decline to 6.469 million tons.

The updated forecast (January 2013) indicates that the commodity group chemicals at Calcasieu Lock start at 9.302 million tons (2011), peak at 11.495 million tons at 2029 and subsequently decline to 11.404 million tons by the end of the EIA projections at 2035.

The updated chemical forecast is substantially different (higher) as a result based on EIA forecasts 2012 versus 2010. The prior forecast for chemicals (2011) had relatively small growth compared to a long term decline starting in 2021. The updated forecast for chemicals (2013) has a net increase between 2011 and 2061 of 2.102 million tons (11.404 – 9.320 = 2.102).

However, the relatively more robust forecast of real growth for chemicals as updated (2013), versus secular decline from the previous forecast (2011), did not transpose to the petrochemicals commodity group when comparing the 2012 versus 2010 EIA forecasts. The 2013 forecasted commodity tonnages for the petrochemicals group are very similar to 2011 forecasted tonnages based on EIA forecasts in 2012 and 2010, respectively. Petrochemicals tonnages transiting Calcasieu Lock were 16.755 million tons in 2008 and projected to grow to 16.576 million tons in 2035 at the end of the EIA forecast (2010). As updated by the EIA 2012 forecast petrochemicals tonnages transiting Calcasieu Lock were 16.229 million tons in 2011 projected to increase to 16.893 million tons by 2035at the end of the EIA forecast (2012).

Accordingly, the increased growth of the chemicals commodity group in the updated forecast has not been accompanied by a similar resurgence in the petrochemicals sector. Consequently, for the biggest single commodity group, petrochemicals, defined by total annual tons transiting Calcasieu Lock (and the GIWW), there is nearly "no growth" since petrochemical tonnages increase only 0.664 million by 2035 compared to 2011 (16.893 – 16.229 = 0.664). For the second largest commodity group transiting Calcasieu Lock, chemicals, there is modest positive growth which is relatively significant growth when compared to the absolute decline in tonnage projected in 2011 based on EIA 2010 forecasts and trends extrapolated beyond 2035.

Nearly half of the forecasted growth in Calcasieu total lock tonnage between 2011 and 2061, 4.507 million tons (42.490 – 37.983 = 4.507), comes from growth in chemicals (2.102 million tons). Petrochemical total tonnages increase 0.664 million tons from 2011 to 2061. Total annual tonnages of aggregates increase 1.891 million tons (4.309 – 2.418 = 1.891) from 2011 to 2061. Total growth in these three commodity groups accounts for 4.657 million tons (2.102 + 0.664 + 1.891 = 4.657) which is offset by forecasted decline in crude petroleum between 2011 (4.035 million tons) and 2061 (3.885 million tons). Crude petroleum is projected to grow in the early stages of the forecast, peaking at 5.002 million tons in 2020. The overall decline in crude petroleum between 2011 and 2061 is 0.150 million tons (4.035 – 3.885 = 0.150). The net increase of total annual Calcasieu Lock commodity tonnage (with rounding) of 4.507 million tons represents the net growth in chemicals, petrochemicals and aggregates, 4.657 million tons, less the decrease in crude petroleum, 0.150 million tons (4.507 = 4.657 – 0.150).

Figure ES-1 compares the total annual tonnages forecasted for Calcasieu Lock for the period 2011 – 2061 as updated (2013) with the forecasted total annual lock tonnages from the previous (2011) forecast. The 2011 forecast exhibits a modest increase in total tonnage from 37.000 million in 2011 to 39.122 million by 2035 and then declining to 38.614 million by 2060. The updated (2013) forecast exhibits a more substantial increase in total tonnage from 37.983 million tons in 2011 to 42.123 million tons in 2035 and then very slow growth thereafter to 42.490 million tons in 2061. The slow growth for the updated forecast after 2035 is attributable to constant values for the two largest commodity groups, petrochemicals and chemicals, after 2035 while there is a slight decline in crude oil tons projected after 2035.

From Figure ES-1 it seems clear that the updated forecast (2013) is substantially higher than the 2011 forecast for the EIA period of projections, 2011-2035. Maintaining the EIA constant values for the two major commodity groups, petrochemicals and chemicals, after 2035 results in a slow taper growth for the updated forecast (2013) unlike the slow tapered decline in the 2011 forecast after 2035.

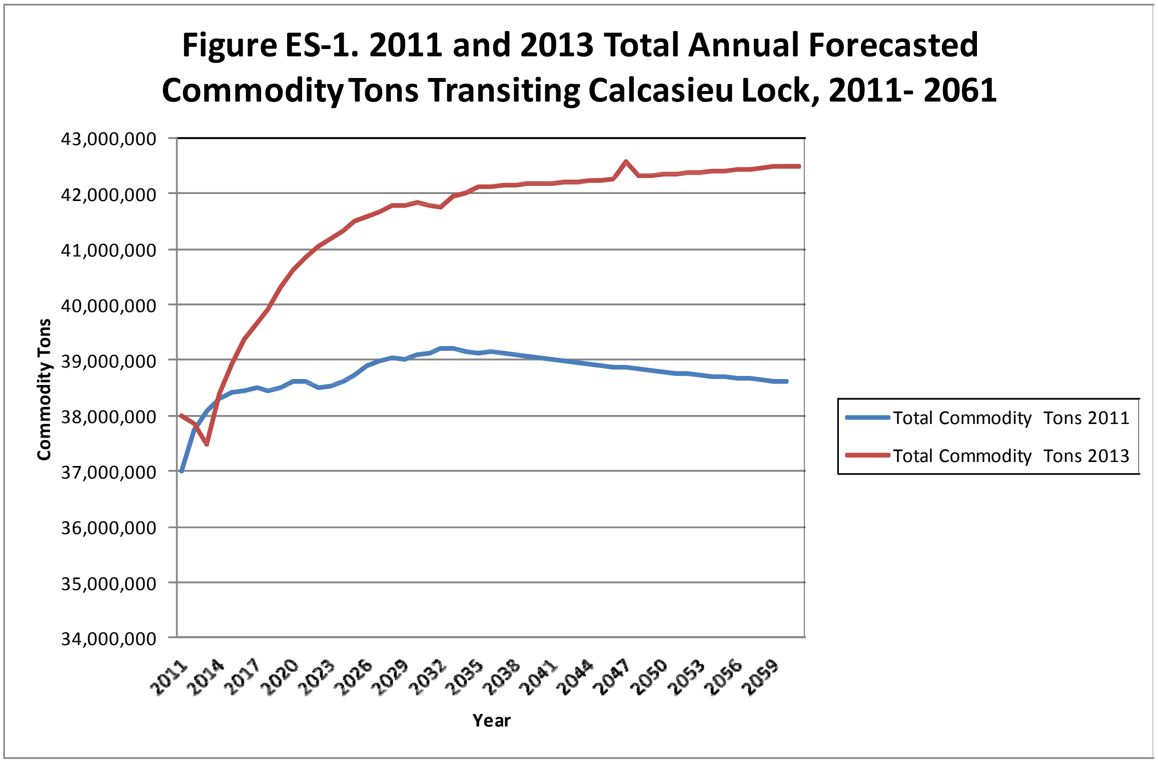

Figure ES-1. 2011 and 2013 Total Annual Forecasted Commodity Tons Transiting Calcasieu Lock, 2011- 2061
43,000,000
42,000,000
41,000,000
40,000,000
39,000,000
38,000,000
37,000,000
36,000,000
35,000,000
34,000,000
Commodity Tons
2011
2014
2017
2020
2023
2026
2029
2032
2035
2038
2041
2044
2047
2050
2053
2056
2059
Year
Total Commodity Tons 2011
Total Commodity Tons 2013

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UPDATED VESSEL TRAFFIC FORECAST FOR THE GIWW

UPDATED VESSEL TRAFFIC FORECAST FOR THE GIWW AS IT RELATES TO THE CALCASIEU LOCK

Section 1. INTRODUCTION

The vessel traffic forecasts for the GIWW and Calcasieu Lock were submitted as a revised draft report in January 2011. Very long term forecasts of energy used to project the majority of the commodity tonnages transiting the lock, consisting of petroleum and petrochemicals, are based on U.S. Department of Energy projections, Energy Information Administration (EIA), Annual Energy Outlook (AEO). The EIA projections were for the period 2010 through 2035 from the 2010 AEO. The AEO is released annually, usually in early part of the year as an "advance" release that contains only the baseline (reference case) and then subsequently the full release later in the year that contains any revisions to the reference case as well as the high and low forecast cases.

The 2010 AEO was based primarily on energy trends and developments prior to that year. Significantly, the very recent developments in natural gas extraction, "fracking" had not been fully implemented in the vast new onshore domestic gas fields and reflected in the AEO projections. Table 1-1 contains the projected natural gas prices from the 2010 and 2012 AEO. The 2010 AEO shows continually rising natural gas prices based on 2010 index value (2010 = 100) increasing to 1.39 (2015), 1.48 (2020), 1.55 (2025), 1.79 (2030) and 1.97 (2035). Subsequently, the 2012 AEO projects substantially lower gas prices that display little or no increase between 2010 and 2020 and thereafter are projected at levels substantially less than projected in 2010 AEO such as 1.28 (2025), 1.43 (2030) and 1.68 (2035).

Table 1-1. Natural Gas Prices and Production Forecast

Prices (2010 dollars per million Btu)	2010	2015	2020	2025	2030	2035
2010 Energy Outlook	$4.50	$6.27	$6.64	$6.99	$8.05	$8.88
2012 Energy Outlook	$4.39	4.29	4.58	$5.63	$6.29	$7.37
2010 Outlook Growth Indices (2010=100)	1.00	1.39	1.48	1.55	1.79	1.97
2012 Outlook Growth Indices (2010=100)	1.00	0.98	1.04	1.28	1.43	1.68
Dry Production (Trillion cubic feet) 4/	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
United States Total 2010 Energy Outlook	20.01	19.29	19.98	21.31	22.38	23.27
Lower 48 Onshore 2010 Energy Outlook	17.01	16.09	16.23	15.96	16.59	17.07
United States Total 2012 Energy Outlook	21.58	23.65	25.09	26.28	26.94	27.93
Lower 48 Onshore 2012 Energy Outlook	18.66	21.48	22.48	23.64	24.11	24.97
United States 2010 Outlook Growth Indices (2010=100)	1.00	0.96	1.00	1.07	1.12	1.16
Lower 48 Onshore 2010 Outlook Growth Indices (2010=100)	1.00	0.95	0.95	0.94	0.98	1.00
United States 2012 Outlook Growth Indices (2010=100)	1.00	1.10	1.16	1.22	1.25	1.29
Lower 48 Onshore 2012 Outlook Growth Indices (2010=100)	1.00	1.15	1.20	1.27	1.29	1.34

Source: Table 14 Oil and Gas Supply from 2010 and 2012 Annual Energy Outlook.

The distinctly lower natural gas prices are a result of a substantial increase in domestic production from advances in extraction (fracking) technology. Table 1 compares the AEO natural gas production forecasts from 2010 and 2012 releases. The 2010 AEO shows relatively constant domestic onshore production or slightly declining onshore domestic production compared to 2010 index value (2010 = 100) decreasing to 0.95 in 2015 and 2020, 0.94 in 2025, 0.98 in 2030 and 1.00 in 2035. Comparatively, the 2012 AEO shows continually rising onshore domestic natural gas production compared to 2010 index value (2010 = 100) rising to 1.15 in 2015, 1.20 in 2020, 1.27 in 2025, 1.29 and 2030 and 1.34 in 2035.

It is evident that there has been a significant paradigm shift akin to a “game changer” for domestic natural gas in terms of significantly increased production (upward) and decreased prices (downward) when the 2010 and 2012 AEO forecasts are compared. The changes in natural gas markets have significant spill over impacts on the major commodity sectors, petro chemicals (heavily dependent upon natural gas as feedstock for production of basic chemicals), using the GIWW and transiting Calcasieu Lock. Table 1-2 contains the AEO bulk chemical projections for the period 2010 through 2035. The 2010 AEO used for the GIWW/Calcasieu Lock projections show a slight increase in bulk chemical production after 2010 index value (2010 = 100) rising to 1.13 (2015), 1.14 (2020) and then declining to 1.11(2025), 1.06 (2030) and 1.00 (2035). Essentially, there is no sustained growth in bulk chemical production using the 2010 AEO beyond 2035. Conversely, the 2012 AEO shows sustained growth in bulk chemical industry from an index value of 1.00 (2010) to 1.14 (2020), 1.22 (2025), 1.24 (2030) and 1.23 (2035). Consequently, while the 2010 AEO extrapolated beyond 2035 had constant or declining bulk chemical production compared to 2010 the 2012 AEO suggests sustained increases in production that would continue beyond 2035. This distinction has important implications for very long term forecasts of waterway traffic beyond 2035.

Table 1-2. Bulk Chemical Industry Energy Consumption Forecasts

Value of Shipments	2010	2015	2020	2025	2030	2035
2010 Energy Outlook (2000 Billion $)	191.23	215.69	218.5	212.49	202.43	190.61
2012 Energy Outlook (2005 Billion $)	275.82	276.81	315.68	337.63	341.69	340.05
2010 Outlook Growth Indices (2010=100)	1.00	1.13	1.14	1.11	1.06	1.00
2012 Outlook Growth Indices (2010=100)	1.00	1.00	1.14	1.22	1.24	1.23

Source: Table 37 Bulk Chemical Industry Energy Consumption from 2010 and 2012 Annual Energy Outlook.

Consequently, there is every reason to expect that the 2012 AEO energy and related forecasts used in place of the 2010 AEO energy and related forecasts would result in a very different forecast for GIWW/Calcasieu Lock. This is particularly the case for extrapolations of the AEO forecasts beyond 2035 to cover the time frame of 50-year with-project conditions commencing in 2022. Moreover, there have been increases in the base line lock tonnages compared to those used from 2009 for the 2010 Calcasieu Lock projections. The Calcasieu Lock tonnages used as the 2009 base line totaled 33.0 million tons, a decrease from 38.4 and 41.7 million tons in 2008 and 2007, respectively. Calcasieu Lock tonnages increased to 37.0 and 36.7 million tons in 2010 and 2011, respectively.

The improved base line tonnage for both Calcasieu Lock is an important contrast with the decided downward trend of declining lock tonnages associated with the recession and prior to the recent paradigm shift in natural gas production (upward) and prices (downward). There is evidence that the shift in natural gas supply and price will foster redevelopment of the domestic petro chemical sector in the Gulf Coast such as plant expansions and new development. These developments were not in place when the 2010 forecast was being prepared by EIA in 2009.

METHODOLOGY

The 2010 AEO projections are updated with the 2012 projections to update the vessel traffic forecast as it relates to the GIWW and Calcasieu Lock. The 2010 AEO related tables as contained in the January 2011 draft report are updated with current data from the 2012 AEO reference case and associated high and low forecasts. The tonnages for the Calcasieu Lock are updated to reflect the addition of calendar years 2009, 2010 and 2011. The corresponding commodity growth rates for the GIWW are likewise updated.

RESULTS

This updated report is submitted in the same format as 2011 with regard to forecasts (tables and figures) to reflect the same methodology and inputs revised to the current AEO (2012).[1]

The time frame for with-project conditions is assumed to be 2022 for Calcasieu Lock. Accordingly, the updated forecasts are prepared for each of the major commodity groups annually as presented in the 2011 draft report for the period 2011 (baseline) through 2061 (refer to Section 2). In addition a high and low set of forecasts based on EIA scenarios are presented for sensitivity analyses (refer to Section 3). The updated forecasts of lockages by commodity and barges/tows are presented in Section 4. Finally, Section 5 as updated presents the GIWW tonnage forecast indices for the period 2011 through 2061. All tables and figures for the sections are included in the Appendix.

Section 2: REFERENCE CASE

All of the tables and figures from the January 2011 report are reproduced as updated with additional commodity lock tonnages for calendar years 2009, 2010 and 2011 and or the more recent AEO 2012 Annual Energy Outlook (2011-2035) replacing the prior AEO 2010 Annual Energy Outlook (2008-2035). The tables pertaining to the detailed disaggregation of chemicals, tables 2-9, 2-10, 2-11, and 2-12, have not been updated. Otherwise tables 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-13, 2-14, 2-15, 2-16, 2-17, 2-18, 2-19, 2-20, 2-21, 2-22, 2-23, 2-24, and 2-25 have been updated.

Similarly, the updated figures include figures 2-1, 2-2, 2-3, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12 and 2-13. Figure 2-4 is not updated.

Section 3: HIGH AND LOW CASES

All of the tables and figures from the January 2011 report are reproduced as updated with additional commodity lock tonnages for calendar years 2009, 2010 and 2011 and or the more

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[1] Tables 3-9 and 3-10 are a compendium of Calcasieu Lock tonnages 2011-2061 for the high and low world oil prices and low and high other dry bulk commodities (exclusive of aggregate) which were not specifically compiled in the 2011 report.

recent AEO 2012 Annual Energy Outlook (2011-2035) replacing the prior AEO 2010 Annual Energy Outlook (2008-2035). All of section three tables are updated including tables 3-1, 3-2, 3-3, 3-4, 3-5, 3-6, 3-7, and 3-8. Tables 3-9 and 3-10 were developed for the updated sensitivity analysis for the AEO scenarios for low and high world oil prices (which are generally favorable and unfavorable to demand for petrochemicals and chemicals, respectively) and high and low values of other dry bulk commodities exclusive of aggregates.

Similarly, the updated figures include figures 3-1 through 3-15. Figure 3-16 is not updated.

Section 4: BARGES AND LOCKAGES

All of the tables and figures from the January 2011 report are reproduced as updated with the more recent AEO 2012 Annual Energy Outlook (2011-2035) replacing the prior AEO 2010 Annual Energy Outlook (2008-2035). All of the section four tables are updated including tables 4-1, 4-2, 4-3, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9, 4-10, 4-11, and 4-12.

Similarly, figures 4-1 and 4-2 are updated for total annual number of forecasted loaded barges, and total annual number of forecasted lockages, 2011 through 2061.

Section 5: GIWW COMMODITY TONNAGE INDICES

All of the tables of indices from the January 2011 report are reproduced as updated with the more recent AEO 2012 Annual Energy Outlook (2011-2035) replacing the prior AEO 2010 Annual Energy Outlook (2008-2035). Tables 5-6 (reference case), 5-7 (high forecast) and 5-8 (low forecast) replace the corresponding tables in the 2011 report.

Section 6: UPDATED 2013 VERSUS PREVIOUS 2011 FORECASTS

The most current EIA long term annual energy forecasts released in the latter part of 2012 for 2011-2035 are an expression of how the natural gas revolution, characterized by proliferation of exploration and increased production, has thus far to date affected the annual EIA projections (2010 versus 2012). The EIA 2012 forecasts show a distinctly different rate of real growth for chemicals compared to the stagnation and decline of this sector in the earlier 2010 forecast.[2]

Table 2-25 from the January 2011 report contained the long term commodity tonnages projected for Calcasieu Lock, 2008-2060. The previous forecast for the commodity group chemicals at Calcasieu Lock started at 9.450 million tons (2008) peaked at 9.471 million tons at 2021 and subsequently steadily declined to 8.564 million tons by the end of the EIA projections at 2035. Extrapolating the EIA long term downward trend line forward to 2060 the chemical tonnages were projected to further decline to 6.469 million tons.

[2] The EIA projections appear to have lagged the paradigm shift in natural gas exploration and production resulting in very low energy prices not anticipated as recently as three years ago. Such an evolution in shifts in raw materials supply normally require a sufficient time frame to fully incorporate into long term investment and production decisions as well as forecasts based on adjustments to past trends that reflect a different supply curve as in the case of natural gas. It is entirely possible that in the near term future EIA long term annual energy forecasts will further capture increased domestic chemicals production resulting from a continuation of very low natural gas prices relative to just a few years ago.

Table 2-25 as updated (January 2013) for the long term commodity tonnages projected for Calcasieu Lock indicates that the commodity group chemicals at Calcasieu Lock start at 9.302 million tons (2011), peak at 11.495 million tons at 2029 and subsequently decline to 11.404 million tons by the end of the EIA projections at 2035. Given the small decline so late in the forecast after 2029 the update froze the 2035 tonnage and carried this value forward as a constant to 2061. The alternative would have been to show a slight annual decline based on EIA projected declines after forecasted annual chemical tonnages peak at 11.495 million in 2029, thence declining as follows (millions of annual tons): 11.549 – 2030; 11.434 – 3031; 11.417 – 2032; 11.414 – 2033; 11.405 – 2034; and 11.404 – 2035.

The updated chemical forecast is substantially different (higher) as a result based on EIA forecasts 2012 versus 2010. In the previous 2011 forecast there is small growth of total chemical tonnages at Calcasieu Lock compared to a long term decline starting in 2021. The updated forecast (2013) for chemicals has a net increase between 2011 and 2061 of 2.102 million tons (11.404 – 9.320 = 2.102).[3]

However, the relatively more robust forecast in terms of real growth for chemicals as updated (2013), versus secular decline from the previous forecast (2011), did not transpose to the petrochemicals commodity group when comparing the 2012 versus 2010 EIA forecasts. The 2013 forecasted commodity tonnages for the petrochemicals group are very similar to 2011 forecasted tonnages based on EIA projections in 2012 and 2010, respectively. Petrochemicals tonnages transiting Calcasieu Lock were 16.755 million tons in 2008 and projected to slightly decline to 16.576 million tons by 2035 at the end of the EIA forecast (2010). Rather than decline 0.179 million tons between 2008 and 2035 (16.755 – 16.576 = 0.179) the updated forecast has petrochemicals increasing. As updated by the EIA 2012 forecast petrochemicals tonnages transiting Calcasieu Lock were 16.229 million tons in 2011 projected to increase to 16.893 million tons by 2035 for a net increase of 0.664 million tons (16.893 – 16.229 = 0.664).

Accordingly, the growth of the chemicals commodity group in the updated forecast has not been accompanied by a similar resurgence in the petrochemicals sector, although there is now projected small growth (2013) versus small decline (2011) in petrochemicals. Consequently, for the biggest single commodity group defined by total annual tons transiting Calcasieu Lock (and the GIWW), petrochemicals, (actually a collection of components which are forecasted separately before compiled as “petrochemicals”) there is nearly "no growth" since petrochemical tonnages increase 0.664 million by 2035 compared to 2011 (16.893 – 16.229 = 0.664). For the second largest commodity group transiting Calcasieu Lock, chemicals, there is modest positive growth but really significant growth when compared to the absolute decline in chemicals tonnage projected in 2011 based on EIA 2010 forecasts and trends extrapolated beyond 2035.

Nearly half of the forecasted growth in Calcasieu total lock tonnage between 2011 and 2061, 4.507 million tons, (42.490 – 37.983 = 4.507) comes from growth in chemicals (2.102 million

[3] Chemical industry literature has addressed the “game changer” of low cost natural gas for new investments in domestic chemical production, including basic chemicals which as recent as two and three years ago were assumed to drift overseas because of lower cost natural gas.

tons). Petrochemical total tonnages increase 0.664 million tons from 2011 to 2061.[4] Total annual tonnages of aggregates increase 1.891 million tons (4.309 – 2.418 = 1.891) from 2011 to 2061. Total growth in these three commodity groups accounts for 4.657 million tons (2.102 + 0.664 + 1.891 = 4.657) which is offset by forecasted decline in crude petroleum between 2011 (4.035 million tons) and 2061 (3.885 million tons). Crude petroleum is projected to grow in the early stages of the forecast, peaking at 5.002 million tons in 2020. The overall decline in crude petroleum between 2011 and 2061 is 0.150 million tons (4.035 – 3.885 = 0.150). Conversely the 2011 forecast showed a slight increase in crude tonnage albeit on a lower baseline.[5] The net increase of total annual Calcasieu Lock commodity tonnage (with rounding) of 4.507 million tons represents the net growth in chemicals, petrochemicals and aggregates, 4.657 million tons less the decrease in crude petroleum, 0.150 million tons (4.507 = 4.657 – 0.150).

Figure 6-1 compares the total annual tonnages forecasted for Calcasieu Lock for the period 2011 – 2061 as updated (2013) with the forecasted total lock tonnages from the previous (2011) forecast. The 2011 forecast exhibits a modest increase in total tonnage from 37.000 million in 2011 to 39.122 million by 2035 and then declining to 38.614 million by 2060. The increase in total tonnage over the entire forecast is 1.614 million tons (38.614 - 37.000 = 1.614). The updated (2013) forecast exhibits a more substantial increase in total tonnage of 4.140 million tons between 2011 and 2035 (42.123 – 37.983 = 4.140). After 2035 there is very slow growth from 42.123 million tons in 2035 to 42.490 million tons in 2061. Overall growth for the updated forecast 2011 – 2061 is 4.507 million tons (42.490 – 37.983 = 4.507). The slow growth for the updated forecast after 2035 is attributable to constant values for the two largest commodity groups, petrochemicals and chemicals, after the EIA projections cease in 2035 while there is a slight decline in crude oil tons projected after 2035.

From Figure 6-1 it seems clear that the updated forecast is substantially higher than the 2011 forecast for the EIA period of projections, 2011-2035. Maintaining the EIA constant values for the two major commodity groups, petrochemicals and chemicals, after 2035 results in a slow tapered positive growth unlike the slow tapered negative growth in the 2011 forecast after 2035.

[4] The lack of clear trends in EIA projections for the individual components of "petrochemicals" resulted in extrapolating the 2035 values forward as constants through year 2061.

[5] The 2011 forecast showed crude petroleum tonnage growing from 2.961 million tons in 2008 to 3.062 million tons in 2011, peaking at 3.756 million tons in 2032 and declining to 3.305 million tons by 2060.

Appendix

TABLES and FIGURES

Section 2:
TABLES AND FIGURES

Table 2-1. Calcasieu Lock Commodity Annual Tonnages, 2000-2011

Commodity Name	2000 (Tons)	2001 (Tons)	2002 (Tons)	2003 (Tons)	2004 (Tons)	2005 (Tons)	2006 (Tons)	2007 (Tons)	2008 (Tons)	2009 (Tons)	2010 (Tons)	2011 (Tons)	Average 2000-2011
Coal	263,667	218,097	233,790	298,483	314,704	360,228	412,618	358,339	401,744	150,923	148,328	65,342	268,855
Grains	455,592	327,530	348,279	341,957	392,267	239,415	187,952	185,258	152,309	205,022	295,419	259,732	282,561
Nonmetallic Minerals	1,537,504	1,003,857	987,579	1,584,080	2,355,859	1,805,015	1,497,855	1,047,621	876,419	486,470	743,314	693,218	1,218,233
Iron & Steel	2,775,952	2,261,417	1,791,745	2,355,408	2,626,277	2,673,106	2,553,349	3,110,369	3,124,990	1,144,518	1,973,946	2,625,761	2,418,070
Others	2,345,247	2,156,574	1,795,840	1,689,696	1,964,212	2,108,748	2,559,798	1,972,458	2,209,396	1,479,581	1,906,481	1,809,828	1,999,822
Subtotal	7,377,962	5,967,475	5,157,233	6,269,624	7,653,319	7,186,512	7,211,572	6,674,045	6,764,858	3,466,514	5,067,488	5,453,881	6,187,540
Chemicals	11,836,112	10,604,598	10,623,857	11,560,708	11,634,545	11,007,073	11,291,209	11,113,735	9,450,630	8,534,844	9,180,318	9,302,012	10,511,637
Petroleum Products	14,409,733	15,425,635	15,730,826	14,669,469	16,890,179	15,877,402	16,569,967	17,860,399	16,755,583	17,683,157	18,533,930	16,229,684	16,386,330
Crude Petroleum	3,430,354	3,619,149	4,064,812	4,072,039	3,785,353	2,632,493	3,112,266	3,086,868	2,961,038	3,185,560	3,004,397	4,035,558	3,415,824
Subtotal Liquids	29,676,199	29,649,382	30,419,495	30,302,216	32,310,077	29,516,968	30,973,442	32,061,002	29,167,251	29,403,561	30,718,645	29,567,254	30,313,791
Aggregates	1,766,323	1,373,274	1,550,368	1,842,836	2,032,370	2,020,070	1,812,076	2,264,282	1,907,430	776,300	1,055,345	1,454,903	1,654,631
Grand Total	38,820,484	36,990,131	37,127,096	38,414,676	41,995,766	38,723,550	39,997,090	40,999,329	37,839,539	33,646,375	36,841,478	36,476,038	38,155,963

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-2. Calcasieu Lock Commodity Annual Tonnage Distributions, 2000-2011

Commodity Name	2000 (Tons)	2001 (Tons)	2002 (Tons)	2003 (Tons)	2004 (Tons)	2005 (Tons)	2006 (Tons)	2007 (Tons)	2008 (Tons)	2009 (Tons)	2010 (Tons)	2011 (Tons)
Coal	0.68%	0.59%	0.63%	0.78%	0.75%	0.93%	1.03%	0.87%	1.06%	0.45%	0.40%	0.18%
Grains	1.17%	0.89%	0.94%	0.89%	0.93%	0.62%	0.47%	0.45%	0.40%	0.61%	0.80%	0.71%
Nonmetallic Minerals	3.96%	2.71%	2.66%	4.12%	5.61%	4.66%	3.74%	2.56%	2.32%	1.45%	2.02%	1.90%
Iron & Steel	7.15%	6.11%	4.83%	6.13%	6.25%	6.90%	6.38%	7.59%	8.26%	3.40%	5.36%	7.20%
Others	6.04%	5.83%	4.84%	4.40%	4.68%	5.45%	6.40%	4.81%	5.84%	4.40%	5.17%	4.96%
Subtotal	19.01%	16.13%	13.89%	16.32%	18.22%	18.56%	18.03%	16.28%	17.88%	10.30%	13.75%	14.95%
Chemicals	30.49%	28.67%	28.61%	30.09%	27.70%	28.42%	28.23%	27.11%	24.98%	25.37%	24.92%	25.50%
Petroleum Products	37.12%	41.70%	42.37%	38.19%	40.22%	41.00%	41.43%	43.56%	44.28%	52.56%	50.31%	44.49%
Crude Petroleum	8.84%	9.78%	10.95%	10.60%	9.01%	6.80%	7.78%	7.53%	7.83%	9.47%	8.15%	11.06%
Subtotal Liquids	76.44%	80.15%	81.93%	78.88%	76.94%	76.22%	77.44%	78.20%	77.08%	87.39%	83.38%	81.06%
Aggregates	4.55%	3.71%	4.18%	4.80%	4.84%	5.22%	4.53%	5.52%	5.04%	2.31%	2.86%	3.99%
Grand Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: G.E.C., Inc.

Table 2-3. Calcasieu Lock Commodity Annual Tonnage Average Annual Compound Growth Rates, 2000-2011

Commodity Name	2000 (Tons)	2001 (Tons)	2002 (Tons)	2003 (Tons)	2004 (Tons)	2005 (Tons)	2006 (Tons)	2007 (Tons)	2008 (Tons)	2009 (Tons)	2010 (Tons)
Coal	-11.91%	-11.35%	-13.21%	-17.29%	-20.11%	-24.76%	-30.83%	-34.65%	-45.41%	-34.20%	-55.95%
Grains	-4.98%	-2.29%	-3.21%	-3.38%	-5.72%	1.37%	6.68%	8.81%	19.47%	12.55%	-12.08%
Nonmetallic Minerals	-6.99%	-3.63%	-3.86%	-9.81%	-16.03%	-14.74%	-14.28%	-9.81%	-7.52%	19.37%	-6.74%
Iron & Steel	-0.50%	1.51%	4.34%	1.37%	0.00%	-0.30%	0.56%	-4.15%	-5.64%	51.47%	33.02%
Others	-2.33%	-1.74%	0.09%	0.86%	-1.16%	-2.52%	-6.70%	-2.13%	-6.43%	10.60%	-5.07%
Subtotal	-2.71%	-0.90%	0.62%	-1.73%	-4.72%	-4.49%	-5.43%	-4.92%	-6.93%	25.43%	7.62%
Chemicals	-2.17%	-1.30%	-1.47%	-2.68%	-3.15%	-2.77%	-3.80%	-4.35%	-0.53%	4.40%	1.33%
Petroleum Products	1.09%	0.51%	0.35%	1.27%	-0.57%	0.37%	-0.41%	-2.37%	-1.06%	-4.20%	-12.43%
Crude Petroleum	1.49%	1.10%	-0.08%	-0.11%	0.92%	7.38%	5.33%	6.93%	10.87%	12.55%	34.32%
Subtotal Liquids	-0.03%	-0.03%	-0.32%	-0.31%	-1.26%	0.03%	-0.92%	-2.00%	0.46%	0.28%	-3.75%
Aggregates	-1.75%	0.58%	-0.70%	-2.91%	-4.66%	-5.32%	-4.30%	-10.47%	-8.63%	36.90%	37.86%
Grand Total	-0.56%	-0.14%	-0.20%	-0.65%	-1.99%	-0.99%	-1.83%	-2.88%	-1.22%	4.12%	-0.99%

Source: G.E.C., Inc.

Table 2-4. Petroleum Products Shipped through Calcasieu Lock from 2000-2011

WCSC Commodity Name/*EIA Equivalent*	Commodity	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fuel Oils, NEC/*Residual Fuel Oil*	Petroleum Products	3,326,791	2,721,631	2,894,345	3,131,446	3,611,303	3,280,988	2,888,826	3,185,129	3,262,852	3,142,715	3,431,081	2,950,146
Other Light Oils from Petroleum & Bitum Minerals/*Fuel Oils, excluding Redsidual Fuel Oil*	Petroleum Products	995,111	1,240,076	1,685,588	1,690,509	1,789,866	1,831,683	2,603,097	3,131,521	2,801,633	2,709,245	2,990,753	2,258,573
Gas Oils/*Distillate Diesel Oil*	Petroleum Products	1,423,392	1,769,489	1,862,502	1,801,999	2,498,312	2,109,220	2,395,597	2,333,096	2,374,985	2,296,667	2,535,305	1,914,625
Other Medium Oils from Petroleum & Bitum Minerals/*Napthas & solvents (petro feedstocks)*	Petroleum Products	1,271,327	2,072,569	1,910,458	1,968,873	2,490,213	2,025,809	1,882,144	1,820,701	1,891,030	2,367,295	1,917,006	1,959,457
Gasoline Including Aviation (Except Jet)/*Motor and Aviation Gasoline*	Petroleum Products	2,412,851	2,663,001	2,370,617	1,761,236	2,289,479	1,953,476	1,731,114	2,012,818	1,710,910	2,069,833	2,321,640	1,997,677
Lubricating Petroleum Oils from Petrol & Bitum Min/*Lubricants*	Petroleum Products	1,487,499	1,545,392	1,691,376	1,451,029	1,441,098	1,558,200	1,587,050	1,717,304	1,567,783	1,982,155	1,810,600	1,932,303
Petro.Bitumen, Petro. Coke, Asphalt, Butumen mixes NEC/*Petroleum Coke*	Petroleum Products	1,020,819	1,311,362	1,251,727	1,255,986	1,290,896	1,053,256	1,000,106	862,660	891,458	766,642	852,506	681,132
Hydrocarbon & Petrol Gases, Liquefied and Gaseous/*Liquified Refinery Gases*	Petroleum Products	918,366	830,908	423,433	433,893	373,883	489,985	411,708	651,705	659,383	555,030	784,459	470,635
Pitch & Pitch Coke from Coal Tar/Oth Mineral Tars/*Other*	Petroleum Products	788,932	418,023	669,344	529,094	295,029	466,297	441,575	477,787	529,242	624,620	661,849	922,299
Petroleum Products, Not Elsewhere Classified/*Other*	Petroleum Products	319,054	273,638	427,850	352,486	397,105	406,919	655,901	624,780	495,233	507,832	477,949	309,297
Tar Distilled from Coal, Lignite or Peat; Other Tars/*Other*	Petroleum Products	64,225	56,659	27,046	23,216	16,175	130,310	517,988	486,993	272,542	321,659	340,830	474,953
Jet Fuel (Gasoline Type)/*Miscellaneous Products*	Petroleum Products	226,347	236,328	189,125	134,206	129,941	383,678	323,732	363,860	237,559	287,395	322,359	277,377
Petroleum Jelly; Waxes Obtained by Synthesis/Other/*Other*	Petroleum Products	68,180	52,887	41,294	35,958	26,854	46,589	32,177	31,449	54,642	31,061	52,641	53,950
Kerosene (Including Kerosene Type Jet Fuel)/Kerosene	Petroleum Products	27,458	126,312	229,170	89,688	229,464	131,185	95,409	160,596	3,612	21,008	34,952	27,260
Oils & Other Prods, NEC of Distillation of Coal Tar/*Other*	Petroleum Products	59,381	107,360	56,951	9,850	10,561	9,807	3,543	0	2,719	0	0	0
Total	Petroleum Products	14,409,733	15,425,635	15,730,826	14,669,469	16,890,179	15,877,402	16,569,967	17,860,399	16,755,583	17,683,157	18,533,930	16,229,684

Source: G.E.C., Inc.

Table 2-5. Cumulative Petroleum Products Shipped through Calcasieu Lock from 2000-2011

WCSCCommodity Name/*EIA Equivalent*	Commodity	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fuel Oils, NEC/*Residual Fuel Oil*	Petroleum Products	23.1%	17.6%	18.4%	21.3%	21.4%	20.7%	17.4%	17.8%	19.5%	17.8%	18.5%	18.2%
Other Light Oils from Petroleum & Bitum Minerals /*Fuel Oils, excluding Redsidual Fuel Oil*	Petroleum Products	30.0%	25.7%	29.1%	32.9%	32.0%	32.2%	33.1%	35.4%	36.2%	33.1%	34.6%	32.1%
Gas Oils/*Distillate Diesel Oil*	Petroleum	39.9%	37.2%	41.0%	45.2%	46.8%	45.5%	47.6%	48.4%	50.4%	46.1%	48.3%	43.9%
Other Medium Oils from Petroleum & Bitum Minerals /*Napthas & solvents (petro feedstock s)*	Petroleum Products	48.7%	50.6%	53.1%	58.6%	61.5%	58.2%	59.0%	58.6%	61.7%	59.5%	58.7%	56.0%
Gasoline Including Aviation (Except Jet)/*Motor and Aviation Gasoline*	Petroleum Products	65.4%	67.9%	68.2%	70.6%	75.1%	70.5%	69.4%	69.9%	71.9%	71.2%	71.2%	68.3%
Lubricating Petroleum Oils from Petrol & Bitum Min/*Lubricants*	Petroleum Products	75.8%	77.9%	78.9%	80.5%	83.6%	80.4%	79.0%	79.5%	81.2%	82.4%	81.0%	80.2%
Petro.Bitumen, Petro. Coke, Asphalt, Butumen mixes NEC/*Petroleum Coke*	Petroleum Products	82.8%	86.4%	86.9%	89.0%	91.2%	87.0%	85.0%	84.3%	86.5%	86.7%	85.6%	84.4%
Hydrocarbon & Petrol Gases, Liquefied and Gaseous/*Liquified Refinery Gase* s	Petroleum Products	89.2%	91.8%	89.6%	92.0%	93.5%	90.1%	87.5%	88.0%	90.5%	89.9%	89.8%	87.3%
Pitch & Pitch Coke from Coal Tar/Oth Mineral Tars/ *Other*	Petroleum Products	94.7%	94.5%	93.8%	95.6%	95.2%	93.0%	90.2%	90.7%	93.6%	93.4%	93.4%	93.0%
Petroleum Products , Not Elsewhere Classified/*Other*	Petroleum Products	96.9%	96.2%	96.5%	98.0%	97.6%	95.6%	94.1%	94.2%	96.6%	96.3%	95.9%	94.9%
Tar Distilled from Coal, Lignite or Peat; Other Tars/*Other*	Petroleum Products	97.4%	96.6%	96.7%	98.2%	97.7%	96.4%	97.3%	96.9%	98.2%	98.1%	97.8%	97.8%
Jet Fuel (Gasoline Type)/*Miscellaneous Products*	Petroleum Products	98.9%	98.1%	97.9%	99.1%	98.4%	98.8%	99.2%	98.9%	99.6%	99.7%	99.5%	99.5%
Petroleum Jelly; Waxes Obtained by Synthes is/Other/*Other*	Petroleum Products	99.4%	98.5%	98.2%	99.3%	98.6%	99.1%	99.4%	99.1%	100.0%	99.9%	99.8%	99.8%
Keros ene (Including Keros ene Type Jet Fuel)/Keros ene	Petroleum Products	99.6%	99.3%	99.6%	99.9%	99.9%	99.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Oils & Other Prods, NEC of Distillation of Coal Tar/*Other*	Petroleum Products	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	Petroleum Products	14,409,733	15,425,635	15,730,826	14,669,469	16,890,179	15,877,402	16,569,967	17,860,399	16,755,583	17,683,157	18,533,930	16,229,684

Source: G.E.C., Inc.

Table 2-6. Petroleum Products Classified by EIA Shipped through Calcasieu Lock from 2000-2011

EIA Equivalent	EIA Forecast Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Residual Fuel Oil	Residual Fuel Oil	3,326,791	2,721,631	2,894,345	3,131,446	3,611,303	3,280,988	2,888,826	3,185,129	3,262,852	3,142,715	3,431,081	2,950,146
Fuel Oils, excluding Redsidual Fuel Oil, Lubricants, Petroleum Coke, Other	Other Petroleum	5,029,548	5,241,725	6,040,301	5,482,334	5,397,525	5,886,739	7,165,169	7,696,354	6,852,811	7,230,610	7,509,487	6,909,883
Distillate Diesel Oil	Distillate Fuel Oil	1,423,392	1,769,489	1,862,502	1,801,999	2,498,312	2,109,220	2,395,597	2,333,096	2,374,985	2,296,667	2,535,305	1,914,625
Napthas & solvents (petrochemical feedstocks)	Petrochemical Feedstocks	1,271,327	2,072,569	1,910,458	1,968,873	2,490,213	2,025,809	1,882,144	1,820,701	1,891,030	2,367,295	1,917,006	1,959,457
Motor and Aviation Gasoline	Motor Gasoline	2,412,851	2,663,001	2,370,617	1,761,236	2,289,479	1,953,476	1,731,114	2,012,818	1,710,910	2,069,833	2,321,640	1,997,677
Liquified Refinery Gases	Liquified Petroleum	918,366	830,908	423,433	433,893	373,883	489,985	411,708	651,705	659,383	555,030	784,459	470,635
Kerosene/Jet Fuel	Kerosene/Jet Fuel	27,458	126,312	229,170	89,688	229,464	131,185	95,409	160,596	3,612	21,008	34,952	27,260
Total		14,409,733	15,425,635	15,730,826	14,669,469	16,890,179	15,877,402	16,569,967	17,860,399	16,755,583	17,683,157	18,533,930	16,229,684

Source: G.E.C., Inc.

Table 2-7. Energy Consumption by Sector and Source: 2011-2035 (Quadrillion Btu, unless otherwise noted – United States)

Sector and Source	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total Energy Consumption																									
Liquefied Petroleum Gases	2.73	2.75	2.42	2.48	2.51	2.56	2.62	2.66	2.7	2.74	2.78	2.81	2.82	2.84	2.86	2.87	2.87	2.89	2.89	2.88	2.88	2.87	2.87	2.86	2.86
E85 8/	0	0	0.01	0.01	0.01	0.01	0.01	0.08	0.08	0.13	0.22	0.26	0.27	0.28	0.3	0.37	0.44	0.6	0.63	0.72	0.94	1.24	1.15	1.16	1.22
Motor Gasoline 2/	16.76	16.79	16.69	16.59	16.46	16.33	16.18	15.95	15.82	15.66	15.46	15.37	15.31	15.28	15.25	15.2	15.18	15.07	15.07	15.04	14.85	14.58	14.77	14.85	14.88
Jet Fuel 9/	3.02	3.01	3.01	3.01	3.03	3.04	3.05	3.07	3.08	3.09	3.11	3.13	3.15	3.17	3.19	3.21	3.22	3.24	3.25	3.27	3.28	3.29	3.3	3.32	3.33
Kerosene	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Distillate Fuel Oil	8.22	8.23	8.39	8.64	8.78	8.86	8.86	8.86	8.88	8.89	8.92	8.99	9.03	9.05	9.07	9.11	9.13	9.14	9.14	9.17	9.19	9.21	9.26	9.33	9.38
Residual Fuel Oil	1.18	1.26	1.28	1.3	1.29	1.28	1.28	1.28	1.29	1.29	1.29	1.3	1.3	1.3	1.31	1.31	1.31	1.31	1.31	1.32	1.32	1.32	1.33	1.33	1.34
Petrochemical Feedstocks	0.9	0.9	0.91	0.97	1.01	1.05	1.1	1.14	1.17	1.2	1.23	1.25	1.26	1.27	1.29	1.29	1.3	1.31	1.31	1.31	1.3	1.3	1.3	1.3	1.3
Other Petroleum 12/	3.72	3.74	3.49	3.56	3.61	3.57	3.49	3.42	3.39	3.34	3.3	3.28	3.29	3.29	3.27	3.28	3.27	3.25	3.24	3.26	3.26	3.25	3.3	3.33	3.36
Liquid Fuels Subtotal	36.57	36.74	36.23	36.59	36.72	36.74	36.64	36.49	36.44	36.38	36.34	36.42	36.46	36.51	36.58	36.66	36.76	36.83	36.9	36.99	37.06	37.11	37.32	37.51	37.7

Note: Totals may not equal sum of components due to independent rounding. Data for 2009 and 2010 are model results and may differ slightly from official EIA data reports.

2/ Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.

8/ E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.

9/ Includes only kerosene type.

12/ Includes unfinished oils, natural gasoline, motor gasoline blending components, aviation gasoline, lubricants, still gas, asphalt, road oil, petroleum coke, and miscellaneous petroleum products.

Sources: 2009 and 2010 consumption based on: Energy Information Administration (EIA), Annual Energy Review 2010, DOE/EIA-0384(2010) (Washington, DC, October 2011).
2009 and 2010 population and gross domestic product: IHS Global Insight Industry and Employment models, August 2011. 2009 and 2010 carbon dioxide emissions: EIA, Monthly Energy Review, October 2011, DOE/EIA-0035(2011/10) (Washington, D.C., October 2011).
Projections: EIA, AEO2012 National Energy Modeling System run aeo2012r.

Table 2-8. Calcasieu Lock Petrochemical Commodity Tons Forecast, 2011-2035

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total Energy Consumption Reference Case Index (2011=1.00)																									
Liquefied Petroleum Gases	1.00	1.01	0.89	0.91	0.92	0.94	0.96	0.97	0.99	1.00	1.02	1.03	1.03	1.04	1.05	1.05	1.05	1.06	1.06	1.05	1.05	1.05	1.05	1.05	1.05
Motor Gasoline	1.00	1.00	1.00	0.99	0.98	0.97	0.97	0.95	0.94	0.93	0.92	0.92	0.91	0.91	0.91	0.91	0.91	0.90	0.90	0.90	0.89	0.87	0.88	0.89	0.89
Jet Fuel	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.04	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.09	1.09	1.09	1.10	1.10
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.02	1.05	1.07	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.14	1.14
Residual Fuel Oil	1.00	1.07	1.08	1.10	1.09	1.08	1.08	1.08	1.09	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.14
Petrochemical Feedstocks	1.00	1.00	1.01	1.08	1.12	1.17	1.22	1.27	1.30	1.33	1.37	1.39	1.40	1.41	1.43	1.43	1.44	1.46	1.46	1.46	1.44	1.44	1.44	1.44	1.44
Other Petroleum	1.00	1.01	0.94	0.96	0.97	0.96	0.94	0.92	0.91	0.90	0.89	0.88	0.88	0.88	0.88	0.88	0.88	0.87	0.87	0.88	0.88	0.87	0.89	0.90	0.90
Liquid Fuels Subtotal	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.03	1.03
Total Petrochemical Lock Commodity Tons																									
Residual Fuel Oil	2,950,146	3,150,156	3,200,158	3,250,161	3,225,160	3,200,158	3,200,158	3,200,158	3,225,160	3,225,160	3,225,160	3,250,161	3,250,161	3,250,161	3,275,162	3,275,162	3,275,162	3,275,162	3,275,162	3,300,163	3,300,163	3,300,163	3,325,165	3,325,165	3,350,166
Other Petroleum	6,909,883	6,947,033	6,482,659	6,612,684	6,705,559	6,631,259	6,482,659	6,352,634	6,296,910	6,204,035	6,129,735	6,092,585	6,111,160	6,111,160	6,074,010	6,092,585	6,074,010	6,036,860	6,018,285	6,055,435	6,055,435	6,036,860	6,129,735	6,185,460	6,241,185
Distillate Fuel Oil	1,914,625	1,916,954	1,954,222	2,012,453	2,045,062	2,063,696	2,063,696	2,063,696	2,068,354	2,070,683	2,077,671	2,093,976	2,103,292	2,107,951	2,112,609	2,121,926	2,126,585	2,128,914	2,128,914	2,135,902	2,140,560	2,145,219	2,156,865	2,173,169	2,184,815
Petrochemical Feedstocks	1,959,457	1,959,457	1,981,229	2,111,859	2,198,946	2,286,033	2,394,892	2,481,979	2,547,294	2,612,609	2,677,925	2,721,468	2,743,240	2,765,012	2,808,555	2,808,555	2,830,327	2,852,099	2,852,099	2,852,099	2,830,327	2,830,327	2,830,327	2,830,327	2,830,327
Motor Gasoline	1,997,677	2,001,253	1,989,333	1,977,414	1,961,919	1,946,424	1,928,545	1,901,131	1,885,635	1,866,565	1,842,726	1,831,999	1,824,847	1,821,271	1,817,695	1,811,736	1,809,352	1,796,241	1,796,241	1,792,665	1,770,018	1,737,836	1,760,483	1,770,018	1,773,594
Liquified Petroleum Gases	470,635	474,083	417,193	427,537	432,708	441,328	451,672	458,567	465,463	472,359	479,255	484,427	486,150	489,598	493,046	494,770	494,770	498,218	498,218	496,494	496,494	494,770	494,770	493,046	493,046
Kerosene/Jet Fuel	27,260	27,260	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
Total	16,229,683	16,476,196	16,045,239	16,412,552	16,589,798	16,589,343	16,542,067	16,478,610	16,509,261	16,471,855	16,452,916	16,495,059	16,539,295	16,565,598	16,601,523	16,625,179	16,630,651	16,607,938	16,589,363	16,653,202	16,613,442	16,565,620	16,717,789	16,797,630	16,893,578

Source: G.E.C., Inc.

Table 2-9. Chemicals Shipped Through Calcasieu Lock, 2000-2008

Commodity Name		Commodity Group	2000	2001	2002	2003	2004	2005	2006	2007	2008
1,2-Dichloroethane (Ethylene Dichloride)	*Other Bulk*	Chemicals	342,747	303,121	359,293	297,885	183,985	195,447	177,721	347,256	*294,404*
Acetic Acid and Its Salts	**Bulk Model**	Chemicals	15,879	14,390	13,717	15,260	16,104	22,429	25,138	4,882	**4,733**
Acetone	*Other Bulk*	Chemicals	212,292	210,977	189,434	193,495	185,441	197,495	218,889	191,147	190,662
Acrylonitrile	**Bulk Model**	Chemicals	446,302	406,793	448,183	396,209	387,048	328,806	285,893	299,517	**256,158**
Acyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	230,598	73,245	123,799	114,750	245,415	207,097	202,030	202,673	198,927
Acyclic Ketones without Other Oxygen Function, NEC		Chemicals	13,454	9,660	5,316	3,496	21,194	17,843	12,792	23,972	15,423
Acyclic Polyamides and Their Derivatives; Salts of		Chemicals	14,955	17,517	14,422	10,548	11,031	10,785	14,704	15,330	9,716
Alcohols, NEC		Chemicals	63,497	41,932	49,834	59,015	41,636	51,864	53,573	36,551	30,606
Aluminum Hydroxide		Chemicals	75,217	67,930	86,990	63,980	106,837	130,016	78,042	33,835	7,787
Ammonium Nitrate Fertilizers	Fertilizers	Chemicals	20,100	6,472	23,620	56,038	25,666	25,378	9,567	3,300	3,269
Ammonium Sulfate Fertilizers	Fertilizers	Chemicals	41,469	21,440	30,514	37,201	42,620	72,081	49,572	67,013	24,715
Antiknock Preparations	*Other Bulk*	Chemicals	127,503	239,470	263,166	198,118	321,093	128,778	99,221	26,446	1,252
Aromatic Monoamines and Derivatives; Salts Thereof		Chemicals	58,096	89,092	89,049	62,914	60,129	77,249	65,558	52,310	35,674
Benzene, Pure	*Other Bulk*	Chemicals	634,172	595,029	516,428	1,478,149	1,467,702	1,325,901	993,191	975,106	*880,571*
Butanols	*Other Bulk*	Chemicals	203,844	213,943	169,691	201,532	167,185	158,933	154,646	124,000	121,700
Butanone (Ethyl Methyl Ketone)		Chemicals	91,090	33,723	31,818	34,487	37,389	21,209	25,565	21,849	14,125
Butylenes, Butadienes, Methylbutadienes	**Bulk Model**	Chemicals	157,450	207,865	198,135	286,270	228,345	239,500	225,260	212,382	**195,734**
Calcium Chloride	*Other Bulk*	Chemicals	21,906	80,495	58,581	27,379	103,877	121,710	64,549	51,350	83,032
Chemical Waste		Chemicals	50,410	56,644	24,186	9,149	13,380	10,740	10,169	1,273	5,206
Chlorine	**Bulk Model**	Chemicals	5,500	4,400	7,900	5,500	1,100	2,300	2,200	6,600	**5,700**
Cumene	*Other Bulk*	Chemicals	1,172,405	898,437	1,021,897	947,885	1,001,482	877,522	1,079,319	1,053,952	*970,488*
Cyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	78,517	78,094	90,333	113,595	152,246	205,396	245,750	160,797	265,845
Cyclohexane	*Other Bulk*	Chemicals	237,793	183,106	241,764	228,200	264,171	253,034	238,985	215,097	163,062
Diammonium Phosphate (DAP)	Fertilizers	Chemicals	47,538	69,926	57,274	31,019	39,740	19,739	12,656	21,385	64,160
Epoxides, Epoxyalcohols, Epoxyphenols & Deriv, NEC		Chemicals	63,486	75,600	82,600	66,978	88,200	72,800	68,600	56,644	45,112
Esters of Acetic Acid	*Other Bulk*	Chemicals	185,739	144,080	197,982	205,188	223,669	272,742	276,456	273,269	246,834
Ethyl Alcohol (Not Denatured) 80% or More Alcohol	*Other Bulk*	Chemicals	104,554	107,969	137,501	182,788	80,675	14,054	369,294	566,002	250,069
Ethylene Glycol (Ethanedoil)	**Bulk Model**	Chemicals	324,788	438,030	395,143	318,870	272,911	269,053	393,852	363,922	**364,047**
Fertilizers, NEC	Fertilizers	Chemicals	45,242	89,926	42,887	18,284	18,725	4,751	3,625	12,808	13,343
Halogenated Derivatives of Hydrocarbons, NEC		Chemicals	999	1,100	7,681	5,312	2,739	5,535	6,618	6,929	6,919
Hydrogen Chloride; Chlorosulfuric Acid		Chemicals	99,564	180,162	59,915	24,797	38,913	24,009	34,968	34,714	27,486
Methacrylic Acid and Its Salts and Esters		Chemicals	61,053	71,464	30,217	66,770	69,382	74,818	80,603	42,375	20,182
Methanol (Methyl Alcohol)	*Other Bulk*	Chemicals	515,424	164,730	89,958	57,429	68,987	53,127	23,397	30,847	18,056
Mineral or Chemical Fertilizers, Nitrogenous, NEC	Fertilizers	Chemicals	316,662	225,021	216,300	123,244	134,600	99,000	120,600	64,000	67,200
Mineral or Chemical Fertilizers, Potassic, NEC	Fertilizers	Chemicals	10,276	9,170	20,337	20,922	19,774	2,926	20,393	20,338	4,502
Other Acyclic Alcohols, NEC	*Other Bulk*	Chemicals	175,295	147,657	132,428	147,943	103,473	140,755	154,913	156,744	159,220
Other Monohydric Alcohols, NEC		Chemicals	10,990	8,138	8,509	2,778	2,650	12	31,377	22,958	9,716
Other Organic Compounds, NEC		Chemicals	47,829	47,950	48,259	45,073	33,284	46,563	61,215	57,377	54,534
Other Phenols and Phenol-Alcohols, NEC	*Other Bulk*	Chemicals	40,624	64,220	20,002	47,310	44,050	61,801	121,393	124,182	104,016
Phthalic Anhydride		Chemicals	25,952	28,573	39,286	37,330	30,748	29,991	33,973	65,932	27,528
Potassium Hydroxide; Peroxides of Sodium, Potassium	*Other Bulk*	Chemicals	85,747	81,324	79,157	81,760	91,985	98,229	101,601	147,307	145,176
Propan-1-ol(propyl), Propan-2-ol(isopropyl alcohol)	*Other Bulk*	Chemicals	229,219	157,905	187,698	179,528	161,746	153,498	132,216	173,347	137,311
Propene	*Other Bulk*	Chemicals	267,399	183,067	225,213	280,427	213,664	177,838	218,751	352,176	280,285
Saturated Chlor Deriv of Acyclic Hydrocrabons, NEC		Chemicals	25,546	12,999	35,474	63,689	72,313	67,994	56,990	48,421	45,209
Sodium Hydroxide Aqueous Soln(Soda Lye, Liq Soda)	*Other Bulk*	Chemicals	999,554	851,112	900,014	784,554	763,761	695,008	626,378	692,084	*541,116*
Sodium Sulfide		Chemicals	80,627	76,404	62,903	48,436	47,516	48,419	37,081	32,100	10,870
Styrene	**Bulk Model**	Chemicals	1,537,937	1,291,896	1,215,931	1,104,658	1,034,403	1,079,411	1,112,026	973,522	**751,274**
Sulfur, Sublimed or Precipitated; Colloidal Sulfur		Chemicals	25,878	100,269	219,638	35,859	88,714	9,658	17,700	9,970	17,438
Sulfuric Acid; Oleum	**Bulk Model**	Chemicals	182,202	239,674	182,275	226,624	211,707	209,869	237,602	167,260	**269,924**
Superphosphate Fertilizers	Fertilizers	Chemicals	7,090	4,200	7,860	5,949	10,875	13,314	13,438	14,072	11,683
Tetrechloroethylene (Perechoroethylene)		Chemicals	45,772	32,542	45,289	59,473	48,982	46,494	37,952	41,341	37,088
Toluene, Pure	*Other Bulk*	Chemicals	332,723	333,632	405,849	452,395	512,120	599,097	640,993	610,714	*549,402*
Trichloroethylene		Chemicals	151,572	156,117	155,449	79,474	78,426	81,999	79,688	52,976	56,641
Unsaturated Acyclic Monocarboxylic Acids, NEC; Deriv		Chemicals	46,220	41,284	57,442	64,988	73,303	51,428	45,774	43,750	38,586
Urea Fertilizers	Fertilizers	Chemicals	115,867	175,015	130,320	158,401	158,492	126,106	128,193	127,488	239,822
Xylenes, Pure	*Other Bulk*	Chemicals	620,530	877,801	690,603	1,095,336	1,287,743	1,134,269	1,307,186	1,215,762	*743,619*

Notes: Excludes chemicals not reported to be continously shipped during the time frame 2000-2008

Source: G.E.C., Inc.

Table 2-10. Chemicals Shipped Through Calcasieu Lock, 2000-2008 as Classified by EIA Bulk Model

Commodity Name	EIA Grouping	Commodity Group	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cumene	*Other Bulk*	Chemicals	1,172,405	898,437	1,021,897	947,885	1,001,482	877,522	1,079,319	1,053,952	*970,488*
Benzene, Pure	*Other Bulk*	Chemicals	634,172	595,029	516,428	1,478,149	1,467,702	1,325,901	993,191	975,106	*880,571*
Styrene	**Bulk Model**	Chemicals	1,537,937	1,291,896	1,215,931	1,104,658	1,034,403	1,079,411	1,112,026	973,522	**751,274**
Xylenes, Pure	*Other Bulk*	Chemicals	620,530	877,801	690,603	1,095,336	1,287,743	1,134,269	1,307,186	1,215,762	*743,619*
Toluene, Pure	*Other Bulk*	Chemicals	332,723	333,632	405,849	452,395	512,120	599,097	640,993	610,714	*549,402*
Sodium Hydroxide Aqueous Soln(Soda Lye, Liq Soda)	*Other Bulk*	Chemicals	999,554	851,112	900,014	784,554	763,761	695,008	626,378	692,084	*541,116*
Ethylene Glycol (Ethanedoil)	**Bulk Model**	Chemicals	324,788	438,030	395,143	318,870	272,911	269,053	393,852	363,922	**364,047**
1,2-Dichloroethane (Ethylene Dichloride)	*Other Bulk*	Chemicals	342,747	303,121	359,293	297,885	183,985	195,447	177,721	347,256	*294,404*
Propene	*Other Bulk*	Chemicals	267,399	183,067	225,213	280,427	213,664	177,838	218,751	352,176	280,285
Sulfuric Acid; Oleum	**Bulk Model**	Chemicals	182,202	239,674	182,275	226,624	211,707	209,869	237,602	167,260	**269,924**
Cyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	78,517	78,094	90,333	113,595	152,246	205,396	245,750	160,797	265,845
Acrylonitrile	**Bulk Model**	Chemicals	446,302	406,793	448,183	396,209	387,048	328,806	285,893	299,517	**256,158**
Ethyl Alcohol (Not Denatured) 80% or More Alcohol	*Other Bulk*	Chemicals	104,554	107,969	137,501	182,788	80,675	14,054	369,294	566,002	250,069
Esters of Acetic Acid	*Other Bulk*	Chemicals	185,739	144,080	197,982	205,188	223,669	272,742	276,456	273,269	246,834
Urea Fertilizers	Fertilizers	Chemicals	115,867	175,015	130,320	158,401	158,492	126,106	128,193	127,488	239,822
Acyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	230,598	73,245	123,799	114,750	245,415	207,097	202,030	202,673	198,927
Butylenes , Butadienes , Methylbutadienes	**Bulk Model**	Chemicals	157,450	207,865	198,135	286,270	228,345	239,500	225,260	212,382	**195,734**
Acetone	*Other Bulk*	Chemicals	212,292	210,977	189,434	193,495	185,441	197,495	218,889	191,147	190,662
Cyclohexane	*Other Bulk*	Chemicals	237,793	183,106	241,764	228,200	264,171	253,034	238,985	215,097	163,062
Other Acyclic Alcohols, NEC	*Other Bulk*	Chemicals	175,295	147,657	132,428	147,943	103,473	140,755	154,913	156,744	159,220
Potassium Hydroxide; Peroxides of Sodium, Potassium	*Other Bulk*	Chemicals	85,747	81,324	79,157	81,760	91,985	98,229	101,601	147,307	145,176
Propan-1-ol(propyl), Propan-2-ol(isopropyl alcohol)	*Other Bulk*	Chemicals	229,219	157,905	187,698	179,528	161,746	153,498	132,216	173,347	137,311
Butanols	*Other Bulk*	Chemicals	203,844	213,943	169,691	201,532	167,185	158,933	154,646	124,000	121,700
Other Phenols and Phenol-Alcohols, NEC	*Other Bulk*	Chemicals	40,624	64,220	20,002	47,310	44,050	61,801	121,393	124,182	104,016
Calcium Chloride	*Other Bulk*	Chemicals	21,906	80,495	58,581	27,379	103,877	121,710	64,549	51,350	83,032
Mineral or Chemical Fertilizers , Nitrogenous , NEC	Fertilizers	Chemicals	316,662	225,021	216,300	123,244	134,600	99,000	120,600	64,000	67,200
Diammonium Phos phate (DAP)	Fertilizers	Chemicals	47,538	69,926	57,274	31,019	39,740	19,739	12,656	21,385	64,160
Trichloroethylene		Chemicals	151,572	156,117	155,449	79,474	78,426	81,999	79,688	52,976	56,641
Other Organic Compounds , NEC		Chemicals	47,829	47,950	48,259	45,073	33,284	46,563	61,215	57,377	54,534
Saturated Chlor Deriv of Acyclic Hydrocrabons , NEC		Chemicals	25,546	12,999	35,474	63,689	72,313	67,994	56,990	48,421	45,209
Epoxides , Epoxyalcohols , Epoxyphenols & Deriv, NEC		Chemicals	63,486	75,600	82,600	66,978	88,200	72,800	68,600	56,644	45,112
Unsaturated Acyclic Monocarboxylic Acids , NEC; Deriv		Chemicals	46,220	41,284	57,442	64,988	73,303	51,428	45,774	43,750	38,586
Tetrechloroethylene (Perechoroethylene)		Chemicals	45,772	32,542	45,289	59,473	48,982	46,494	37,952	41,341	37,088
Aromatic Monoamines and Derivatives ; Salts Thereof		Chemicals	58,096	89,092	89,049	62,914	60,129	77,249	65,558	52,310	35,674
Alcohols , NEC		Chemicals	63,497	41,932	49,834	59,015	41,636	51,864	53,573	36,551	30,606
Phthalic Anhydride		Chemicals	25,952	28,573	39,286	37,330	30,748	29,991	33,973	65,932	27,528
Hydrogen Chloride; Chloros ulfuric Acid		Chemicals	99,564	180,162	59,915	24,797	38,913	24,009	34,968	34,714	27,486
Ammonium Sulfate Fertilizers	Fertilizers	Chemicals	41,469	21,440	30,514	37,201	42,620	72,081	49,572	67,013	24,715
Methacrylic Acid and Its Salts and Esters		Chemicals	61,053	71,464	30,217	66,770	69,382	74,818	80,603	42,375	20,182
Methanol (Methyl Alcohol)	*Other Bulk*	Chemicals	515,424	164,730	89,958	57,429	68,987	53,127	23,397	30,847	18,056
Sulfur, Sublimed or Precipitated; Colloidal Sulfur		Chemicals	25,878	100,269	219,638	35,859	88,714	9,658	17,700	9,970	17,438
Acyclic Ketones without Other Oxygen Function, NEC		Chemicals	13,454	9,660	5,316	3,496	21,194	17,843	12,792	23,972	15,423
Butanone (Ethyl Methyl Ketone)		Chemicals	91,090	33,723	31,818	34,487	37,389	21,209	25,565	21,849	14,125
Fertilizers , NEC	Fertilizers	Chemicals	45,242	89,926	42,887	18,284	18,725	4,751	3,625	12,808	13,343
Superphos phate Fertilizers	Fertilizers	Chemicals	7,090	4,200	7,860	5,949	10,875	13,314	13,438	14,072	11,683
Sodium Sulfide		Chemicals	80,627	76,404	62,903	48,436	47,516	48,419	37,081	32,100	10,870
Other Monohydric Alcohols , NEC		Chemicals	10,990	8,138	8,509	2,778	2,650	12	31,377	22,958	9,716
Acyclic Polyamides and Their Derivatives ; Salts of		Chemicals	14,955	17,517	14,422	10,548	11,031	10,785	14,704	15,330	9,716
Aluminum Hydroxide		Chemicals	75,217	67,930	86,990	63,980	106,837	130,016	78,042	33,835	7,787
Halogenated Derivatives of Hydrocarbons , NEC		Chemicals	999	1,100	7,681	5,312	2,739	5,535	6,618	6,929	6,919
Chlorine	**Bulk Model**	Chemicals	5,500	4,400	7,900	5,500	1,100	2,300	2,200	6,600	**5,700**
Chemical Waste		Chemicals	50,410	56,644	24,186	9,149	13,380	10,740	10,169	1,273	5,206
Acetic Acid and Its Salts	**Bulk Model**	Chemicals	15,879	14,390	13,717	15,260	16,104	22,429	25,138	4,882	**4,733**
Mineral or Chemical Fertilizers , Potas sic, NEC	Fertilizers	Chemicals	10,276	9,170	20,337	20,922	19,774	2,926	20,393	20,338	4,502
Ammonium Nitrate Fertilizers	Fertilizers	Chemicals	20,100	6,472	23,620	56,038	25,666	25,378	9,567	3,300	3,269
Antik nock Preparations	*Other Bulk*	Chemicals	127,503	239,470	263,166	198,118	321,093	128,778	99,221	26,446	1,252
Total All Chemicals			11,836,112	10,604,598	10,623,857	11,560,708	11,634,545	11,007,073	11,291,209	11,113,735	9,450,630

Notes: Excludes chemicals not reported to be continous ly shipped during the time frame 2000-2008

Source: G.E.C., Inc.

Table 2-11. Cumulative Volumes of Chemicals Shipped Through Calcasieu Lock, 2000-2008

Commodity Name		Commodity Group	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cumene	*Other Bulk*	Chemicals	10.5%	8.7%	10.0%	8.6%	8.9%	8.4%	9.9%	9.8%	10.6%
Benzene, Pure	*Other Bulk*	Chemicals	16.2%	14.4%	15.0%	22.1%	22.0%	21.1%	18.9%	18.9%	20.3%
Styrene	**Bulk Model**	Chemicals	30.0%	26.9%	26.9%	32.2%	31.2%	31.4%	29.1%	27.9%	28.5%
Xylenes, Pure	*Other Bulk*	Chemicals	35.6%	35.4%	33.6%	42.2%	42.7%	42.2%	41.1%	39.2%	36.6%
Toluene, Pure	*Other Bulk*	Chemicals	38.6%	38.6%	37.6%	46.3%	47.3%	47.9%	46.9%	44.9%	42.6%
Sodium Hydroxide Aqueous Soln (Soda Lye, Liq Soda)	*Other Bulk*	Chemicals	47.5%	46.9%	46.4%	53.5%	54.1%	54.6%	52.6%	51.4%	48.6%
Ethylene Glycol (Ethanedoil)	**Bulk Model**	Chemicals	50.4%	51.1%	50.2%	56.4%	56.5%	57.1%	56.2%	54.7%	52.5%
1,2-Dichloroethane (Ethylene Dichloride)	*Other Bulk*	Chemicals	53.5%	54.0%	53.7%	59.1%	58.2%	59.0%	57.9%	58.0%	55.8%
Propene	*Other Bulk*	Chemicals	55.9%	55.8%	55.9%	61.7%	60.1%	60.7%	59.9%	61.3%	58.8%
Sulfuric Acid; Oleum	**Bulk Model**	Chemicals	57.6%	58.1%	57.7%	63.7%	62.0%	62.7%	62.0%	62.8%	61.8%
Cyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	58.3%	58.9%	58.6%	64.8%	63.3%	64.7%	64.3%	64.3%	64.7%
Acrylonitrile	**Bulk Model**	Chemicals	62.3%	62.8%	63.0%	68.4%	66.8%	67.8%	66.9%	67.1%	67.5%
Ethyl Alcohol (Not Denatured) 80% or More Alcohol	*Other Bulk*	Chemicals	63.2%	63.9%	64.3%	70.0%	67.5%	68.0%	70.3%	72.4%	70.2%
Esters of Acetic Acid	*Other Bulk*	Chemicals	64.9%	65.3%	66.2%	71.9%	69.5%	70.6%	72.8%	74.9%	72.9%
Urea Fertilizers	Fertilizers	Chemicals	65.9%	66.9%	67.5%	73.4%	70.9%	71.8%	74.0%	76.1%	75.6%
Acyclic Hydrocarbons, NEC	*Other Bulk*	Chemicals	68.0%	67.7%	68.7%	74.4%	73.1%	73.7%	75.8%	78.0%	77.7%
Butylenes, Butadienes, Methylbutadienes	**Bulk Model**	Chemicals	69.4%	69.7%	70.7%	77.0%	75.1%	76.0%	77.9%	79.9%	79.9%
Acetone	*Other Bulk*	Chemicals	71.3%	71.7%	72.5%	78.8%	76.8%	77.9%	79.9%	81.7%	82.0%
Cyclohexane	*Other Bulk*	Chemicals	73.4%	73.5%	74.9%	80.9%	79.1%	80.3%	82.1%	83.7%	83.7%
Other Acyclic Alcohols, NEC	*Other Bulk*	Chemicals	75.0%	74.9%	76.2%	82.2%	80.1%	81.7%	83.5%	85.2%	85.5%
Potassium Hydroxide; Peroxides of Sodium, Potassium	*Other Bulk*	Chemicals	75.8%	75.7%	76.9%	83.0%	80.9%	82.6%	84.4%	86.6%	87.1%
Propan-1-ol(propyl), Propan-2-ol(isopropyl alcohol)	*Other Bulk*	Chemicals	77.8%	77.2%	78.8%	84.6%	82.3%	84.1%	85.6%	88.2%	88.6%
Butanols	*Other Bulk*	Chemicals	79.7%	79.3%	80.4%	86.4%	83.8%	85.6%	87.0%	89.3%	89.9%
Other Phenols and Phenol-Alcohols, NEC	*Other Bulk*	Chemicals	80.0%	79.9%	80.6%	86.9%	84.2%	86.2%	88.1%	90.5%	91.1%
Calcium Chloride	*Other Bulk*	Chemicals	80.2%	80.7%	81.2%	87.1%	85.1%	87.4%	88.7%	91.0%	92.0%
Mineral or Chemical Fertilizers, Nitrogenous, NEC	Fertilizers	Chemicals	83.1%	82.9%	83.3%	88.2%	86.3%	88.3%	89.8%	91.6%	92.7%
Diammonium Phosphate (DAP)	Fertilizers	Chemicals	83.5%	83.5%	83.9%	88.5%	86.7%	88.5%	89.9%	91.7%	93.4%
Trichloroethylene		Chemicals	84.8%	85.0%	85.4%	89.2%	87.4%	89.3%	90.7%	92.2%	94.0%
Other Organic Compounds, NEC		Chemicals	85.3%	85.5%	85.8%	89.7%	87.7%	89.7%	91.2%	92.8%	94.6%
Saturated Chlor Deriv of Acyclic Hydrocrabons, NEC		Chemicals	85.5%	85.6%	86.2%	90.2%	88.3%	90.4%	91.8%	93.2%	95.1%
Epoxides, Epoxyalcohols, Epoxyphenols & Deriv, NEC		Chemicals	86.1%	86.4%	87.0%	90.8%	89.1%	91.1%	92.4%	93.8%	95.6%
Unsaturated Acyclic Monocarboxylic Acids, NEC; Deriv		Chemicals	86.5%	86.8%	87.6%	91.4%	89.8%	91.6%	92.8%	94.2%	96.0%
Tetrechloroethylene (Perechoroethylene)		Chemicals	86.9%	87.1%	88.0%	92.0%	90.2%	92.0%	93.2%	94.5%	96.4%
Aromatic Monoamines and Derivatives; Salts Thereof		Chemicals	87.4%	87.9%	88.9%	92.6%	90.8%	92.7%	93.8%	95.0%	96.8%
Alcohols, NEC		Chemicals	88.0%	88.3%	89.4%	93.1%	91.1%	93.2%	94.2%	95.4%	97.2%
Phthalic Anhydride		Chemicals	88.2%	88.6%	89.7%	93.4%	91.4%	93.5%	94.6%	96.0%	97.5%
Hydrogen Chloride; Chlorosulfuric Acid		Chemicals	89.1%	90.4%	90.3%	93.7%	91.7%	93.7%	94.9%	96.3%	97.8%
Ammonium Sulfate Fertilizers	Fertilizers	Chemicals	89.5%	90.6%	90.6%	94.0%	92.1%	94.4%	95.3%	96.9%	98.0%
Methacrylic Acid and Its Salts and Esters		Chemicals	90.0%	91.3%	90.9%	94.6%	92.7%	95.2%	96.1%	97.3%	98.3%
Methanol (Methyl Alcohol)	*Other Bulk*	Chemicals	94.7%	92.9%	91.8%	95.1%	93.4%	95.7%	96.3%	97.6%	98.4%
Sulfur, Sublimed or Precipitated; Colloidal Sulfur		Chemicals	94.9%	93.8%	93.9%	95.5%	94.1%	95.8%	96.4%	97.7%	98.6%
Acyclic Ketones without Other Oxygen Function, NEC		Chemicals	95.0%	93.9%	94.0%	95.5%	94.3%	95.9%	96.6%	97.9%	98.8%
Butanone (Ethyl Methyl Ketone)		Chemicals	95.8%	94.2%	94.3%	95.8%	94.7%	96.1%	96.8%	98.1%	99.0%
Fertilizers, NEC	Fertilizers	Chemicals	96.2%	95.1%	94.7%	96.0%	94.8%	96.2%	96.8%	98.3%	99.1%
Superphosphate Fertilizers	Fertilizers	Chemicals	96.3%	95.1%	94.8%	96.0%	94.9%	96.3%	96.9%	98.4%	99.2%
Sodium Sulfide		Chemicals	97.0%	95.9%	95.4%	96.5%	95.4%	96.8%	97.3%	98.7%	99.4%
Other Monohydric Alcohols, NEC		Chemicals	97.1%	96.0%	95.5%	96.5%	95.4%	96.8%	97.6%	98.9%	99.5%
Acyclic Polyamides and Their Derivatives; Salts of		Chemicals	97.3%	96.1%	95.6%	96.6%	95.5%	96.9%	97.7%	99.0%	99.6%
Aluminum Hydroxide		Chemicals	97.9%	96.8%	96.5%	97.2%	96.4%	98.1%	98.4%	99.4%	99.7%
Halogenated Derivatives of Hydrocarbons, NEC		Chemicals	97.9%	96.8%	96.6%	97.2%	96.5%	98.2%	98.5%	99.4%	99.7%
Chlorine	**Bulk Model**	Chemicals	98.0%	96.8%	96.6%	97.3%	96.5%	98.2%	98.5%	99.5%	99.8%
Chemical Waste		Chemicals	98.4%	97.4%	96.9%	97.4%	96.6%	98.3%	98.6%	99.5%	99.8%
Acetic Acid and Its Salts	**Bulk Model**	Chemicals	98.6%	97.5%	97.0%	97.5%	96.7%	98.5%	98.8%	99.5%	99.9%
Mineral or Chemical Fertilizers, Potassic, NEC	Fertilizers	Chemicals	98.7%	97.6%	97.2%	97.7%	96.9%	98.5%	99.0%	99.7%	100.0%
Ammonium Nitrate Fertilizers	Fertilizers	Chemicals	98.9%	97.7%	97.4%	98.2%	97.1%	98.8%	99.1%	99.8%	100.0%
Antiknock Preparations	*Other Bulk*	Chemicals	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total All Chemicals			100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes: Excludes chemicals not reported to be continously shipped during the time frame 2000-2008.

Source: G.E.C., Inc.

Table 2-12. Chemical Groups Shipped Through Calcasieu Lock, 2000-2008

Chemical Groupings	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total All Chemicals	11,836,112	10,604,598	10,623,857	11,560,708	11,634,545	11,007,073	11,291,209	11,113,735	9,450,630
Subtotal high volume continuous chemicals	11,145,094	10,342,732	10,245,464	10,964,641	11,213,346	10,465,820	10,939,836	10,749,354	9,137,157
Bulk Model chemicals	2,670,058	2,603,048	2,461,284	2,353,391	2,151,618	2,151,368	2,281,971	2,028,085	1,847,570
Other bulk chemicals	6,818,585	5,989,414	6,100,791	7,315,646	7,644,470	7,071,731	7,446,879	7,690,258	6,345,047
Subtotal bulk chemicals	9,488,643	8,592,462	8,562,075	9,669,037	9,796,088	9,223,099	9,728,850	9,718,343	8,192,617
Fertilizers	604,244	601,170	529,112	451,058	450,492	363,295	358,044	330,404	428,694
Other (not included in above)	1,052,207	1,149,100	1,154,277	844,546	966,766	879,426	852,942	700,607	515,846
Other exclusve of above from all chemicals	691,018	261,866	378,393	596,067	421,199	541,253	351,373	364,381	313,473
Total other	1,743,225	1,410,966	1,532,670	1,440,613	1,387,965	1,420,679	1,204,315	1,064,988	829,319
Total All Chemicals	100%	100%	100%	100%	100%	100%	100%	100%	100%
Subtotal high volume continuous chemicals	94%	98%	96%	95%	96%	95%	97%	97%	97%
Bulk Model chemicals	23%	25%	23%	20%	18%	20%	20%	18%	20%
Other bulk chemicals	58%	56%	57%	63%	66%	64%	66%	69%	67%
Subtotal bulk chemicals	80%	81%	81%	84%	84%	84%	86%	87%	87%
Fertilizers	5%	6%	5%	4%	4%	3%	3%	3%	5%
Other (not included in above)	9%	11%	11%	7%	8%	8%	8%	6%	5%
Other exclusve of above from all chemicals	6%	2%	4%	5%	4%	5%	3%	3%	3%
Total other	15%	13%	14%	12%	12%	13%	11%	10%	9%

Source: G.E.C., Inc.

Table 2-13. Calcasieu Lock Chemicals Projections, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Value of Shipments - Reference Case	**277.35**	**261**	**260.87**	**271.45**	**276.81**	**283.23**	**292.06**	**299.94**	**307.71**	**315.68**	**322.76**	**328.2**	**330.43**	**333.78**	**337.63**	**338.43**	**339.41**	**342.09**	**342.76**	**341.69**	**340.92**	**340.43**	**340.33**	**340.08**	**340.05**
Index	1.00	0.94	0.94	0.98	1.00	1.02	1.05	1.08	1.11	1.14	1.16	1.18	1.19	1.20	1.22	1.22	1.22	1.23	1.24	1.23	1.23	1.23	1.23	1.23	1.23
Total All Chemicals	9,302,012	8,753,651	8,749,291	9,104,133	9,283,901	9,499,221	9,795,369	10,059,656	10,320,253	10,587,558	10,825,013	11,007,465	11,082,256	11,194,612	11,323,736	11,350,568	11,383,436	11,473,320	11,495,791	11,459,904	11,434,079	11,417,645	11,414,291	11,405,907	11,404,901

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Value of Shipments - Reference Case	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**	**340.05**
Index	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
Total All Chemicals	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901

Notes: Based on EIA "Bulk Chemicals" projections, 2011-2035 except fertilizer.
Chemical projections beyond 2035 extrapolated from EIA trends.

Source: G.E.C., Inc.

Table 2-14. Offshore Natural Gas Production and Calcasieu Lock Fertilizer Annual Tons

Year	Offshore Gas Production	Fertilizers	Y=86009+110487	Y=109745 X-1047
2000	5.17	604,244	555,154	566,335
2001	5.33	601,170	568,915	583,894
2002	4.75	529,112	519,030	520,242
2003	4.76	451,058	519,890	521,339
2004	4.22	450,492	473,445	462,077
2005	3.37	363,295	400,337	368,794
2006	3.1	358,044	377,115	339,163
2007	2.98	330,404	366,794	325,993
2008	2.62	428,694	335,831	286,485
2009	2.7		342,711	295,265
2010	2.56		330,670	279,900
2011	2.17		297,127	237,100
2012	2.01		283,365	219,540
2013	1.79		264,443	195,397
2014	1.76		261,863	192,104
2015	1.88		272,184	205,274
2016	2.1		291,106	229,418
2017	2.16		296,266	236,002
2018	2.12		292,826	231,612
2019	2.2		299,707	240,392
2020	2.34		311,748	255,756
2021	2.38		315,188	260,146
2022	2.36		313,468	257,951
2023	2.35		312,608	256,854
2024	2.39		316,049	261,244
2025	2.38		315,188	260,146
2026	2.38		315,188	260,146
2027	2.41		317,769	263,438
2028	2.48		323,789	271,121
2029	2.52		327,230	275,510
2030	2.58		332,390	282,095
2031	2.59		333,250	283,193
2032	2.69		341,851	294,167
2033	2.81		352,172	307,336
2034	2.77		348,732	302,947
2035	2.72		344,431	297,459

Notes: Natural gas production by source, 2000-2035 (billion cubic feet).
Source: EIA Report # DOE/EIA-0383(2010), release date May 11, 2010.

Table 2-15. Calcasieu Lock Fertilizer Tons Based on Offshore Natural Gas Production, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference Case	2.17	2.01	1.79	1.76	1.88	2.1	2.16	2.12	2.2	2.34	2.38	2.36	2.35	2.39	2.38	2.38	2.41	2.48	2.52	2.58	2.59	2.69	2.81	2.77	2.72
	1.00	0.93	0.82	0.81	0.87	0.97	1.00	0.98	1.01	1.08	1.10	1.09	1.08	1.10	1.10	1.10	1.11	1.14	1.16	1.19	1.19	1.24	1.29	1.28	1.25
Fertilizer tons	297,127	283,365	264,443	261,863	272,184	291,106	296,266	292,826	299,707	311,748	315,188	313,468	312,608	316,049	315,188	315,188	317,769	323,789	327,230	332,390	333,250	341,851	352,172	348,732	344,431

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Reference Case	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Fertilizer tons	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431

Notes: EIA Reference Case offshore natural gas production forecast 2011-2035. Offshore natural gas production >2035 extrapolated from EIA trends.

Source: G.E.C., Inc.

Table 2-16. Crude Petroleum Shipped Through Calcasieu Lock, 2000-2011

Commodity Name	Commodity Group	2000 (Tons)	2001 (Tons)	2002 (Tons)	2003 (Tons)	2004 (Tons)	2005 (Tons)	2006 (Tons)	2007 (Tons)	2008 (Tons)	2009 (Tons)	2010 (Tons)	2011 (Tons)
Petroleum Oils/Oils from Bituminous Minerals, Crude	Crude Petroleum	3,430,354	3,619,149	4,064,812	4,072,039	3,785,353	2,632,493	3,112,266	3,086,868	2,961,038	3,185,560	3,004,397	4,035,558

Source: G.E.C., Inc.

Table 2-17. Crude Petroleum Production Forecast and Calcasieu Lock Tonnage, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Crude Petroleum Production, y=-0.0369x + 6.041071																									
United States Total	5.57	5.74	5.9	6	6.15	6.42	6.47	6.55	6.64	6.7	6.62	6.51	6.45	6.41	6.4	6.44	6.48	6.47	6.41	6.37	6.27	6.21	6.18	6.07	5.99
Lower 48 Onshore	3.58	3.8	3.94	4.01	4.09	4.16	4.21	4.29	4.33	4.38	4.41	4.41	4.42	4.43	4.43	4.43	4.42	4.37	4.34	4.29	4.23	4.15	4.09	4.03	3.99
Lower 48 Offshore	1.43	1.4	1.46	1.51	1.6	1.78	1.76	1.74	1.81	1.83	1.75	1.66	1.64	1.62	1.57	1.55	1.57	1.63	1.62	1.65	1.65	1.71	1.77	1.74	1.74
Lower 48 On/Offshore	5.01	5.20	5.40	5.52	5.69	5.94	5.97	6.03	6.14	6.21	6.16	6.07	6.06	6.05	6.00	5.98	5.99	6.00	5.96	5.94	5.88	5.86	5.86	5.77	5.73
Notes: Millon barrels per day																									
Crude Petroleum Production Index (2011 = 1.00)																									
United States Total	1.00	1.03	1.06	1.08	1.10	1.15	1.16	1.18	1.19	1.20	1.19	1.17	1.16	1.15	1.15	1.16	1.16	1.16	1.15	1.14	1.13	1.11	1.11	1.09	1.08
Lower 48 Onshore	1.00	1.06	1.10	1.12	1.14	1.16	1.18	1.20	1.21	1.22	1.23	1.23	1.23	1.24	1.24	1.24	1.23	1.22	1.21	1.20	1.18	1.16	1.14	1.13	1.11
Lower 48 Offshore	1.00	0.98	1.02	1.06	1.12	1.24	1.23	1.22	1.27	1.28	1.22	1.16	1.15	1.13	1.10	1.08	1.10	1.14	1.13	1.15	1.15	1.20	1.24	1.22	1.22
Lower 48 On/Offshore	1.00	1.04	1.08	1.10	1.14	1.19	1.19	1.20	1.23	1.24	1.23	1.21	1.21	1.21	1.20	1.19	1.20	1.20	1.19	1.19	1.17	1.17	1.17	1.15	1.14
Crude Petroleum Lock Tonnage	4,035,558	4,188,603	4,349,703	4,446,363	4,583,298	4,784,674	4,808,839	4,857,169	4,945,774	5,002,159	4,961,884	4,889,389	4,881,334	4,873,279	4,833,004	4,816,894	4,824,949	4,833,004	4,800,784	4,784,674	4,736,344	4,720,234	4,720,234	4,647,738	4,615,518

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Crude Petroleum Production, y=-0.0369x + 6.041071																										
United States Total																										
Lower 48 Onshore																										
Lower 48 Offshore																										
Lower 48 On/Offshore	5.71	5.67	5.64	5.60	5.56	5.52	5.49	5.45	5.41	5.38	5.34	5.67	5.30	5.27	5.23	5.19	5.16	5.12	5.08	5.04	5.01	4.97	4.93	4.93	4.86	4.82
Notes: Millon barrels per day																										
Crude Petroleum Production Index (2011 = 1.00)																										
United States Total																										
Lower 48 Onshore																										
Lower 48 Offshore																										
Lower 48 On/Offshore	1.14	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.07	1.13	1.06	1.05	1.04	1.04	1.03	1.02	1.01	1.01	1.00	0.99	0.98	0.98	0.97	0.96
Crude Petroleum Lock Tonnage	4,598,580	4,568,857	4,539,134	4,509,411	4,479,688	4,449,965	4,420,242	4,390,519	4,360,796	4,331,073	4,301,350	4,568,857	4,271,627	4,241,904	4,212,181	4,182,458	4,152,735	4,123,012	4,093,289	4,063,566	4,033,843	4,004,120	3,974,397	3,974,397	3,914,951	3,885,228

Sources: EIA and G.E.C., Inc.

Table 2-18. Aggregates Shipped Through Calcasieu Lock, 2000-2011

Commodity Name	WCSC Code	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Gypsum and Anhydrite	27323	155,084	178,886	152,496	169,203	50,279	19,693	0	37,369	73,721	53,926	55,112	85,368
Limestone Flux & Calcareous Stone Used in Lime Mfg	27322	446,219	546,641	772,063	878,517	1,200,633	1,540,732	1,407,197	1,027,110	1,108,640	619,638	419,415	339,058
Materials Used in Waterway Improvement, Govt Matrl	27350	541,455	252,117	383,820	649,689	466,223	227,382	217,930	983,768	599,970	68,035	468,099	589,451
Pebbles, Gravel, Crushed Stone (Specialized Use)	27340	616,562	391,666	229,982	142,947	312,894	230,148	183,039	215,703	122,855	34,087	110,697	433,115
Sands, Natural, of all Kinds (Exc Silica & Quartz)	27330	7,003	3,964	12,007	2,480	2,341	2,115	3,910	332	2,244	623	2,022	7,911
Total		1,766,323	1,373,274	1,550,368	1,842,836	2,032,370	2,020,070	1,812,076	2,264,282	1,907,430	776,309	1,055,345	1,454,903

Source: G.E.C., Inc.

Table 2-19. Aggregate Tonnages Projected for Calcasieu Lock Based on EIA Energy Consumption for Nonfuel Use, 2011-2061

=120,176x-6,135,78	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference Case	71.18	71.45	70.54	71.29	71.59	71.91	71.93	72	72.22	72.43	72.7	73.15	73.35	73.58	73.92	74.24	74.61	74.94	75.27	75.64	76	76.45	76.93	77.33	77.75
AACGR	0.37%	0.37%	0.44%	0.41%	0.41%	0.41%	0.43%	0.45%	0.46%	0.47%	0.48%	0.47%	0.49%	0.50%	0.51%	0.51%	0.52%	0.53%	0.54%	0.55%	0.57%	0.56%	0.53%	0.54%	
Aggregate Tons	2,418,340	2,450,787	2,341,427	2,431,559	2,467,612	2,506,068	2,508,472	2,516,884	2,543,323	2,568,560	2,601,007	2,655,086	2,679,122	2,706,762	2,747,622	2,786,078	2,830,543	2,870,201	2,909,860	2,954,325	2,997,588	3,051,667	3,109,352	3,157,422	3,207,896

=120,176x-6,135,78	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Reference Case	77.92	78.28	78.64	79.00	79.36	79.72	80.08	80.44	80.80	81.16	81.52	81.88	82.24	82.60	82.96	83.32	83.68	84.04	84.40	84.76	85.12	85.48	85.84	86.20	86.56	86.92
AACGR																										
Aggregate Tons	3,228,735	3,271,962	3,315,188	3,358,414	3,401,641	3,444,867	3,488,094	3,531,320	3,574,546	3,617,773	3,660,999	3,704,226	3,747,452	3,790,678	3,833,905	3,877,131	3,920,357	3,963,584	4,006,810	4,050,037	4,093,263	4,136,489	4,179,716	4,222,942	4,266,168	4,309,395

Notes: EIA Reference Case Energy Consumption for Nonfuel Use (quadrillon btu) 2008-2035 extrapolated to 2061.
AACGR = Average Annual Compound Growth for EIA projections for 2035.
Aggregate Tons = Calcasieu Lock tonnages based on regression Y=120,176X-6,135,788.

Source: G.E.C., Inc.

Table 2-20. Iron Ore and Iron and Steel Group Commodity Tonnages Transiting Calcasieu Lock, 2006-2011

Commodity Name	LRH_Name	2011 Sum Of Tons	2010 Sum Of Tons	2009 Sum Of Tons	2008 Sum Of Tons	2007 Sum Of Tons	2006 Sum Of Tons	Total 2006-2011	2011 % Total Tons	2010 % Total Tons	2009 % Total Tons	2008 % Total Tons	2007 % Total Tons	2006 % Total Tons	Total 2006-2011
Ferrous Waste & Scrap; Remelting Ingots of Iron/Stl	Iron Ore & Iron & Steel Products	1,077,680	971,337	548,271	1,198,575	1,079,725	1,031,234	5,906,822	41.04%	49.21%	47.90%	38.33%	35.57%	40.39%	40.85%
Flat-Rolled Products of Iron & Steel, Not Clad, Pltd	Iron Ore & Iron & Steel Products	694,444	467,361	264,474	1,113,881	1,082,556	706,107	4,328,823	26.45%	23.68%	23.11%	35.62%	35.66%	27.65%	29.94%
Tubes, Pipes, Hollow Profiles of Iron or Steel	Iron Ore & Iron & Steel Products	133,601	74,527	102,671	171,066	245,954	333,113	1,060,932	5.09%	3.78%	8.97%	5.47%	8.10%	13.05%	7.34%
Wire of Iron or Steel	Iron Ore & Iron & Steel Products	411,776	133,587	46,595	323,799	274,137	197,562	1,387,456	15.68%	6.77%	4.07%	10.35%	9.03%	7.74%	9.59%
Pig Iron & Spiegeleisen, in Pigs, Blocks, Other Form	Iron Ore & Iron & Steel Products	58,034	49,921	72,907	156,772	117,375	99,886	554,895	2.21%	2.53%	6.37%	5.01%	3.87%	3.91%	3.84%
Other Ferro-Alloys (Exc Radioactive Ferro-Alloys)	Iron Ore & Iron & Steel Products	14,217	26,472	18,434	34,853	30,252	34,498	158,726	0.54%	1.34%	1.61%	1.11%	1.00%	1.35%	1.10%
Iron and Steel Bars, Rods, Angles, Shapes & Sections	Iron Ore & Iron & Steel Products	193,181	152,920	79,678	83,305	116,818	79,266	705,168	7.36%	7.75%	6.96%	2.66%	3.85%	3.10%	4.88%
Flat-Rolled Prods of Iron/Non-Alloy Steel, Clad, Plt	Iron Ore & Iron & Steel Products	0	0	0	7,004	33,375	45,599	85,978	0.00%	0.00%	0.00%	0.22%	1.10%	1.79%	0.59%
Iron Ore and Concentrates	Iron Ore & Iron & Steel Products	8,468	16,816	8,783	30,563	25,907	18,093	108,630	0.32%	0.85%	0.77%	0.98%	0.85%	0.71%	0.75%
Ingots and Other Primary Forms of Iron or Steel	Iron Ore & Iron & Steel Products	34,360	81,005	2,705	7,531	19,230	7,991	152,822	1.31%	4.10%	0.24%	0.24%	0.63%	0.31%	1.06%
Ferro-Manganese	Iron Ore & Iron & Steel Products	0	0	0	0	6,706	0	6,706	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.05%
Rails/Railway Track Const Material, of Iron/Steel	Iron Ore & Iron & Steel Products	0	0	0	0	3,699	0	3,699	0.00%	0.00%	0.00%	0.00%	0.12%	0.00%	0.03%
Subtotal		2,625,761	1,973,946	1,144,518	3,127,349	3,035,734	2,553,349	14,460,657	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-21. Nonmetallic Minerals Group Commodity Tonnages Transiting Calcasieu Lock, 2006-2011

Commodity Name	LRH_Name	2011 Sum Of Tons	2010 Sum Of Tons	2009 Sum Of Tons	2008 Sum Of Tons	2007 Sum Of Tons	2006 Sum Of Tons	Total 2006-2011	2011 % Total Tons	2010 % Total Tons	2009 % Total Tons	2008 % Total Tons	2007 % Total Tons	2006 % Total Tons	Total 2006-2011
Aluminum Ores & Concentrates (Including Alumina)	Non-Metallic Ores & Minerals	492,668	538,078	330,899	665,766	775,771	1,067,602	3,870,784	71.07%	72.39%	68.02%	73.84%	72.74%	72.47%	72.16%
Barium Sulphate, Barytes, Barium Carbonate	Non-Metallic Ores & Minerals	94,516	76,044	79,279	117,029	185,616	262,457	814,941	13.63%	10.23%	16.30%	12.98%	17.40%	17.82%	15.19%
Manganese Ores and Concentrates	Non-Metallic Ores & Minerals	36,514	63,357	16,644	22,756	44,808	89,349	273,428	5.27%	8.52%	3.42%	2.52%	4.20%	6.07%	5.10%
Clays and Other Refractory Minerals, NEC	Non-Metallic Ores & Minerals	20,676	17,443	15,592	32,201	22,978	7,277	116,167	2.98%	2.35%	3.21%	3.57%	2.15%	0.49%	2.17%
Quartz,Mica,Felspar,Fluorspar,Cryolite & Chiolite	Non-Metallic Ores & Minerals	17,997	14,480	15,096	22,284	8,044	25,971	103,872	2.60%	1.95%	3.10%	2.47%	0.75%	1.76%	1.94%
Vermiculite, Perlite, Chlorites	Non-Metallic Ores & Minerals	13,231	10,645	11,098	16,383	10,404	6,198	67,960	1.91%	1.43%	2.28%	1.82%	0.98%	0.42%	1.27%
Non-Ferrous Base Metal Waste and Scrap, NEC	Non-Metallic Ores & Minerals	0	10,622	10,134	13,486	12,981	0	47,223	0.00%	1.43%	2.08%	1.50%	1.22%	0.00%	0.88%
Ores & Concentrates of Molybdeum,Niobium,Tantalum	Non-Metallic Ores & Minerals	7,205	6,421	2,981	1,820	2,783	7,679	28,889	1.04%	0.86%	0.61%	0.20%	0.26%	0.52%	0.54%
Chalk	Non-Metallic Ores & Minerals	5,312	4,274	4,455	6,577	1,604	6,580	28,802	0.77%	0.57%	0.92%	0.73%	0.15%	0.45%	0.54%
Zinc Ores and Concentrates	Non-Metallic Ores & Minerals	4,750	1,670	0	2,840	0	0	9,260	0.69%	0.22%	0.00%	0.32%	0.00%	0.00%	0.17%
Mineral Substances, NEC	Non-Metallic Ores & Minerals	348	280	292	431	1,500	0	2,851	0.05%	0.04%	0.06%	0.05%	0.14%	0.00%	0.05%
Subtotal		693,218	743,314	486,470	901,573	1,066,489	1,473,113	5,364,177	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-22. Grains Group Commodity Tonnages Transiting Calcasieu Lock, 2006-2011

Commodity Name	LRH_Name	2011 Sum Of Tons	2010 Sum Of Tons	2009 Sum Of Tons	2008 Sum Of Tons	2007 Sum Of Tons	2006 Sum Of Tons	Total 2006-2011	2011 % Total Tons	2010 % Total Tons	2009 % Total Tons	2008 % Total Tons	2007 % Total Tons	2006 % Total Tons	Total 2006-2011
Rice	Grains & Grain Products	90,635	75,911	63,008	84,961	142,733	166,282	623,530	34.90%	25.70%	30.73%	55.78%	77.05%	88.47%	48.50%
Maize (Not Including Sweet Corn), Unmilled	Grains & Grain Products	34,710	24,146	43,349	28,920	7,691	9,163	147,979	13.36%	8.17%	21.14%	18.99%	4.15%	4.88%	11.51%
Flours,Meals & Pellets (Meat, Offal, Fish, Etc.)Inedibl	Grains & Grain Products	73,849	49,486	25,034	14,307	13,551	8,884	185,111	28.43%	16.75%	12.21%	9.39%	7.31%	4.73%	14.40%
Soya Beans	Grains & Grain Products	4,986	19,384	10,760	9,702	1,618	0	46,450	1.92%	6.56%	5.25%	6.37%	0.87%	0.00%	3.61%
Grain Sorghum, Unmilled	Grains & Grain Products	3,245	40,088	18,147	3,498	9,618	684	75,280	1.25%	13.57%	8.85%	2.30%	5.19%	0.36%	5.86%
Wheat (Including Spelt) and Meslin, Unmilled	Grains & Grain Products	52,307	86,406	44,724	7,959	0	0	191,396	20.14%	29.25%	21.81%	5.23%	0.00%	0.00%	14.89%
Food Wastes and Prepared Animal Feeds, NEC	Grains & Grain Products	0	0	0	2,962	5,967	0	8,929	0.00%	0.00%	0.00%	1.94%	3.22%	0.00%	0.69%
Bran,Sharps & Oth Residues From Cereals or Legumes	Grains & Grain Products	0	0	0	0	4,080	0	4,080	0.00%	0.00%	0.00%	0.00%	2.20%	0.00%	0.32%
Cereal Preps & Preps of Flour/Starch of Fruit/Vegs	Grains & Grain Products	0	0	0	0	0	2,939	2,939	0.00%	0.00%	0.00%	0.00%	0.00%	1.56%	0.23%
Subtotal	Grains & Grain Products	259,732	295,421	205,022	152,309	185,258	187,952	1,285,694	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-23. Coal Group Commodity Tonnages Transiting Calcasieu Lock, 2006-2011

Commodity Name	LRH_Name	2011 Sum of Tons	2010 Sum of Tons	2009 Sum of Tons	2008 Sum of Tons	2007 Sum of Tons	2006 Sum of Tons	Total 2006-2011	2011 % Total Tons	2010 % Total Tons	2009 % Total Tons	2008 % Total Tons	2007 % Total Tons	2006 % Total Tons	Total 2006-2011
Coal, Whether or not Pulverized, but Not Agglomerat	Coal	0	0	0	200,886	97,507	13,966	312,359	0.00%	0.00%	0.00%	50.00%	27.21%	3.38%	20.32%
Coke, Semi-Coke of Coal, of Lignite or of Peat	Coal	50,562	123,452	111,650	168,488	257,710	398,652	1,110,514	77.38%	83.23%	74.08%	41.94%	71.92%	96.62%	72.25%
Briquettes, Ovoids & Similar Solid Fuels from Coal	Coal	14,780	24,876	39,073	32,370	3,122	0	114,221	22.62%	16.77%	25.92%	8.06%	0.87%	0.00%	7.43%
Subtotal		65,342	148,328	150,723	401,744	358,339	412,618	1,537,094	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-24. Other Group Commodity Tonnages Transiting Calcasieu Lock, 2006-2011

Commodity Name	LRH_Name	2011 Sum Of Tons	2010 Sum Of Tons	2009 Sum Of Tons	2008 Sum Of Tons	2007 Sum Of Tons	2006 Sum Of Tons	Total 2006-2011	2011 % Total Tons	2010 % Total Tons	2009 % Total Tons	2008 % Total Tons	2007 % Total Tons	2006 % Total Tons	Total 2006-2011
Portland, Aluminous, Slag, or Supersulfate Cement	Others	626,747	738,291	514,838	967,611	914,365	1,256,723	5,018,575	34.63%	38.73%	34.80%	43.80%	46.36%	49.09%	42.04%
Waste Water	Others	466,703	490,040	387,436	604,938	582,155	708,794	3,240,066	25.79%	25.71%	26.19%	27.38%	29.51%	27.69%	27.14%
Manufactures of Metals, NEC	Others	206,100	282,574	150,263	196,646	34,122	58,452	928,157	11.39%	14.82%	10.16%	8.90%	1.73%	2.28%	7.78%
Sugars, Beet or Cane, Raw, Solid Form, No additives	Others	142,146	113,995	147,408	143,236	169,342	179,601	895,728	7.85%	5.98%	9.96%	6.48%	8.59%	7.02%	7.50%
Fixed Vegetable Fats & Oils,Crude,Refined or Fract	Others	168,124	29,229	111,283	46,358	37,220	50,655	442,869	9.29%	1.53%	7.52%	2.10%	1.89%	1.98%	3.71%
Slag & Ash, NEC, Including Seaweed Ash (Kelp)	Others	33,532	49,766	47,075	49,199	56,959	43,198	279,729	1.85%	2.61%	3.18%	2.23%	2.89%	1.69%	2.34%
Machinery Specialized for Particular Industries	Others	27,643	21,762	17,377	86,171	31,391	24,823	209,167	1.53%	1.14%	1.17%	3.90%	1.59%	0.97%	1.75%
Slag, Dross, Scalings & Waste of Iron or Steel	Others	15,415	22,877	21,641	22,617	37,991	55,163	175,704	0.85%	1.20%	1.46%	1.02%	1.93%	2.15%	1.47%
Miscellaneous Manufactured Articles, NEC	Others	25,022	35,000	16,468	26,581	68,692	102,317	274,080	1.38%	1.84%	1.11%	1.20%	3.48%	4.00%	2.30%
Alcoholic Beverages	Others	35,172	22,056	22,590	22,179	3,207	12,627	117,831	1.94%	1.16%	1.53%	1.00%	0.16%	0.49%	0.99%
Aluminum	Others	10,400	13,194	4,989	9,548	4,719	11,474	54,324	0.57%	0.69%	0.34%	0.43%	0.24%	0.45%	0.46%
Molasses Resulting From the Extraction/Refin Sugar	Others	17,873	14,330	2,743	7,047	9,467	0	51,460	0.99%	0.75%	0.19%	0.32%	0.48%	0.00%	0.43%
Zinc	Others	0	0	0	6,279	1,400	424	8,103	0.00%	0.00%	0.00%	0.28%	0.07%	0.02%	0.07%
Mechanical Handling Equipment & Parts Thereof, NEC	Others	1,833	1,443	1,152	5,713	4,074	0	14,215	0.10%	0.08%	0.08%	0.26%	0.21%	0.00%	0.12%
Water (Inc Natural or Artif/Aerated) No Sugar/Flav	Others	657	1,772	1,925	5,260	736	2,032	12,382	0.04%	0.09%	0.13%	0.24%	0.04%	0.08%	0.10%
Tin	Others	0	0	0	3,137	0	0	3,137	0.00%	0.00%	0.00%	0.14%	0.00%	0.00%	0.03%
Manufactures of Mineral Materials, NEC	Others	0	0	7,405	2,800	1,400	12,683	24,288	0.00%	0.00%	0.50%	0.13%	0.07%	0.50%	0.20%
Electrical Machinery,Appar & Appliances, NEC;Parts	Others	0	100	2,600	1,668	0	0	4,368	0.00%	0.01%	0.18%	0.08%	0.00%	0.00%	0.04%
Other Solid Sugars; Sugar Syrups (No Additv); Caramel	Others	29,137	60,072	22,285	1,406	8,459	35,226	156,585	1.61%	3.15%	1.51%	0.06%	0.43%	1.38%	1.31%
Wood Manufactures, Not Elsewhere Classified	Others	1,564	250	0	502	0	282	2,598	0.09%	0.01%	0.00%	0.02%	0.00%	0.01%	0.02%
Oth Non-Electrical Machinery, Tools, Apparatus; Parts	Others	160	126	101	500	0	0	887	0.01%	0.01%	0.01%	0.02%	0.00%	0.00%	0.01%
Monumental or Building Stone and Articles Thereof	Others	0	0	0	0	1,600	0	1,600	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.01%
Land Fill	Others	0	0	0	0	1,531	0	1,531	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.01%
Containers (Multi-Modal)	Others	1,600	9,384	0	0	2,978	0	13,962	0.09%	0.49%	0.00%	0.00%	0.15%	0.00%	0.12%
Paper and Paperboard, Cut to Size, Shape; Articles of	Others	0	0	0	0	369	282	651	0.00%	0.00%	0.00%	0.00%	0.02%	0.01%	0.01%
Ships, Boats (Inc Hovercraft) & Floating Structures	Others	0	0	0	0	279	83	362	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Quicklime, Slaked Lime & Hydraulic Lime	Others	0	0	0	0	0	2,709	2,709	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.02%
Wood in the Rough or Roughly Squared	Others	0	0	0	0	0	423	423	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
Nickel	Others	0	0	0	0	0	1,201	1,201	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.01%
Lumber	Others	0	0	0	0	0	282	282	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Aircraft and Assoc Equip; Spacecraft & Launch Veh	Others	0	0	0	0	0	233	233	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Parts & Accessories of Motor Vehicles (722,781-783)	Others	0	0	0	0	0	111	111	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Motor Veh for Transport of Goods; Spec Use Motr Veh	Others	0	0	0	0	2	0	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Subtotal		1,809,828	1,906,261	1,479,579	2,209,396	1,972,458	2,559,798	11,937,320	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 2-25. Annual Commodity Tons Projected for Calcasieu Lock, 2011-2061

Commodity Group	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Liquid Bulks																									
Petrochemicals	16,229,683	16,476,196	16,045,239	16,412,552	16,589,798	16,589,343	16,542,067	16,478,610	16,509,261	16,471,855	16,452,916	16,495,059	16,539,295	16,565,598	16,601,523	16,625,179	16,630,651	16,607,938	16,589,363	16,653,202	16,613,442	16,565,620	16,717,789	16,797,630	16,893,578
Chemicals	9,302,012	8,753,651	8,749,291	9,104,133	9,283,901	9,499,221	9,795,369	10,059,656	10,320,253	10,587,558	10,825,013	11,007,465	11,082,256	11,194,612	11,323,736	11,350,568	11,383,436	11,473,320	11,495,791	11,459,904	11,434,079	11,417,645	11,414,291	11,405,907	11,404,901
Crude Petroleum	4,035,558	4,188,603	4,349,703	4,446,363	4,583,298	4,784,674	4,808,839	4,857,169	4,945,774	5,002,159	4,961,884	4,889,389	4,881,334	4,873,279	4,833,004	4,816,894	4,824,949	4,833,004	4,800,784	4,784,674	4,736,344	4,720,234	4,720,234	4,647,738	4,615,518
Subtotal Liquid Bulk	29,567,253	29,418,450	29,144,234	29,963,048	30,456,998	30,873,237	31,146,274	31,395,434	31,775,287	32,061,572	32,239,812	32,391,913	32,502,886	32,633,488	32,758,263	32,792,640	32,839,035	32,914,262	32,885,938	32,897,780	32,783,865	32,703,499	32,852,314	32,851,275	32,913,997
Dry Bulks																									
Aggregates	2,418,340	2,450,787	2,341,427	2,431,559	2,467,612	2,506,068	2,508,472	2,516,884	2,543,323	2,568,560	2,601,007	2,655,086	2,679,122	2,706,762	2,747,622	2,786,078	2,830,543	2,870,201	2,909,860	2,954,325	2,997,588	3,051,667	3,109,352	3,157,422	3,207,896
Iron and Steel	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070
Nonmetallic Minerals	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233
Coal	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855
Grain	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561
Other	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828
Subtotal Dry Bulks	8,415,886	8,448,334	8,338,974	8,429,106	8,465,159	8,503,615	8,506,018	8,514,431	8,540,869	8,566,106	8,598,554	8,652,633	8,676,668	8,704,309	8,745,169	8,783,625	8,828,090	8,867,748	8,907,406	8,951,871	8,995,135	9,049,214	9,106,898	9,154,969	9,205,443
Total Commodity Tons	37,983,139	37,866,784	37,483,207	38,392,154	38,922,156	39,376,852	39,652,293	39,909,865	40,316,157	40,627,678	40,838,366	41,044,546	41,179,554	41,337,797	41,503,432	41,576,265	41,667,125	41,782,010	41,793,344	41,849,652	41,779,000	41,752,713	41,959,212	42,006,244	42,119,439

Commodity Group	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Liquid Bulks																										
Petrochemicals	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578	16,893,578
Chemicals	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901
Crude Petroleum	4,598,580	4,568,857	4,539,134	4,509,411	4,479,688	4,449,965	4,420,242	4,390,519	4,360,796	4,331,073	4,301,350	4,568,857	4,271,627	4,241,904	4,212,181	4,182,458	4,152,735	4,123,012	4,093,289	4,063,566	4,033,843	4,004,120	3,974,397	3,974,397	3,914,951	3,885,228
Subtotal Liquid Bulk	32,897,058	32,867,335	32,837,612	32,807,889	32,778,166	32,748,443	32,718,720	32,688,997	32,659,274	32,629,551	32,599,828	32,867,335	32,570,105	32,540,382	32,510,659	32,480,936	32,451,213	32,421,490	32,391,767	32,362,044	32,332,321	32,302,598	32,272,875	32,272,875	32,213,429	32,183,707
Dry Bulks																										
Aggregates	3,228,735	3,271,962	3,315,188	3,358,414	3,401,641	3,444,867	3,488,094	3,531,320	3,574,546	3,617,773	3,660,999	3,704,226	3,747,452	3,790,678	3,833,905	3,877,131	3,920,357	3,963,584	4,006,810	4,050,037	4,093,263	4,136,489	4,179,716	4,222,942	4,266,168	4,309,395
Iron and Steel	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070	2,418,070
Nonmetallic Minerals	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233	1,218,233
Coal	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855	268,855
Grain	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561	282,561
Other	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828	1,809,828
Subtotal Dry Bulks	9,226,282	9,269,508	9,312,735	9,355,961	9,399,188	9,442,414	9,485,640	9,528,867	9,572,093	9,615,319	9,658,546	9,701,772	9,744,999	9,788,225	9,831,451	9,874,678	9,917,904	9,961,130	10,004,357	10,047,583	10,090,810	10,134,036	10,177,262	10,220,489	10,263,715	10,306,942
Total Commodity Tons	42,123,340	42,136,843	42,150,347	42,163,850	42,177,353	42,190,857	42,204,360	42,217,864	42,231,367	42,244,871	42,258,374	42,569,107	42,315,104	42,328,607	42,342,111	42,355,614	42,369,117	42,382,621	42,396,124	42,409,628	42,423,131	42,436,634	42,450,138	42,493,364	42,477,145	42,490,648

Notes: EIA projections for liquid bulks and aggregates extend to 2035 and are extraploted beyond based on trends for chemicals, crude petroleum and aggregates. Petrochemicals trends are assumed to remain constant beyond 2035 for extrapolation purposes.
EIA extrapolations past 2035 arbitrarily extend to 2061 which is slightly greater than the EIA projection period from 2012-2035.
Dry bulk commodity categories of iron and steel, nonmetallic minerals, coal, grain and other are extrapolated from average of annual tonnages recorded during 2000-2011.

Source: G.E.C., Inc.

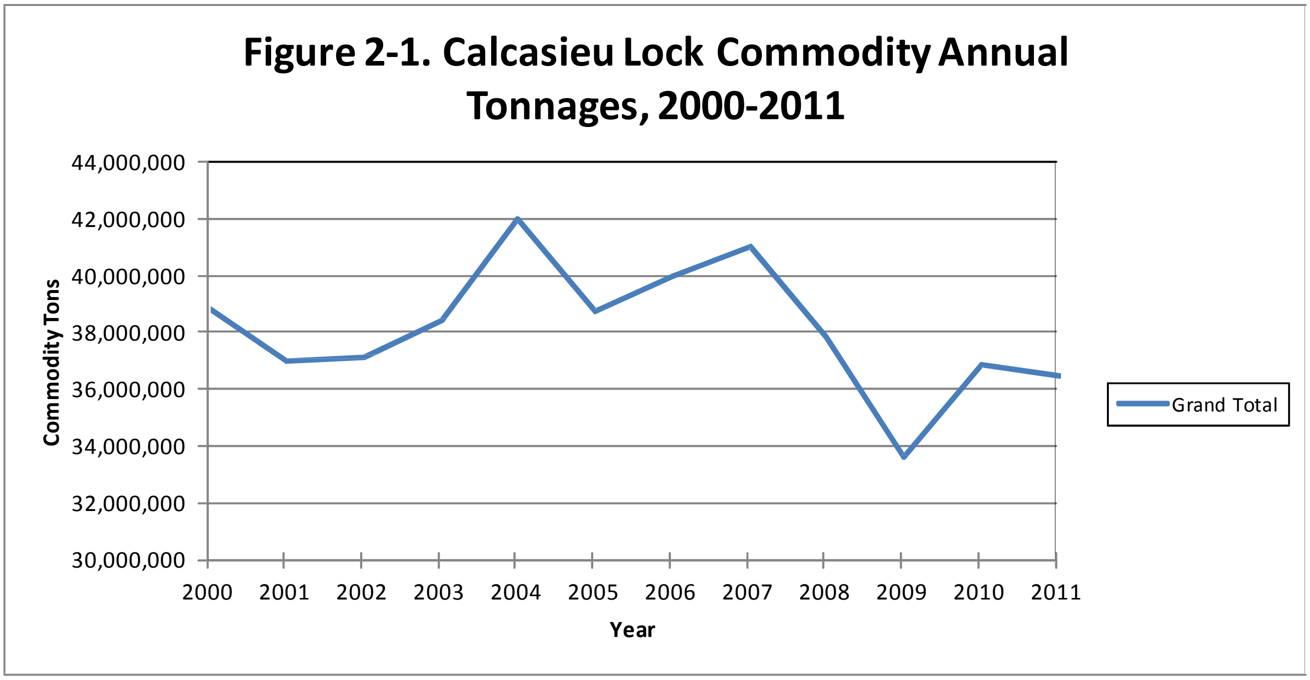


Figure 2-1. Calcasieu Lock Commodity Annual Tonnages, 2000-2011
Commodity Tons
44,000,000
42,000,000
40,000,000
38,000,000
36,000,000
34,000,000
32,000,000
30,000,000
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Grand Total

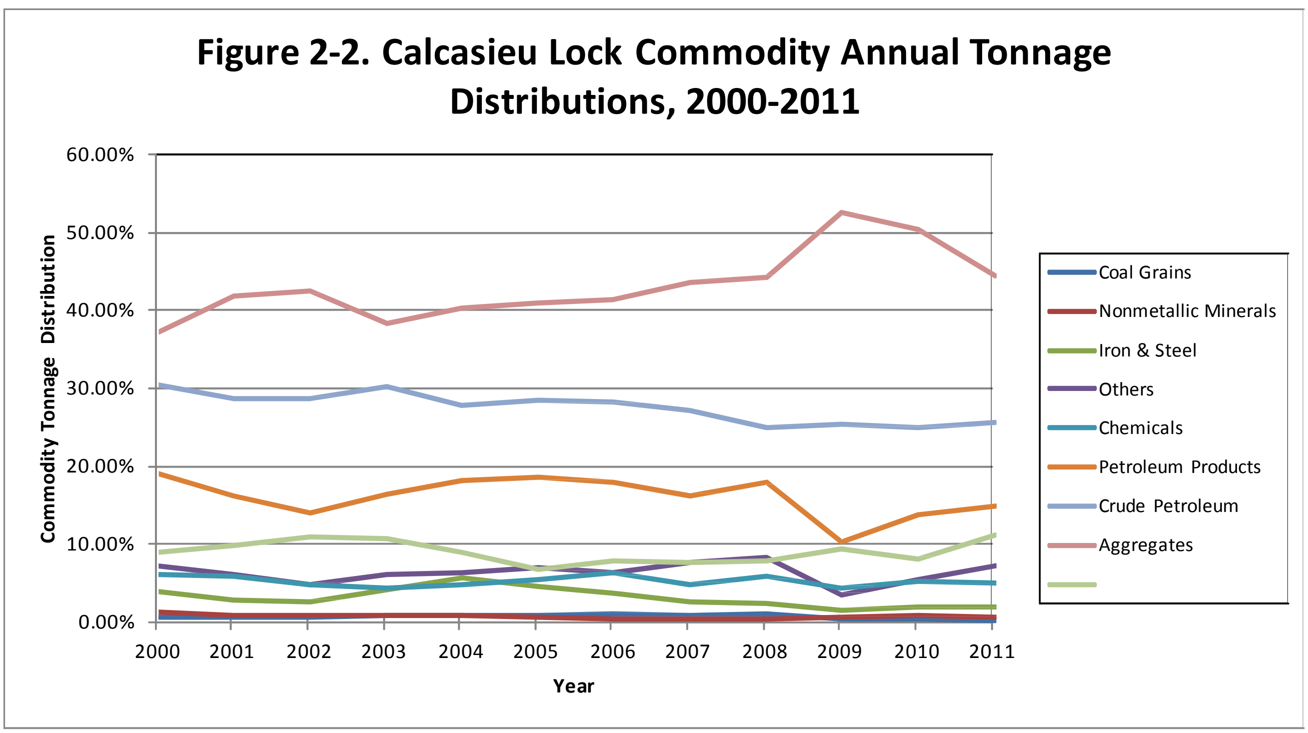


Figure 2-2. Calcasieu Lock Commodity Annual Tonnage Distributions, 2000-2011
Commodity Tonnage Distribution
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Coal Grains
Nonmetallic Minerals
Iron & Steel
Others
Chemicals
Petroleum Products
Crude Petroleum
Aggregates

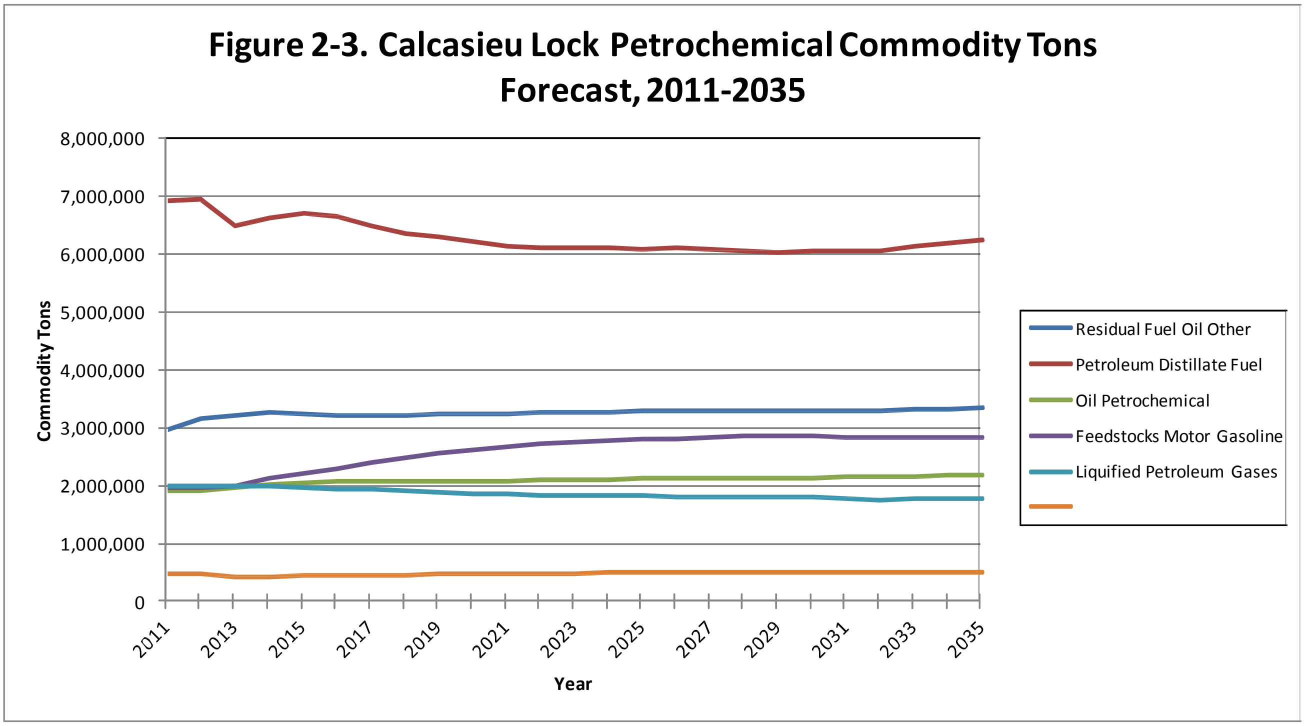


Figure 2-3. Calcasieu Lock Petrochemical Commodity Tons Forecast, 2011-2035
Commodity Tons
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
Year
Residual Fuel Oil Other
Petroleum Distillate Fuel
Oil Petrochemical
Feedstocks Motor Gasoline
Liquified Petroleum Gases

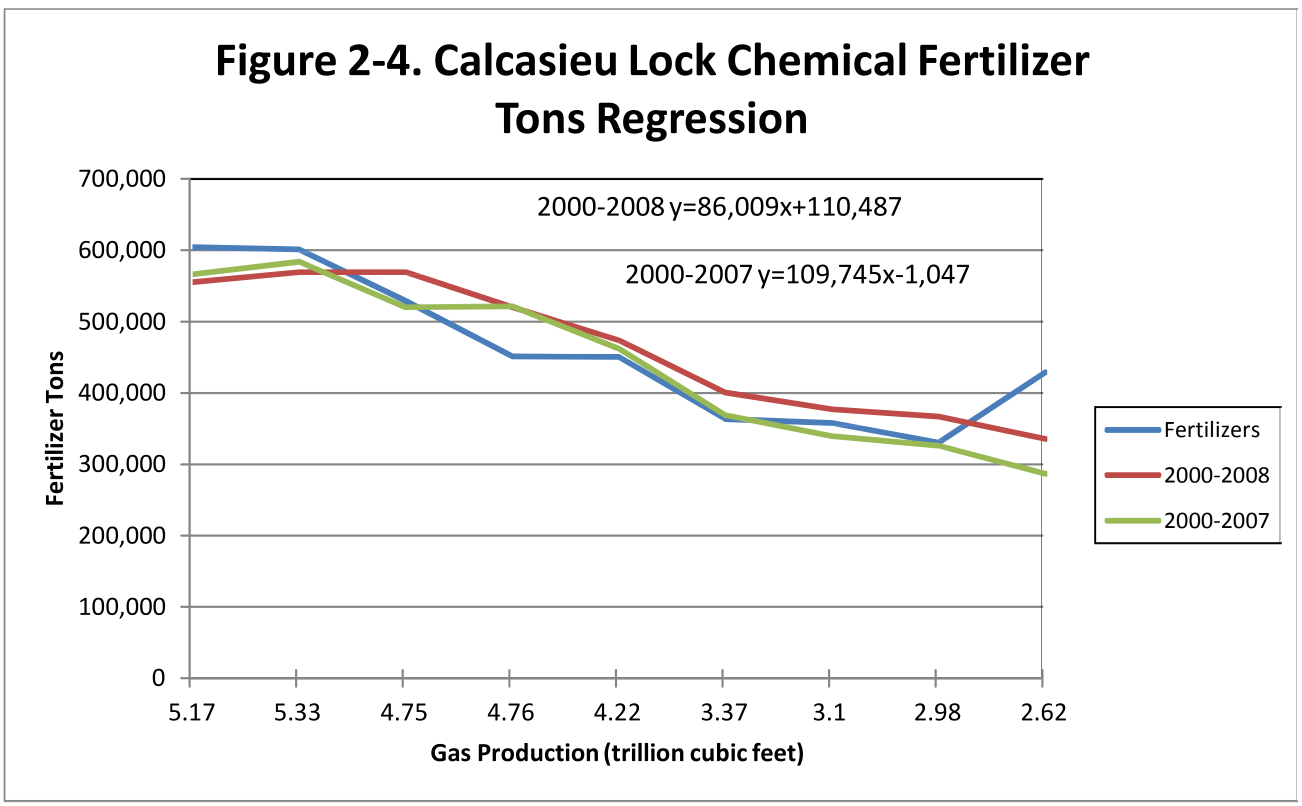


Figure 2-4. Calcasieu Lock Chemical Fertilizer Tons Regression
2000-2008 y=86,009x+110,487
2000-2007 y=109,745x-1,047
Fertilizer Tons
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
5.17
5.33
4.75
4.76
4.22
3.37
3.1
2.98
2.62
Gas Production (trillion cubic feet)
Fertilizers
2000-2008
2000-2007

*Not updated.

Figure 2-5. Calcasieu Lock Chemicals Projections, 2011-2061

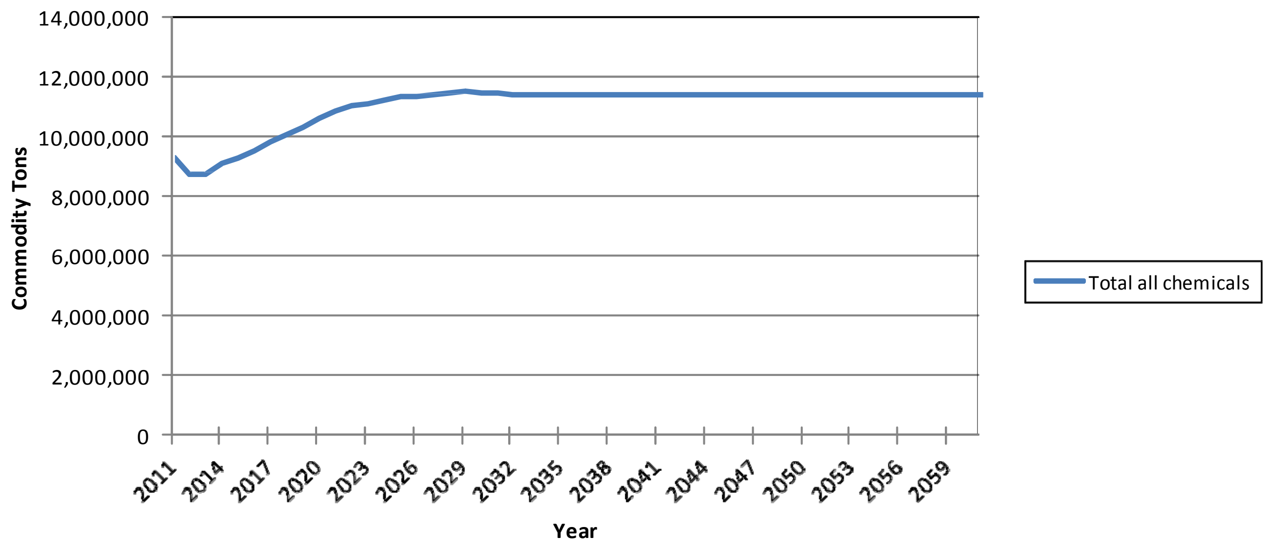


Figure 2-6. Crude Petroleum Production Forecast and Calcasieu Lock Tonnages, 2011-2061

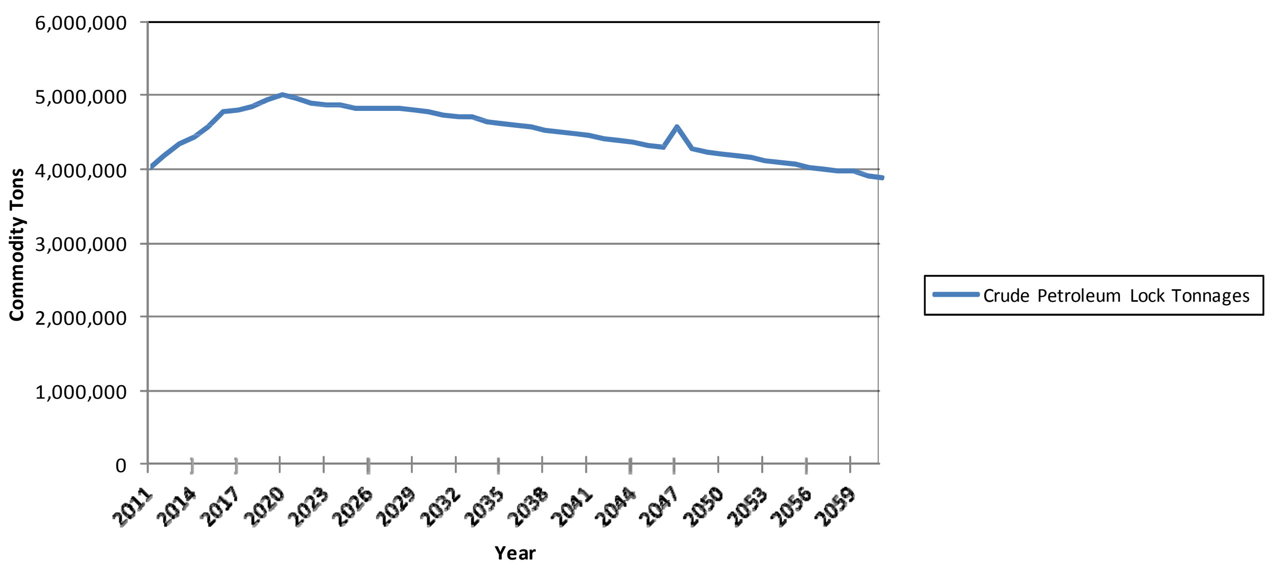


Figure 2-7. Aggregate Tonnages Projected for Calcasieu Lock, 2011-2061

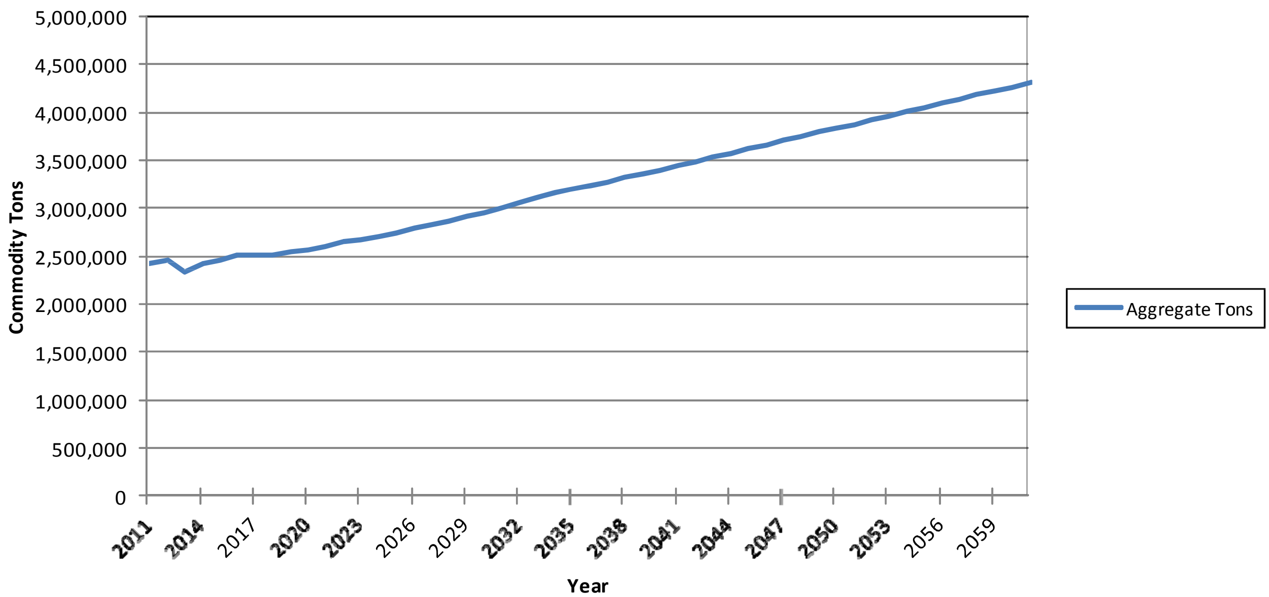
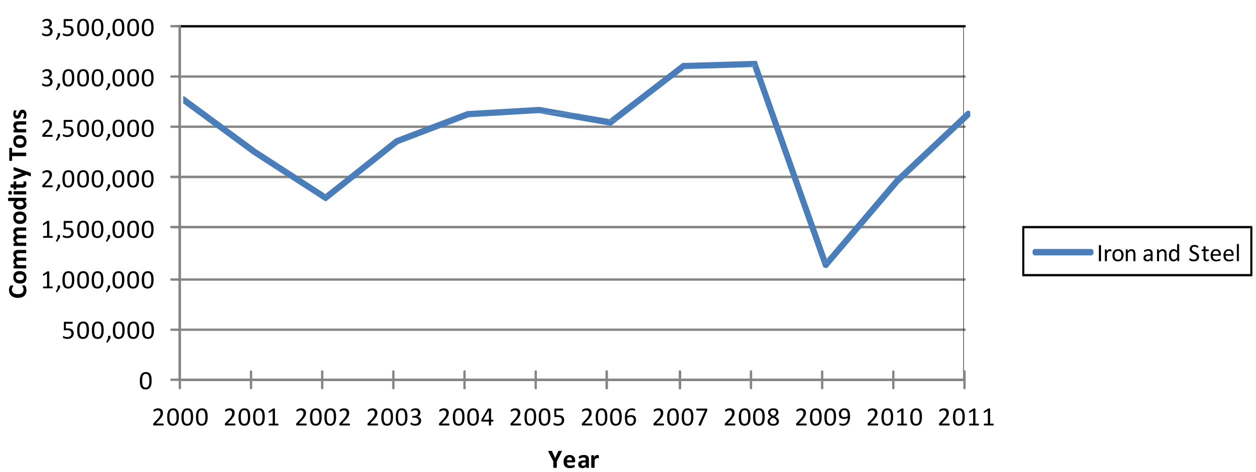


Figure 2-8. Iron and Steel Commodity Tons, 2000-2011



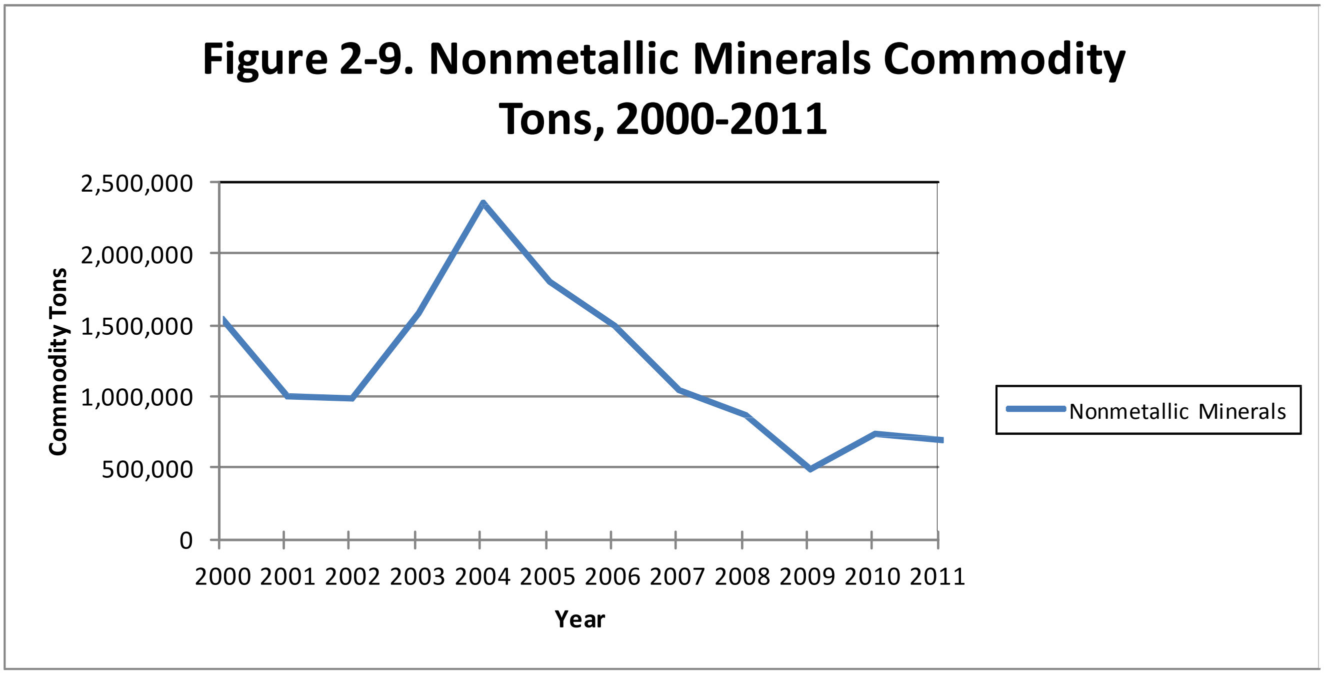


Figure 2-9. Nonmetallic Minerals Commodity Tons, 2000-2011
Commodity Tons
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Nonmetallic Minerals

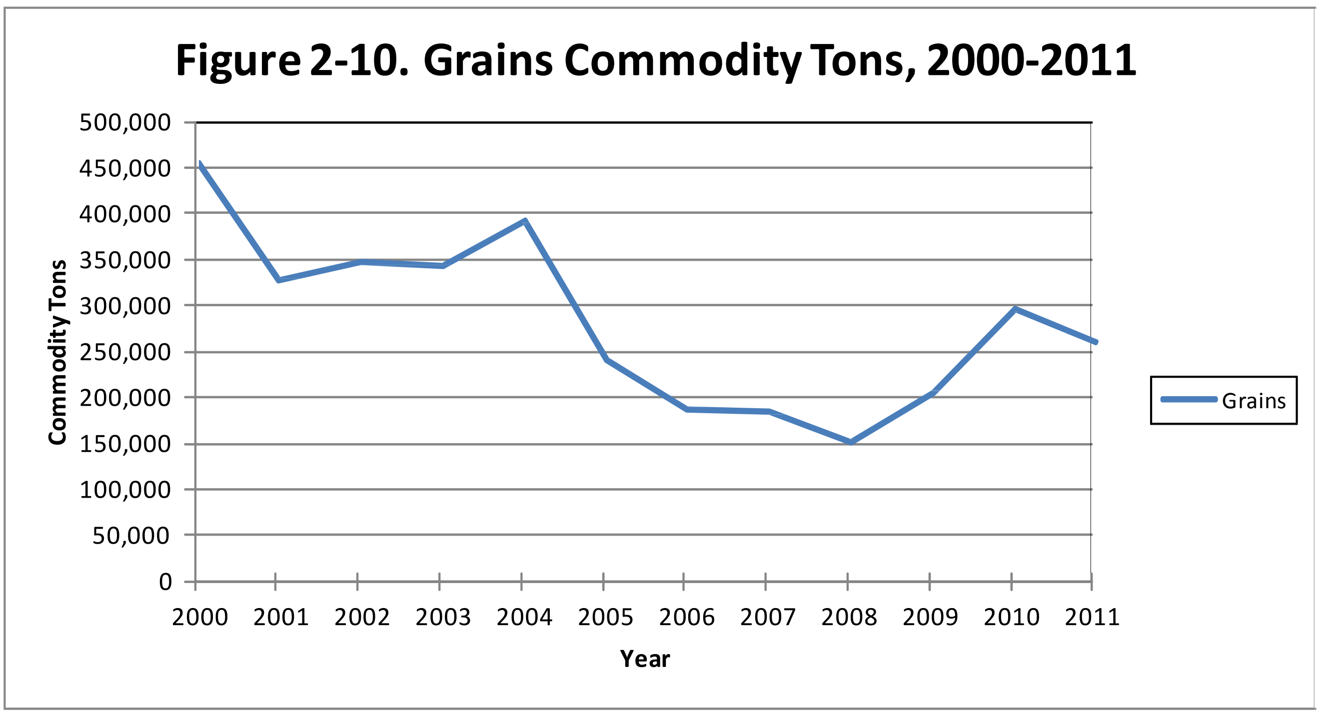


Figure 2-10. Grains Commodity Tons, 2000-2011
Commodity Tons
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Grains

Figure 2-11. Coal Commodity Tons, 2000-2011

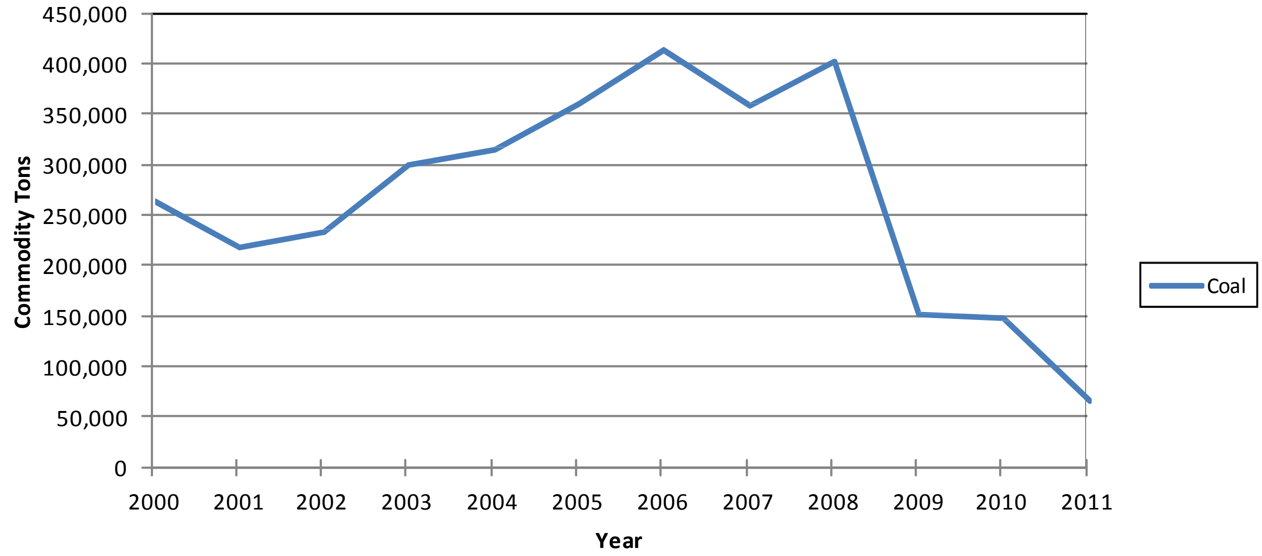
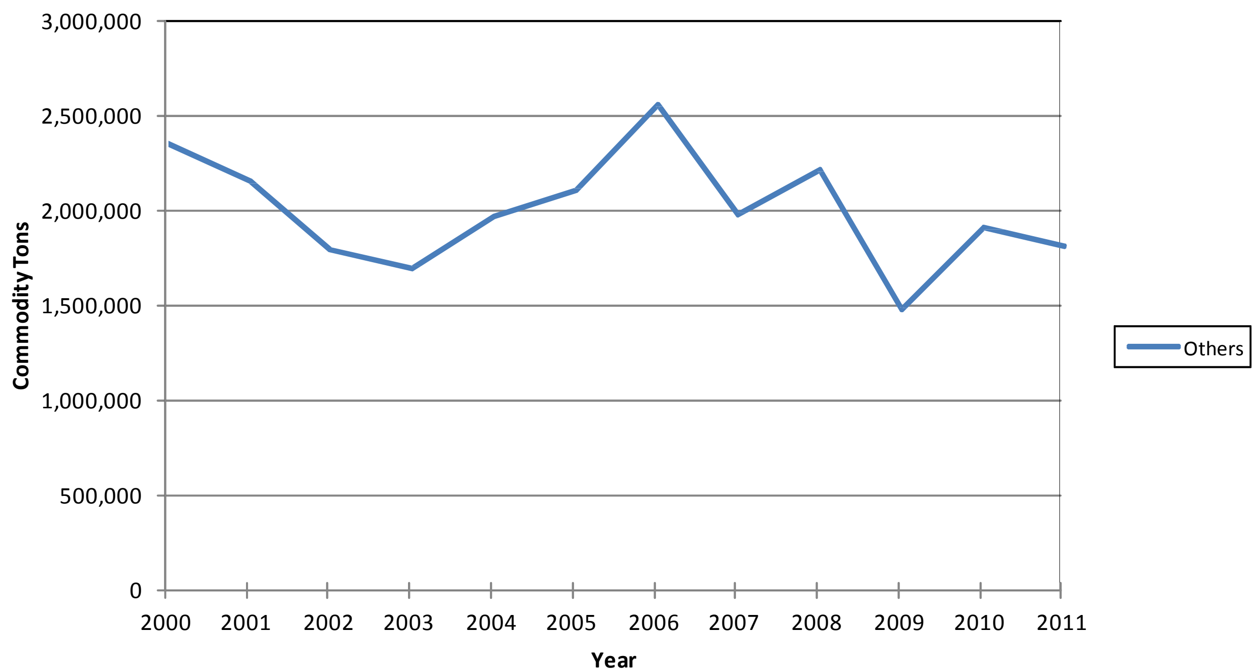


Figure 2-12. Others Commodity Tons, 2000-2011



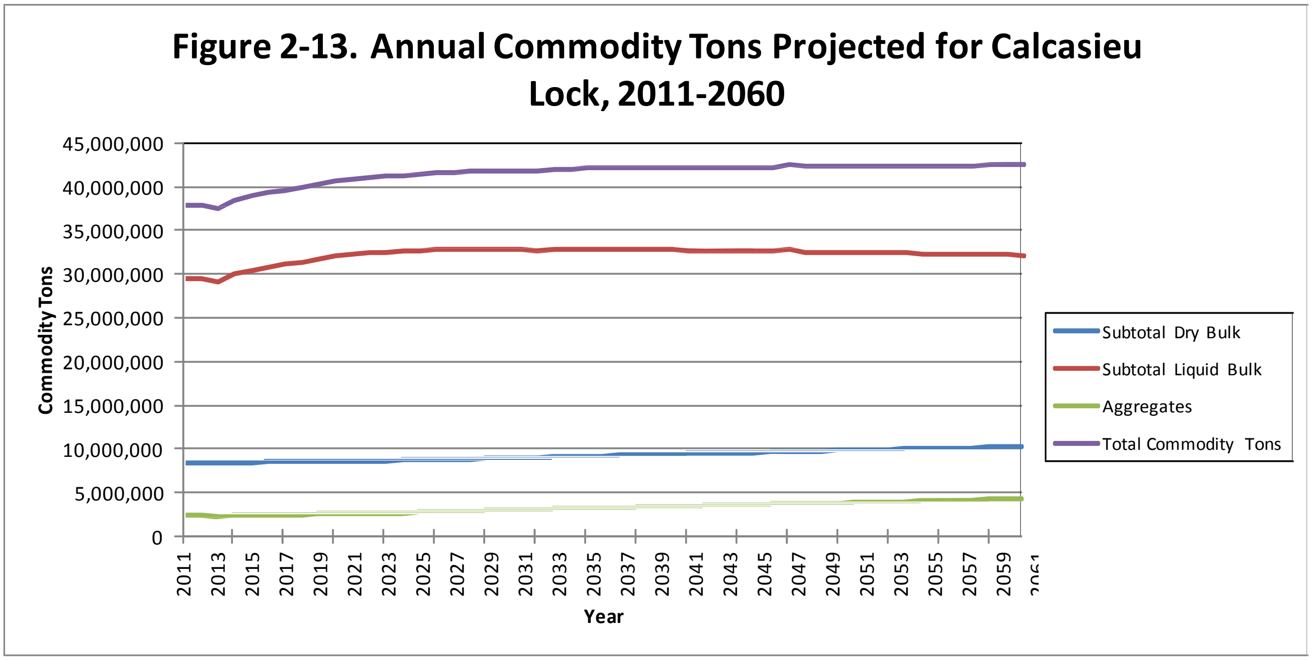


Figure 2-13. Annual Commodity Tons Projected for Calcasieu Lock, 2011-2060
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Commodity Tons
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
2051
2053
2055
2057
2059
Year
Subtotal Dry Bulk
Subtotal Liquid Bulk
Aggregates
Total Commodity Tons

Section 3:
TABLES AND FIGURES

Table 3-1. Calcasieu Lock Petrochemical Commodity Tons Forecasts for Low/High World Oil Prices and High/Low Economic Growth, 2011-2035

Total Energy Consumption Low World Oil Prices	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Liquefied Petroleum Gases	1.00	1.01	0.91	0.94	0.95	0.97	0.99	1.01	1.03	1.04	1.06	1.07	1.08	1.08	1.09	1.10	1.10	1.11	1.11	1.11	1.10	1.10	1.10	1.10	1.11
Motor Gasoline 2/	1.00	1.00	1.03	1.04	1.05	1.05	1.04	1.04	1.04	1.04	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05	1.06	1.06	1.07	1.08	1.09	1.09
Jet Fuel 9/	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.07	1.08	1.08	1.09	1.09	1.09	1.10	1.10	1.11
Kerosene	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Distillate Fuel Oil	1.00	1.01	1.05	1.09	1.11	1.11	1.11	1.11	1.11	1.11	1.12	1.13	1.13	1.13	1.14	1.14	1.14	1.15	1.15	1.16	1.16	1.17	1.17	1.18	1.19
Residual Fuel Oil	1.00	1.09	1.14	1.17	1.17	1.17	1.17	1.17	1.19	1.21	1.22	1.23	1.23	1.23	1.24	1.23	1.23	1.24	1.25	1.26	1.26	1.26	1.28	1.29	1.31
Petrochemical Feedstocks	1.00	1.00	1.02	1.09	1.12	1.18	1.23	1.28	1.31	1.34	1.38	1.40	1.41	1.42	1.44	1.46	1.46	1.48	1.48	1.48	1.47	1.47	1.47	1.47	1.47
Other Petroleum 12/	1.00	1.02	1.01	1.05	1.07	1.08	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.07	1.07	1.08	1.08	1.08	1.09	1.10	1.10	1.11	1.12	1.14	1.15
Liquid Fuels Subtotal ex E85	1.00	1.01	1.02	1.05	1.06	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08	1.08	1.09	1.09	1.09	1.10	1.10	1.11	1.12	1.12	1.13	1.14	1.14
Petrochemicals - Low Oil Prices																									
Residual Fuel Oil	2,950,146	3,225,160	3,375,167	3,450,171	3,450,171	3,450,171	3,450,171	3,450,171	3,500,173	3,575,177	3,600,178	3,625,179	3,625,179	3,625,179	3,650,181	3,625,179	3,625,179	3,650,181	3,675,182	3,725,184	3,725,184	3,725,184	3,775,187	3,800,188	3,875,192
Other Petroleum	6,909,883	7,039,908	6,965,608	7,244,232	7,392,832	7,429,982	7,411,407	7,392,832	7,374,257	7,374,257	7,355,682	7,355,682	7,355,682	7,374,257	7,392,832	7,429,982	7,467,132	7,485,707	7,504,282	7,578,581	7,615,731	7,652,881	7,727,181	7,857,206	7,931,505
Distillate Fuel Oil	1,914,625	1,930,930	2,005,465	2,080,000	2,119,597	2,133,572	2,131,243	2,126,585	2,131,243	2,133,572	2,140,560	2,154,535	2,161,523	2,166,182	2,173,169	2,182,486	2,189,474	2,196,462	2,201,120	2,212,766	2,226,741	2,233,729	2,245,375	2,261,680	2,277,984
Petrochemical Feedstocks	1,959,457	1,959,457	2,003,000	2,133,631	2,198,946	2,307,805	2,416,664	2,503,751	2,569,066	2,634,381	2,699,696	2,743,240	2,765,012	2,786,783	2,830,327	2,852,099	2,852,099	2,895,642	2,895,642	2,895,642	2,873,870	2,873,870	2,873,870	2,873,870	2,873,870
Motor Gasoline	1,997,677	2,002,445	2,048,930	2,087,072	2,094,223	2,091,840	2,084,688	2,077,536	2,070,385	2,068,001	2,064,425	2,060,849	2,063,233	2,068,001	2,072,769	2,079,920	2,083,496	2,088,264	2,095,415	2,108,527	2,119,254	2,127,598	2,150,244	2,170,507	2,187,194
Liquified Petroleum Gases	470,635	475,807	429,260	443,052	448,224	456,843	467,187	475,807	484,427	491,322	498,218	503,390	506,838	510,286	513,733	515,457	517,181	520,629	522,353	520,629	518,905	518,905	518,905	518,905	520,629
Kerosene/Jet Fuel	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260	27,260
Total	16,229,683	16,660,965	16,854,691	17,465,418	17,731,253	17,897,473	17,988,619	18,053,941	18,156,810	18,303,970	18,386,020	18,470,136	18,504,727	18,557,948	18,660,271	18,712,383	18,761,821	18,864,144	18,921,254	19,068,590	19,106,947	19,159,428	19,318,023	19,509,616	19,693,635
Total Energy Consumption High World Oil Prices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Liquefied Petroleum Gases	1.00	1.00	0.86	0.88	0.90	0.92	0.94	0.95	0.97	0.98	1.00	1.01	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02
Motor Gasoline 2/	1.00	1.00	0.96	0.92	0.91	0.89	0.87	0.85	0.83	0.82	0.81	0.80	0.79	0.78	0.76	0.75	0.74	0.73	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Jet Fuel 9/	1.00	0.99	0.99	0.99	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.07	1.07	1.08	1.08	1.09	1.09	1.10	1.10
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.00	1.02	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.11	1.12	1.12	1.13	1.13	1.14	1.15
Residual Fuel Oil	1.00	1.06	1.06	1.08	1.08	1.07	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.11	1.11
Petrochemical Feedstocks	1.00	1.00	1.00	1.07	1.12	1.17	1.22	1.26	1.30	1.33	1.37	1.39	1.39	1.40	1.42	1.42	1.42	1.44	1.44	1.43	1.43	1.43	1.43	1.43	1.43
Other Petroleum 12/	1.00	1.00	0.88	0.90	0.91	0.91	0.90	0.88	0.87	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81
Liquid Fuels Subtotal ex E85	1.00	1.00	0.96	0.96	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97	0.98
Petrochemicals - High Oil Prices																									
Residual Fuel Oil	2,950,146	3,125,155	3,125,155	3,200,158	3,175,157	3,150,156	3,150,156	3,150,156	3,150,156	3,175,157	3,175,157	3,175,157	3,200,158	3,200,158	3,200,158	3,200,158	3,225,160	3,225,160	3,225,160	3,225,160	3,250,161	3,250,161	3,250,161	3,275,162	3,275,162
Other Petroleum	6,909,883	6,909,883	6,092,585	6,204,035	6,296,910	6,278,335	6,185,460	6,092,585	5,999,710	5,943,985	5,851,111	5,795,386	5,758,236	5,721,086	5,665,361	5,628,211	5,572,486	5,535,336	5,498,186	5,516,761	5,516,761	5,498,186	5,516,761	5,535,336	5,572,486
Distillate Fuel Oil	1,914,625	1,914,625	1,905,308	1,951,893	2,003,136	2,035,745	2,049,720	2,056,708	2,068,354	2,080,000	2,089,317	2,105,622	2,114,939	2,114,939	2,119,597	2,126,585	2,128,914	2,128,914	2,131,243	2,140,560	2,152,206	2,161,523	2,168,511	2,182,486	2,201,120
Petrochemical Feedstocks	1,959,457	1,959,457	1,959,457	2,090,087	2,198,946	2,286,033	2,394,892	2,460,207	2,547,294	2,612,609	2,677,925	2,721,468	2,721,468	2,743,240	2,786,783	2,786,783	2,786,783	2,830,327	2,830,327	2,808,555	2,808,555	2,808,555	2,808,555	2,808,555	2,808,555
Motor Gasoline	1,997,677	2,001,253	1,917,818	1,847,494	1,808,160	1,777,170	1,739,028	1,693,734	1,657,977	1,634,138	1,610,299	1,593,612	1,575,733	1,549,511	1,528,056	1,504,217	1,470,843	1,452,964	1,443,429	1,442,237	1,438,661	1,435,085	1,433,893	1,433,893	1,436,277
Liquified Petroleum Gases	470,635	468,911	403,401	415,469	424,089	432,708	443,052	448,224	455,120	462,015	468,911	474,083	475,807	477,531	480,979	480,979	482,703	484,427	484,427	482,703	480,979	480,979	479,255	479,255	480,979
Kerosene/Jet Fuel	27,260	27,260	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
Total	16,229,683	16,406,544	15,424,169	15,729,581	15,926,842	15,980,592	15,982,753	15,922,059	15,899,055	15,928,350	15,893,165	15,885,773	15,866,786	15,826,909	15,801,379	15,747,379	15,687,334	15,677,573	15,633,216	15,636,421	15,667,768	15,654,934	15,677,581	15,735,133	15,795,024
Total Energy Consumption High Economic Growth	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Liquefied Petroleum Gases	1.00	1.01	0.89	0.91	0.92	0.94	0.96	0.98	1.00	1.01	1.03	1.04	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.08	1.08	1.07	1.08	1.08
Motor Gasoline 2/	1.00	1.00	1.00	1.00	0.99	0.99	0.98	0.97	0.97	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.95	0.94	0.94
Jet Fuel 9/	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.11	1.12	1.12	1.13	1.13
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.05	1.09	1.10	1.12	1.12	1.13	1.13	1.14	1.15	1.16	1.17	1.17	1.18	1.19	1.19	1.20	1.20	1.21	1.22	1.23	1.23	1.25	1.26
Residual Fuel Oil	1.00	1.07	1.08	1.10	1.10	1.10	1.10	1.10	1.10	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.14	1.14	1.14	1.14	1.14	1.14	1.15	1.15	1.15
Petrochemical Feedstocks	1.00	1.00	1.01	1.08	1.12	1.17	1.23	1.27	1.30	1.33	1.37	1.39	1.40	1.41	1.43	1.44	1.44	1.46	1.47	1.47	1.47	1.47	1.47	1.47	1.48
Other Petroleum 12/	1.00	1.01	0.98	1.00	1.01	1.00	0.99	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.97	0.97	0.98	0.99	0.99	1.00	1.01	1.01
Liquid Fuels Subtotal ex E85	1.00	1.00	1.00	1.02	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.05	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.09	1.10
Petrochemicals - High Economic Growth																									
Residual Fuel Oil	2,950,146	3,150,156	3,200,158	3,250,161	3,250,161	3,250,161	3,250,161	3,250,161	3,250,161	3,275,162	3,275,162	3,300,163	3,300,163	3,300,163	3,325,165	3,325,165	3,350,166	3,350,166	3,350,166	3,375,167	3,375,167	3,375,167	3,400,168	3,400,168	3,400,168
Other Petroleum	6,909,883	6,947,033	6,761,283	6,909,883	6,984,183	6,928,458	6,854,158	6,761,283	6,761,283	6,724,133	6,668,409	6,705,559	6,686,984	6,705,559	6,724,133	6,761,283	6,779,858	6,724,133	6,724,133	6,798,433	6,835,583	6,854,158	6,909,883	6,965,608	7,002,758
Distillate Fuel Oil	1,914,625	1,916,954	2,007,794	2,077,671	2,114,939	2,140,560	2,145,219	2,154,535	2,170,840	2,182,486	2,196,462	2,219,754	2,236,058	2,243,046	2,259,351	2,273,326	2,284,972	2,291,960	2,301,277	2,312,923	2,329,227	2,345,532	2,364,166	2,387,458	2,417,738
Petrochemical Feedstocks	1,959,457	1,959,457	1,981,229	2,111,859	2,198,946	2,286,033	2,416,664	2,481,979	2,547,294	2,612,609	2,677,925	2,721,468	2,743,240	2,765,012	2,808,555	2,830,327	2,830,327	2,852,099	2,873,870	2,873,870	2,873,870	2,873,870	2,873,870	2,873,870	2,895,642
Motor Gasoline	1,997,677	2,001,253	1,998,869	1,992,909	1,982,182	1,969,071	1,954,767	1,936,888	1,929,737	1,916,626	1,896,363	1,891,595	1,893,979	1,892,787	1,891,595	1,889,211	1,892,787	1,885,635	1,883,252	1,877,292	1,874,908	1,872,524	1,888,019	1,883,252	1,879,676
Liquified Petroleum Gases	470,635	474,083	418,917	429,260	434,432	443,052	453,396	460,291	468,911	475,807	482,703	487,874	491,322	494,770	498,218	499,942	501,666	505,114	506,838	506,838	506,838	506,838	505,114	506,838	508,562
Kerosene/Jet Fuel	27,260	27,260	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
Total	16,229,683	16,476,196	16,388,695	16,792,189	16,985,288	17,037,780	17,094,809	17,065,583	17,148,671	17,207,269	17,217,467	17,346,858	17,372,191	17,421,782	17,527,462	17,599,699	17,660,221	17,629,552	17,659,981	17,764,968	17,816,039	17,848,534	17,961,666	18,037,639	18,124,989
Total Energy Consumption Low Economic Growth	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Liquefied Petroleum Gases	1.00	1.01	0.89	0.90	0.91	0.93	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.01	1.00	1.00	1.01	1.01	1.00	1.00	0.99	0.99	0.99	0.99
Motor Gasoline 2/	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.93	0.92	0.91	0.89	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.85	0.84	0.83	0.82	0.81	0.82	0.82
Jet Fuel 9/	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.07	1.07	1.08
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.00	1.02	1.03	1.04	1.03	1.02	1.02	1.02	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
Residual Fuel Oil	1.00	1.07	1.08	1.10	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.11	1.11
Petrochemical Feedstocks	1.00	1.00	1.02	1.08	1.11	1.14	1.20	1.23	1.27	1.29	1.31	1.33	1.33	1.34	1.36	1.36	1.37	1.37	1.37	1.37	1.36	1.36	1.34	1.34	1.34
Other Petroleum 12/	1.00	1.01	0.91	0.92	0.93	0.91	0.89	0.87	0.85	0.84	0.82	0.81	0.81	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.79	0.79	0.78	0.79	0.80
Liquid Fuels Subtotal ex E85	1.00	1.00	0.98	0.99	0.99	0.98	0.98	0.97	0.96	0.96	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.96	0.96
Petrochemicals - Low Economic Growth																									
Residual Fuel Oil	2,950,146	3,150,156	3,175,157	3,250,161	3,200,158	3,200,158	3,175,157	3,175,157	3,175,157	3,200,158	3,200,158	3,200,158	3,225,160	3,225,160	3,225,160	3,225,160	3,225,160	3,225,160	3,225,160	3,225,160	3,250,161	3,250,161	3,250,161	3,275,162	3,275,162
Other Petroleum	6,909,883	6,947,033	6,259,760	6,371,209	6,408,359	6,296,910	6,148,310	5,999,710	5,888,261	5,776,811	5,665,361	5,591,061	5,572,486	5,553,911	5,516,761	5,516,761	5,479,612	5,461,037	5,442,462	5,442,462	5,442,462	5,442,462	5,423,887	5,461,037	5,516,761
Distillate Fuel Oil	1,914,625	1,916,954	1,923,942	1,961,210	1,979,843	1,982,173	1,968,197	1,956,551	1,951,893	1,944,905	1,942,576	1,951,893	1,951,893	1,951,893	1,954,222	1,954,222	1,954,222	1,954,222	1,956,551	1,963,539	1,975,185	1,986,831	2,003,136	2,026,428	2,056,708
Petrochemical Feedstocks	1,959,457	1,959,457	2,003,000	2,111,859	2,177,174	2,242,490	2,351,348	2,416,664	2,481,979	2,525,522	2,569,066	2,612,609	2,612,609	2,634,381	2,656,153	2,656,153	2,677,925	2,677,925	2,677,925	2,677,925	2,656,153	2,656,153	2,634,381	2,634,381	2,634,381
Motor Gasoline	1,997,677	2,001,253	1,982,182	1,964,303	1,945,232	1,922,585	1,898,747	1,860,605	1,839,150	1,812,928	1,786,705	1,771,210	1,759,291	1,748,563	1,737,836	1,725,917	1,715,189	1,694,926	1,688,967	1,674,664	1,655,593	1,642,481	1,623,411	1,632,946	1,638,906
Liquified Petroleum Gases	470,635	474,083	417,193	425,813	429,260	436,156	444,776	449,948	455,120	460,291	465,463	468,911	468,911	470,635	474,083	472,359	472,359	474,083	474,083	470,635	468,911	467,187	465,463	463,739	463,739
Kerosene/Jet Fuel	27,260	27,260	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
Total	16,229,683	15,726,405	15,626,415	15,951,596	16,195,214	16,132,190	15,991,113	15,872,782	15,709,433	15,511,493	15,411,208	15,405,621	15,372,722	15,318,578	15,281,093	15,253,826	15,237,394	15,212,090	15,185,074	15,128,249	15,073,976	15,043,176	15,001,780	14,973,374	14,901,142

Notes: The format and derivation of this table is identical to Table 2-8 for the EIA
2/ Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.
The annual average ethanol content of 74 percent is used for this forecast.
9/ Includes only kerosene type.
12/ Includes unfinished oils, natural gasoline, motor gasoline blending components, aviation gasoline, lubricants, still gas, asphalt, road oil, petroleum coke, and miscellaneous petroleum products.
Totals may not equal sum of components due to independent rounding. Data for 2007 and 2008 are model results and may differ slightly from official EIA data reports.
Sources: 2009 and 2010 consumption based on: Energy Information Administration (EIA), Annual Energy Review 2010, DOE/EIA-0384(2010) (Washington, D.C., October 2011).
2009 and 2010 population and gross domestic product: IHS Global Insight Industry and Employment models, August 2011. 2009 and 2010 carbon dioxide emissions: EIA,
Monthly Energy Review, October 2011, DOE/EIA-0035(2011/10) (Washington, D.C., October 2011).
Projections: EIA, AEO2012 National Energy Modeling System.

Source: G.E.C., Inc.

Table 3-2. Calcasieu Lock Total Petrochemical Commodity Tons Forecasts for Low/High World Oil Prices and High/Low Economic Growth, 2011-2035

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Petrochemicals - Reference Case	16,229,683	16,476,196	16,045,239	16,412,552	16,589,798	16,589,343	16,542,067	16,478,610	16,509,261	16,471,855	16,452,916	16,495,059	16,539,295	16,565,598	16,601,523	16,625,179	16,630,651	16,607,938	16,589,363	16,653,202	16,613,442	16,565,620	16,717,789	16,797,630	16,893,578
Petrochemicals - Low Oil Prices	16,229,683	16,660,965	16,854,691	17,465,418	17,731,253	17,897,473	17,988,619	18,053,941	18,156,810	18,303,970	18,386,020	18,470,136	18,504,727	18,557,948	18,660,271	18,712,383	18,761,821	18,864,144	18,921,254	19,068,590	19,106,947	19,159,428	19,318,023	19,509,616	19,693,635
Petrochemicals - High Oil Prices	16,229,683	16,406,544	15,424,169	15,729,581	15,926,842	15,980,592	15,982,753	15,922,059	15,899,055	15,928,350	15,893,165	15,885,773	15,866,786	15,826,909	15,801,379	15,747,379	15,687,334	15,677,573	15,633,216	15,636,421	15,667,768	15,654,934	15,677,581	15,735,133	15,795,024
Petrochemicals - High Economic Growth	16,229,683	16,476,196	16,388,695	16,792,189	16,985,288	17,037,780	17,094,809	17,065,583	17,148,671	17,207,269	17,217,467	17,346,858	17,372,191	17,421,782	17,527,462	17,599,699	17,660,221	17,629,552	17,659,981	17,764,968	17,816,039	17,848,534	17,961,666	18,037,639	18,124,989
Petrochemicals - Low Economic Growth	16,229,683	15,726,405	15,626,415	15,951,596	16,195,214	16,132,190	15,991,113	15,872,782	15,709,433	15,511,493	15,411,208	15,405,621	15,372,722	15,318,578	15,281,093	15,253,826	15,237,394	15,212,090	15,185,074	15,128,249	15,073,976	15,043,176	15,001,780	14,973,374	14,901,142

Notes: EIA forecasts not extrapolated beyond 2035.

Source: G.E.C., Inc.

Table 3-3. Calcasieu Lock Chemicals Commodity Tons Forecasts for Low/High World Oil Prices and High/Low Economic Growth, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Value of Shipments - Low World Oil Price	**277.35**	**263.32**	**265.45**	**275.42**	**280.18**	**286.28**	**294.79**	**302.61**	**310.29**	**317.86**	**324.63**	**329.94**	**332.06**	**335.36**	**339.27**	**340.13**	**341.29**	**344.13**	**345.05**	**344.16**	**343.18**	**342.37**	**342.04**	**341.9**	**342.1**
Index	1.00	0.95	0.96	0.99	1.01	1.03	1.06	1.09	1.12	1.15	1.17	1.19	1.20	1.21	1.22	1.23	1.23	1.24	1.24	1.24	1.24	1.23	1.23	1.23	1.23
TOTAL ALL CHEMICALS	9,302,012	8,831,461	8,902,899	9,237,282	9,396,927	9,601,514	9,886,930	10,149,204	10,406,783	10,660,673	10,887,731	11,065,822	11,136,925	11,247,603	11,378,740	11,407,584	11,446,489	11,541,739	11,572,595	11,542,745	11,509,877	11,482,711	11,471,643	11,466,948	11,473,655
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Value of Shipments - High World Oil Price	**277.35**	**259.49**	**256.22**	**267.44**	**275.51**	**283.21**	**291.67**	**299.49**	**307.64**	**315.82**	**322.81**	**328.19**	**330.55**	**333.48**	**336.59**	**336.72**	**337.4**	**339.98**	**340.64**	**339.78**	**339.1**	**338.62**	**338.33**	**338.35**	**339.12**
Index	1.00	0.94	0.92	0.96	0.99	1.02	1.05	1.08	1.11	1.14	1.16	1.18	1.19	1.20	1.21	1.21	1.22	1.23	1.23	1.23	1.22	1.22	1.22	1.22	1.22
TOTAL ALL CHEMICALS	9,302,012	8,703,007	8,593,335	8,969,642	9,240,300	9,498,550	9,782,289	10,044,563	10,317,905	10,592,253	10,826,690	11,007,129	11,086,281	11,184,550	11,288,856	11,293,216	11,316,023	11,402,553	11,424,689	11,395,845	11,373,039	11,356,940	11,347,214	11,347,884	11,373,709
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Value of Shipments - High Economic Growth	**277.35**	**261.78**	**261.13**	**271.84**	**276.98**	**283.82**	**292.5**	**300.55**	**308.31**	**315.86**	**323.03**	**328.99**	**331.5**	**334.75**	**338.96**	**339.64**	**340.8**	**343.64**	**344.73**	**344.42**	**344.2**	**344.21**	**344.47**	**344.98**	**346.46**
Index	1.00	0.94	0.94	0.98	1.00	1.02	1.05	1.08	1.11	1.14	1.16	1.19	1.20	1.21	1.22	1.22	1.23	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.25
TOTAL ALL CHEMICALS	9,302,012	8,779,811	8,758,011	9,117,213	9,289,603	9,519,009	9,810,126	10,080,114	10,340,376	10,593,595	10,834,069	11,033,960	11,118,143	11,227,144	11,368,343	11,391,150	11,430,055	11,525,305	11,561,863	11,551,466	11,544,087	11,544,422	11,553,143	11,570,247	11,619,885
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Value of Shipments - Low Economic Growth	**277.35**	**258.04**	**261.04**	**269.45**	**274.03**	**279.01**	**286.91**	**293.02**	**299.13**	**304.96**	**310.16**	**314.11**	**314.99**	**317.39**	**319.97**	**319.76**	**320.02**	**321.55**	**321.34**	**319.6**	**318.25**	**317.09**	**316.15**	**314.94**	**314.22**
Index	1.00	0.93	0.94	0.97	0.99	1.01	1.03	1.06	1.08	1.10	1.12	1.13	1.14	1.14	1.15	1.15	1.15	1.16	1.16	1.15	1.15	1.14	1.14	1.14	1.13
TOTAL ALL CHEMICALS	9,302,012	8,654,376	8,754,993	9,037,055	9,190,663	9,357,687	9,622,644	9,827,566	10,032,489	10,228,021	10,402,423	10,534,902	10,564,416	10,644,909	10,731,440	10,724,396	10,733,117	10,784,431	10,777,388	10,719,030	10,673,753	10,634,848	10,603,321	10,562,739	10,538,591

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Value of Shipments - Low World Oil Price	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**	**342.1**
Index	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
TOTAL ALL CHEMICALS	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Value of Shipments - High World Oil Price	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**	**339.12**
Index	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
TOTAL ALL CHEMICALS	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Value of Shipments - High Economic Growth	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**	**346.46**
Index	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
TOTAL ALL CHEMICALS	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Value of Shipments - Low Economic Growth	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**	**314.22**
Index	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
TOTAL ALL CHEMICALS	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591

Notes: Based on EIA "Bulk Chemicals" projections, 2011-2035 except fertilizer.
Chemical projections beyond 2035 extrapolated from EIA trends.

Source: G.E.C., Inc.

Table 3-4. Calcasieu Lock Total Chemicals Commodity Tons Forecasts for Low/High World Oil Prices and High/Low Economic Growth, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
TOTAL ALL CHEMICALS																									
Chemicals - Reference Case	9,302,012	8,753,651	8,749,291	9,104,133	9,283,901	9,499,221	9,795,369	10,059,656	10,320,253	10,587,558	10,825,013	11,007,465	11,082,256	11,194,612	11,323,736	11,350,568	11,383,436	11,473,320	11,495,791	11,459,904	11,434,079	11,417,645	11,414,291	11,405,907	11,404,901
Chemicals - Low Oil Price	9,302,012	8,831,461	8,902,899	9,237,282	9,396,927	9,601,514	9,886,930	10,149,204	10,406,783	10,660,673	10,887,731	11,065,822	11,136,925	11,247,603	11,378,740	11,407,584	11,446,489	11,541,739	11,572,595	11,542,745	11,509,877	11,482,711	11,471,643	11,466,948	11,473,655
Chemicals - High Oil Price	9,302,012	8,703,007	8,593,335	8,969,642	9,240,300	9,498,550	9,782,289	10,044,563	10,317,905	10,592,253	10,826,690	11,007,129	11,086,281	11,184,550	11,288,856	11,293,216	11,316,023	11,402,553	11,424,689	11,395,845	11,373,039	11,356,940	11,347,214	11,347,884	11,373,709
Chemicals - High Economic Growth	9,302,012	8,779,811	8,758,011	9,117,213	9,289,603	9,519,009	9,810,126	10,080,114	10,340,376	10,593,595	10,834,069	11,033,960	11,118,143	11,227,144	11,368,343	11,391,150	11,430,055	11,525,305	11,561,863	11,551,466	11,544,087	11,544,422	11,553,143	11,570,247	11,619,885
Chemicals - Low Economic Growth	9,302,012	8,654,376	8,754,993	9,037,055	9,190,663	9,357,687	9,622,644	9,827,566	10,032,489	10,228,021	10,402,423	10,534,902	10,564,416	10,644,909	10,731,440	10,724,396	10,733,117	10,784,431	10,777,388	10,719,030	10,673,753	10,634,848	10,603,321	10,562,739	10,538,591

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
TOTAL ALL CHEMICALS																										
Chemicals - Reference Case	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901	11,404,901
Chemicals - Low Oil Price	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655
Chemicals - High Oil Price	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709
Chemicals - High Economic Growth	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885	11,619,885
Chemicals - Low Economic Growth	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591	10,538,591

Notes: EIA forecasts extrapolated beyond 2035.

Source: G.E.C., Inc.

Table 3-5. Calcasieu Lock Crude Petroleum Commodity Tons Forecasts for Low/High World Oil Prices, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
United States Total	5.57	5.74	5.9	6	6.15	6.42	6.47	6.55	6.64	6.7	6.62	6.51	6.45	6.41	6.4	6.44	6.48	6.47	6.41	6.37	6.27	6.21	6.18	6.07	5.99
Lower 48 Onshore	3.58	3.8	3.94	4.01	4.09	4.16	4.21	4.29	4.33	4.38	4.41	4.41	4.42	4.43	4.43	4.43	4.42	4.37	4.34	4.29	4.23	4.15	4.09	4.03	3.99
Lower 48 Offshore	1.43	1.4	1.46	1.51	1.6	1.78	1.76	1.74	1.81	1.83	1.75	1.66	1.64	1.62	1.57	1.55	1.57	1.63	1.62	1.65	1.65	1.71	1.77	1.74	1.74
Lower 48 On/Offshore	5.01	5.20	5.40	5.52	5.69	5.94	5.97	6.03	6.14	6.21	6.16	6.07	6.06	6.05	6.00	5.98	5.99	6.00	5.96	5.94	5.88	5.86	5.86	5.77	5.73
High United States Total	5.57	5.74	6.07	6.22	6.41	6.76	6.93	7.12	7.28	7.4	7.39	7.39	7.35	7.28	7.25	7.27	7.25	7.26	7.21	7.09	7.04	6.96	6.84	6.7	6.68
High Lower 48 Onshore	3.58	3.8	4.1	4.23	4.35	4.47	4.55	4.66	4.71	4.76	4.8	4.82	4.81	4.77	4.76	4.76	4.75	4.73	4.7	4.64	4.58	4.5	4.44	4.37	4.29
High Lower 48 Offshore	1.43	1.4	1.46	1.51	1.6	1.79	1.77	1.78	1.87	1.95	1.92	1.89	1.85	1.81	1.81	1.83	1.8	1.86	1.86	1.84	1.91	1.95	1.94	1.93	2.03
High Lower 48 On/Offshore	5.01	5.20	5.56	5.74	5.95	6.26	6.32	6.44	6.58	6.71	6.72	6.71	6.66	6.58	6.57	6.59	6.55	6.59	6.56	6.48	6.49	6.45	6.38	6.30	6.32
Low United States Total	5.57	5.74	5.78	5.81	5.88	6.06	6.02	5.99	6.01	5.98	5.88	5.74	5.58	5.47	5.38	4.96	4.9	4.88	4.87	4.83	4.81	4.79	4.82	4.81	4.79
Low Lower 48 Onshore	3.58	3.8	3.81	3.82	3.83	3.83	3.81	3.82	3.8	3.78	3.77	3.77	3.76	3.75	3.73	3.72	3.69	3.67	3.66	3.64	3.63	3.6	3.59	3.57	3.55
Low Lower 48 Offshore	1.43	1.4	1.46	1.51	1.59	1.75	1.7	1.65	1.71	1.71	1.63	1.53	1.43	1.35	1.31	1.24	1.2	1.21	1.21	1.19	1.18	1.19	1.23	1.23	1.24
Low Lower 48 On/Offshore	5.01	5.20	5.27	5.33	5.42	5.58	5.51	5.47	5.51	5.49	5.40	5.30	5.19	5.10	5.04	4.96	4.89	4.88	4.87	4.83	4.81	4.79	4.82	4.80	4.79
LowLower/High Lower	1	1	0.947841727	0.928571429	0.91092437	0.891373802	0.87183544	0.84937888	0.83738602	0.818181818	0.803571429	0.789865872	0.77927928	0.775075988	0.767123288	0.75265554	0.746564885	0.74051593	0.742378049	0.74537037	0.741140216	0.742635659	0.755485893	0.761904762	0.75791139
Production (million barrels per day) 2/																									
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
United States Total	1.00	1.03	1.06	1.08	1.10	1.15	1.16	1.18	1.19	1.20	1.19	1.17	1.16	1.15	1.15	1.16	1.16	1.16	1.15	1.14	1.13	1.11	1.11	1.09	1.08
Lower 48 Onshore	1.00	1.06	1.10	1.12	1.14	1.16	1.18	1.20	1.21	1.22	1.23	1.23	1.23	1.24	1.24	1.24	1.23	1.22	1.21	1.20	1.18	1.16	1.14	1.13	1.11
Lower 48 Offshore	1.00	0.98	1.02	1.06	1.12	1.24	1.23	1.22	1.27	1.28	1.22	1.16	1.15	1.13	1.10	1.08	1.10	1.14	1.13	1.15	1.15	1.20	1.24	1.22	1.22
Lower 48 On/Offshore	1.00	1.04	1.08	1.10	1.14	1.19	1.19	1.20	1.23	1.24	1.23	1.21	1.21	1.21	1.20	1.19	1.20	1.20	1.19	1.19	1.17	1.17	1.17	1.15	1.14
High United States Total	1.00	1.03	1.09	1.12	1.15	1.21	1.24	1.28	1.31	1.33	1.33	1.33	1.32	1.31	1.30	1.31	1.30	1.30	1.29	1.27	1.26	1.25	1.23	1.20	1.20
High Lower 48 Onshore	1.00	1.06	1.15	1.18	1.22	1.25	1.27	1.30	1.32	1.33	1.34	1.35	1.34	1.33	1.33	1.33	1.33	1.32	1.31	1.30	1.28	1.26	1.24	1.22	1.20
High Lower 48 Offshore	1.00	0.98	1.02	1.06	1.12	1.25	1.24	1.24	1.31	1.36	1.34	1.32	1.29	1.27	1.27	1.28	1.26	1.30	1.30	1.29	1.34	1.36	1.36	1.35	1.42
High Lower 48 On/Offshore	1.00	1.04	1.11	1.15	1.19	1.25	1.26	1.29	1.31	1.34	1.34	1.34	1.33	1.31	1.31	1.32	1.31	1.32	1.31	1.29	1.30	1.29	1.27	1.26	1.26
Low United States Total	1.00	1.03	1.04	1.04	1.06	1.09	1.08	1.08	1.08	1.07	1.06	1.03	1.00	0.98	0.97	0.89	0.88	0.88	0.87	0.87	0.86	0.86	0.87	0.86	0.86
Low Lower 48 Onshore	1.00	1.06	1.06	1.07	1.07	1.07	1.06	1.07	1.06	1.06	1.05	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.01	1.01	1.00	1.00	0.99
Low Lower 48 Offshore	1.00	0.98	1.02	1.06	1.11	1.22	1.19	1.15	1.20	1.20	1.14	1.07	1.00	0.94	0.92	0.87	0.84	0.85	0.85	0.83	0.83	0.83	0.86	0.86	0.87
Low Lower 48 On/Offshore	1.00	1.04	1.05	1.06	1.08	1.11	1.10	1.09	1.10	1.10	1.08	1.06	1.04	1.02	1.01	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96
Crude Petroleum Production	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
United States Total	5.57	5.74	5.90	6.00	6.15	6.42	6.47	6.55	6.64	6.70	6.62	6.51	6.45	6.41	6.40	6.44	6.48	6.47	6.41	6.37	6.27	6.21	6.18	6.07	5.99
Lower 48 Onshore	3.58	3.80	3.94	4.01	4.09	4.16	4.21	4.29	4.33	4.38	4.41	4.41	4.42	4.43	4.43	4.43	4.42	4.37	4.34	4.29	4.23	4.15	4.09	4.03	3.99
Lower 48 Offshore	1.43	1.40	1.46	1.51	1.60	1.78	1.76	1.74	1.81	1.83	1.75	1.66	1.64	1.62	1.57	1.55	1.57	1.63	1.62	1.65	1.65	1.71	1.77	1.74	1.74
Lower 48 On/Offshore	5.01	5.20	5.40	5.52	5.69	5.94	5.97	6.03	6.14	6.21	6.16	6.07	6.06	6.05	6.00	5.98	5.99	6.00	5.96	5.94	5.88	5.86	5.86	5.77	5.73
Notes: Millon barrels per day																									
Crude Petroleum Production Index (2011 = 1.00)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
United States Total	1.00	1.03	1.09	1.12	1.15	1.21	1.24	1.28	1.31	1.33	1.33	1.33	1.32	1.31	1.30	1.31	1.30	1.30	1.29	1.27	1.26	1.25	1.23	1.20	1.20
Lower 48 Onshore	1.00	1.06	1.15	1.18	1.22	1.25	1.27	1.30	1.32	1.33	1.34	1.35	1.34	1.33	1.33	1.33	1.33	1.32	1.31	1.30	1.28	1.26	1.24	1.22	1.20
Lower 48 Offshore	1.00	0.98	1.02	1.06	1.12	1.25	1.24	1.24	1.31	1.36	1.34	1.32	1.29	1.27	1.27	1.28	1.26	1.30	1.30	1.29	1.34	1.36	1.36	1.35	1.42
Lower 48 On/Offshore	1.00	1.04	1.11	1.15	1.19	1.25	1.26	1.29	1.31	1.34	1.34	1.34	1.33	1.31	1.31	1.32	1.31	1.32	1.31	1.29	1.30	1.29	1.27	1.26	1.26
Crude Petroleum Lock Tonnage	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Lower 48 On/Offshore	4,035,558	4,188,603	4,349,703	4,446,363	4,583,298	4,784,674	4,808,839	4,857,169	4,945,774	5,002,159	4,961,884	4,889,389	4,881,334	4,873,279	4,833,004	4,816,894	4,824,949	4,833,004	4,800,784	4,784,674	4,736,344	4,720,234	4,720,234	4,647,738	4,615,518
High Lower 48 On/Offshore	4,035,558	4,188,603	4,478,583	4,623,573	4,792,729	5,042,434	5,090,764	5,187,424	5,300,194	5,404,909	5,412,964	5,404,909	5,364,634	5,300,194	5,292,139	5,308,249	5,276,029	5,308,249	5,284,084	5,219,644	5,227,699	5,195,479	5,139,094	5,074,654	5,090,764
Low Lower 48 On/Offshore	4,035,558	4,188,603	4,244,988	4,293,318	4,365,813	4,494,693	4,438,308	4,406,088	4,438,308	4,422,198	4,349,703	4,269,153	4,180,548	4,108,053	4,059,723	3,995,283	3,938,898	3,930,843	3,922,788	3,890,568	3,874,458	3,858,348	3,882,513	3,866,403	3,858,348

Table 3-5 (cont'd). Calcasieu Lock Crude Petroleum Commodity Tons Forecasts for Low/High World Oil Prices, 2011-2061

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
United States Total																										
Lower 48 Onshore																										
Lower 48 Offshore																										
Lower 48 On/Offshore	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
High United States Total																										
High Lower 48 Onshore																										
High Lower 48 Offshore																										
High Lower 48 On/Offshore	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32	6.32
Low United States Total																										
Low Lower 48 Onshore																										
Low Lower 48 Offshore																										
Low Lower 48 On/Offshore	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79
LowLower/High Lower	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392	0.757911392
Production (million barrels per day) 2/																										
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
United States Total																										
Lower 48 Onshore																										
Lower 48 Offshore																										
Lower 48 On/Offshore	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
High United States Total																										
High Lower 48 Onshore																										
High Lower 48 Offshore																										
High Lower 48 On/Offshore	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Low United States Total																										
Low Lower 48 Onshore																										
Low Lower 48 Offshore																										
Low Lower 48 On/Offshore	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Crude Petroleum Production	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
United States Total	6.27																									
Lower 48 Onshore	3.46																									
Lower 48 Offshore	2.44																									
Lower 48 On/Offshore	5.90	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99
Notes: Millon barrels per day																										
Crude Petroleum Production Index (2011 = 1.00)	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
United States Total	0.00																									
Lower 48 Onshore	0.00																									
Lower 48 Offshore	0.00																									
Lower 48 On/Offshore	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Crude Petroleum Lock Tonnage	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Lower 48 On/Offshore	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518	4,615,518
High Lower 48 On/Offshore	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764
Low Lower 48 On/Offshore	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348

Sources: EIA and G.E.C., Inc.

Table 3-6. Calcasieu Lock Fertilizer Tons Based on Offshore Natural Gas Production Forecasts, Low/High World Oil Prices and High/Low Economic Growth, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference Case	2.17	2.01	1.79	1.76	1.88	2.1	2.16	2.12	2.2	2.34	2.38	2.36	2.35	2.39	2.38	2.38	2.41	2.48	2.52	2.58	2.59	2.69	2.81	2.77	2.72
Reference/High Oil																									
Fertilizer tons	297,127	283,365	264,443	261,863	272,184	291,106	296,266	292,826	299,707	311,748	315,188	313,468	312,608	316,049	315,188	315,188	317,769	323,789	327,230	332,390	333,250	341,851	352,172	348,732	344,431
Index (2011=1.00)	1.00	0.95	0.89	0.88	0.92	0.98	1.00	0.99	1.01	1.05	1.06	1.05	1.05	1.06	1.06	1.06	1.07	1.09	1.10	1.12	1.12	1.15	1.19	1.17	1.16
Low World Oil Price	2.17	2.01	1.79	1.76	1.87	2.04	2.05	1.98	1.98	2.06	2.09	2.05	1.94	1.87	1.87	1.83	1.78	1.77	1.77	1.76	1.79	1.86	1.94	1.95	1.93
Low Oil/High Oil																									
Fertilizer tons	297,127	283,365	264,443	261,863	271,324	285,945	286,805	280,785	280,785	287,666	290,246	286,805	277,344	271,324	271,324	267,883	263,583	262,723	262,723	261,863	264,443	270,464	277,344	278,205	276,484
Index (2011=1.00)	1.00	0.95	0.89	0.88	0.91	0.96	0.97	0.95	0.95	0.97	0.98	0.97	0.93	0.91	0.91	0.90	0.89	0.88	0.88	0.88	0.89	0.91	0.93	0.94	0.93
High World Oil Price	2.17	2.01	1.77	1.75	1.9	2.11	2.17	2.22	2.34	2.62	2.75	2.8	2.77	2.74	2.74	2.82	2.84	2.89	2.89	2.85	2.95	3.02	3.05	3.08	3.15
Y=-0.0374X + 4.1739																									
Fertilizer tons	297,127	283,365	262,723	261,003	273,904	291,966	297,127	301,427	311,748	335,831	347,012	351,312	348,732	346,152	346,152	353,032	354,753	359,053	359,053	355,613	364,214	370,234	372,814	375,395	381,415
Index (2011=1.00)	1.00	0.95	0.88	0.88	0.92	0.98	1.00	1.01	1.05	1.13	1.17	1.18	1.17	1.16	1.16	1.19	1.19	1.21	1.21	1.20	1.23	1.25	1.25	1.26	1.28
High Economic Growth	2.17	2.01	1.8	1.76	1.88	2.1	2.15	2.14	2.21	2.34	2.4	2.41	2.4	2.43	2.41	2.37	2.4	2.48	2.58	2.66	2.76	2.87	2.9	2.89	2.85
High Economic/High Oil																									
Fertilizer tons	297,127	283,365	265,303	261,863	272,184	291,106	295,406	294,546	300,567	311,748	316,909	317,769	316,909	319,489	317,769	314,328	316,909	323,789	332,390	339,271	347,872	357,333	359,913	359,053	355,613
Index (2011=1.00)	1.00	0.95	0.89	0.88	0.92	0.98	0.99	0.99	1.01	1.05	1.07	1.07	1.07	1.08	1.07	1.06	1.07	1.09	1.12	1.14	1.17	1.20	1.21	1.21	1.20
Low Economic Growth	2.17	2.01	1.78	1.75	1.88	2.09	2.15	2.12	2.2	2.33	2.34	2.32	2.32	2.32	2.33	2.32	2.3	2.33	2.37	2.45	2.52	2.56	2.62	2.65	2.6
Low Economic/High Oil																									
Fertilizer tons	297,127	283,365	263,583	261,003	272,184	290,246	295,406	292,826	299,707	310,888	311,748	310,028	310,028	310,028	310,888	310,028	308,308	310,888	314,328	321,209	327,230	330,670	335,831	338,411	334,110
Index (2011=1.00)	1.00	0.95	0.89	0.88	0.92	0.98	0.99	0.99	1.01	1.05	1.05	1.04	1.04	1.04	1.05	1.04	1.04	1.05	1.06	1.08	1.10	1.11	1.13	1.14	1.12

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Reference Case	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
Reference/High Oil																										
Fertilizer tons	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431	344,431
Index (2011=1.00)	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Low World Oil Price	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93
Low Oil/High Oil																										
Fertilizer tons	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484
Index (2011=1.00)	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
High World Oil Price	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15
Y=-0.0374X + 4.1739			3.8747	3.8373	3.7999	3.7625	3.7251	3.6877	3.6503	3.6129	3.5755	3.5381	3.5007	3.4633	3.4259	3.3885	3.3511	3.3137	3.2763	3.2389	3.2015	3.1641	3.1267	3.0893	3.0519	3.0145
Fertilizer tons	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415
Index (2011=1.00)	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
High Economic Growth	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
High Economic/High Oil																										
Fertilizer tons	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613	355,613
Index (2011=1.00)	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Low Economic Growth	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Low Economic/High Oil																										
Fertilizer tons	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110	334,110
Index (2011=1.00)	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12

Notes: EIA offshore natural gas production forecast 2009-2035. Offshore natural gas production >2035 extrapolated from EIA trends.

Source: G.E.C., Inc.

Table 3-7. Calcasieu Lock Aggregate Tons Based on Energy Consumption for Nonfuel Use Forecasts, Low/High World Oil Prices and High/Low Economic Growth, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference Case	71.18	71.45	70.54	71.29	71.59	71.91	71.93	72.00	72.22	72.43	72.70	73.15	73.35	73.58	73.92	74.24	74.61	74.94	75.27	75.64	76.00	76.45	76.93	77.33	77.75
AACGR	0.37%	0.37%	0.44%	0.41%	0.41%	0.41%	0.43%	0.45%	0.46%	0.47%	0.48%	0.47%	0.49%	0.50%	0.51%	0.51%	0.52%	0.53%	0.54%	0.55%	0.57%	0.56%	0.53%	0.54%	
Aggregate Tons	2,418,340	2,450,787	2,341,427	2,431,559	2,467,612	2,506,068	2,508,472	2,516,884	2,543,323	2,568,560	2,601,007	2,655,086	2,679,122	2,706,762	2,747,622	2,786,078	2,830,543	2,870,201	2,909,860	2,954,325	2,997,588	3,051,667	3,109,352	3,157,422	3,207,896
Index (2011=1.00)	1.00	1.01	0.97	1.01	1.02	1.04	1.04	1.04	1.05	1.06	1.08	1.10	1.11	1.12	1.14	1.15	1.17	1.19	1.20	1.22	1.24	1.26	1.29	1.31	1.33
Low World Oil Price	70.92	71.6	71.78	73.04	73.71	74	74.14	74.32	74.6	74.88	75.16	75.59	75.79	76.07	76.47	76.85	77.23	77.63	78	78.43	78.88	79.2	79.65	80.11	80.58
AACGR	0.53%	0.52%	0.53%	0.47%	0.45%	0.45%	0.46%	0.48%	0.48%	0.49%	0.50%	0.49%	0.51%	0.52%	0.52%	0.53%	0.53%	0.53%	0.54%	0.54%	0.53%	0.58%	0.58%	0.59%	
Aggregate Tons	2,387,094	2,468,814	2,490,445	2,641,867	2,722,385	2,757,236	2,774,061	2,795,692	2,829,342	2,862,991	2,896,640	2,948,316	2,972,351	3,006,000	3,054,071	3,099,738	3,145,404	3,193,475	3,237,940	3,289,616	3,343,695	3,382,151	3,436,230	3,491,511	3,547,994
Index (2011=1.00)	1.00	1.03	1.04	1.11	1.14	1.16	1.16	1.17	1.19	1.20	1.21	1.24	1.25	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.49
High World Oil Price	71.17	71.37	69.14	69.71	70.26	70.63	70.81	71.04	71.44	71.8	72.17	72.71	73.06	73.4	73.87	74.35	74.82	75.35	75.88	76.55	77.2	77.74	78.26	78.84	79.48
AACGR	0.46%	0.47%	0.64%	0.63%	0.62%	0.62%	0.64%	0.66%	0.67%	0.68%	0.69%	0.69%	0.70%	0.73%	0.73%	0.74%	0.76%	0.77%	0.78%	0.75%	0.73%	0.74%	0.78%	0.81%	
Aggregate Tons	2,417,138	2,441,173	2,173,181	2,241,681	2,307,778	2,352,243	2,373,875	2,401,515	2,449,585	2,492,849	2,537,314	2,602,209	2,644,271	2,685,130	2,741,613	2,799,298	2,855,780	2,919,474	2,983,167	3,063,685	3,141,799	3,206,694	3,269,186	3,338,888	3,415,800
Index (2011=1.00)	1.00	1.01	0.90	0.93	0.95	0.97	0.98	0.99	1.01	1.03	1.05	1.08	1.09	1.11	1.13	1.16	1.18	1.21	1.23	1.27	1.30	1.33	1.35	1.38	1.41
High Economic Growth	71.17	71.46	71.33	72.2	72.69	73.13	73.33	73.58	74.05	74.43	74.9	75.55	75.91	76.29	76.86	77.32	77.87	78.4	78.91	79.5	80.16	80.76	81.38	82.11	83.01
AACGR	0.64%	0.65%	0.69%	0.67%	0.67%	0.67%	0.69%	0.71%	0.72%	0.73%	0.74%	0.73%	0.75%	0.77%	0.77%	0.79%	0.80%	0.82%	0.85%	0.87%	0.88%	0.92%	1.00%	1.10%	
Aggregate Tons	2,417,138	2,451,989	2,436,366	2,540,919	2,599,805	2,652,683	2,676,718	2,706,762	2,763,245	2,808,912	2,865,394	2,943,509	2,986,772	3,032,439	3,100,939	3,156,220	3,222,317	3,286,010	3,347,300	3,418,204	3,497,520	3,569,626	3,644,135	3,731,863	3,840,022
Index (2011=1.00)	1.00	1.01	1.01	1.05	1.08	1.10	1.11	1.12	1.14	1.16	1.19	1.22	1.24	1.25	1.28	1.31	1.33	1.36	1.38	1.41	1.45	1.48	1.51	1.54	1.59
Low Economic Growth	71.18	71.44	70.12	70.55	70.54	70.43	70.15	69.99	69.96	69.9	69.94	70.12	70.11	70.16	70.3	70.39	70.54	70.68	70.85	71.03	71.33	71.59	71.89	72.13	72.39
AACGR	0.07%	0.06%	0.14%	0.12%	0.13%	0.14%	0.17%	0.20%	0.21%	0.23%	0.25%	0.25%	0.27%	0.28%	0.29%	0.31%	0.32%	0.34%	0.36%	0.38%	0.37%	0.37%	0.35%	0.36%	
Aggregate Tons	2,418,340	2,449,585	2,290,953	2,342,629	2,341,427	2,328,208	2,294,558	2,275,330	2,271,725	2,264,514	2,269,321	2,290,953	2,289,751	2,295,760	2,312,585	2,323,401	2,341,427	2,358,252	2,378,682	2,400,313	2,436,366	2,467,612	2,503,665	2,532,507	2,563,753
Index (2011=1.00)	1.00	1.01	0.95	0.97	0.97	0.96	0.95	0.94	0.94	0.94	0.94	0.95	0.95	0.95	0.96	0.96	0.97	0.98	0.98	0.99	1.01	1.02	1.04	1.05	1.06

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Reference Case	77.92	78.28	78.64	79.00	79.36	79.72	80.08	80.44	80.80	81.16	81.52	81.88	82.24	82.60	82.96	83.32	83.68	84.04	84.40	84.76	85.12	85.48	85.84	86.20	86.56	86.92
AACGR																										
Aggregate Tons	3,228,735	3,271,962	3,315,188	3,358,414	3,401,641	3,444,867	3,488,094	3,531,320	3,574,546	3,617,773	3,660,999	3,704,226	3,747,452	3,790,678	3,833,905	3,877,131	3,920,357	3,963,584	4,006,810	4,050,037	4,093,263	4,136,489	4,179,716	4,222,942	4,266,168	4,309,395
Index (2011=1.00)	1.34	1.35	1.37	1.39	1.41	1.42	1.44	1.46	1.48	1.50	1.51	1.53	1.55	1.57	1.59	1.60	1.62	1.64	1.66	1.67	1.69	1.71	1.73	1.75	1.76	1.78
Low World Oil Price	80.92	81.33	81.74	82.15	82.56	82.98	83.39	83.80	84.21	84.62	85.03	85.44	85.86	86.27	86.68	87.09	87.50	87.91	88.32	88.74	89.15	89.56	89.97	90.38	90.79	91.20
AACGR																										
Aggregate Tons	3,588,693	3,638,133	3,687,573	3,737,012	3,786,452	3,835,892	3,885,331	3,934,771	3,984,211	4,033,651	4,083,090	4,132,530	4,181,970	4,231,409	4,280,849	4,330,289	4,379,728	4,429,168	4,478,608	4,528,047	4,577,487	4,626,927	4,676,366	4,725,806	4,775,246	4,824,685
Index (2011=1.00)	1.50	1.52	1.54	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83	1.86	1.88	1.90	1.92	1.94	1.96	1.98	2.00	2.02
High World Oil Price	80.02	80.59	81.17	81.75	82.32	82.90	83.47	84.05	84.63	85.20	85.78	86.36	86.93	87.51	88.08	88.66	89.24	89.81	90.39	90.97	91.54	92.12	92.70	93.27	93.85	94.42
AACGR																										
Aggregate Tons	3,480,294	3,549,552	3,618,810	3,688,068	3,757,326	3,826,583	3,895,841	3,965,099	4,034,357	4,103,615	4,172,872	4,242,130	4,311,388	4,380,646	4,449,904	4,519,161	4,588,419	4,657,677	4,726,935	4,796,192	4,865,450	4,934,708	5,003,966	5,073,224	5,142,481	5,211,739
Index (2011=1.00)	1.44	1.47	1.50	1.53	1.55	1.58	1.61	1.64	1.67	1.70	1.73	1.76	1.78	1.81	1.84	1.87	1.90	1.93	1.96	1.98	2.01	2.04	2.07	2.10	2.13	2.16
High Economic Growth	83.34	83.96	84.58	85.20	85.81	86.43	87.05	87.67	88.29	88.91	89.52	90.14	90.76	91.38	92.00	92.61	93.23	93.85	94.47	95.09	95.71	96.32	96.94	97.56	98.18	98.80
AACGR																										
Aggregate Tons	3,879,920	3,954,211	4,028,502	4,102,792	4,177,083	4,251,374	4,325,664	4,399,955	4,474,246	4,548,536	4,622,827	4,697,117	4,771,408	4,845,699	4,919,989	4,994,280	5,068,571	5,142,861	5,217,152	5,291,443	5,365,733	5,440,024	5,514,315	5,588,605	5,662,896	5,737,186
Index (2011=1.00)	1.61	1.64	1.67	1.70	1.73	1.76	1.79	1.82	1.85	1.88	1.91	1.94	1.97	2.00	2.04	2.07	2.10	2.13	2.16	2.19	2.22	2.25	2.28	2.31	2.34	2.37
Low Economic Growth	72.54	72.77	73.00	73.22	73.45	73.68	73.91	74.14	74.37	74.60	74.82	75.05	75.28	75.51	75.74	75.97	76.19	76.42	76.65	76.88	77.11	77.34	77.57	77.79	78.02	78.25
AACGR																										
Aggregate Tons	2,581,619	2,609,077	2,636,535	2,663,994	2,691,452	2,718,911	2,746,369	2,773,827	2,801,286	2,828,744	2,856,203	2,883,661	2,911,120	2,938,578	2,966,036	2,993,495	3,020,953	3,048,412	3,075,870	3,103,328	3,130,787	3,158,245	3,185,704	3,213,162	3,240,621	3,268,079
Index (2011=1.00)	1.07	1.08	1.09	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.31	1.32	1.33	1.34	1.35

Notes: EIA Reference Case Energy Consumption for Nonfuel Use (quadrillon btu) 2008-2035 extrapolated to 2061.
AACGR = Average Annual Compound Growth Rate for EIA projections for 2035.
Aggregate Tons = Calcasieu Lock tonnages based on regression Y=120,176X-6,135,788.

Source: G.E.C., Inc.

Table 3-8. Calcasieu Lock Dry Bulk Commodity Estimated Annual High and Low Tonnages (exclusive of Aggregates)

Commodity	Mean	Standard Deviation	High	Low	High/Mean	Low/Mean
Iron & Steel	2,418,070	565,433	3,526,318	1,309,822	1.46	0.54
Nonmetallic Minerals	1,218,233	542,238	2,281,019	155,446	1.87	0.13
Grains	282,561	93,317	465,462	99,660	1.65	0.35
Coal	268,855	92,826	450,793	86,917	1.68	0.32
Other	1,999,822	296,727	2,581,406	1,418,237	1.29	0.71
Subtotal	6,187,540	1,224,583	8,587,723	3,787,358	1.39	0.61

Source: G.E.C., Inc.

Table 3-9. Calcasieu Lock High World Oil Price and Low Other Dry Bulk (ex. Aggregates) Estimated Annual Tonnages, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Petrochemicals - High Oil Prices	16,229,683	16,406,544	15,424,169	15,729,581	15,926,842	15,980,592	15,982,753	15,922,059	15,899,055	15,928,350	15,893,165	15,885,773	15,866,786	15,826,909	15,801,379	15,747,379	15,687,334	15,677,573	15,633,216	15,636,421	15,667,768	15,654,934	15,677,581	15,735,133	15,795,024
Chemicals - High Oil Price	9,302,012	8,703,007	8,593,335	8,969,642	9,240,300	9,498,550	9,782,289	10,044,563	10,317,905	10,592,253	10,826,690	11,007,129	11,086,281	11,184,550	11,288,856	11,293,216	11,316,023	11,402,553	11,424,689	11,395,845	11,373,039	11,356,940	11,347,214	11,347,884	11,373,709
Crude Oil - High Lower 48 On/Offshore	4,035,558	4,188,603	4,478,583	4,623,573	4,792,729	5,042,434	5,090,764	5,187,424	5,300,194	5,404,909	5,412,964	5,404,909	5,364,634	5,300,194	5,292,139	5,308,249	5,276,029	5,308,249	5,284,084	5,219,644	5,227,699	5,195,479	5,139,094	5,074,654	5,090,764
Fertilizer High World Oil Price	297,127	283,365	262,723	261,003	273,904	291,966	297,127	301,427	311,748	335,831	347,012	351,312	348,732	346,152	346,152	353,032	354,753	359,053	359,053	355,613	364,214	370,234	372,814	375,395	381,415
Aggregate - High World Oil Price	2,417,138	2,441,173	2,173,181	2,241,681	2,307,778	2,352,243	2,373,875	2,401,515	2,449,585	2,492,849	2,537,314	2,602,209	2,644,271	2,685,130	2,741,613	2,799,298	2,855,780	2,919,474	2,983,167	3,063,685	3,141,799	3,206,694	3,269,186	3,338,888	3,415,800
Subtotal - High World Oil Price	32,281,517	32,022,692	30,931,991	31,825,480	32,541,553	33,165,784	33,526,806	33,856,988	34,278,488	34,754,192	35,017,145	35,251,332	35,310,704	35,342,935	35,470,139	35,501,174	35,489,918	35,666,901	35,684,209	35,671,207	35,774,519	35,784,282	35,805,889	35,871,954	36,056,713
Low Other Dry Bulk (ex aggregate)																									
Iron & Steel	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822
Nonmetallic Minerals	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446
Grains	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660
Coal	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917
Other	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237
Subtotal Other Dry Bulk (ex aggregate)	3,787,358	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8
Total High Oil and Low Other Dry Bulk	36,068,875	35,810,050	34,719,349	35,612,837	36,328,911	36,953,142	37,314,164	37,644,346	38,065,846	38,541,550	38,804,502	39,038,690	39,098,061	39,130,293	39,257,497	39,288,531	39,277,276	39,454,259	39,471,567	39,458,565	39,561,876	39,571,640	39,593,247	39,659,311	39,844,071

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Petrochemicals - High Oil Prices	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024	15,795,024
Chemicals - High Oil Price	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709	11,373,709
Crude Oil - High Lower 48 On/Offshore	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764	5,090,764
Fertilizer High World Oil Price	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415	381,415
Aggregate - High World Oil Price	3,480,294	3,549,552	3,618,810	3,688,068	3,757,326	3,826,583	3,895,841	3,965,099	4,034,357	4,103,615	4,172,872	4,242,130	4,311,388	4,380,646	4,449,904	4,519,161	4,588,419	4,657,677	4,726,935	4,796,192	4,865,450	4,934,708	5,003,966	5,073,224	5,142,481	5,211,739
Subtotal - High World Oil Price	36,121,207	36,190,465	36,259,723	36,328,981	36,398,239	36,467,496	36,536,754	36,606,012	36,675,270	36,744,527	36,813,785	36,883,043	36,952,301	37,021,559	37,090,816	37,160,074	37,229,332	37,298,590	37,367,848	37,437,105	37,506,363	37,575,621	37,644,879	37,714,137	37,783,394	37,852,652
Low Other Dry Bulk (ex aggregate)																										
Iron & Steel	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822	1,309,822
Nonmetallic Minerals	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446	155,446
Grains	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660	99,660
Coal	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917	86,917
Other	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237	1,418,237
Subtotal Other Dry Bulk (ex aggregate)	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3787357.8	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358	3,787,358
Total High Oil and Low Other Dry Bulk	39,908,565	39,977,823	40,047,081	40,116,339	40,185,596	40,254,854	40,324,112	40,393,370	40,462,627	40,531,885	40,601,143	40,670,401	40,739,659	40,808,916	40,878,174	40,947,432	41,016,690	41,085,948	41,155,205	41,224,463	41,293,721	41,362,979	41,432,237	41,501,494	41,570,752	41,640,010

Petrochemicals from Table 3-2.
Chemicals from Table 3-4.
Crude Oil from Table 3-5.
Fertilizer from Table 3-6.
Aggregate from Table 3-7.
Other Dry Bulk (ex aggregate) from Table 3-8.

Table 3-10. Calcasieu Lock Low World Oil Price and Low Other Dry Bulk (ex. Aggregates) Estimated Annual Tonnages, 2011-2061

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Petrochemicals - Low Oil Prices	16,229,683	16,660,965	16,854,691	17,465,418	17,731,253	17,897,473	17,988,619	18,053,941	18,156,810	18,303,970	18,386,020	18,470,136	18,504,727	18,557,948	18,660,271	18,712,383	18,761,821	18,864,144	18,921,254	19,068,590	19,106,947	19,159,428	19,318,023	19,509,616	19,693,635
Chemicals - Low Oil Price	9,302,012	8,831,461	8,902,899	9,237,282	9,396,927	9,601,514	9,886,930	10,149,204	10,406,783	10,660,673	10,887,731	11,065,822	11,136,925	11,247,603	11,378,740	11,407,584	11,446,489	11,541,739	11,572,595	11,542,745	11,509,877	11,482,711	11,471,643	11,466,948	11,473,655
Crude Oil - Low Lower 48 On/Offshore	4,035,558	4,188,603	4,244,988	4,293,318	4,365,813	4,494,693	4,438,308	4,406,088	4,438,308	4,422,198	4,349,703	4,269,153	4,180,548	4,108,053	4,059,723	3,995,283	3,938,898	3,930,843	3,922,788	3,890,568	3,874,458	3,858,348	3,882,513	3,866,403	3,858,348
Fertilizer - Low World Oil Price	297,127	283,365	264,443	261,863	271,324	285,945	286,805	280,785	280,785	287,666	290,246	286,805	277,344	271,324	271,324	267,883	263,583	262,723	262,723	261,863	264,443	270,464	277,344	278,205	276,484
Aggregate - Low World Oil Price	2,387,094	2,468,814	2,490,445	2,641,867	2,722,385	2,757,236	2,774,061	2,795,692	2,829,342	2,862,991	2,896,640	2,948,316	2,972,351	3,006,000	3,054,071	3,099,738	3,145,404	3,193,475	3,237,940	3,289,616	3,343,695	3,382,151	3,436,230	3,491,511	3,547,994
Subtotal - Low World Oil Price	32,251,473	32,433,209	32,757,467	33,899,748	34,487,702	35,036,862	35,374,724	35,685,711	36,112,028	36,537,498	36,810,340	37,040,233	37,071,895	37,190,928	37,424,128	37,482,871	37,556,195	37,792,924	37,917,300	38,053,382	38,099,420	38,153,101	38,385,754	38,612,683	38,850,117
High Other Dry Bulk (ex aggregate)																									
Iron & Steel	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318
Nonmetallic Minerals	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019
Grains	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462
Coal	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793
Other	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406
Subtotal Other Dry Bulk (ex aggregate)	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723
Total Low Oil and High Other Dry Bulk	40,839,196	41,020,931	41,345,189	42,487,471	43,075,425	43,624,585	43,962,447	44,273,434	44,699,751	45,125,220	45,398,062	45,627,955	45,659,618	45,778,651	46,011,851	46,070,594	46,143,918	46,380,646	46,505,023	46,641,104	46,687,143	46,740,824	46,973,476	47,200,405	47,437,840

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Petrochemicals - Low Oil Prices	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635	19,693,635
Chemicals - Low Oil Price	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655	11,473,655
Crude Oil - Low Lower 48 On/Offshore	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348	3,858,348
Fertilizer - Low World Oil Price	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484	276,484
Aggregate - Low World Oil Price	3,588,693	3,638,133	3,687,573	3,737,012	3,786,452	3,835,892	3,885,331	3,934,771	3,984,211	4,033,651	4,083,090	4,132,530	4,181,970	4,231,409	4,280,849	4,330,289	4,379,728	4,429,168	4,478,608	4,528,047	4,577,487	4,626,927	4,676,366	4,725,806	4,775,246	4,824,685
Subtotal - Low World Oil Price	38,890,816	38,940,256	38,989,696	39,039,135	39,088,575	39,138,015	39,187,454	39,236,894	39,286,334	39,335,773	39,385,213	39,434,653	39,484,092	39,533,532	39,582,972	39,632,412	39,681,851	39,731,291	39,780,731	39,830,170	39,879,610	39,929,050	39,978,489	40,027,929	40,077,369	40,126,808
High Other Dry Bulk (ex aggregate)																										
Iron & Steel	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318	3,526,318
Nonmetallic Minerals	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019	2,281,019
Grains	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462	465,462
Coal	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793	450,793
Other	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406	2,581,406
Subtotal Other Dry Bulk (ex aggregate)	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723	8,587,723
Total Low Oil and High Other Dry Bulk	47,478,539	47,527,979	47,577,418	47,626,858	47,676,298	47,725,737	47,775,177	47,824,617	47,874,056	47,923,496	47,972,936	48,022,375	48,071,815	48,121,255	48,170,695	48,220,134	48,269,574	48,319,014	48,368,453	48,417,893	48,467,333	48,516,772	48,566,212	48,615,652	48,665,091	48,714,531

Petrochemicals from Table 3-2.
Chemicals from Table 3-4.
Crude Oil from Table 3-5.
Fertilizer from Table 3-6.
Aggregate from Table 3-7.
Other Dry Bulk (ex aggregate) from Table 3-8.

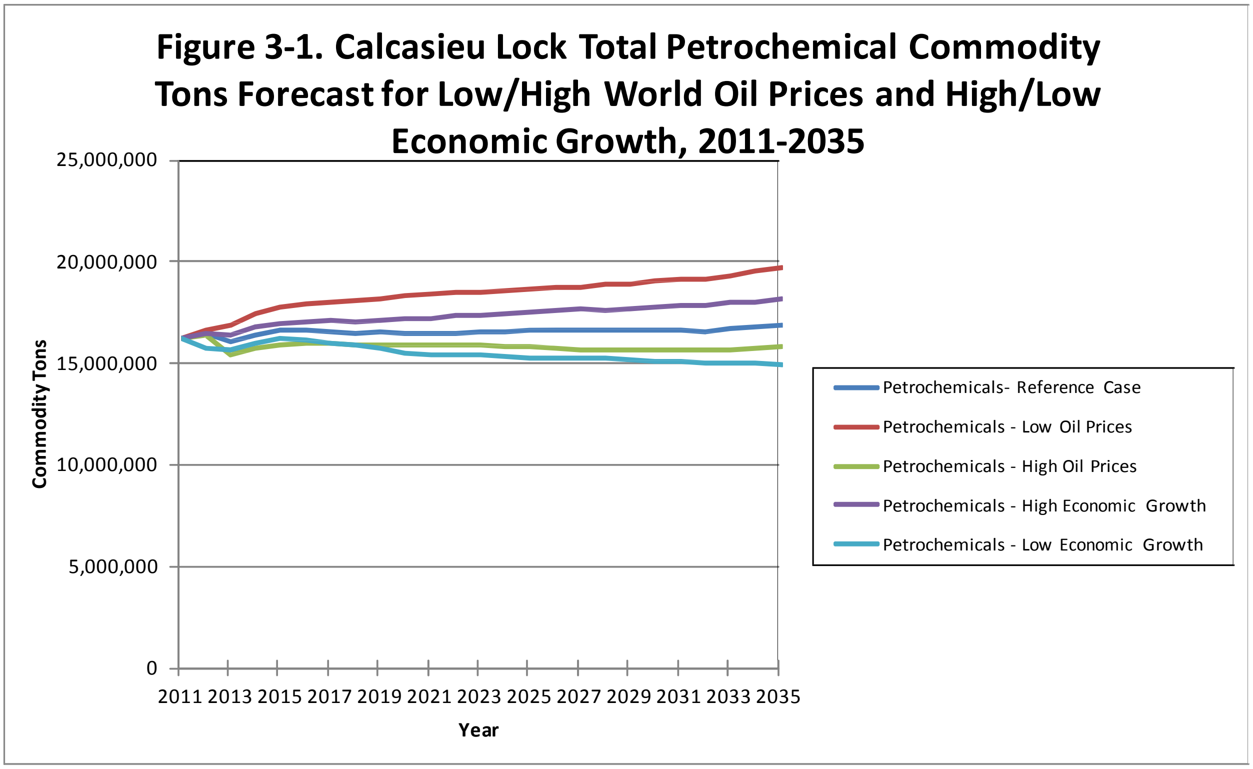


Figure 3-1. Calcasieu Lock Total Petrochemical Commodity Tons Forecast for Low/High World Oil Prices and High/Low Economic Growth, 2011-2035
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Commodity Tons
2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035
Year
Petrochemicals- Reference Case
Petrochemicals - Low Oil Prices
Petrochemicals - High Oil Prices
Petrochemicals - High Economic Growth
Petrochemicals - Low Economic Growth

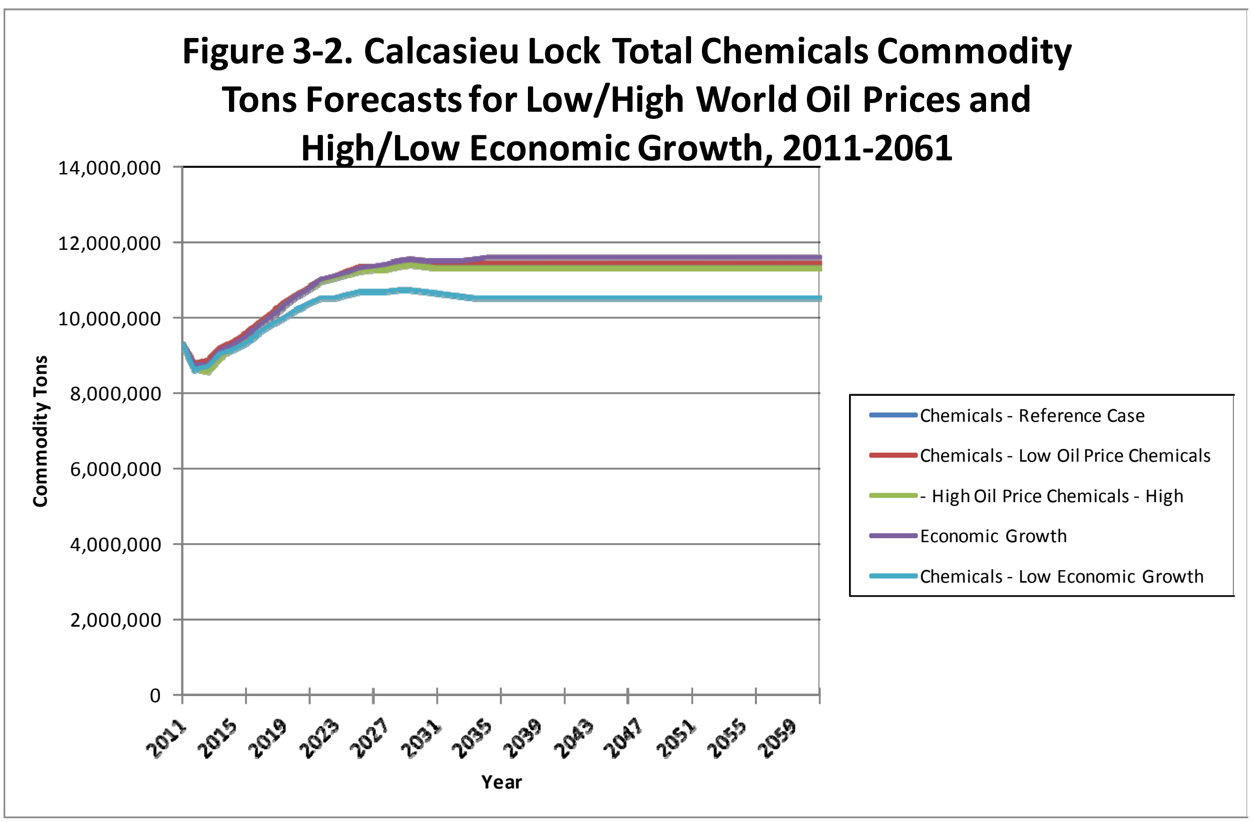


Figure 3-2. Calcasieu Lock Total Chemicals Commodity Tons Forecasts for Low/High World Oil Prices and High/Low Economic Growth, 2011-2061
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
Commodity Tons
2011 2015 2019 2023 2027 2031 2035 2039 2043 2047 2051 2055 2059
Year
Chemicals - Reference Case
Chemicals - Low Oil Price Chemicals
- High Oil Price Chemicals - High
Economic Growth
Chemicals - Low Economic Growth

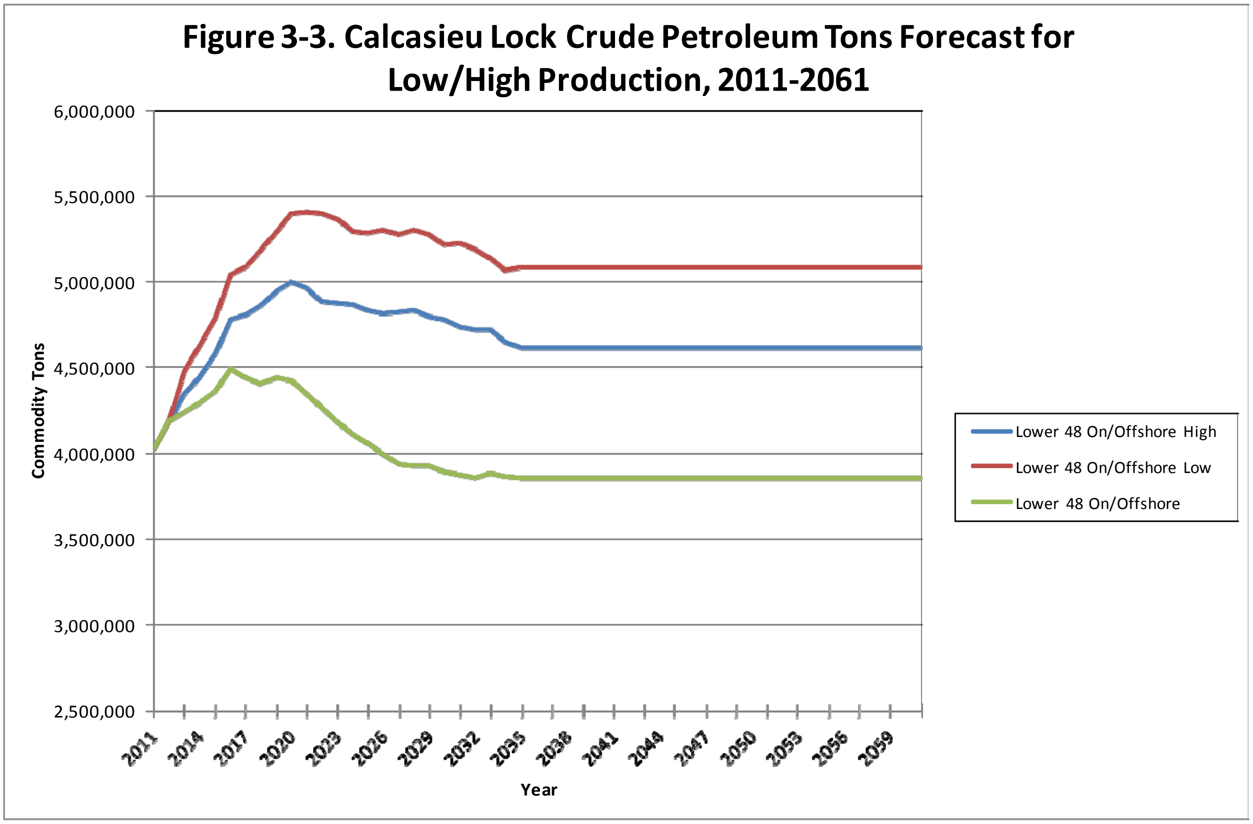


Figure 3-3. Calcasieu Lock Crude Petroleum Tons Forecast for Low/High Production, 2011-2061
Commodity Tons
Year
Lower 48 On/Offshore High
Lower 48 On/Offshore Low
Lower 48 On/Offshore

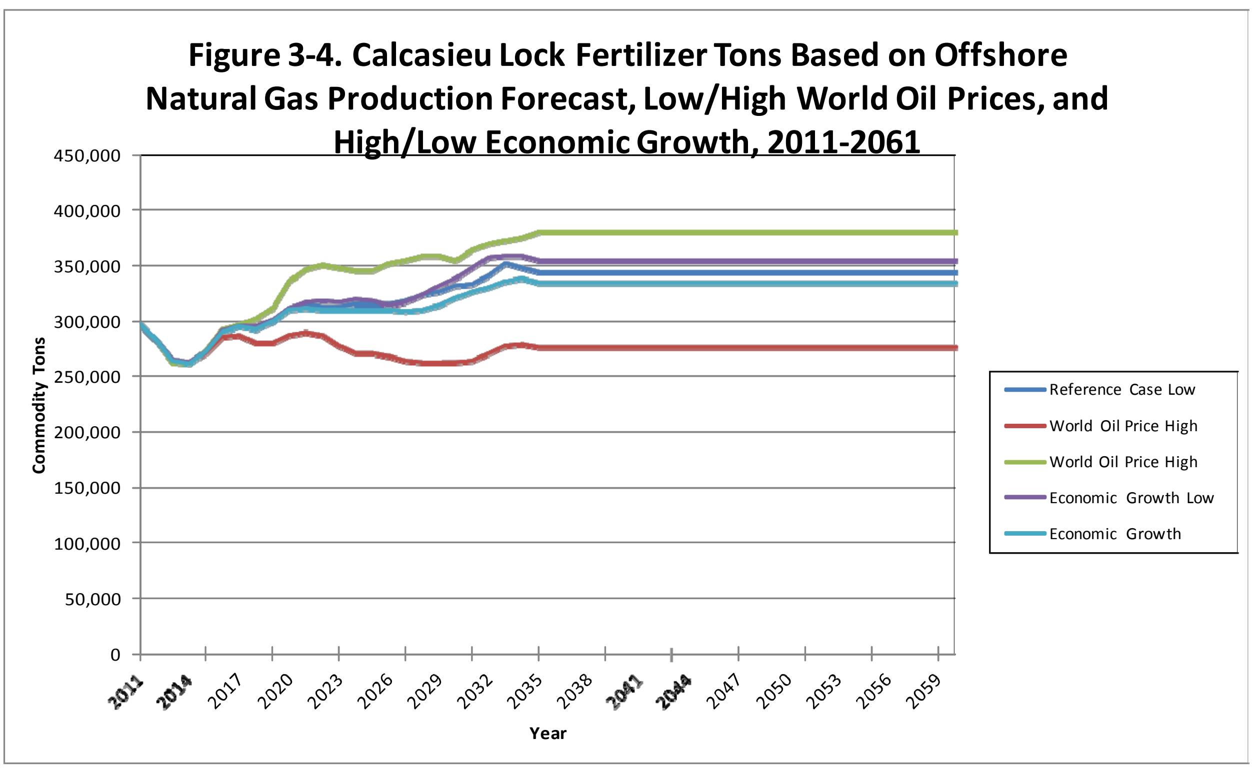


Figure 3-4. Calcasieu Lock Fertilizer Tons Based on Offshore Natural Gas Production Forecast, Low/High World Oil Prices, and High/Low Economic Growth, 2011-2061
Commodity Tons
Year
Reference Case Low
World Oil Price High
World Oil Price High
Economic Growth Low
Economic Growth

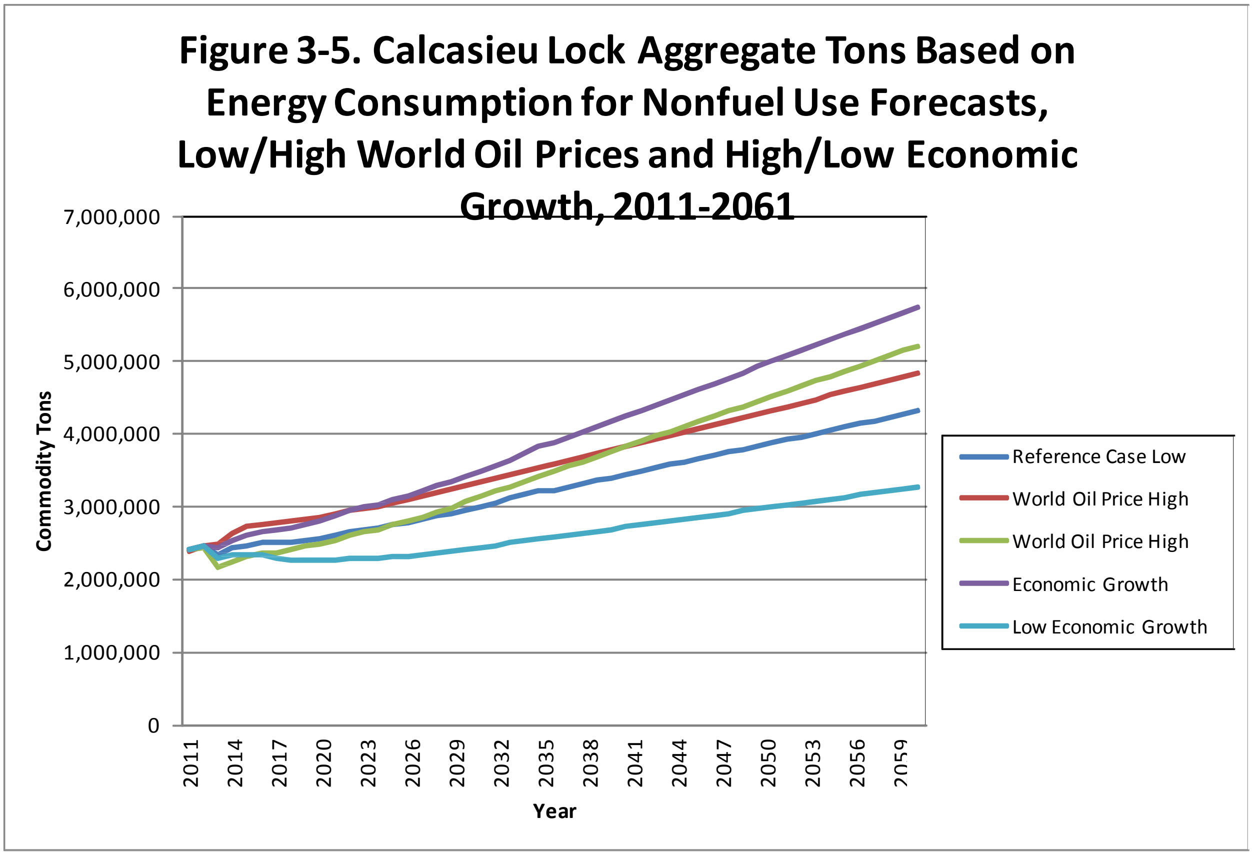


Figure 3-5. Calcasieu Lock Aggregate Tons Based on Energy Consumption for Nonfuel Use Forecasts, Low/High World Oil Prices and High/Low Economic Growth, 2011-2061
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
Commodity Tons
2011
2014
2017
2020
2023
2026
2029
2032
2035
2038
2041
2044
2047
2050
2053
2056
2059
Year
Reference Case Low
World Oil Price High
World Oil Price High
Economic Growth
Low Economic Growth

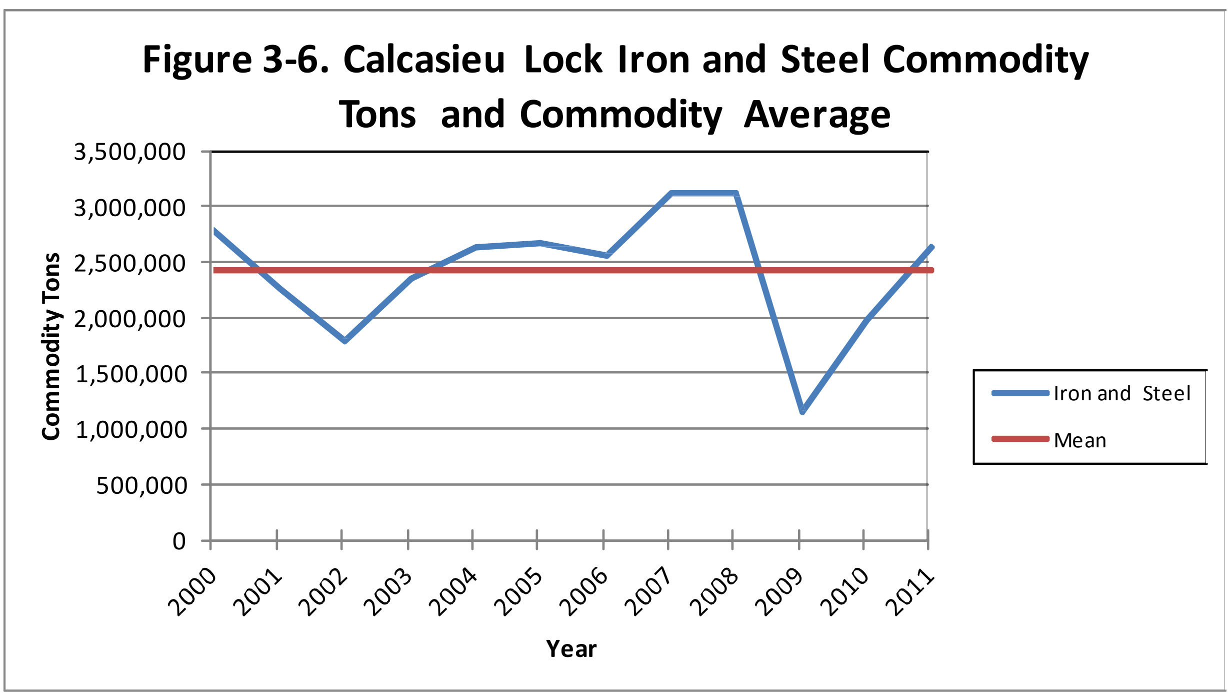


Figure 3-6. Calcasieu Lock Iron and Steel Commodity Tons and Commodity Average
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Iron and Steel
Mean

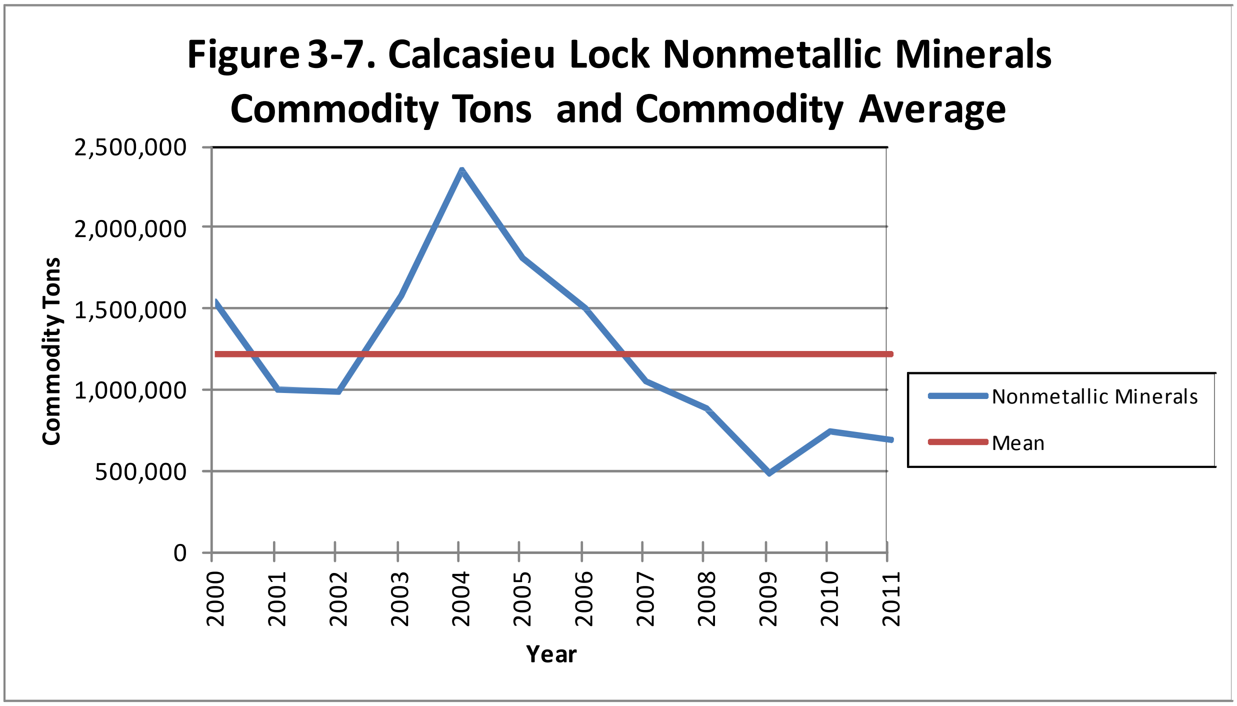


Figure 3-7. Calcasieu Lock Nonmetallic Minerals Commodity Tons and Commodity Average
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Nonmetallic Minerals
Mean

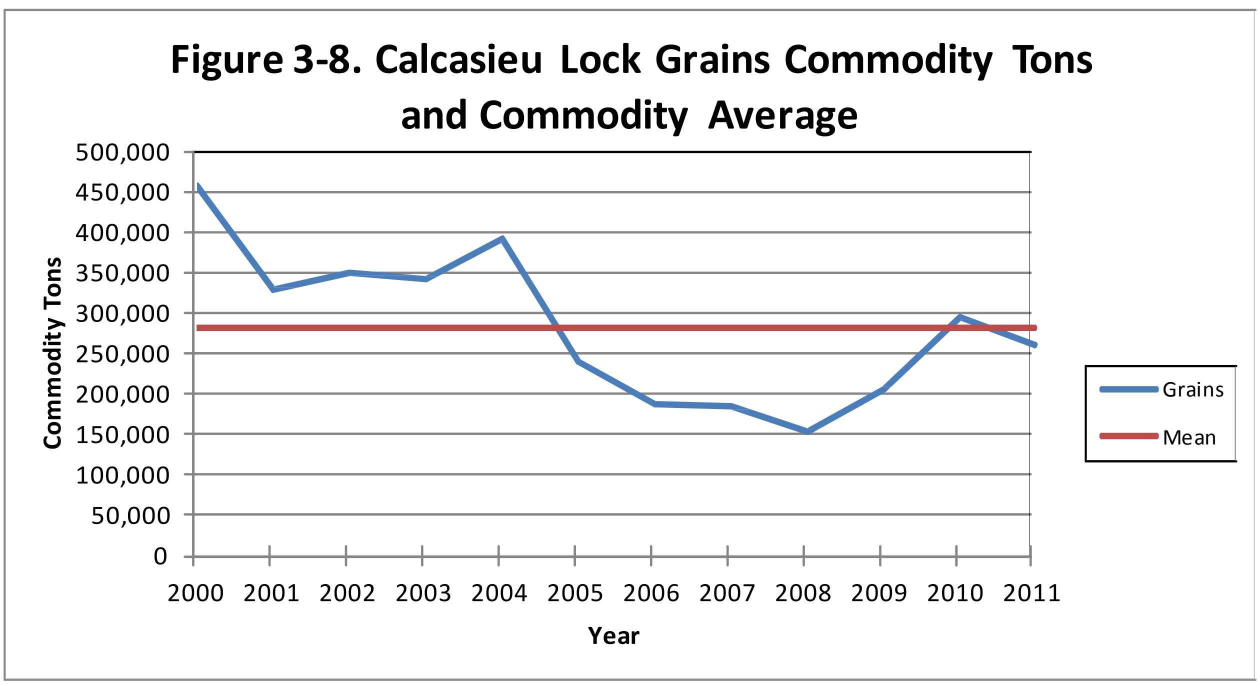


Figure 3-8. Calcasieu Lock Grains Commodity Tons and Commodity Average
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Grains
Mean

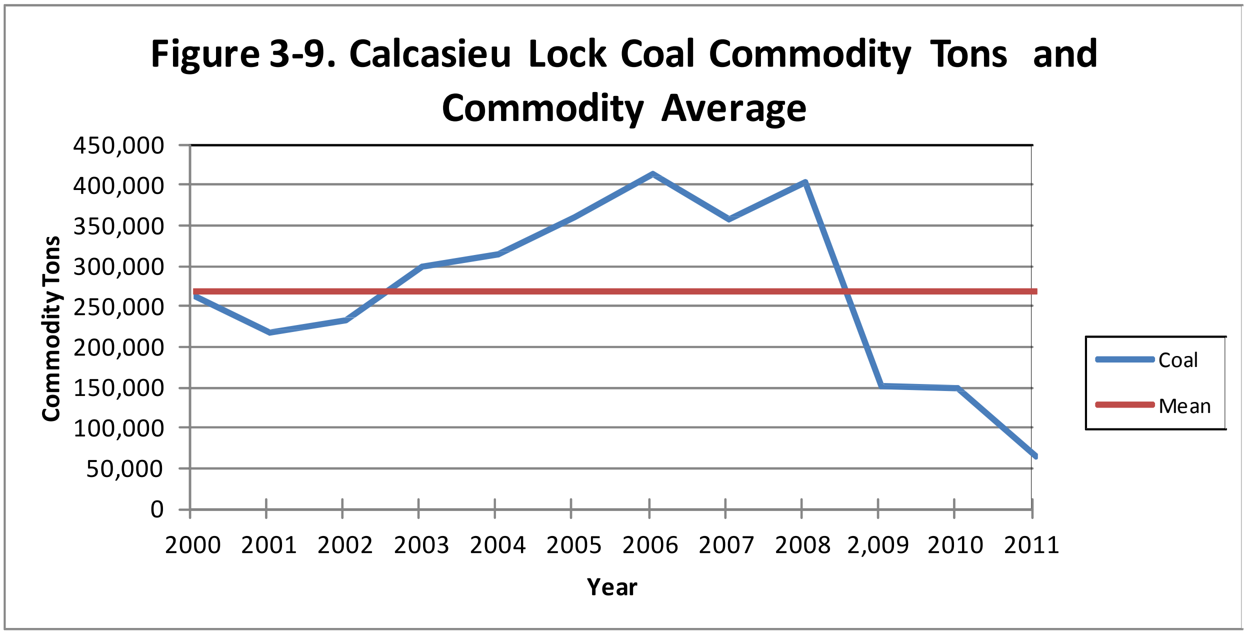


Figure 3-9. Calcasieu Lock Coal Commodity Tons and Commodity Average
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2,009
2010
2011
Year
Coal
Mean

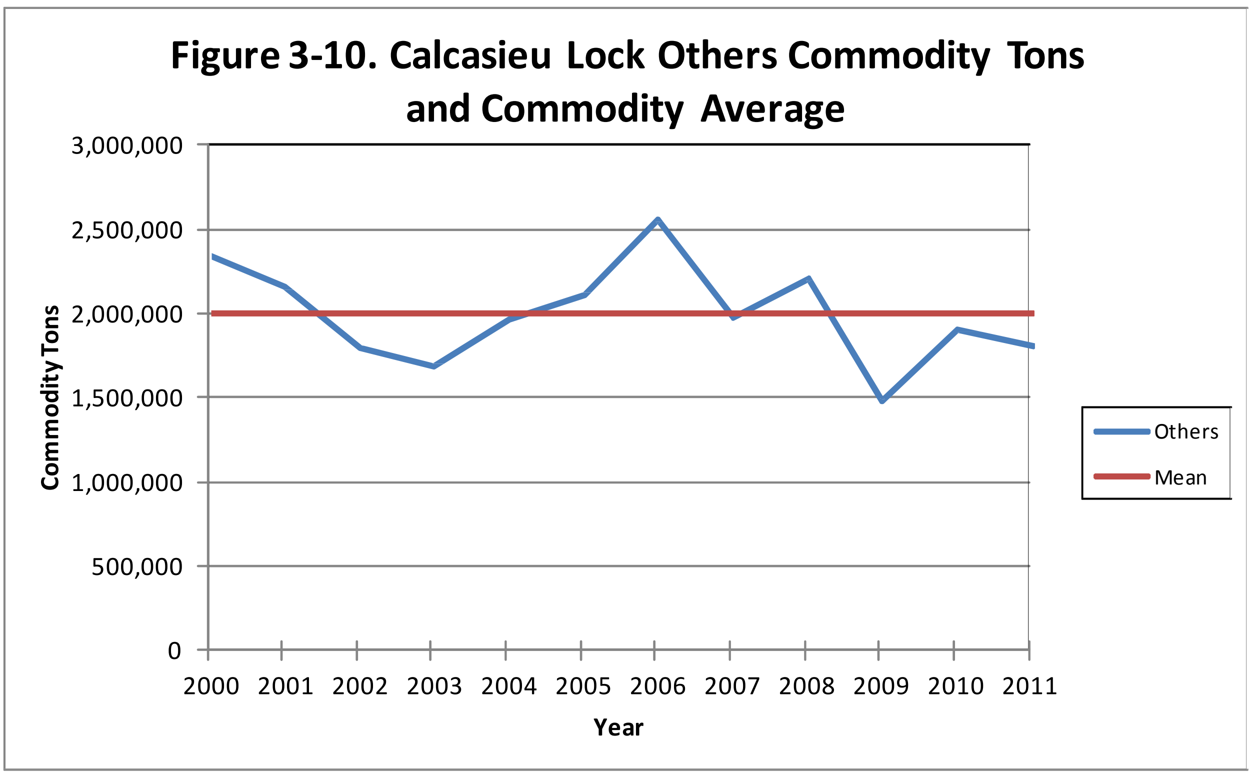


Figure 3-10. Calcasieu Lock Others Commodity Tons and Commodity Average
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Others
Mean

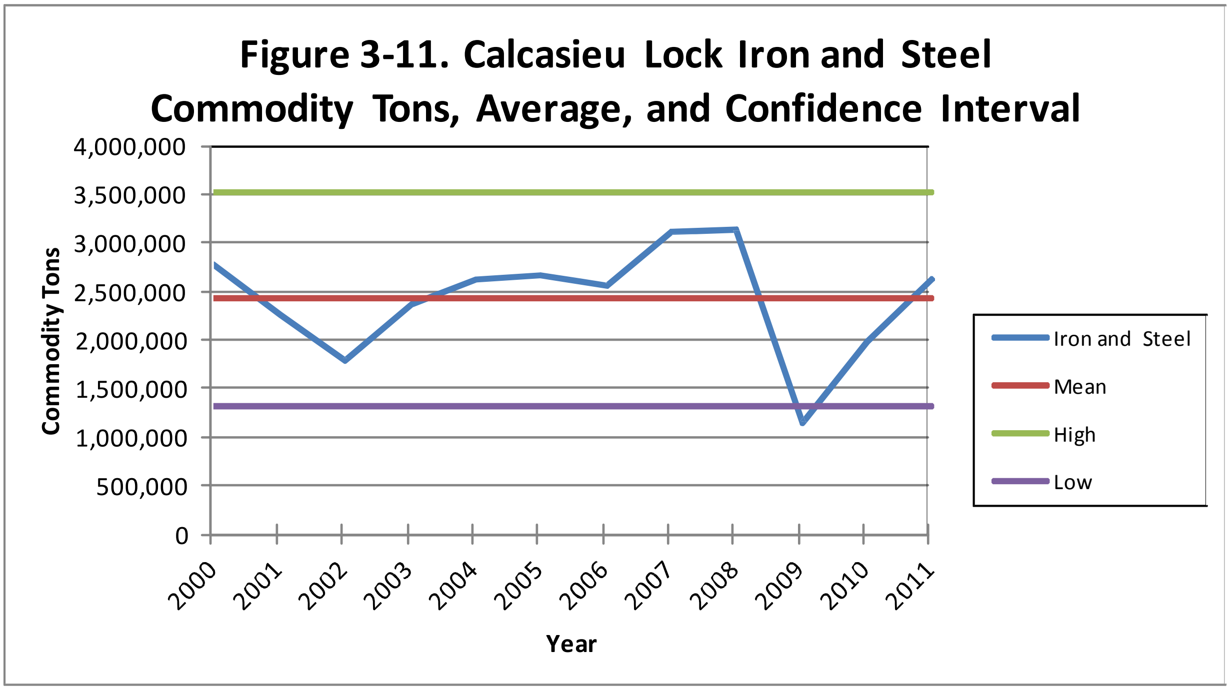


Figure 3-11. Calcasieu Lock Iron and Steel Commodity Tons, Average, and Confidence Interval
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Iron and Steel
Mean
High
Low

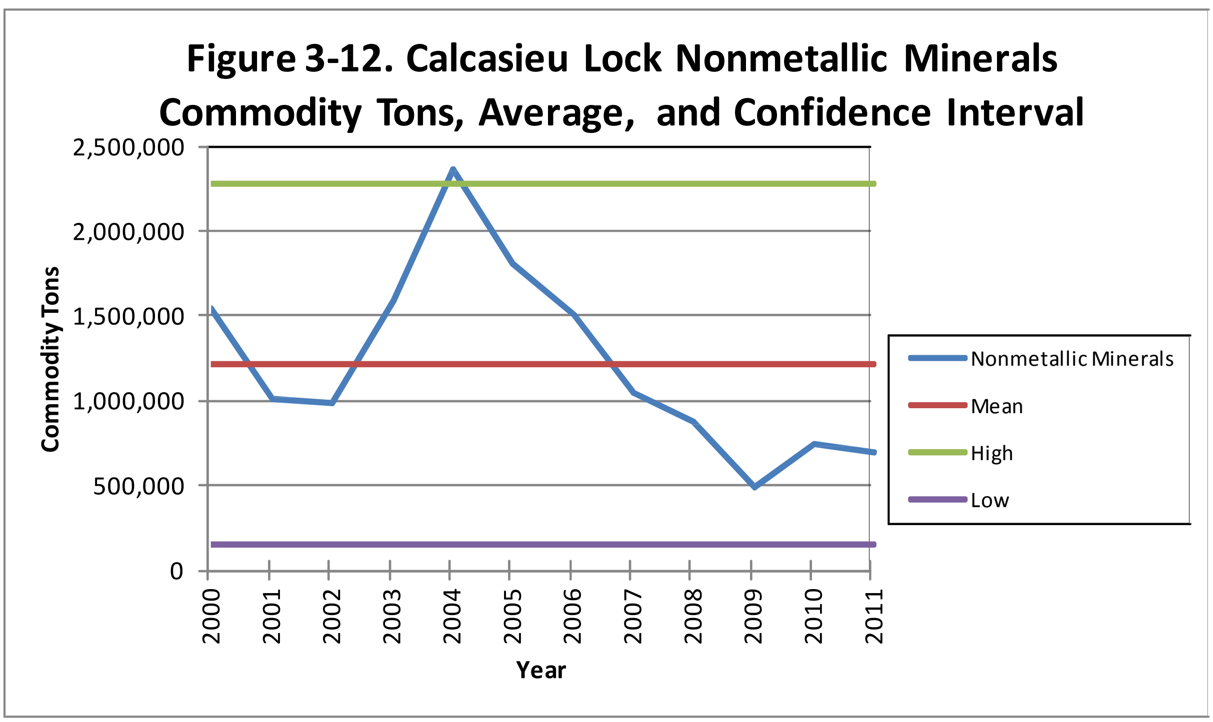


Figure 3-12. Calcasieu Lock Nonmetallic Minerals Commodity Tons, Average, and Confidence Interval
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Commodity Tons
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Nonmetallic Minerals
Mean
High
Low

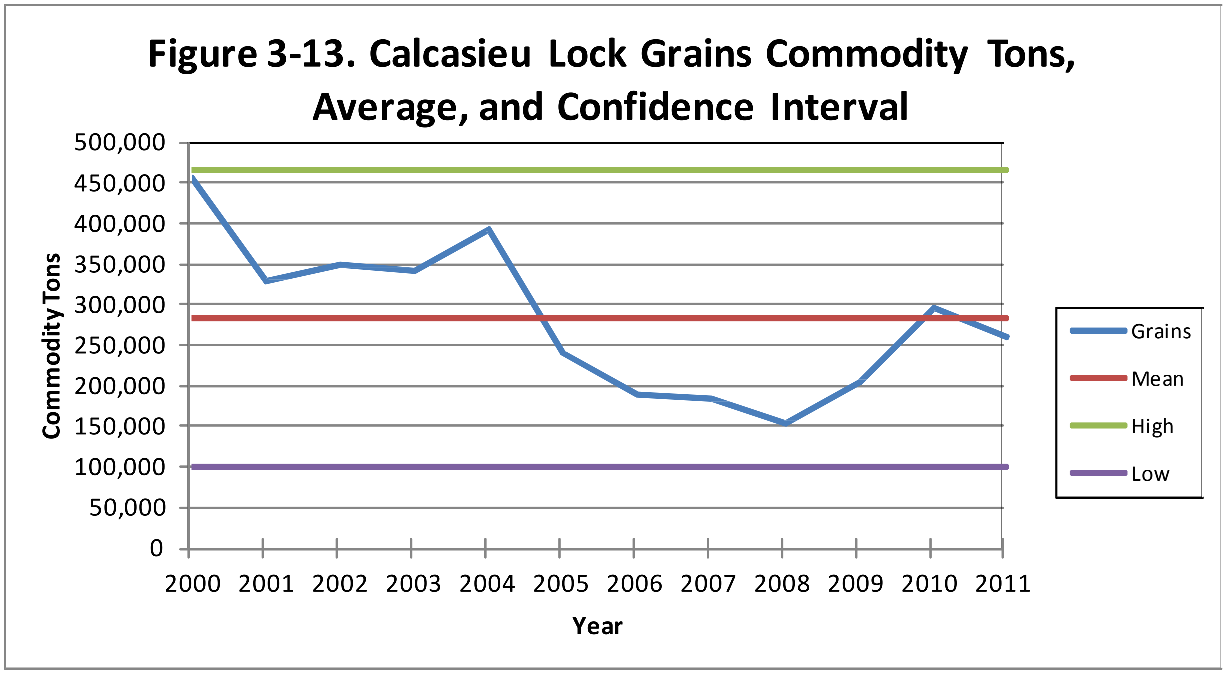


Figure 3-13. Calcasieu Lock Grains Commodity Tons, Average, and Confidence Interval
Commodity Tons
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Grains
Mean
High
Low

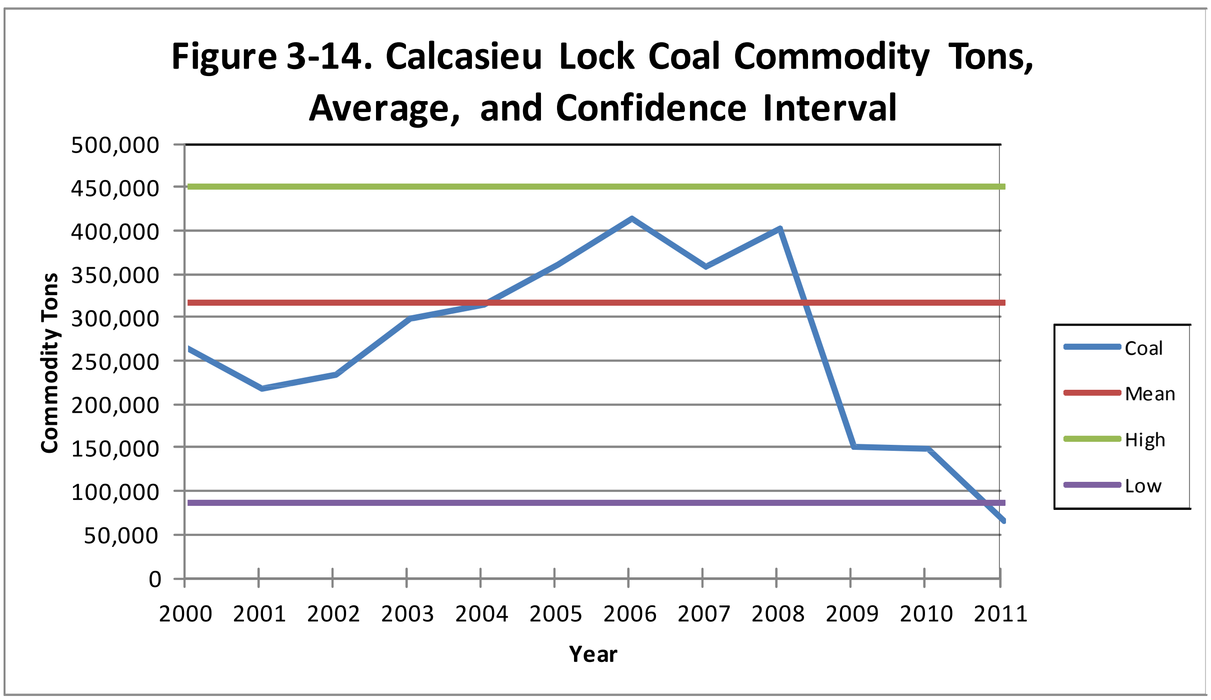


Figure 3-14. Calcasieu Lock Coal Commodity Tons, Average, and Confidence Interval
Commodity Tons
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Coal
Mean
High
Low

Figure 3-15. Calcasieu Lock Others Commodity Tons, Average, and Confidence Interval

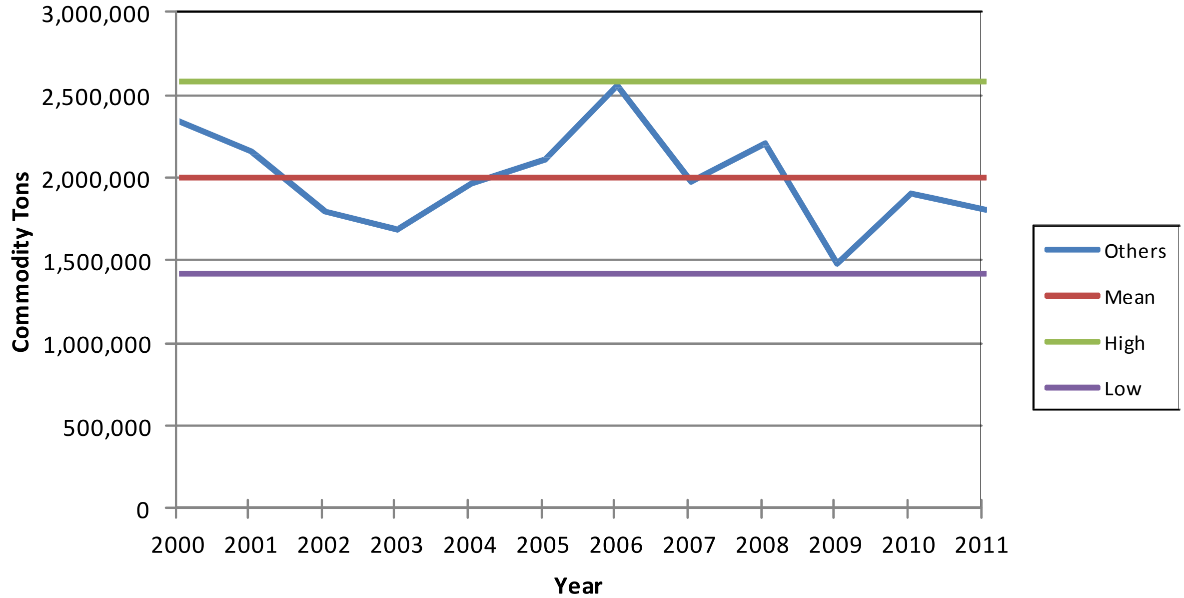
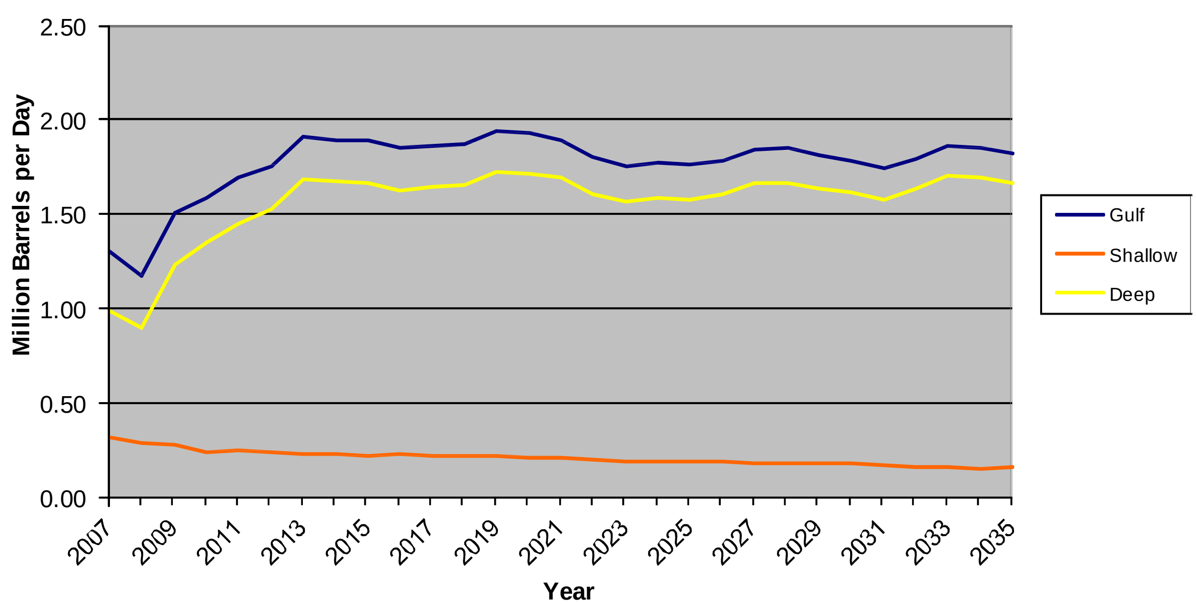


Figure 3-16. EIA 2010 GOM Crude Oil Production by Source, 2007-2035



Section 4:
TABLES AND FIGURES

Table 4-1. Calcasieu Lock Loaded Barges, Chemicals, 2011-2061

Chemicals, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0		2						2
Tow								0								0
Dry Cargo Barge						62		62			1			114		115
Tanker Barge	91	751	78	166	201	1397	11	2695	113	371	49	222	95	775		1625
Total Tons	323,048	2,463,134	206,807	360,571	338,850	2,162,491	18,351	5,873,252	428,670	1,287,206	114,589	354,217	133,084	1,288,562		3,606,328
Average tons/barge	3,550	3,280	2,651	2,172	1,686	1,482	1,668		3,794	3,470	2,292	1,596	1,401	1,449	0	
Tons Distribution	3.41%	25.98%	2.18%	3.80%	3.57%	22.81%	0.19%	61.96%	4.52%	13.58%	1.21%	3.74%	1.40%	13.59%	0.00%	38.04%
Barges 2011	89	737	77	163	197	1,432	11	2,705	111	364	49	218	93	872	0	1,707
Barges 2012	84	693	72	153	186	1,347	10	2,546	104	343	46	205	88	821	0	1,607
Barges 2013	84	693	72	153	186	1,347	10	2,545	104	342	46	205	88	821	0	1,606
Barges 2014	87	721	75	159	193	1,401	11	2,648	109	356	48	213	91	854	0	1,671
Barges 2015	89	735	76	163	197	1,429	11	2,700	111	363	49	217	93	871	0	1,704
Barges 2016	91	753	78	166	201	1,462	11	2,763	113	372	50	222	95	891	0	1,744
Barges 2017	94	776	81	172	208	1,508	11	2,849	117	383	52	229	98	919	0	1,798
Barges 2018	97	797	83	176	213	1,548	12	2,926	120	394	53	236	101	943	0	1,846
Barges 2019	99	818	85	181	219	1,588	12	3,001	123	404	54	242	103	968	0	1,894
Barges 2020	102	839	87	185	224	1,630	12	3,079	126	414	56	248	106	993	0	1,943
Barges 2021	104	858	89	190	230	1,666	13	3,148	129	424	57	254	108	1,015	0	1,987
Barges 2022	106	872	91	193	233	1,694	13	3,201	131	431	58	258	110	1,032	0	2,020
Barges 2023	106	878	91	194	235	1,706	13	3,223	132	434	58	260	111	1,039	0	2,034
Barges 2024	107	887	92	196	237	1,723	13	3,256	133	438	59	262	112	1,050	0	2,055
Barges 2025	109	897	93	198	240	1,743	13	3,293	135	443	60	265	113	1,062	0	2,078
Barges 2026	109	899	93	199	241	1,747	13	3,301	135	444	60	266	114	1,064	0	2,083
Barges 2027	109	902	94	199	241	1,752	13	3,311	136	446	60	267	114	1,068	0	2,089
Barges 2028	110	909	94	201	243	1,766	13	3,337	137	449	61	269	115	1,076	0	2,106
Barges 2029	110	911	95	201	244	1,769	13	3,343	137	450	61	269	115	1,078	0	2,110
Barges 2030	110	908	94	201	243	1,764	13	3,333	137	449	60	268	115	1,075	0	2,103
Barges 2031	110	906	94	200	242	1,760	13	3,325	136	447	60	268	115	1,072	0	2,099
Barges 2032	110	905	94	200	242	1,757	13	3,321	136	447	60	267	114	1,071	0	2,096
Barges 2033	110	904	94	200	242	1,757	13	3,320	136	447	60	267	114	1,070	0	2,095
Barges 2034	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,094
Barges 2035	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2036	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2037	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2038	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2039	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2040	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2041	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2042	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2043	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2044	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2045	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2046	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2047	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2048	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2049	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2050	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2051	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2052	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2053	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2054	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2055	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2056	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2057	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2058	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2059	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2060	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093
Barges 2061	109	904	94	200	242	1,755	13	3,317	136	446	60	267	114	1,070	0	2,093

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-2. Calcasieu Lock Loaded Barges, Petroleum Products, 2011-2061

Petroleum Products, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0		2						2
Tow						1		1								0
Dry Cargo Barge						59		59						460		460
Tanker Barge	178	1559	83	103	98	511	63	2595	247	2035	13	40	62	394		2791
Total Tons	679,011	5,363,088	217,047	155,902	165,558	829,462	75,208	7,485,276	872,461	7,061,518	32,934	96,495	125,237	1,264,015		9,452,660
Average tons/barge	3,815	3,440	2,615	1,514	1,689	1,455	1,194		3,532	3,470	2,533	2,412	2,020	1,480	0	
Tons Distribution	4.01%	31.66%	1.28%	0.92%	0.98%	4.90%	0.44%	44.19%	5.15%	41.69%	0.19%	0.57%	0.74%	7.46%	0.00%	55.81%
Barges 2011	171	1,494	80	99	94	546	60	2,543	237	1,950	12	38	59	818	0	3,115
Barges 2012	173	1,517	81	100	95	554	61	2,582	240	1,980	13	39	60	831	0	3,162
Barges 2013	169	1,477	79	98	93	540	60	2,514	234	1,928	12	38	59	809	0	3,080
Barges 2014	172	1,511	80	100	95	552	61	2,572	239	1,972	13	39	60	828	0	3,150
Barges 2015	174	1,527	81	101	96	558	62	2,599	242	1,993	13	39	61	836	0	3,184
Barges 2016	174	1,527	81	101	96	558	62	2,599	242	1,993	13	39	61	836	0	3,184
Barges 2017	174	1,523	81	101	96	557	62	2,592	241	1,987	13	39	61	834	0	3,175
Barges 2018	173	1,517	81	100	95	555	61	2,582	240	1,980	13	39	60	831	0	3,163
Barges 2019	173	1,520	81	100	96	556	61	2,587	241	1,983	13	39	60	832	0	3,169
Barges 2020	173	1,516	81	100	95	554	61	2,581	240	1,979	13	39	60	831	0	3,162
Barges 2021	173	1,514	81	100	95	554	61	2,578	240	1,977	13	39	60	830	0	3,158
Barges 2022	173	1,518	81	100	95	555	61	2,585	241	1,982	13	39	60	832	0	3,166
Barges 2023	174	1,522	81	101	96	557	62	2,592	241	1,987	13	39	61	834	0	3,174
Barges 2024	174	1,525	81	101	96	557	62	2,596	242	1,990	13	39	61	835	0	3,180
Barges 2025	174	1,528	81	101	96	559	62	2,601	242	1,995	13	39	61	837	0	3,186
Barges 2026	175	1,530	81	101	96	559	62	2,605	242	1,997	13	39	61	838	0	3,191
Barges 2027	175	1,531	81	101	96	560	62	2,606	243	1,998	13	39	61	839	0	3,192
Barges 2028	175	1,529	81	101	96	559	62	2,602	242	1,995	13	39	61	837	0	3,188
Barges 2029	174	1,527	81	101	96	558	62	2,599	242	1,993	13	39	61	836	0	3,184
Barges 2030	175	1,533	82	101	96	560	62	2,609	243	2,001	13	39	61	840	0	3,196
Barges 2031	175	1,529	81	101	96	559	62	2,603	242	1,996	13	39	61	838	0	3,189
Barges 2032	174	1,525	81	101	96	557	62	2,596	242	1,990	13	39	61	835	0	3,180
Barges 2033	176	1,539	82	102	97	563	62	2,620	244	2,009	13	39	61	843	0	3,209
Barges 2034	177	1,546	82	102	97	565	62	2,632	245	2,018	13	40	61	847	0	3,224
Barges 2035	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2036	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2037	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2038	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2039	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2040	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2041	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2042	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2043	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2044	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2045	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2046	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2047	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2048	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2049	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2050	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2051	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2052	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2053	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2054	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2055	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2056	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2057	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2058	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2059	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2060	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242
Barges 2061	178	1,555	83	103	98	569	63	2,647	246	2,030	13	40	62	852	0	3,242

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-3. Calcasieu Lock Loaded Barges, Crude Oil, 2011-2061

Crude Petroleum, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge								0								0
Tanker Barge	19	347		7	26	115		514	3	377	4	17		163	1243	1807
Total Tons	67,243	1,206,043		18,419	40,093	149,674		1,481,472	11,372	1,105,757	11,215	48,356		204,306	0	1,381,006
Average tons/barge	3,539	3,476	0	2,631	1,542	1,302	0		3,791	2,933	2,804	2,844	0	1,253	0	
Tons Distribution	2.35%	42.13%	0.00%	0.64%	1.40%	5.23%	0.00%	51.75%	0.40%	38.63%	0.39%	1.69%	0.00%	7.14%	0.00%	48.25%
Barges 2011	27	489	0	10	37	162	0	725	4	531	6	24	0	230	0	795
Barges 2012	28	508	0	10	38	168	0	752	4	552	6	25	0	239	0	825
Barges 2013	29	527	0	11	40	175	0	781	5	573	6	26	0	248	0	857
Barges 2014	30	539	0	11	40	179	0	798	5	586	6	26	0	253	0	876
Barges 2015	30	556	0	11	42	184	0	823	5	604	6	27	0	261	0	903
Barges 2016	32	580	0	12	43	192	0	859	5	630	7	28	0	272	0	943
Barges 2017	32	583	0	12	44	193	0	863	5	633	7	29	0	274	0	947
Barges 2018	32	589	0	12	44	195	0	872	5	640	7	29	0	277	0	957
Barges 2019	33	600	0	12	45	199	0	888	5	651	7	29	0	282	0	974
Barges 2020	33	606	0	12	45	201	0	898	5	659	7	30	0	285	0	986
Barges 2021	33	601	0	12	45	199	0	891	5	654	7	29	0	283	0	978
Barges 2022	32	593	0	12	44	196	0	878	5	644	7	29	0	278	0	963
Barges 2023	32	592	0	12	44	196	0	877	5	643	7	29	0	278	0	962
Barges 2024	32	591	0	12	44	196	0	875	5	642	7	29	0	278	0	960
Barges 2025	32	586	0	12	44	194	0	868	5	637	7	29	0	275	0	952
Barges 2026	32	584	0	12	44	194	0	865	5	634	7	29	0	274	0	949
Barges 2027	32	585	0	12	44	194	0	866	5	635	7	29	0	275	0	951
Barges 2028	32	586	0	12	44	194	0	868	5	637	7	29	0	275	0	952
Barges 2029	32	582	0	12	44	193	0	862	5	632	7	29	0	273	0	946
Barges 2030	32	580	0	12	43	192	0	859	5	630	7	28	0	272	0	943
Barges 2031	31	574	0	12	43	190	0	850	5	624	7	28	0	270	0	933
Barges 2032	31	572	0	12	43	190	0	848	5	622	7	28	0	269	0	930
Barges 2033	31	572	0	12	43	190	0	848	5	622	7	28	0	269	0	930
Barges 2034	31	563	0	11	42	187	0	835	5	612	6	28	0	265	0	916
Barges 2035	31	560	0	11	42	185	0	829	5	608	6	27	0	263	0	909
Barges 2036	31	557	0	11	42	185	0	826	5	606	6	27	0	262	0	906
Barges 2037	30	554	0	11	41	184	0	820	5	602	6	27	0	260	0	900
Barges 2038	30	550	0	11	41	182	0	815	5	598	6	27	0	258	0	894
Barges 2039	30	547	0	11	41	181	0	810	5	594	6	27	0	257	0	888
Barges 2040	30	543	0	11	41	180	0	804	5	590	6	27	0	255	0	883
Barges 2041	30	539	0	11	40	179	0	799	5	586	6	26	0	253	0	877
Barges 2042	29	536	0	11	40	178	0	794	5	582	6	26	0	252	0	871
Barges 2043	29	532	0	11	40	176	0	788	5	578	6	26	0	250	0	865
Barges 2044	29	529	0	11	40	175	0	783	5	574	6	26	0	248	0	859
Barges 2045	29	525	0	11	39	174	0	778	5	570	6	26	0	247	0	853
Barges 2046	29	521	0	11	39	173	0	772	5	567	6	26	0	245	0	848
Barges 2047	30	554	0	11	41	184	0	820	5	602	6	27	0	260	0	900
Barges 2048	28	518	0	10	39	172	0	767	4	563	6	25	0	243	0	842
Barges 2049	28	514	0	10	39	170	0	762	4	559	6	25	0	242	0	836
Barges 2050	28	511	0	10	38	169	0	756	4	555	6	25	0	240	0	830
Barges 2051	28	507	0	10	38	168	0	751	4	551	6	25	0	238	0	824
Barges 2052	28	503	0	10	38	167	0	746	4	547	6	25	0	236	0	818
Barges 2053	27	500	0	10	37	166	0	740	4	543	6	24	0	235	0	812
Barges 2054	27	496	0	10	37	164	0	735	4	539	6	24	0	233	0	807
Barges 2055	27	493	0	10	37	163	0	730	4	535	6	24	0	231	0	801
Barges 2056	27	489	0	10	37	162	0	724	4	531	6	24	0	230	0	795
Barges 2057	27	485	0	10	36	161	0	719	4	527	6	24	0	228	0	789
Barges 2058	26	482	0	10	36	160	0	714	4	523	6	24	0	226	0	783
Barges 2059	26	482	0	10	36	160	0	714	4	523	6	24	0	226	0	783
Barges 2060	26	475	0	10	36	157	0	703	4	516	5	23	0	223	0	771
Barges 2061	26	471	0	10	35	156	0	698	4	512	5	23	0	221	0	766

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-4. Calcasieu Lock Loaded Barges, Aggregates, 2011-2061

Aggregates, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge						1		1						1173	1793	2966
Tanker Barge								0						1		1
Total Tons						1640		1640						1903997	1	1903998
Average tons/barge	0	0	0	0	0	1,640	0		0	0	0	0	0	1,622	0	
Tons Distribution	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	99.91%	0.00%	99.91%
Barges 2011	0	0	0	0	0	1	0	1	0	0	0	0	0	1,490	0	1,490
Barges 2012	0	0	0	0	0	1	0	1	0	0	0	0	0	1,510	0	1,510
Barges 2013	0	0	0	0	0	1	0	1	0	0	0	0	0	1,442	0	1,442
Barges 2014	0	0	0	0	0	1	0	1	0	0	0	0	0	1,498	0	1,498
Barges 2015	0	0	0	0	0	1	0	1	0	0	0	0	0	1,520	0	1,520
Barges 2016	0	0	0	0	0	1	0	1	0	0	0	0	0	1,544	0	1,544
Barges 2017	0	0	0	0	0	1	0	1	0	0	0	0	0	1,545	0	1,545
Barges 2018	0	0	0	0	0	1	0	1	0	0	0	0	0	1,551	0	1,551
Barges 2019	0	0	0	0	0	1	0	1	0	0	0	0	0	1,567	0	1,567
Barges 2020	0	0	0	0	0	1	0	1	0	0	0	0	0	1,582	0	1,582
Barges 2021	0	0	0	0	0	1	0	1	0	0	0	0	0	1,602	0	1,602
Barges 2022	0	0	0	0	0	1	0	1	0	0	0	0	0	1,636	0	1,636
Barges 2023	0	0	0	0	0	1	0	1	0	0	0	0	0	1,651	0	1,651
Barges 2024	0	0	0	0	0	1	0	1	0	0	0	0	0	1,668	0	1,668
Barges 2025	0	0	0	0	0	1	0	1	0	0	0	0	0	1,693	0	1,693
Barges 2026	0	0	0	0	0	1	0	1	0	0	0	0	0	1,716	0	1,716
Barges 2027	0	0	0	0	0	1	0	1	0	0	0	0	0	1,744	0	1,744
Barges 2028	0	0	0	0	0	2	0	2	0	0	0	0	0	1,768	0	1,768
Barges 2029	0	0	0	0	0	2	0	2	0	0	0	0	0	1,793	0	1,793
Barges 2030	0	0	0	0	0	2	0	2	0	0	0	0	0	1,820	0	1,820
Barges 2031	0	0	0	0	0	2	0	2	0	0	0	0	0	1,847	0	1,847
Barges 2032	0	0	0	0	0	2	0	2	0	0	0	0	0	1,880	0	1,880
Barges 2033	0	0	0	0	0	2	0	2	0	0	0	0	0	1,916	0	1,916
Barges 2034	0	0	0	0	0	2	0	2	0	0	0	0	0	1,945	0	1,945
Barges 2035	0	0	0	0	0	2	0	2	0	0	0	0	0	1,976	0	1,976
Barges 2036	0	0	0	0	0	2	0	2	0	0	0	0	0	1,989	0	1,989
Barges 2037	0	0	0	0	0	2	0	2	0	0	0	0	0	2,016	0	2,016
Barges 2038	0	0	0	0	0	2	0	2	0	0	0	0	0	2,042	0	2,042
Barges 2039	0	0	0	0	0	2	0	2	0	0	0	0	0	2,069	0	2,069
Barges 2040	0	0	0	0	0	2	0	2	0	0	0	0	0	2,096	0	2,096
Barges 2041	0	0	0	0	0	2	0	2	0	0	0	0	0	2,122	0	2,122
Barges 2042	0	0	0	0	0	2	0	2	0	0	0	0	0	2,149	0	2,149
Barges 2043	0	0	0	0	0	2	0	2	0	0	0	0	0	2,176	0	2,176
Barges 2044	0	0	0	0	0	2	0	2	0	0	0	0	0	2,202	0	2,202
Barges 2045	0	0	0	0	0	2	0	2	0	0	0	0	0	2,229	0	2,229
Barges 2046	0	0	0	0	0	2	0	2	0	0	0	0	0	2,255	0	2,255
Barges 2047	0	0	0	0	0	2	0	2	0	0	0	0	0	2,282	0	2,282
Barges 2048	0	0	0	0	0	2	0	2	0	0	0	0	0	2,309	0	2,309
Barges 2049	0	0	0	0	0	2	0	2	0	0	0	0	0	2,335	0	2,335
Barges 2050	0	0	0	0	0	2	0	2	0	0	0	0	0	2,362	0	2,362
Barges 2051	0	0	0	0	0	2	0	2	0	0	0	0	0	2,389	0	2,389
Barges 2052	0	0	0	0	0	2	0	2	0	0	0	0	0	2,415	0	2,415
Barges 2053	0	0	0	0	0	2	0	2	0	0	0	0	0	2,442	0	2,442
Barges 2054	0	0	0	0	0	2	0	2	0	0	0	0	0	2,468	0	2,468
Barges 2055	0	0	0	0	0	2	0	2	0	0	0	0	0	2,495	0	2,495
Barges 2056	0	0	0	0	0	2	0	2	0	0	0	0	0	2,522	0	2,522
Barges 2057	0	0	0	0	0	2	0	2	0	0	0	0	0	2,548	0	2,548
Barges 2058	0	0	0	0	0	2	0	2	0	0	0	0	0	2,575	0	2,575
Barges 2059	0	0	0	0	0	2	0	2	0	0	0	0	0	2,602	0	2,602
Barges 2060	0	0	0	0	0	2	0	2	0	0	0	0	0	2,628	0	2,628
Barges 2061	0	0	0	0	0	2	0	2	0	0	0	0	0	2,655	0	2,655

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-5. Calcasieu Lock Loaded Barges, Iron and Steel, 2011-2061

Iron and Steel, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge			1			911	2	914						1143		1143
Tanker Barge						5		5						33		33
Total Tons			1,671			1,396,733	2,650	1,401,054						1,723,936		1,723,936
Average tons/barge	0	0	1,671	0	0	1,525	1,325		0	0	0	0	0	1,466	0	
Tons Distribution	0.00%	0.00%	0.05%	0.00%	0.00%	44.70%	0.08%	44.83%	0.00%	0.00%	0.00%	0.00%	0.00%	55.17%	0.00%	55.17%
Barges 2011	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2012	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2013	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2014	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2015	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2016	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2017	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2018	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2019	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2020	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2021	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2022	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2023	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2024	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2025	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2026	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2027	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2028	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2029	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2030	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2031	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2032	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2033	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2034	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2035	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2036	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2037	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2038	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2039	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2040	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2041	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2042	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2043	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2044	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2045	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2046	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2047	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2048	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2049	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2050	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2051	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2052	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2053	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2054	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2055	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2056	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2057	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2058	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2059	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2060	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910
Barges 2061	0	0	1	0	0	709	2	711	0	0	0	0	0	910	0	910

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-6. Calcasieu Lock Loaded Barges, Nonmetallic Minerals, 2011-2061

Nonmetallic Minerals, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge						401	62	463						82	85	167
Tanker Barge						29	3	32						4	20	24
Total Tons						689,927	34,943	724,870						119,558	57,145	176,703
Average Tons/Barge	0	0	0	0	0	1,604	538		0	0	0	0	0	1,390	544	
Tons Distribution	0.00%	0.00%	0.00%	0.00%	0.00%	76.52%	3.88%	80.40%	0.00%	0.00%	0.00%	0.00%	0.00%	13.26%	6.34%	19.60%
Barges 2011	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2012	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2013	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2014	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2015	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2016	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2017	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2018	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2019	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2020	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2021	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2022	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2023	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2024	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2025	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2026	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2027	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2028	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2029	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2030	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2031	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2032	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2033	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2034	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2035	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2036	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2037	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2038	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2039	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2040	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2041	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2042	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2043	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2044	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2045	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2046	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2047	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2048	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2049	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2050	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2051	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2052	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2053	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2054	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2055	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2056	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2057	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2058	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2059	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2060	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258
Barges 2061	0	0	0	0	0	581	88	669	0	0	0	0	0	116	142	258

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-7. Calcasieu Lock Loaded Barges, Coal, 2011-2061

Coal, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge						62	2	64						178		178
Tanker Barge						1		1								0
Total Tons						101,641	3,193	104,834						293,910		293,910
Average Tons/Barge	0	0	0	0	0	1,613	1,597		0	0	0	0	0	1,651	0	
Tons Distribution	0.00%	0.00%	0.00%	0.00%	0.00%	25.49%	0.80%	26.29%	0.00%	0.00%	0.00%	0.00%	0.00%	73.71%	0.00%	73.71%
Barges 2011	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2012	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2013	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2014	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2015	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2016	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2017	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2018	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2019	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2020	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2021	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2022	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2023	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2024	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2025	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2026	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2027	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2028	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2029	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2030	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2031	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2032	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2033	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2034	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2035	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2036	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2037	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2038	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2039	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2040	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2041	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2042	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2043	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2044	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2045	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2046	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2047	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2048	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2049	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2050	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2051	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2052	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2053	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2054	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2055	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2056	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2057	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2058	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2059	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2060	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120
Barges 2061	0	0	0	0	0	42	1	44	0	0	0	0	0	120	0	120

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-8. Calcasieu Lock Loaded Barges, Grain, 2011-2061

Grain, 2008																
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo								0								0
Self-Propelled Tanker								0								0
Tow								0								0
Dry Cargo Barge						10		10						80		80
Tanker Barge								0						2		2
Total Tons						16,250		16,250						136,059		136,059
Average Tons/Barge	0	0	0	0	0	1,625	0		0	0	0	0	0	1,659	0	
Tons Distribution	0.00%	0.00%	0.00%	0.00%	0.00%	10.67%	0.00%	10.67%	0.00%	0.00%	0.00%	0.00%	0.00%	89.33%	0.00%	89.33%
Barges 2011	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2012	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2013	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2014	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2015	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2016	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2017	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2018	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2019	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2020	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2021	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2022	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2023	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2024	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2025	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2026	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2027	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2028	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2029	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2030	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2031	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2032	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2033	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2034	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2035	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2036	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2037	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2038	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2039	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2040	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2041	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2042	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2043	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2044	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2045	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2046	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2047	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2048	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2049	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2050	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2051	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2052	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2053	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2054	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2055	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2056	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2057	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2058	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2059	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2060	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152
Barges 2061	0	0	0	0	0	19	0	19	0	0	0	0	0	152	0	152

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-9. Calcasieu Lock Loaded Barges, Other Commodities, 2011-2061

	Other Commodities, 2008															
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Self-Propelled Dry Cargo			5	1		4	104	114			1	2		5	171	179
Self-Propelled Tanker								0								0
Tow							18	18							12	12
Dry Cargo Barge		1				252		253					1	912	19	932
Tanker Barge		1				11		12		2				263	15	280
Total Tons		3,750	1,179	2,052		354,704	4,803	366,488		2,884	1,145	1,160	500	1,805,265	26,304	1,837,258
Average Tons/Barge	0	1,875	0	0	0	1,349	0		0	1,442	0	0	500	1,536	774	
Tons Distribution	0.00%	0.17%	0.05%	0.09%	0.00%	16.10%	0.22%	16.63%	0.00%	0.13%	0.05%	0.05%	0.02%	81.92%	1.19%	83.37%
Barges 2011	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2012	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2013	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2014	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2015	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2016	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2017	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2018	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2019	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2020	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2021	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2022	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2023	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2024	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2025	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2026	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2027	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2028	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2029	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2030	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2031	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2032	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2033	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2034	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2035	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2036	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2037	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2038	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2039	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2040	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2041	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2042	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2043	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2044	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2045	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2046	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2047	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2048	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2049	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2050	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2051	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2052	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2053	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2054	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2055	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2056	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2057	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2058	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2059	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2060	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100
Barges 2061	0	2	0	0	0	239	0	240	0	2	0	0	1	1,066	31	1,100

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-10. Calcasieu Lock Loaded Barges, All Commodities, 2011-2061

	All Commodities, 2008															
	Upbound								Downbound							
	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total	>300 & >50	290-300 & >50	250-289.99 & >50	190-249.99 & >50	<190 & >50	180-200 & <50	Others	Total
Barges 2011	287	2,722	157	271	328	3,731	162	7,657	352	2,847	67	280	154	5,775	173	9,648
Barges 2012	285	2,720	154	264	319	3,661	162	7,564	349	2,876	65	269	149	5,765	173	9,644
Barges 2013	281	2,699	151	261	318	3,652	161	7,524	343	2,845	65	269	147	5,684	173	9,525
Barges 2014	289	2,773	156	270	328	3,723	162	7,702	353	2,916	67	278	152	5,797	173	9,735
Barges 2015	294	2,820	158	275	334	3,762	163	7,807	357	2,962	68	284	155	5,853	173	9,852
Barges 2016	297	2,861	160	279	341	3,803	163	7,905	360	2,997	70	290	157	5,908	173	9,954
Barges 2017	300	2,883	162	284	347	3,848	164	7,988	363	3,006	71	297	160	5,936	173	10,006
Barges 2018	302	2,904	164	288	353	3,889	164	8,064	365	3,015	72	303	162	5,966	173	10,057
Barges 2019	305	2,939	167	293	359	3,934	164	8,161	369	3,041	74	310	165	6,013	173	10,144
Barges 2020	308	2,963	169	298	365	3,976	164	8,243	372	3,054	75	317	167	6,055	173	10,213
Barges 2021	310	2,975	170	302	370	4,010	164	8,301	374	3,056	77	322	170	6,094	173	10,265
Barges 2022	311	2,985	172	305	373	4,037	165	8,348	377	3,058	78	326	172	6,143	173	10,326
Barges 2023	313	2,994	173	307	375	4,049	165	8,375	378	3,066	78	328	173	6,166	173	10,361
Barges 2024	314	3,004	174	309	377	4,067	165	8,411	380	3,072	79	330	174	6,195	173	10,402
Barges 2025	315	3,013	175	311	380	4,087	166	8,447	382	3,076	79	333	175	6,232	173	10,450
Barges 2026	316	3,015	176	312	381	4,091	166	8,455	383	3,078	79	334	176	6,258	173	10,480
Barges 2027	316	3,019	176	312	381	4,097	166	8,467	383	3,081	80	335	176	6,289	173	10,516
Barges 2028	317	3,025	177	314	383	4,110	166	8,491	384	3,083	80	337	177	6,321	173	10,554
Barges 2029	317	3,021	177	314	383	4,111	166	8,489	384	3,077	80	337	177	6,345	173	10,573
Barges 2030	317	3,023	177	314	383	4,107	166	8,486	384	3,081	80	336	177	6,371	173	10,603
Barges 2031	316	3,011	176	313	382	4,100	166	8,463	384	3,069	80	335	176	6,391	173	10,607
Barges 2032	315	3,003	176	312	381	4,096	166	8,448	383	3,061	80	335	176	6,419	173	10,625
Barges 2033	317	3,017	177	313	382	4,100	166	8,471	385	3,079	80	335	176	6,462	173	10,690
Barges 2034	317	3,015	177	313	381	4,099	166	8,468	386	3,078	80	334	177	6,491	173	10,719
Barges 2035	318	3,020	177	314	381	4,100	167	8,477	387	3,086	80	334	177	6,525	173	10,762
Barges 2036	318	3,018	177	314	381	4,100	167	8,474	387	3,083	80	334	177	6,537	173	10,771
Barges 2037	317	3,014	177	314	381	4,099	167	8,469	387	3,080	80	334	177	6,562	173	10,792
Barges 2038	317	3,011	177	314	381	4,097	167	8,464	387	3,076	79	334	177	6,587	173	10,813
Barges 2039	317	3,007	177	313	381	4,096	167	8,458	387	3,072	79	334	177	6,612	173	10,833
Barges 2040	317	3,003	177	313	380	4,095	167	8,453	387	3,068	79	334	177	6,637	173	10,854
Barges 2041	317	3,000	177	313	380	4,094	167	8,448	387	3,064	79	333	177	6,662	173	10,875
Barges 2042	316	2,996	177	313	380	4,093	167	8,442	387	3,060	79	333	177	6,687	173	10,896
Barges 2043	316	2,992	177	313	379	4,092	167	8,437	387	3,056	79	333	177	6,711	173	10,917
Barges 2044	316	2,989	177	313	379	4,090	167	8,432	387	3,052	79	333	177	6,736	173	10,937
Barges 2045	316	2,985	177	313	379	4,089	167	8,426	387	3,048	79	333	177	6,761	173	10,958
Barges 2046	316	2,982	177	313	379	4,088	167	8,421	387	3,044	79	333	177	6,786	173	10,979
Barges 2047	317	3,014	177	314	381	4,099	167	8,469	387	3,080	80	334	177	6,828	173	11,058
Barges 2048	315	2,978	177	313	378	4,087	167	8,416	387	3,040	79	332	177	6,838	173	11,026
Barges 2049	315	2,974	177	313	378	4,086	167	8,411	387	3,037	79	332	177	6,863	173	11,047
Barges 2050	315	2,971	177	313	378	4,085	167	8,405	387	3,033	79	332	177	6,888	173	11,068
Barges 2051	315	2,967	177	313	378	4,083	167	8,400	387	3,029	79	332	177	6,913	173	11,089
Barges 2052	315	2,964	177	313	377	4,082	167	8,395	387	3,025	79	332	177	6,938	173	11,109
Barges 2053	314	2,960	177	313	377	4,081	167	8,389	387	3,021	79	331	177	6,963	173	11,130
Barges 2054	314	2,956	177	312	377	4,080	167	8,384	387	3,017	79	331	177	6,987	173	11,151
Barges 2055	314	2,953	177	312	376	4,079	167	8,379	387	3,013	79	331	177	7,012	173	11,172
Barges 2056	314	2,949	177	312	376	4,078	167	8,373	387	3,009	79	331	177	7,037	173	11,192
Barges 2057	314	2,946	177	312	376	4,076	167	8,368	387	3,005	79	331	177	7,062	173	11,213
Barges 2058	313	2,942	177	312	376	4,075	167	8,363	386	3,001	79	331	177	7,087	173	11,234
Barges 2059	313	2,942	177	312	376	4,075	167	8,363	386	3,001	79	331	177	7,114	173	11,261
Barges 2060	313	2,935	177	312	375	4,073	167	8,352	386	2,993	79	330	177	7,137	173	11,276
Barges 2061	313	2,931	177	312	375	4,072	167	8,347	386	2,990	79	330	177	7,162	173	11,296

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-11. Calcasieu Lock Statistics, 1993-2011

	CY2011	CY2010	CY2009	CY2008	CY2007	CY2006	CY2005	CY2004	CY2003	CY2002	CY2001	CY2000	CY1999	CY1998	CY1997	CY1996	CY1995	CY1994	CY1993
Barges Empty (#)	11,453	11,330	10,903	12,634	14,494	13,595	13,772	14,229	14,338	14,704	14,859	15,637	14,774	13,789	14,646	14,928	14,680	14,981	14,771
Barges Loaded (#)	17,837	17,785	15,708	19,786	21,763	21,854	22,177	23,541	21,514	20,790	21,495	22,655	21,914	21,123	22,501	22,031	22,492	22,863	22,770
Total Barges	29,290	29,115	26,611	32,420	36,257	35,449	35,949	37,770	35,852	35,494	36,354	38,292	36,688	34,912	37,147	36,959	37,172	37,844	37,541
Percent Empty Barges	39.10%	38.91%	40.97%	38.97%	39.98%	38.35%	38.31%	37.67%	39.99%	41.43%	40.87%	40.84%	40.27%	39.50%	39.43%	40.39%	39.49%	39.59%	39.35%
Percent Load Barges	60.90%	61.09%	59.03%	61.03%	60.02%	61.65%	61.69%	62.33%	60.01%	58.57%	59.13%	59.16%	59.73%	60.50%	60.57%	59.61%	60.51%	60.41%	60.65%
Barges Per Lockage	2.71	2.68	2.46	2.78	2.90	3.04	3.08	2.91	2.87	2.75	2.69	3.14	3.12	2.99	3.14	3.13	3.10	3.11	2.98
Commercial Lockages (#)	10,814	10,851	10,811	11,678	12,524	11,662	11,657	12,988	12,508	12,896	13,534	12,189	11,756	11,694	11,823	11,799	12,006	12,169	12,604
Commercial Vessels (#)	13,355	13,101	12,710	13,961	15,060	14,284	14,202	15,027	15,491	14,949	15,952	15,006	14,725	14,084	14,635	14,937	15,113	15,061	14,826

Sources: Waterborne Commerce Statistics and G.E.C., Inc.

Table 4-12. Calcasieu Lock Barges and Lockages, 2011-2061

	Loaded Barges	Empty Barges	Total Barges	Total Commercial Lockages
Barges 2011	17,305	11,536	28,841	11,536
Barges 2012	17,208	11,472	28,680	11,472
Barges 2013	17,049	11,366	28,415	11,366
Barges 2014	17,437	11,625	29,062	11,625
Barges 2015	17,658	11,772	29,430	11,772
Barges 2016	17,860	11,907	29,766	11,907
Barges 2017	17,994	11,996	29,991	11,996
Barges 2018	18,121	12,081	30,202	12,081
Barges 2019	18,305	12,203	30,508	12,203
Barges 2020	18,456	12,304	30,759	12,304
Barges 2021	18,566	12,378	30,944	12,378
Barges 2022	18,674	12,449	31,123	12,449
Barges 2023	18,736	12,491	31,227	12,491
Barges 2024	18,813	12,542	31,355	12,542
Barges 2025	18,897	12,598	31,494	12,598
Barges 2026	18,935	12,624	31,559	12,624
Barges 2027	18,983	12,656	31,639	12,656
Barges 2028	19,045	12,697	31,742	12,697
Barges 2029	19,062	12,708	31,770	12,708
Barges 2030	19,089	12,726	31,814	12,726
Barges 2031	19,071	12,714	31,785	12,714
Barges 2032	19,074	12,716	31,790	12,716
Barges 2033	19,161	12,774	31,935	12,774
Barges 2034	19,187	12,791	31,978	12,791
Barges 2035	19,239	12,826	32,065	12,826
Barges 2036	19,245	12,830	32,076	12,830
Barges 2037	19,261	12,841	32,101	12,841
Barges 2038	19,276	12,851	32,127	12,851
Barges 2039	19,292	12,861	32,153	12,861
Barges 2040	19,307	12,871	32,179	12,871
Barges 2041	19,323	12,882	32,204	12,882
Barges 2042	19,338	12,892	32,230	12,892
Barges 2043	19,354	12,902	32,256	12,902
Barges 2044	19,369	12,913	32,282	12,913
Barges 2045	19,385	12,923	32,308	12,923
Barges 2046	19,400	12,933	32,333	12,933
Barges 2047	19,527	13,018	32,546	13,018
Barges 2048	19,442	12,961	32,403	12,961
Barges 2049	19,458	12,972	32,429	12,972
Barges 2050	19,473	12,982	32,455	12,982
Barges 2051	19,488	12,992	32,481	12,992
Barges 2052	19,504	13,003	32,507	13,003
Barges 2053	19,519	13,013	32,532	13,013
Barges 2054	19,535	13,023	32,558	13,023
Barges 2055	19,550	13,034	32,584	13,034
Barges 2056	19,566	13,044	32,610	13,044
Barges 2057	19,581	13,054	32,635	13,054
Barges 2058	19,597	13,064	32,661	13,064
Barges 2059	19,623	13,082	32,706	13,082
Barges 2060	19,628	13,085	32,713	13,085
Barges 2061	19,643	13,095	32,738	13,095

Source: G.E.C., Inc.

Figure 4-1. Calcasieu Lock Total Annual Number of Forecasted Loaded Barges, 2009-2060

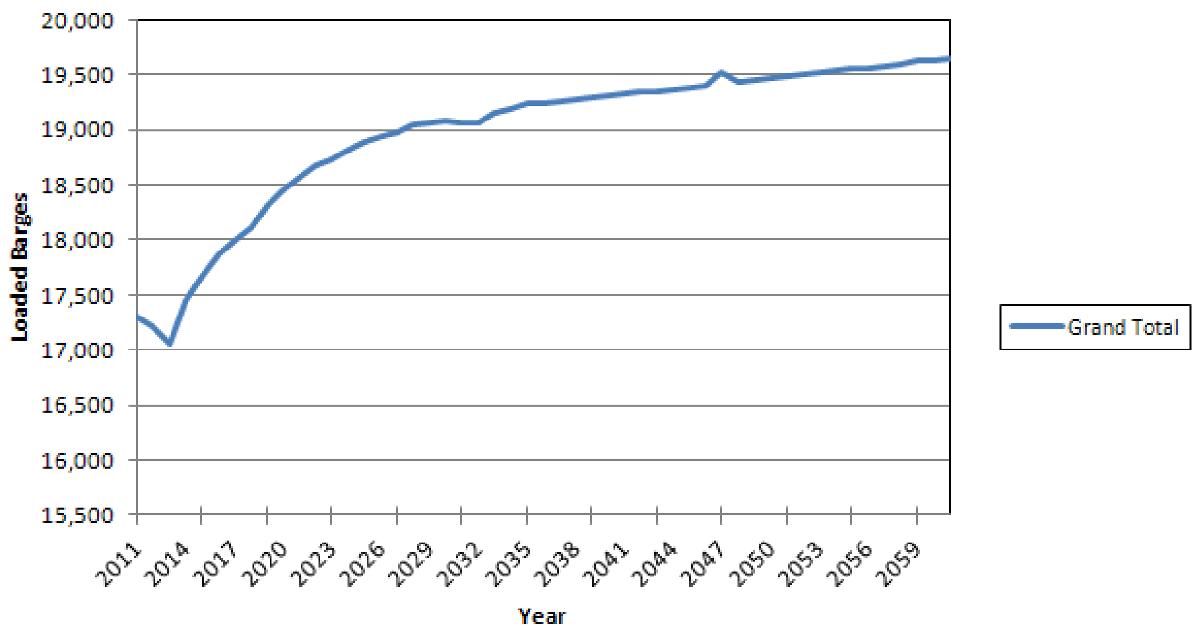
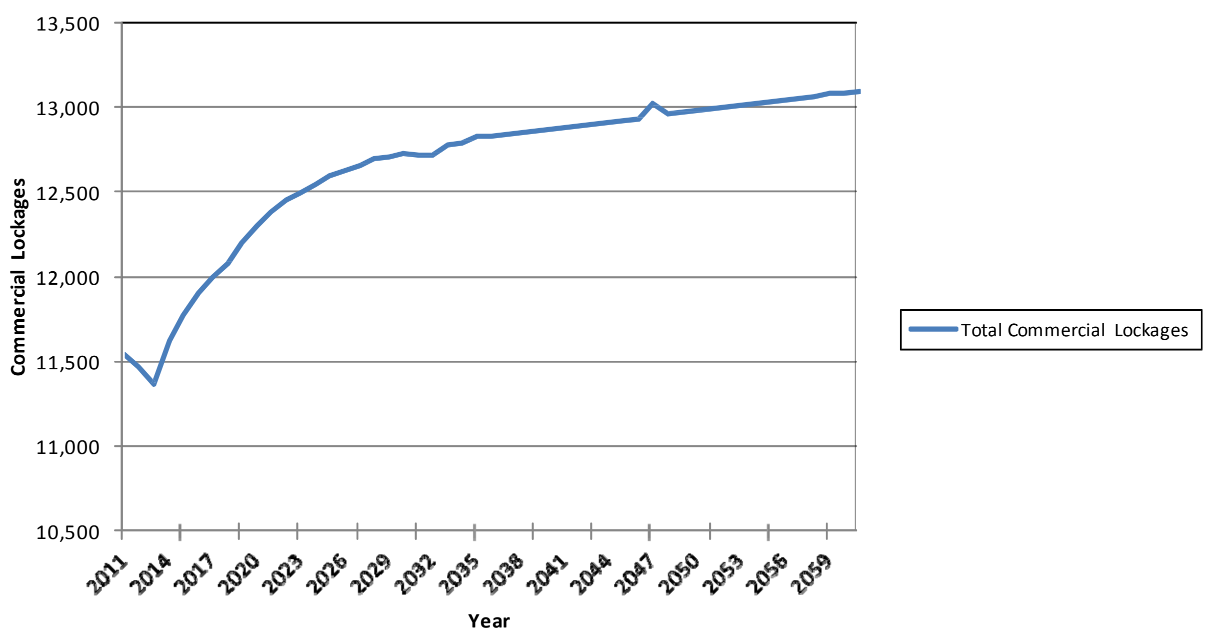


Figure 4-2. Calcasieu Lock Total Annual Number of Forecasted Commercial Lockages, 2009-2060



Section 5:
TABLES

Table 5-1. Petroleum Products

WCSCCommodity Name	EIA Forecast Category	WCSC Code	LRH_Name
Fuel Oils, NEC/Residual Fuel Oil	Residual Fuel Oil	33440	Petroleum Products
Other Light Oils from Petroleum & Bitum Minerals/Fuel Oils, excluding Redsidual	Other Petroleum	33419	Petroleum Products
Gas Oils/Distillate Diesel Oil	Distillate Fuel Oil	33430	Petroleum Products
Other Medium Oils from Petroleum & Bitum Minerals/Napthas & Solvents	Petrochemical Feedstocks	33429	Petroleum Products
Gasoline Including Aviation (Except Jet)/Motor and Aviation Gasoline	Motor Gasoline	33411	Petroleum Products
Lubricating Petroleum Oils from Petrol & Bitum Min/Lubricants	Other Petroleum	33450	Petroleum Products
Petro, Bitumen, Pet. Coke, Asphalt, Bitumen Mixes NEC/Petroleum Coke	Other Petroleum	33540	Petroleum Products
Hydrocarbon & Petrol Gases, Liquefied and Gaseous/Liquified Refinery Gases	Liquified Petroleum Gases	34000	Petroleum Products
Pitch & Pitch Coke from Coal Tar/Oth Mineral Tars/Other	Other Petroleum	33530	Petroleum Products
Petroleum Products, Not Elsewhere Classified/Other	Other Petroleum	33590	Petroleum Products
Tar Distilled from Coal, Lignite or Peat; Other Tars/Other	Other Petroleum	33521	Petroleum Products
Jet Fuel (Gasoline Type)/Miscellaneous Products	Kerosene/Jet Fuel	33412	Petroleum Products
Petroleum Jelly; Waxes Obtained by Synthesis/Other/Other	Other Petroleum	33510	Petroleum Products
Kerosene (Including Kerosene Type Jet Fuel)/Kerosene	Kerosene/Jet Fuel	33421	Petroleum Products
Oils & Other Prods, NEC of Distillation of Coal Tar/Other	Other Petroleum	33525	Petroleum Products

Table 5-2. Chemicals

WCSC Commodity Name	WCSC	LRH_Name
Acetic Acid and Its Salts	51371	**Bulk Model**
Acrylonitrile	51483	**Bulk Model**
Butylenes, Butadienes, Methylbutadienes	51113	**Bulk Model**
Chlorine	52224	**Bulk Model**
Ethylene Glycol (Ethane doil)	51221	**Bulk Model**
Styrene	51125	**Bulk Model**
Sulfuric Acid; Oleum	52232	**Bulk Model**
Acyclic Ketones without Other Oxygen Function, NEC	51625	Chemicals
Acyclic Polyamides and Their Derivatives; Salts of	51452	Chemicals
Alcohols, NEC	51299	Chemicals
Aluminum Hydroxide	52266	Chemicals
Aromatic Monoamines and Derivatives; Salts Thereof	51454	Chemicals
Butanone (Ethyl Methyl Ketone)	51624	Chemicals
Chemical Waste	59990	Chemicals
Epoxides, Epoxyalcohols, Epoxyphenols & Deriv, NEC	51615	Chemicals
Halogenated Derivatives of Hydrocarbons, NEC	51139	Chemicals
Hydrogen Chloride; Chlorosulfuric Acid	52231	Chemicals
Methacrylic Acid and Its Salts and Esters	51373	Chemicals
Other Monohydric Alcohols, NEC	51219	Chemicals
Other Organic Compounds, NEC	51699	Chemicals
Phthalic Anhydride	51382	Chemicals
Saturated Chlor Deriv of Acyclic Hydrocrabons, NEC	51136	Chemicals
Sodium Sulfide	52341	Chemicals
Sulfur, Sublimed or Precipitated; Colloidal Sulfur	52226	Chemicals
Tetrechloroethylene (Perechoroethylene)	51133	Chemicals
Trichloroethylene	51132	Chemicals
Unsaturated Acyclic Monocarboxylic Acids, NEC; Deriv	51379	Chemicals
Ammonium Nitrate Fertilizers	56211	Fertilizers
Ammonium Sulfate Fertilizers	56213	Fertilizers
Diammonium Phosphate (DAP)	56293	Fertilizers
Fertilizers, NEC	56299	Fertilizers
Mineral or Chemical Fertilizers, Nitrogenous, NEC	56239	Fertilizers
Mineral or Chemical Fertilizers, Potassic, NEC	51229	Fertilizers
Superphosphate Fertilizers	56222	Fertilizers
Urea Fertilizers	56216	Fertilizers
1,2-Dichloroethane (Ethylene Dichloride)	51135	*Other Bulk*
Acetone	51623	*Other Bulk*
Acyclic Hydrocarbons, NEC	51119	*Other Bulk*
Antiknock Preparations	59721	*Other Bulk*
Benzene, Pure	51122	*Other Bulk*
Butanols	51213	*Other Bulk*
Calcium Chloride	52322	*Other Bulk*
Cumene	51127	*Other Bulk*
Cyclic Hydrocarbons, NEC	51129	*Other Bulk*
Cyclohexane	51121	*Other Bulk*
Esters of Acetic Acid	51372	*Other Bulk*
Ethyl Alcohol (Not Denatured) 80% or More Alcohol	51215	*Other Bulk*
Methanol (Methyl Alcohol)	51211	*Other Bulk*
Other Acyclic Alcohols, NEC	51219	*Other Bulk*
Other Phenols and Phenol-Alcohols, NEC	51243	*Other Bulk*
Potassium Hydroxide; Peroxides of Sodium,	52264	*Other Bulk*
Propan-1-ol(propyl), Propan-2-ol(isopropyl alcohol)	51212	*Other Bulk*
Propene	51112	*Other Bulk*
Sodium Hydroxide Aqueous Soln(Soda Lye, Liq	52263	*Other Bulk*
Toluene, Pure	51123	*Other Bulk*

Table 5-2 (cont'd). Chemicals

WCSC Commodity Name	Code	LRH_Name
Xylenes, Pure	51124	*Other Bulk*
Acetals, Hemiacetals & Their Halogenated,Etc Deriv	51612	Chemicals (Others)
Activated Carbon	59864	Chemicals (Others)
Acyclic Amides(Inc Carbamates) & Derivatives;Salts	51471	Chemicals (Others)
Acyclic Monoamides and Their Derivatives; Salts of	51451	Chemicals (Others)
Acyclic,Cyclanic,Cyclenic,Cycloterpenic Ethers;Der	51616	Chemicals (Others)
Amino-Alcohols,Ethers & Esters; Salts Thereof	51461	Chemicals (Others)
Ammonia, Anhydrous, or in Aqueous Solution	52261	Chemicals (Others)
Antifreezing Preparations and Prep De-icing Fluids	59733	Chemicals (Others)
Basic Slag Fertilizers (Thomas Slag)	56221	Chemicals (Others)
Benzene, Pure	51122	Chemicals (Others)
Carbides(Exc Calcium Carbide) Chem Defined or Not	52494	Chemicals (Others)
Carbon (Including Carbon Black), NEC	52210	Chemicals (Others)
Carboxyimide-Function & Amine-Function Compounds	51482	Chemicals (Others)
Chemical Products and Preparations, NEC	59890	Chemicals (Others)
Chlorides,Bromides,Iodides,; Oxides & Hydroxides	52329	Chemicals (Others)
Chromium Oxides and Hydroxides	52252	Chemicals (Others)
Cyanides, Cyanide Oxides and Complex Cyanides	52381	Chemicals (Others)
Ether-Alcohols,Ether-Phenols,Ether-Alcohol-Phenols	51617	Chemicals (Others)
Ethyl Alcohol & Other Spirits,Denatured Any Streng	51216	Chemicals (Others)
Ethylene	51111	Chemicals (Others)
Ethylbenzene	51126	Chemicals (Others)
Fatty Alcohols, Industrial	51217	Chemicals (Others)
Fertilizers, Urea & Ammonium Nitrate Mixes,Etc	56217	Chemicals (Others)
Fertilizers-Phosphorus,Potassium (Mix)	56292	Chemicals (Others)
Fertilizers-Nitrogen,Phosphorus,Potassium (Mix)	56291	Chemicals (Others)
Flourides;Fluorosilicates,Fluoroaluminates, Etc.	52310	Chemicals (Others)
Fluorinated,Etc Derivatives of Acyclic Hydrocarbns	51137	Chemicals (Others)
Glycerol(Glycerine),Glycerol Waters & Glycerol Lye	51222	Chemicals (Others)
Halogenated Derivatives of Hydrocarbons, NEC	51139	Chemicals (Others)
Heterocyclic Compounds w/Oxygen Hetero-	51569	Chemicals (Others)
Hydrogen, Rare Gases, Nitrogen and Oxygen	52221	Chemicals (Others)
Insecticides,In Forms, Packed for Retail Sale,Etc	59110	Chemicals (Others)
Iron Oxides & Hydroxides;Earth Colors >= 70% FE203	52254	Chemicals (Others)
Manganese Oxides	52253	Chemicals (Others)
Mannitol	51224	Chemicals (Others)
Methyloxirane (Propylene Oxide)	51614	Chemicals (Others)
Mineral or Chemical Fertilizers, Phosphatic, NEC	56229	Chemicals (Others)
Mixed Alkybenzenes, Not Elsewhere Classified	59840	Chemicals (Others)
Monoammonium Phosphate(MAP) & DAP/MAP mix	56294	Chemicals (Others)
Nitrile-Function Compounds, NEC	51484	Chemicals (Others)
Oleic, Linoleic or Linolenic Acids, Salts & Esters	51378	Chemicals (Others)
Oth Inorganic Bases,Metal Oxides, Hydroxides, Peroxi	52269	Chemicals (Others)
Other Phosphates	52363	Chemicals (Others)
Other Sulfates; ALUMS	52349	Chemicals (Others)
Plastics in Primary Forms	57000	Chemicals (Others)
Polycarboxylic Acids,NEC; Anhydrides, Halides, Etc.	51389	Chemicals (Others)
Potassium Chloride Fertilizers	56231	Chemicals (Others)
Prods to Treat Textiles, Leather, Fur, w/Petrolm Oils	59771	Chemicals (Others)
Salts of Oxometallic or Peroxometallic Acids	52431	Chemicals (Others)
Saturated Acyclic Hydrocarbons	51114	Chemicals (Others)
Saturated Acyclic Monocarboxylic Acids, NEC & Deriv	51377	Chemicals (Others)
Selenium, Tellurium, Phosphorus, Arsenic and Boron	52222	Chemicals (Others)
Sodium Hydroxide (Caustic Soda), Solid	52262	Chemicals (Others)
Sulphonated,Nitrated,Nitrosated Hydrocarbon Deriv	51140	Chemicals (Others)
Ureines and Their Derivatives; Salts Thereof	51473	Chemicals (Others)
Vinyl Chloride (Chloroethylene)	51131	Chemicals (Others)
Wood and Resin Based Chemical Products	59810	Chemicals (Others)

Table 5-3. Crude Petroleum

WCSCCommodity Name	WCSC Code	LRH_Name
Petroleum Oils/Oils from Bituminous Minerals, Crude	33300	Crude Petroleum

Table 5-4. Aggregates

WCSC Commodity Name	WCSC Code	LRH_Name
Gypsum and Anhydrite	27323	Aggregates
Limestone Flux & Calcareous Stone Used in Lime	27322	Aggregates
Materials Used in Waterway Improvement, Govt	27350	Aggregates
Pebbles, Gravel, Crushed Stone (Specialized Use)	27340	Aggregates
Sands, Natural, of all Kinds (Exc Silica & Quartz)	27330	Aggregates

Table 5-5. Other Dry Bulk

WCSCCommodity Name	WCSC Code	LRH_Name
Coal, Whether or Not Pulverized,but Not Agglomerate	32100	Coal
Coke, Semi-Coke of Coal, of Lignite or of Peat	32500	Coal
Briquettes, Ovoids & Similar Solid Fuels from Coal	32210	Coal
Rice	4200	Grains & Grain Products
Maize (Not Including Sweet Corn), Unmilled	4400	Grains & Grain Products
Flours, Meals & Pellets (Meat, Offal, Fish, Etc.) Inedibl	8140	Grains & Grain Products
Soya Beans	22220	Grains & Grain Products
Grain Sorghum, Unmilled	4530	Grains & Grain Products
Wheat (Including Spelt) and Meslin, Unmilled	4100	Grains & Grain Products
Food Wastes and Prepared Animal Feeds, NEC	8190	Grains & Grain Products
Bran, Sharps & Oth Residues From Cereals or Legumes	8120	Grains & Grain Products
Cereal Preps & Preps of Flour/Starch of Fruit/Vegs	4800	Grains & Grain Products
Ferrous Waste & Scrap; Remelting Ingots of Iron/Stl	28200	Iron Ore & Iron & Steel Products
Flat-Rolled Products of Iron & Steel, Not Clad, Pltd	67300	Iron Ore & Iron & Steel Products
Tubes, Pipes, Hollow Profiles of Iron or Steel	67900	Iron Ore & Iron & Steel Products
Wire of Iron or Steel	67800	Iron Ore & Iron & Steel Products
Pig Iron & Spiegeleisen, in Pigs, Blocks, Other Form	67120	Iron Ore & Iron & Steel Products
Other Ferro-Alloys (Exc Radioactive Ferro-Alloys)	67150	Iron Ore & Iron & Steel Products
Iron and Steel Bars, Rods, Angles, Shapes & Sections	67600	Iron Ore & Iron & Steel Products
Flat-Rolled Prods of Iron/Non-Alloy Steel, Clad, Plt	67400	Iron Ore & Iron & Steel Products
Iron Ore and Concentrates	28100	Iron Ore & Iron & Steel Products
Ingots and Other Primary Forms of Iron or Steel	67200	Iron Ore & Iron & Steel Products
Ferro-Manganese	67140	Iron Ore & Iron & Steel Products
Rails/Railway Track Const Material, of Iron/Steel	67700	Iron Ore & Iron & Steel Products
Aluminum Ores & Concentrates (Including Alumina)	28500	Non-Metallic Ores & Minerals
Barium Sulphate, Barytes, Barium Carbonate	27892	Non-Metallic Ores & Minerals
Manganese Ores and Concentrates	28770	Non-Metallic Ores & Minerals
Clays and Other Refractory Minerals, NEC	27820	Non-Metallic Ores & Minerals
Quartz, Mica, Felspar, Fluorspar, Cryolite & Chiolite	27850	Non-Metallic Ores & Minerals
Vermiculite, Perlite, Chlorites	27898	Non-Metallic Ores & Minerals
Non-Ferrous Base Metal Waste and Scrap, NEC	28800	Non-Metallic Ores & Minerals
Ores & Concentrates of Molybdeum, Niobium, Tantalum	28780	Non-Metallic Ores & Minerals
Chalk	27891	Non-Metallic Ores & Minerals
Zinc Ores and Concentrates	28750	Non-Metallic Ores & Minerals
Mineral Substances, NEC	27899	Non-Metallic Ores & Minerals
Portland, Aluminous, Slag, or Supersulfate Cement	66120	Others
Waste Water	99940	Others
Manufactures of Metals, NEC	69000	Others
Sugars, Beet or Cane, Raw, Solid Form, No Additives	6110	Others
Fixed Vegetable Fats & Oils, Crude, Refined or Fract	42000	Others
Slag & Ash, NEC, Including Seaweed Ash (Kelp)	27869	Others
Machinery Specialized for Particular Industries	72000	Others
Slag, Dross, Scalings & Waste of Iron or Steel	27862	Others
Miscellaneous Manufactured Articles, NEC	89900	Others
Alcoholic Beverages	11200	Others
Aluminum	68400	Others
Molasses Resulting From the Extraction/Refin Sugar	6150	Others
Zinc	68600	Others
Mechanical Handling Equipment & Parts Thereof, NEC	74400	Others
Water (Inc Natural or Artif/Aerated) No Sugar/Flav	11101	Others
Tin	68700	Others
Manufactures of Mineral Materials, NEC	66330	Others
Electrical Machinery, Appar & Appliances, NEC; Parts	77000	Others
Other Solid Sugars; Sugar Syrups (No Additv); Caramel	6190	Others
Wood Manufactures, Not Elsewhere Classified	63500	Others
Oth Non-Electrical Machinery, Tools, Apparatus; Parts	74500	Others
Monumental or Building Stone and Articles Thereof	66130	Others
Land Fill	99920	Others
Containers (Multi-Modal)	55	Others
Paper and Paperboard, Cut to Size, Shape; Articles of	64200	Others
Ships,Boats (Inc Hovercraft) & Floating Structures	79300	Others
Quicklime, Slaked Lime & Hydraulic Lime	66110	Others
Wood in the Rough or Roughly Squared	24700	Others
Nickel	68300	Others
Lumber	24890	Others
Aircraft and Assoc Equip; Spacecraft & Launch Veh	79200	Others
Parts & Accessories of Motor Vehicles(722,781-783)	78400	Others
Motor Veh for Transport of Goods;Spec Use Motr Veh	78200	Others

Table 5-6. GIWW Tonnages Indices Reference Case, 2011-2061

Petrochemicals Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Liquefied Petroleum Gases	1.00	1.01	0.89	0.91	0.92	0.94	0.96	0.97	0.99	1.00	1.02	1.03	1.03	1.04	1.05	1.05	1.05	1.06	1.06	1.05	1.05	1.05	1.05	1.05	1.05
Motor Gasoline	1.00	1.00	1.00	0.99	0.98	0.97	0.97	0.95	0.94	0.93	0.92	0.92	0.91	0.91	0.91	0.91	0.91	0.90	0.90	0.90	0.89	0.87	0.88	0.89	0.89
Jet Fuel	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.04	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.09	1.09	1.09	1.10	1.10
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.02	1.05	1.07	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.14	1.14
Residual Fuel Oil	1.00	1.07	1.08	1.10	1.09	1.08	1.08	1.08	1.09	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.14
Petrochemical Feedstocks	1.00	1.00	1.01	1.08	1.12	1.17	1.22	1.27	1.30	1.33	1.37	1.39	1.40	1.41	1.43	1.43	1.44	1.46	1.46	1.46	1.44	1.44	1.44	1.44	1.44
Other Petroleum	1.00	1.01	0.94	0.96	0.97	0.96	0.94	0.92	0.91	0.90	0.89	0.88	0.88	0.88	0.88	0.88	0.88	0.87	0.87	0.88	0.88	0.87	0.89	0.90	0.90
Bulk Chemicals	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index	1.00	0.94	0.94	0.98	1.00	1.02	1.05	1.08	1.11	1.14	1.16	1.18	1.19	1.20	1.22	1.22	1.22	1.23	1.24	1.23	1.23	1.23	1.23	1.23	1.23
Crude Petroleum	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index	1.00	1.04	1.08	1.10	1.14	1.19	1.19	1.20	1.23	1.24	1.23	1.21	1.21	1.21	1.20	1.19	1.20	1.20	1.19	1.19	1.17	1.17	1.17	1.15	1.14
Fertilizer Chemicals	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index	1.00	0.95	0.89	0.88	0.92	0.98	1.00	0.99	1.01	1.05	1.06	1.05	1.05	1.06	1.06	1.06	1.07	1.09	1.10	1.12	1.12	1.15	1.19	1.17	1.16
Aggregate	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index	1.00	1.01	0.97	1.01	1.02	1.04	1.04	1.04	1.05	1.06	1.08	1.10	1.11	1.12	1.14	1.15	1.17	1.19	1.20	1.22	1.24	1.26	1.29	1.31	1.33
Other Dry Bulk (ex aggregates)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Iron & Steel Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Nonmetallic Minerals Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grains Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Coal Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Petrochemicals Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Liquefied Petroleum Gases	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Motor Gasoline	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Jet Fuel	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Kerosene	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Residual Fuel Oil	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Petrochemical Feedstocks	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
Other Petroleum	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Bulk Chemicals	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
Crude Petroleum	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index	1.14	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.07	1.13	1.06	1.05	1.04	1.04	1.03	1.02	1.01	1.01	1.00	0.99	0.98	0.98	0.97	0.96
Fertilizer Chemicals	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Aggregate	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index	1.34	1.35	1.37	1.39	1.41	1.42	1.44	1.46	1.48	1.50	1.51	1.53	1.55	1.57	1.59	1.60	1.62	1.64	1.66	1.67	1.69	1.71	1.73	1.75	1.76	1.78
Other Dry Bulk (ex aggregates)	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Iron & Steel Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Nonmetallic Minerals Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grains Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Coal Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Notes: Petrochemicals from Table 2-8. Values beyond 2035 = 2035.
Bulk chemicals (other than fertilizers) from Table 2-13.
Crude Petroleum from Table 2-17.
Fertilizer chemicals from Table 2-15
Aggregates from Table 2-19.
Other Dry Bulk (ex aggregates) from Table 3-8.

Table 5-7. GIWW Tonnages Indices High Case, 2011-2061

Petrochemicals Indices	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Index Low World Oil Price																									
Liquefied Petroleum Gases	1.00	1.01	0.91	0.94	0.95	0.97	0.99	1.01	1.03	1.04	1.06	1.07	1.08	1.08	1.09	1.10	1.10	1.11	1.11	1.11	1.10	1.10	1.10	1.10	1.11
Motor Gasoline	1.00	1.00	1.03	1.04	1.05	1.05	1.04	1.04	1.04	1.04	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05	1.06	1.06	1.07	1.08	1.09	1.09
Jet Fuel	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.07	1.08	1.08	1.09	1.09	1.09	1.10	1.10	1.11
Kerosene	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Distillate Fuel Oil	1.00	1.01	1.05	1.09	1.11	1.11	1.11	1.11	1.11	1.11	1.12	1.13	1.13	1.13	1.14	1.14	1.14	1.15	1.15	1.16	1.16	1.17	1.17	1.18	1.19
Residual Fuel Oil	1.00	1.09	1.14	1.17	1.17	1.17	1.17	1.17	1.19	1.21	1.22	1.23	1.23	1.23	1.24	1.23	1.23	1.24	1.25	1.26	1.26	1.26	1.28	1.29	1.31
Petrochemical Feedstocks	1.00	1.00	1.02	1.09	1.12	1.18	1.23	1.28	1.31	1.34	1.38	1.40	1.41	1.42	1.44	1.46	1.46	1.48	1.48	1.48	1.47	1.47	1.47	1.47	1.47
Other Petroleum	1.00	1.02	1.01	1.05	1.07	1.08	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.07	1.07	1.08	1.08	1.08	1.09	1.10	1.10	1.11	1.12	1.14	1.15
Bulk Chemicals Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index Low World Oil Price	1.00	0.95	0.96	0.99	1.01	1.03	1.06	1.09	1.12	1.15	1.17	1.19	1.20	1.21	1.22	1.23	1.23	1.24	1.24	1.24	1.24	1.23	1.23	1.23	1.23
Crude Petroleum Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index Low World Oil Price	1.00	1.04	1.05	1.06	1.08	1.11	1.10	1.09	1.10	1.10	1.08	1.06	1.04	1.02	1.01	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96
Fertilizer Chemicals Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index Low World Oil Price	1.00	0.95	0.89	0.88	0.91	0.96	0.97	0.95	0.95	0.97	0.98	0.97	0.93	0.91	0.91	0.90	0.89	0.88	0.88	0.88	0.89	0.91	0.93	0.94	0.93
Aggregates Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index Low World Oil Price	1.00	1.03	1.04	1.11	1.14	1.16	1.16	1.17	1.19	1.20	1.21	1.24	1.25	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.49
Other Dry Bulk (ex aggregates)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Iron & Steel Index	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Nonmetallic Minerals Index	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
Grains Index	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Coal Index	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Other Index	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29

Petrochemicals Indices	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Index Low World Oil Price																										
Liquefied Petroleum Gases	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Motor Gasoline	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Jet Fuel	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Kerosene	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Distillate Fuel Oil	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
Residual Fuel Oil	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
Petrochemical Feedstocks	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
Other Petroleum	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Bulk Chemicals Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index Low World Oil Price	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
Crude Petroleum Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index Low World Oil Price	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Fertilizer Chemicals Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index Low World Oil Price	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Aggregates Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index Low World Oil Price	1.50	1.52	1.54	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83	1.86	1.88	1.90	1.92	1.94	1.96	1.98	2.00	2.02
Other Dry Bulk (ex aggregates)	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Iron & Steel Index	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Nonmetallic Minerals Index	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
Grains Index	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Coal Index	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Other Index	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29

Notes: Petrochemicals from Table 3-1. Values beyond 2035 = 2035.
Bulk chemicals (other than fertilizers) from Table 3-3.
Crude Petroleum from Table 3-5.
Fertilizer chemicals from Table 3-6.
Aggregates from Table 3-7.
Other Dry Bulk (ex aggregates) from Table 3-8.

Table 5-8. GIWW Tonnages Indices Low Case, 2011-2061

Petrochemicals Indices	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Index High World Oil Price																									
Liquefied Petroleum Gases	1.00	1.00	0.86	0.88	0.90	0.92	0.94	0.95	0.97	0.98	1.00	1.01	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02
Motor Gasoline	1.00	1.00	0.96	0.92	0.91	0.89	0.87	0.85	0.83	0.82	0.81	0.80	0.79	0.78	0.76	0.75	0.74	0.73	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Jet Fuel	1.00	0.99	0.99	0.99	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.07	1.07	1.08	1.08	1.09	1.09	1.10	1.10
Kerosene	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.00	1.00	1.00	1.02	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.11	1.12	1.12	1.13	1.13	1.14	1.15
Residual Fuel Oil	1.00	1.06	1.06	1.08	1.08	1.07	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.11	1.11
Petrochemical Feedstocks	1.00	1.00	1.00	1.07	1.12	1.17	1.22	1.26	1.30	1.33	1.37	1.39	1.39	1.40	1.42	1.42	1.42	1.44	1.44	1.43	1.43	1.43	1.43	1.43	1.43
Other Petroleum	1.00	1.00	0.88	0.90	0.91	0.91	0.90	0.88	0.87	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81
Bulk Chemicals Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index High World Oil Price	1.00	0.94	0.92	0.96	0.99	1.02	1.05	1.08	1.11	1.14	1.16	1.18	1.19	1.20	1.21	1.21	1.22	1.23	1.23	1.23	1.22	1.22	1.22	1.22	1.22
Crude Petroleum Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index High World Oil Price	1.00	1.04	1.11	1.15	1.19	1.25	1.26	1.29	1.31	1.34	1.34	1.34	1.33	1.31	1.31	1.32	1.31	1.32	1.31	1.29	1.30	1.29	1.27	1.26	1.26
Fertilizer Chemicals Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index High World Oil Price	1.00	0.95	0.88	0.88	0.92	0.98	1.00	1.01	1.05	1.13	1.17	1.18	1.17	1.16	1.16	1.19	1.19	1.21	1.21	1.20	1.23	1.25	1.25	1.26	1.28
Aggregates Indices	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Index High World Oil Price	1.00	1.01	0.90	0.93	0.95	0.97	0.98	0.99	1.01	1.03	1.05	1.08	1.09	1.11	1.13	1.16	1.18	1.21	1.23	1.27	1.30	1.33	1.35	1.38	1.41
Other Dry Bulk (ex aggregates)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Iron & Steel Index	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Nonmetallic Minerals Index	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Grains Index	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Coal Index	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Other Index	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71

Petrochemicals Indices	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
Index High World Oil Price																										
Liquefied Petroleum Gases	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Motor Gasoline	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Jet Fuel	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Kerosene	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Distillate Fuel Oil	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Residual Fuel Oil	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Petrochemical Feedstocks	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Other Petroleum	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Bulk Chemicals Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index High World Oil Price	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Crude Petroleum Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index High World Oil Price	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Fertilizer Chemicals Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index High World Oil Price	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
Aggregates Indices	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Index High World Oil Price	1.44	1.47	1.50	1.53	1.55	1.58	1.61	1.64	1.67	1.70	1.73	1.76	1.78	1.81	1.84	1.87	1.90	1.93	1.96	1.98	2.01	2.04	2.07	2.10	2.13	2.16
Other Dry Bulk (ex aggregates)	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Iron & Steel Index	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Nonmetallic Minerals Index	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Grains Index	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Coal Index	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Other Index	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71

Notes: Petrochemicals from Table 3-1. Values beyond 2035 = 2035.
Bulk chemicals (other than fertilizers) from Table 3-3.
Crude Petroleum from Table 3-5.
Fertilizer chemicals from Table 3-6.
Aggregates from Table 3-7.
Other Dry Bulk (ex aggregates) from Table 3-8.

Section 6:
FIGURES

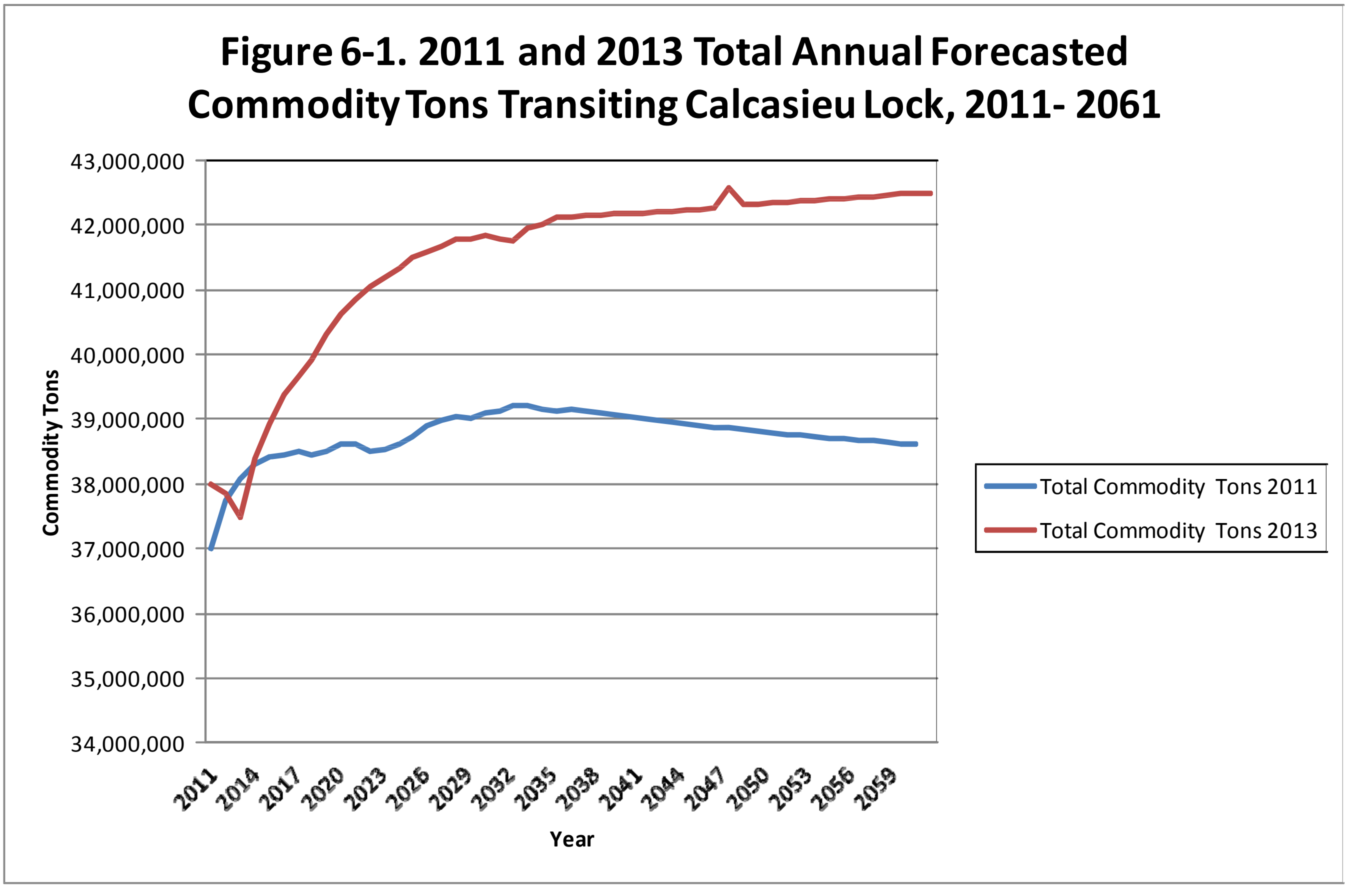


Figure 6-1. 2011 and 2013 Total Annual Forecasted Commodity Tons Transiting Calcasieu Lock, 2011- 2061
43,000,000
42,000,000
41,000,000
40,000,000
39,000,000
38,000,000
37,000,000
36,000,000
35,000,000
34,000,000
Commodity Tons
2011
2014
2017
2020
2023
2026
2029
2032
2035
2038
2041
2044
2047
2050
2053
2056
2059
Year
Total Commodity Tons 2011
Total Commodity Tons 2013

Calcasieu Lock
Louisiana Feasibility Study

Appendix K Attachment 2

ADDENDUM A

Navigation Investment Model (NIM) Movement Input

May 2013

US Army Corps of Engineers

Prepared by:

Navigation Planning Center,
Huntington District

Prepared for:

CEMVN-PDE-N

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List of ATTACHMENT 2 Addendums

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K.2A.1 INTRODUCTION

The NIM Waterway Supply and Demand Module (WSDM) estimates equilibrium system traffic levels from a bottom-up movement level analysis given movement-level waterway demands and their corresponding willingness-to-pay for barge transportation. The model allows two basic methods for specification of the movement level willingness-to-pay, and as a result, two basic methods for the determination of system equilibrium through the use of either an: 1) elastic; or 2) inelastic movement level demand. In fact NIM is capable of equilibrating the system consisting of a mix of elastic and inelastic movements. Transportation rate data only needed when an inelastic movement-level demand is defined. In short, the least-costly all-overland rate serves as a proxy for the movement level willingness-to-pay for barge transportation.

As discussed in **ATTACHMENT 2** GIWW NIM 5.3, the Navigation Investment Model (NIM) 130 database tables can be grouped into ten broad categories. One of the major categories describes the movement characteristics, which includes database tables describing shipment data specifying the origin, destination, commodity group, annual tonnage (historic and forecasted), barge type, barge loading, willingness-to-pay, river closure response, and river closure response externality cost (existing and projected). This addendum discusses the extraction / compilation, aggregation, input, and verification of the movement level data into NIM. Movement data was managed and manipulated in ACCESS 2007 and then exported to the NIMv05_3 SQL Server database on server LRH-AP-NC-PCXIN.

K.2A.2 HISTORIC MOVEMENT EXTRACTION AND AGGREGATION

Waterside origin to destination traffic data is collected and managed by the Navigation Data Center's (NDC) Waterborne Commerce Statistics (WCS) Center. The WCS movement data transiting one or more of the nine study locks was extracted, aggregated into a model level structure, and re-formatted into model input tables. The historic movement aggregation and model reformatting was accomplished in ACCESS file "*GIWW-WCSCData-2000-2010.accdb*" (**FIGURE K**.2A.2.1).

K.2A.0.1 Study Area WCS Data Extraction and Lock Flagging

Historic WCS data from 2000 through 2010 for GIWW-E and GIWW-W was extracted from the DETAILyy and DETAILyyL (loaded and empty vessel) tables from NDC's TOWS database on the iwr24 server. While the flow data is reported monthly, it is aggregated to an annual level and is extracted at a location-dock to location-dock, 5-digit WCSC commodity code, vessel type, barge length-width, and routing level.

This data was subsequently "*flagged*" for transit through the following thirteen structures:

- Study Locks
  - Algiers Lock
  - Bayou Boeuf Lock
  - Bayou Sorrel Lock
  - Calcasieu Lock
  - Harvey Lock
  - Inner Harbor Lock
  - Leland Bowman Lock
  - Old River Lock
  - Port Allen Lock
- Non-Study Locks
  - Brazos East
  - Brazos West
  - Colorado East
  - Colorado West

"*Flagging*" the WCS data entailed deciphering the WCS "*ROUTE*" field which is a maximum 220 character text string of sequential waterway "*links*". Each link number is preceded by a parameter indicating the direction transited and whether the link transited was an origin or destination link. When a structure of interest is in the origin or destination link, additional analysis of the dock and structure mile point along with the direction of travel is needed. An ACCESS update query was developed for each structure to update, or "*flag*", the data file with "*0*" for not transiting, "*1*" for up bound transit, and "*2*" for down bound transit.

Finally, only traffic flows for hopper and tanker barges (VTYPE 2, 4, and 5) through one or more of the nine study locks were extracted into ACCESS database table "*WCS_2000_2010_CalcasieuStudy*". This database table contains 541,988 records.

K.2A.0.0.1 **Dock Level Movement Rate Data**

For the Calcasieu Study, Texas Transportation Institute (TTI) rated 150 Calcasieu Lock movements from calendar year 2008[1]. The rate price level was adjusted to a 4th Quarter 2010 level.

The movement flows in database table "*WCS_2000_2010_CalcasieuStudy*" were updated with the sample rate information (149 of the 31,983 unique dock-to-dock 5-digit commodity movement flows in the 2000-2010 data set). For the remaining movements in the database, the TTI report recommended multiplying a dollar per net ton-mile factor derived from the sample data (and a land/water mileage ratio in the case of the land rate) to the un-sampled movement's water mileage as shown in the equations below.

Existing Water Routing Rate ($/ton) = Average Transportation Rate of Existing Water Routing ($/net ton-mile) x Existing Water Routing Miles (1.2-1)

Least-Cost All-Overland Routing Rate ($/ton) = Average Transportation Rate of Least-Cost All-Overland Routing ($/net ton-mile) x Existing Water Routing Miles x Ratio Land/Water Miles (1.2-2)

The TTI report's dollar per net ton-mile table (Table 3), however, did not contain information for the water routing line-haul portion of the water routed rate. As a result, the sample data was re-analyzed and dollar per net ton-mile factors were developed for the line-haul portion of the water routing, as well as the total water routing and total land routing rates (as shown in **TABLE K.2A.2.1**).

TABLE K.2A.2.1 – Transportation Rates per Net Ton-Mile by Commodity Group

	Average Transportation Rate ($/net ton-mile)			Average Ratio
	Existing WW Routing		Overland Route	Total Land /
Commodity	WWLineHaul	WWRate	(AltRate)	Water Line Haul
1 COAL	$ 0.0220	$ 0.0289	$ 0.0344	3.3258
2 PETROLEUM PRODUCTS	$ 0.0446	$ 0.0507	$ 0.0566	1.8886
3 CRUDE PETROLEUM	$ 0.0450	$ 0.0506	$ 0.0524	2.6420
4 AGGREGATES	$ 0.0105	$ 0.0131	$ 0.0362	1.5510
5 GRAINS & GRAIN PRODUCTS	$ 0.0201	$ 0.0244	$ 0.0553	1.4818
6 CHEMICALS	$ 0.0599	$ 0.0613	$ 0.0560	1.7311
7 NON-METALLIC ORES & MINERALS	$ 0.0129	$ 0.0145	$ 0.0276	1.9848
8 IRON ORE & IRON & STEEL PRODUCTS	$ 0.0167	$ 0.0193	$ 0.0424	1.6741
~~9 OTHERS~~	$ 0.0299	$ 0.0387	$ 0.0373	1.4786

[1] *Transportation Rates and Closure Response Research: Calcasieu Lock, Draft Final Report, TTI, dated February 2011.*

Application of the rate data to the study movements was accomplished in ACCESS file "*GIWW-WCSCData-2000-2010.accdb*" (as shown in **FIGURE K.2A.2.1**). The resulting database table containing all the unique origin to destination by commodity by barge type by routing (O-D-C-BT-RT) movements in the 2000 through 2010 data set (31,983 records), with rates, was stored in table "*UniqueLocDockLocDockCmdyWithRates_N3*"

K.2A.1.1.2 Movement Aggregation Tables

As discussed, the 2000-2010 annual flow data is extracted at a origin location-dock to destination location-dock, 5-digit WCSC commodity code, vessel type, barge length-width, and routing level.

NIM movement specification (i.e., origin, destination, commodity, barge type) is dictated by the model's network, commodity grouping, and barge type groupings. The aggregation of the WCS flow data not only requires straight aggregation ("*group by*" and "*sum*") of the origin and destination nodes, commodity grouping, barge type, and tonnage, but also requires weighted averaging of the rate data as movements are merged.

Aggregation of the 269 5-digit WCS commodity codes, 560 WCS barge dimension types, and 541,988 dock-to-dock flows into 20,271 "*movementID*"s is discussed in the sections below. This process resulted in the conversion of "*WCS_2000_2010_CalcasieuStudy*" into the "*WCS_2000_2010_CalcasieuStudy_N3*" table where "*N3*" represents the waterway network (i.e., networkID) used in the Calcasieu study.

K.2A.1.1.1.1 ***Commodity Grouping***

The 269 5-digit WCSC commodity codes found in the 2000-2010 movement data set were aggregated to a 1-9 commodity grouping. This grouping was dictated by the GEC[2] forecasting effort. The conversion from WCS 5-digit commodity code to 1-9 commodity grouping code is stored in table "*Aggregation_CommodityTypeGrouping*" (**FIGURE K.**2A.2.1).

K.2A.1.1.1.2 ***Barge Type Grouping***

The 560 unique hopper and tanker lengths and widths found in the 2000-2010 movement data set[3] were aggregated into 6 barge types. A discussion of this grouping can be found in the Calibration Addendum 1B. The conversion of the 560 tanker / hopper length-widths into the 6 modeling barge types is stored in table "*Aggregation_BargeTypeGrouping*" (**FIGURE K.2A.2.1**).

K.2A.1.1.1.3 ***Alternative Route Grouping***

While NIM can select the least-cost water route, specification of the historic or existing routing is helpful in the calibration and useful in the analysis of future conditions. The routing in the NIM network is controlled through the model's routing parameters; a forced network sector (ForcedSec) or lock (ForcedLk) and an avoid sector (AvoidSec) fields. Essentially, these fields specify that the routing of the movement must transit the specified sector and/or lock, and/or avoid routing through a specified sector.

WCS data, however, contain a "*ROUTE*" and "*ALTERNATIVE*" field describing the waterway route which must be converted to the modeling ForcedSec-ForcedLk-AvoidSec specification. The WCS "*ROUTE*" field is a maximum 220 character text string of sequential waterway "*links*". The "*ALTERNATIVE*" field is a maximum 20 character text string containing up to 10 2-character codes representing selected sections of the waterway route (e.g., transit through the Tenn-Tom). The WCS "*ALTERNATIVE*" field was used to convert the dock level study movements in "*WCS_2000_2010_CalcasieuStudy*" to a modeling ForcedSec-ForcedLk-AvoidSec specification.

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[2] Gulf Engineering & Consultants.

[3] The unique number of actual length-widths are less; the iwr24 TOWS MAS_MASTER_VESSEL contains errors (e.g., A 1,950' x 35' hopper barge which, according to the DETAIL data, moved an average loading of 1,486 tons. The length of this vessel should most likely be 195.0' instead of 1,950'.)

The first step in this conversion was to identify all the unique "*ALTERNATIVE*" strings in the base data. In the Calcasieu study data, 126 unique "*ALTERNATIVE*"s were identified. Next, each unique "*ALTERNATIVE*" was converted to a ForcedSec-ForcedLk-AvoidSec specification and stored in the "*Aggregation_AlternativeGrouping*" table (**FIGURE K.2A.2.1**).

K.2A.1.1.1.4 ***Modeling Port Aggregation***

A significant portion on the granularity in the 541,988 record 2000-2010 movement data set comes from the dock level waterside origin and destination specification. Before input into the model, the 4,160 unique docks in the movement set require re-specification to 303 NIM pick-up / drop-off nodes (modeling ports). This dock to NIM port conversion (aggregation) was complex.

The first step was to utilize the "*REGION*" code in the DETAIL data file to: 1) set any Atlantic coast dock to the NIM network's east most GIWW-E port; and 2) set any Great Lakes dock to the NIM network's northern most port at Chicago. The next step was to "*snap*" the remaining docks using their longitude and latitude coordinates to the NIM network using the following logic:

- Add the GIWW NIM ports and locks to the NDC GIS waterway network.
- Find the NDC link closest to the dock's latitude longitude that has the same waterway code as the dock (If the NDC network doesn't have a link with the dock's waterway code, then find the closest NDC link to the dock).
- Find the port closest to the dock, using the NDC network, but not going through any locks. Associate that port with the dock.

This code was developed by ORNL and will be incorporated into the national NIM suite.

The dock to port information is stored in the "*Aggregation_PortsGrouping*" table.

K.2A.1.1.3 **Movement Aggregation**

To aggregate the 541,988 record 2000-2010 dock-level base data ("dbo_*WCS_2000_2010_CalcasieuStudy*") into the 49,608 record modeling port-level movement file ("*WCS_2000_2010_CalcasieuStudy_N3*"), the various aggregation tables discussed in the above sections were "*joined*" to the base flow data and "*make table*" queries were performed to group the data to the modeling level network parameters (see **FIGURE K.2A.2.1**). While these query "*group by*" and "*sum*" processes are straight forward, they cannot be used on the rate data information or in calculation of an average barge loading for the model's aggregated movement.

K.2A.1.1.1.5 ***Rate Aggregation***

To aggregate the dollar per ton rate data information, the rates were first multiplied by the movement tonnage prior to summing during the aggregation. The final step in the modeling level movement file was to then divide this total rate summed over all detailed movements by the sum of the tonnage, resulting in a weighted average dollar per ton rate.

K.2A.1.1.1.6 ***Average Barge Loading Aggregation***

Similar to aggregation of the rate data by weighting the average, an additional step was taken in the average barge loading calculation. The WCS flow data does not include a shipment's average barge loading, however, the data includes a "*trip*" field which is defined as the "*number of trips represented by one record*". The trip field is basically equivalent to the number of barges, and the movement tonnage can be divided by the movement number of trips to determine an average barge loading.

Potentially distorting this barge loading average are partial trips which are coded as zero trips. For each vessel dock-level movement, the trips and tons were summed over years 2000 through 2010 and an average loading was calculated. If this loading was more than 10% greater than the vessel's capacity as specified in the NDC MASTER_VESSEL database, the average loading for the vessel dock-level movement was set to the vessel's capacity. Next, as the vessel dock-level movements were aggregated to model-level movements, a simple average of the movement average loadings was used. In short, through time a weighted average for average barge loading was calculated, then across dock-level movements a simple average was calculated.

K.2A.1.1.4 **Calibration Year Movement Aggregation**

To smooth out the model verification, calibration, and validation effort, often multiple years are aggregated together. For the Calcasieu study, years 2005, 2006, and 2007 were averaged. As a result, movement data for these three years were summed and then aggregated to modeling-level. Similar to the 2000-2010 aggregation, the base flow data table was "*joined*" to the aggregation table and "*make table*" queries were performed to group the data to the modeling level network parameters (see **FIGURE K.2A.2.1**). The resulting 8,326 record table was called "*WCS_9999_CalcasieuStudy_N3*". To identify the records as an average, the "*YR*" field is populated with "*9999*".

K.2A.1.1.5 **Movement-Level Barge Transportation Demand Elasticity**

NIM is capable of either modeling movement equilibrium from a fixed-quantity (inelastic) or price-responsive (elastic) perspective. For movements defined as fixed-quantity, field "*AltRate*" of the "*MovementDetail*" table (**TABLE K.2A.2.2**) defines the movement's willingness-to-pay. For movements defined as price-responsive, the willingness-to-pay is defined through four database tables: "*DemandFunctionPlan*", "*DemandFunctionRule*", "*DemandFunctionRuleParameter*", and "*MovementDemandFunction*" tables. Loading of these tables is discussed in Addendum 1D, Movement Demand Curve Input.

K.2A.3 **HISTORIC MOVEMENT FORECASTING**

The initial Gulf Engineering and Consultants (GEC) GIWW traffic demand forecast indices were received in January 2011. An updated Reference level traffic demand forecast was received in December 2012 followed by an updated low and high traffic demand forecasts in January 2013. Each of these forecasted demand scenarios were first applied to the dock level 5-digit WCS commodity level movement data file ("*WCS_2000_2010_CalcasieuStudy*") and then aggregated to the NIM modeling network. In addition to the six GEC forecasted demand scenarios (original and updated low / reference / high) and no growth demand file was created. This forecasted movement indexing, aggregation, and model reformatting was accomplished in seven ACCESS files: 1) "*GIWW-WCSCData-2011-2070-F1-Low2011-01.accdb*"; 2) "*GIWW-WCSCData-2011-2070-F2-Ref2011-01.accdb*"; 3) "*GIWW-WCSCData-2011-2070-F3-High2011-01.accdb*"; 4) "*GIWW-WCSCData-2011-2070-F4-Ref2012-12.accdb*"; 5) "*GIWW-WCSCData-2011-2070-F5-NoGrowth2012-12.accdb*"; 6) "*GIWW-WCSCData-2011-2070-F6-Low2012-12.accdb*"; and 7) "*GIWW-WCSCData-2011-2070-F7-High2012-12.accdb*". A separate ACCESS file was required for each forecast scenario given size constrains within ACCESS.

The 2008 forecast indices in the GEC January 2011 "*Vessel Traffic Forecast for the GIWW as it Relates to the Calcasieu Lock*", and the subsequent workbooks containing the updated indices, were reformatted into database table "*ForecastIndexByCommodity*" and applied to the year 2008 movements found in the dock-level base data movement file ("*WCS_2000_2010_CalcasieuStudy*"). The resulting port-level forecast files contained 241,320 records each (regardless of the forecast scenario). The tables (each in their own ACCESS file) were then transformed into the NIM "*MovementTonnage*" table format:

- MovementTonnage_N3_2011_2070_F1_Low201101
- MovementTonnage_N3_2011_2070_F2_Reference201101
- MovementTonnage_N3_2011_2070_F3_High201101
- MovementTonnage_N3_2011_2070_F4_Reference201212
- MovementTonnage_N3_2011_2070_F5_NoGrowth201212

- MovementTonnage_N3_2011_2070_F6_Low201212
- MovementTonnage_N3_2011_2070_F7_High201212

These ACCESS database tables were then exported into EXCEL for importing into NIM through NIM's data import tool.

K.2A.4 **NIM MOVEMENT TABLES**

To store the movement data efficiently in the model with the greatest flexibility and limited redundancy, NIM stores the movement data in three related tables: 1) "*MovementDetail*"; 2) "*MovementBarge*"; and 3) "*MovementTonnage*". The basic movement data (origin, destination, rates) is loaded into the "*MovementDetail*" table. The barge type and barge loading information is placed in a separate "*MovementBarge*" table to allow easy changing of the movement barge type and loading assumptions. The "*MovementDemandFunction*" is then used to relate each movement to its demand elasticity. The yearly tonnage data are stored in a separate "*MovementTonnage*" table to allow storage of multiple years and multiple forecast scenarios.

K.2A.1.2 **Movement Detail Table**

The NIM "*MovementDetail*" table is built in "*GIWW-WCSCData-2000-2010.accdb*" from the "*WCSC_2000_2010_CalcasieuStudy_N3*" table (**FIGURE K.2A.2.1**). The 49,315 records in "*WCSC_2000_2010_CalcasieuStudy_N3*" are reduced to 12,486 movement IDs. Note that year 2000-2004 movement flows are dropped from this process since these years are not needed for the analysis and eliminating them decreases file sizes.

As in the aggregation from dock-level to port-level, this aggregation from yearly movements to a movement ID required a weighting of the dollar per ton rates. Again, this was accomplished by summing the product of the rate per ton and tonnage, and then dividing by the aggregated tonnage.

The movement detail table is called "*MovementDetail_N3*" with the "*N3*" representing the network ID for the Calcasieu study network. To load into NIM, the table is simply called "*MovementDetail*". The "*MovementDetail*" table is shown in **TABLE K.2A.2.2**.

TABLE K.2A.2.2 – MovementDetail Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
movementID		Unique movement ID
Origin		Movement origin portID (Ports table)
Destination		Movement destination portID (Ports table)
ForcedSec		Movement must be routed through this sectorID (Sectors table)
ForcedLk		Movement must be routed through this lockID (Locks table)
AvoidSec		Movement must not be routed through this sectorID (Sectors table)
Commodity		Movement commodityID group (CommodityTypes table)
WWLineHaul		Base waterway line-haul rate in dollars per ton
WWRate		Total base waterway rate in dollars per ton

K.2A.1.3 Movement Barge Table

The NIM "*MovementBarge*" table is also built in "*GIWW-WCSCData-2000-2010.accdb*" from the "*WCSC_2000_2010_CalcasieuStudy_N3*" table; however, the "*MovementDetail*" table is utilized to assign a movement ID to this table so that it can later be related to the movement detail and to movement tonnages (**FIGURE K.2A.2.1**). As with the "*MovementDetail*" table, year 2000-2004 data is dropped.

The movement barge table is called "*MovementBarge_N3*" with the "*N3*" representing the network ID for the Calcasieu study network. To load into NIM, the table is simply called "*MovementBarge*". The "*MovementDetail*" table is shown in **TABLE K.2A.2.3**.

TABLE K.2A.2.3 – MovementBarge Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion	DB Key	River system network version (1 = Existing Calcasieu with Inner Harbor Lock replacement)
movementID	DB Key	Unique movement ID
bargeTypeID		Movement bargeTypeID class (BargeTypes table)
tonsPerBarge		Movement average barge loading in tons

K.2A.1.4 Movement Willingness-To-Pay

NIM is capable of either modeling movements as fixed-quantity or price-responsive. For movements defined as fixed quantity, field "*AltRate*" of the "*MovementDetail*" table (-------) defines the movement's willingness-to-pay. For movements defined as price- responsive, the willingness-to-pay is defined through four database tables discussed in the following sections. While only one fixed quantity willingness-to-pay value (e.g., the least-costly all-overland rate) is allowed for each network movement (characterized by "*networkID*" and "*movementID*"), the model allows any number of price-responsive demand curves to be specified for each movement. This was done to allow checking and sensitivity tests on various demand curve specifications.

While the demand curves can be defined uniquely to each movement, the demand curves developed for the Calcasieu Lock analysis were only done at a commodity group level (see discussion in Addendum D). In such a case, the demand curves do not have to be duplicated for each movement. The movement is linked to the demand curve through a "*demandFunctionRuleID*"; there is a "*demandFunctionRuleID*" for each commodity group. If each movement has a unique demand curve, then each demand curve is placed under its own "*demandFunctionRuleID*" and there are as many "*demandFunctionRuleID*"s as "*movementID*"s.

K.2A.1.1.6 Demand Function Plan Table

There are also two different methods allowed to define the price responsive demand curve: constant elasticity and piecewise-linear, however, only the more detailed piecewise-linear definition was used in the

Calcasieu Lock analysis. The "*DemandFunctionPlan*" table lists and names the demand function plans developed for each network (**TABLE K.2A.2.4**). As shown in **TABLE K.2A.2.5**, "*demandFunctionPlanID*" 0 is used to represent fixed quantity demand.

TABLE K.2A.2.4 – Demand Function Plan Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionPlanID		Unique demand function plan ID
demandFunctionPlanName		Demand function plan name

TABLE K.2A.2.5 – Demand Function Plans (DemandFunctionPlan Table Data)

networkID	demandFunctionPlanID	demandFunctionPlanName
3	0	none (i.e., fixed quantity demand)
3	1	constant elasticity curves
3	2	piecewise-linear elasticity curves, Wilson Revealed Choice Model (2011)

K.2A.1.1.7 Demand Function Rule Table

The "*DemandFunctionRule*" table (**TABLE K**.2A.2.6) is used to indentify the demand curve to be defined (either as a constant elasticity or as a piecewise-linear). As previously noted, there can be a one-to-one correspondence between the "*demandFunctionRuleID*" and the "*movementID*" when there is a demand curve defined for each movement. In the Calcasieu Lock analysis the price responsive demand curves are defined at a commodity group level as shown in **TABLE K.2A.2.7**.

TABLE K.2A.2.6 – Demand Function Rule Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionRuleID	DB Key	Unique ID for the demand function
demandFunctionRuleName		Movement set name
demandFunctionType		Additional user description if needed

TABLE K.2A.2.7 – Demand Function Rules (DemandFunctionRule Table Data)

networkID	demandFunctionRuleID	demandFunctionRuleName	demandFunctionType
3	0	inelastic	none (fixed quantity demand)
3	1	coal piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	2	petroleum piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	3	crude piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	4	aggregates piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	5	grain piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	6	chemicals piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	7	minerals piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	8	iron piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	9	other piecewise linear	piecewise linear (Wilson revealed choice model, 2011)

K.2A.1.1.8 **Movement Demand Function Table**

The NIM "*MovementDemandFunction*" table is also built in "*GIWW-WCSCData-2000-2010.accdb*" (**FIGURE K**.2A.2.1). The "*demandFunctionRuleID*" is linked to the "*movementID*" through the "*MovementDemandFunction*" table shown in **TABLE K.2A.2.8**. The model allows for re-specification of the demand curve through time through the "*beginYear*" and "*endYear*" fields. This option was not used in the Calcasieu Lock analysis.

TABLE K.2A.2.8 – MovementDemandFunction Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionPlanID	DB Key	Demand function plan ID from DemandFunctionPlan table.
ID	DB Key	movementID from MovementDetail table.
beginYear	DB Key	First year of demandFunctionRuleID
endYear		Last year of demandFunctionRuleID
demandFunctionRuleID		ID from DemandFunctionRule table.

The movement demand function table is called "*MovementDemandFunction_N3*" with the "*N3*" representing the network ID for the Calcasieu study network. The NIM the table is simply called "*MovementDemandFunction*" and it contains data for all networks loaded.

K.2A.1.1.9 **Demand Function Rule Parameter Table**

The "DemandFunctionRuleParameter" table stores parameters that characterize the demand curve (i.e., the "*demandFunctionRuleID*").

TABLE K.2A.2.9 – Demand Function Rule Parameter Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionRuleID	DB Key	ID from DemandFunctionRule table
parameterName	DB Key	Parameter name (x1 … xn or y1 …yn, or elasity for constant)
parameterValue		Proportion of demand (x) or base price (y), or elasticity value for constant

K.2A.1.5 **Movement Tonnage Table**

To understand the storage of the forecasted demand tonnage, the "*Forecast*" table must first be discussed since it provides an identification (ID) for the various forecasted demand scenario tonnages stored in the "*MovementTonnage*" table (**TABLE K.2A.2.10**). As shown in **TABLE K.2A.2.11**, under the Calcasieu network ("*networkID*" = 3) the database contains

TABLE K.2A.2.10 – Forecast Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
forecastID	DB Key	Unique forecasted demand ID
forecastName		Forecast name
comments		Additional description if needed (e.g., GEC GIWW Calcasieu Forecasts dated Jan 2011)

TABLE K.2A.2.11 – Forecast Scenarios (Forecast Table Data)

networkID	forecastID	forecastName	comments
3	0	na (forecastID for historic/actual flows)	year 9999 represents 2005-2007 average
3	1	Low GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011
3	2	Reference (Mid) GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011
3	3	High GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011
3	4	Reference (Mid) Dec 2012 GIWW Forecasts	GIWW Forecasts dated Dec 2012
3	5	No-Growth (flat from 2010)	GIWW Forecasts dated Dec 2012
3	6	LOW Dec 2012 GIWW Forecasts	GIWW Forecasts dated Dec 2012
3	7	HIGH Dec 2012 GIWW Forecasts	GIWW Forecasts dated Dec 2012

As noted, the yearly tonnage data is stored in the "*MovementTonnage*" table under a "*networkID*", "*forecastID*", "*movementSetID*", "*movementID*" (called in this table just "*ID*"), and year.

As discussed in the earlier sections, the port-level modeling movement files for the historic, calibration year, and forecasts were developed separately, and result in the following five tables:

- WCSC_2000_2010_CalcasieuStudy_N3
- WCSC_9999_CalcasieuStudy_N3
- WCSC_2011_2070_CalcasieuStudy_N3_Low
- WCSC_2011_2070_CalcasieuStudy_N3_Reference
- WCSC_2011_2070_CalcasieuStudy_N3_High

As shown in **FIGURE K.2A.2.1** each of these database tables were run through a "*make table*" query and then manually specified with a "*networkID*", "*forecastID*", "*movementSetID*", "*ID*", and "*year*" key specification (setting the key allows for a check that there are no duplicate records), resulting in the following five tables:

- MovementTonnage_2005_2010
- MovementTonnage _9999
- MovementTonnage _2011_2070_Low
- MovementTonnage _2011_2070_Reference
- MovementTonnage _2011_2070_High

Note that year 2000-2004 tonnage data is dropped from the historic tonnage file (MovementTonnage_2005_2010) since they were dropped from the "*MovementDetail*" table and may not have a movement ID.

Next, these five tables are merged using append queries to create the movement tonnage table "*MovementTonnage_N3*" in a separate database, "*GIWW-CalcasieuWCSCCData-2005-2070.accdb*" with the "*N3*" representing the network ID for the Calcasieu study network. In NIM the table is simply called "*MovementTonnage*". The "*MovementTonnage*" table is shown in **TABLE K.2A.12**.

TABLE K.2A.12 – MovementTonnage Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
forecastID	DB Key	Unique movement set ID (defined in table Forecasts)
movementSetID	DB Key	Unique movement set ID (defined in table MovementSets)
ID	DB Key	Unique movement ID
year	DB Key	Year
cargoAmount		Annual tonnage (observed for historic. forecasted for future)

K.2A.5 NIM MOVEMENT VERIFICATION

As discussed, the WCS data extraction was accomplished through determining locks transited by use of the 220 character "*ROUTE*" field. To specify the NIM routing parameters the 20 character WCS "*ALTERNATIVE*" field was used to assign then NIM ForcedSec-ForcedLk-AvoidSec parameters. To verify that the NIM movement set routes traffic similarly to the base WCS data, four quality checks are taken as discussed below. Unfortunately, re-specification of the WCS routing information was not quite so straight forward. As a result, the movement tables were re-built several times as glitches are worked out and bad data was worked around.

K.2A.1.6 **Invalid Model Routes**

The first quality check in NIM's calibration process is to validate the input movements on the model's network. As movements are identified as being invalid they are kicked out for review. In fact, in the first iteration of the movement file development, 144 invalid movements were identified. This process resulted in modification and correction of the "*Aggregation_AlternativeGrouping*" table used to convert the WCS "*ALTERNATIVE*" to a ForcedSec-ForcedLk-AvoidSec modeling route parameter.

The primary adjustments to the WCS movement to model movement transformation process was to explicitly specify an avoid sector (AvoidSec) of the Tennessee Tombigbee waterway (sector 80) unless the WCS routing specifically states Tennessee Tombigbee transit (alternative 59) or the origin or destination is on the Tennessee Tombigbee [4]. This specification of AvoidSec=80 not only applied to movements with WCS alternative codes (i.e., WCS "*ALTERNATIVES*" listed in the "*Aggregation_AlternativeGrouping*" table), but also all the remaining WCS movements without alternative codes. For example, a WCS movement from the GIWW-E to the lower Ohio River moving up the Lower Mississippi will not have any specified alternative routing (despite multiple routing alternatives). NIM will automatically route this movement through the Tennessee Tombigbee (the shortest route) unless told otherwise. In short, WCS field ALTERNATIVES is only partial information on the movement routing, and blank ALTERNATIVES has meaning too.

K.2A.1.7 **Suspect Routes**

The second quality check in NIM's calibration process is to identify suspicious routings (e.g., routing significantly longer than the shortest routing). Many of these improbable routes ended up legitimate according to the raw WCSC specifications. These movements were infrequent (over the 2000-2010 period), were typically only one or two barges, often not in the calibration year range (2005-2007), and often not in the forecast list (forecasts were indexed off year 2008). While the routing parameters in these movements could be in error, they are most likely just special cases (barges traveling with other barges which have different origin-destinations). No attempt was made to remove or "*normalize*" these movements, however, it was decided to drop year 2000-2004 from the NIM database tables to eliminate many of the oddly routed movements.

Of the 12,481 movement ID created, the seventeen following movements had their NIM routing parameters tweaked as shown below.

MovementDetail id 1266 ForcedLk = 205600010

[4] WCS alternative codes represent complete transit only (e.g., movements with an origin and/or destination on the Tennessee Tombigbee do not have a WCS Tennessee Tombigbee alternative code).

MovementDetail id 2721 ForcedLk = 205600010

MovementDetail id 3445 ForcedLk = 205600010

MovementDetail id 3446 AvoidSec = 137

MovementDetail id 3452 ForcedLk = 205600010

MovementDetail id 3456 ForcedLk = 205600010

MovementDetail id 3459 AvoidSec = 137

MovementDetail id 3703 ForcedLk = 625100010

MovementDetail id 4911 ForcedLk = 205600010

MovementDetail id 338 ForcedLk = 624100062

MovementDetail id 6034 ForcedLk = 205600010

MovementDetail id 6671 ForcedLk = 205600010

MovementDetail id 6816 ForcedLk = 205600010

MovementDetail id 8400 ForcedLk = 205600010

MovementDetail id 8536 ForcedLk = 205600010

MovementDetail id 9053 ForcedLk = 205600010

MovementDetail id 10680 ForcedLk = 625100010

K.2A.1.8 **Calibration Year Lock Tonnages**

The third quality check, the calibration year 9999 (average of 2005-2007 flows) tonnages at the nine study projects as summarized by the model were compared against: 1) the lock tonnages calculated from the raw WCS data; and 2) the lock tonnages calculated from the NIM input tables. As shown in **TABLE K.2A.2.13** there was some rounding occurring in the movements as they were aggregated and averaged into the model level movement tables (e.g., the largest difference was 27,839 tons, or 0.1%, of Bayou Boeuf tonnage).

TABLE K.2A.2.13 – Comparison of Output Tonnage

	Tonnage				
		Model			
Navigation Lock Project	Raw WCSC	Input	Output	Difference Absolute	Difference Pct.
Study Project					
CALCASIEU L&D	39,875,410	39,859,885	39,870,353	10,468	0.0%
Gulf Intracoastal Waterway					
ALGIERS L & D	24,233,824	24,229,658	24,253,138	23,480	0.1%
BAYOU BOEUF L & D	25,799,444	25,771,605	25,883,787	112,182	0.4%

Typically the model lock tonnages exactly match the input tonnages, however, in this case they do not. Further investigation revealed an issue with the WCS route string ("*ROUTE*") prior to year 2009 for movements with an origin or destination on the Morgan City Port Allen Route (WTWYs 2346, 2348, and 2350; model sector 39). Prior to year 2009 the mileages on this waterway were reversed. As a result the route strings were built incorrectly, which in turn caused the WCS lock flagging process to incorrectly flag tonnage transiting Bayou Sorrel Lock.

K.2A.1.9 **Calibration Year Lock Loaded Barge Counts**

The forth check, the calibration year 9999 (average of 2005-2007 flows) loaded barge counts at the nine study projects as summarized by the model were compared against the lock loaded barge counts calculated from the NIM input tables as shown in **TABLE K.2A.2.14**.

TABLE K.2A.2.14 – Comparison of Output Loaded Barge Counts

Navigation Lock Project	Number of Loaded Barges			
	Model			
			Difference	
	Input	Output	Absolute	Pct.
Study Project				
CALCASIEU L&D	19,451	19,470	18	0.1%
Gulf Intracoastal Waterway				
ALGIERS L & D	11,791	11,800	9	0.1%
BAYOU BOEUF L & D	14,740	14,778	38	0.3%
BAYOU SORREL LOCK & DAM	12,470	11,878	-592	-5.0%
HARVEY L & D	775	847	72	8.5%
INNER HARDBOR LOCK & DAM	7,641	7,634	-7	-0.1%
LELAND BOWMAN L & D	19,696	19,702	6	0.0%
PORT ALLEN LOCK AND DAM	11,965	11,955	-10	-0.1%
Old River				
OLD RIVER L & D	3,683	3,621	-62	-1.7%

K.2A.1.10 **Forecasted Demand Lock Tonnages**

The fifth check, the future year demand tonnages at Calcasieu Lock are summarized from the NIM input tables and compared against the GEC "*Vessel Traffic Forecast for the GIWW as it Relates to the Calcasieu Lock*" (dated January 2011) report[5] as shown in **TABLE K.2A.2.15**. For the reference forecast

[5] Table 2-25, page 29.

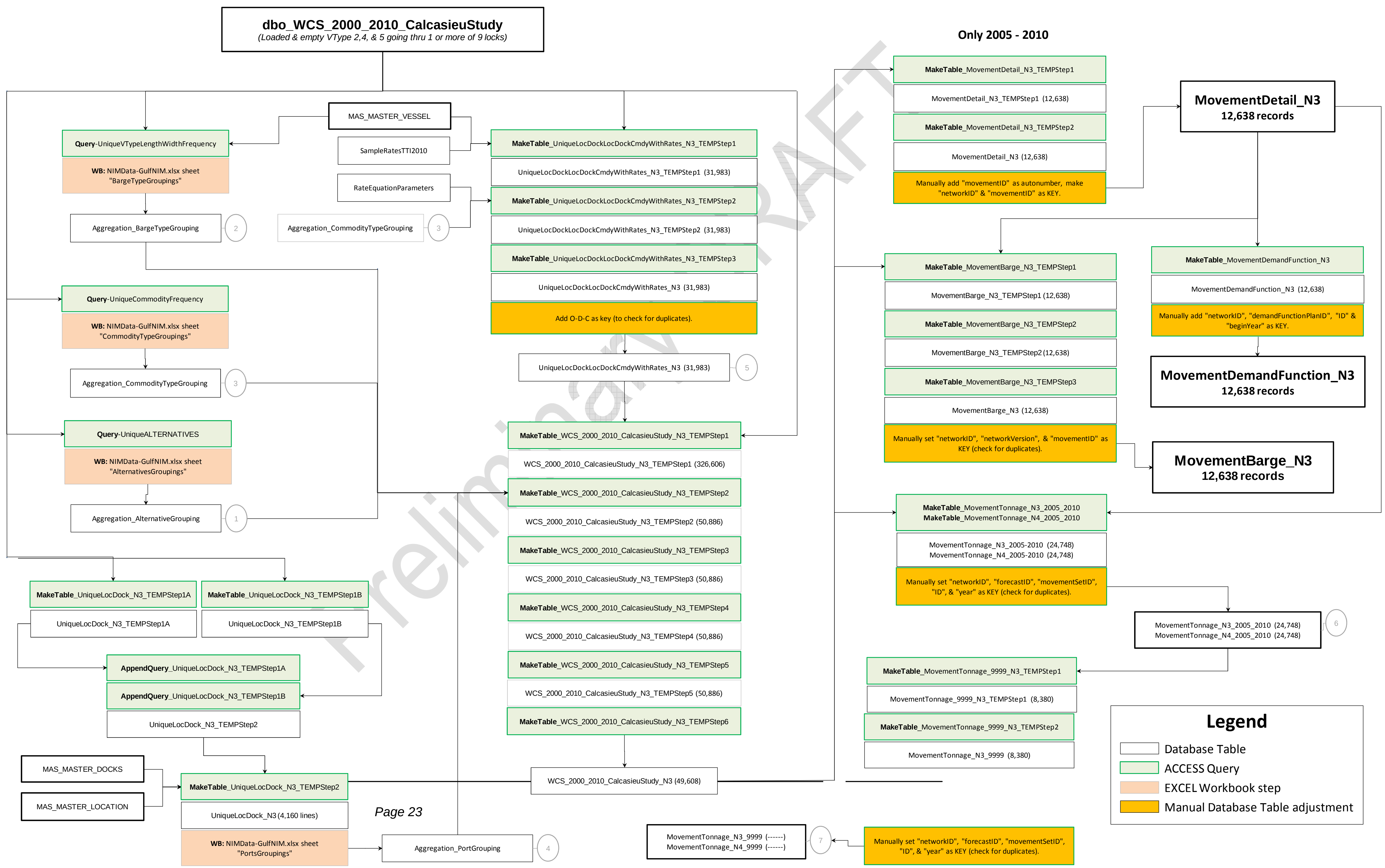
the NIM input file had slightly less traffic, most-likely due to a slightly different WCS movement set. Calcasieu low and high forecasts were not summarized in the GEC report, and a comparison against the NIM input files was not possible.

TABLE K.2A.2.15 – Comparison of Calcasieu Forecasted Demand

	Low		Reference			High	
Year	GEC	Model Input	GEC	Model Input	Pct. Diff.	GEC	Model Input
2015	*na*	35,041,548	38,429,408	38,088,814	-0.9%	*na*	42,799,545
2020	*na*	35,001,910	38,614,962	38,390,024	-0.6%	*na*	44,394,767
2025	*na*	33,811,026	38,743,972	38,448,544	-0.8%	*na*	45,594,706
2030	*na*	33,435,556	39,087,124	38,771,631	-0.8%	*na*	46,679,588
2035	*na*	33,435,389	39,122,936	38,757,983	-0.9%	*na*	47,710,299
2040	*na*	32,870,147	39,034,922	38,644,656	-1.0%	*na*	47,919,933
2045	*na*	32,279,840	38,907,360	38,572,473	-0.9%	*na*	48,176,926
2050	*na*	31,689,532	38,794,394	38,437,289	-0.9%	*na*	48,472,068
2055	*na*	31,118,299	38,696,580	38,362,111	-0.9%	*na*	48,757,999
2060	*na*	30,594,008	38,614,495	38,239,785	-1.0%	*na*	49,097,504

FIGURE K.2A.2.1 – ACCESS GIWW-WCSCData-2000-2010.accdb

Aggregation of dock to dock Waterborne Commerce data to NIM Network Level



Calcasieu Lock
Louisiana Feasibility Study

Appendix K Attachment 2

ADDENDUM B

Navigation Investment Model (NIM) Calibration

June 2013

Prepared by:

Navigation Planning Center,
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US Army Corps
of Engineers

Prepared for:

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K.2.1 INTRODUCTION

A critical step in analysis is the determination of whether the model used is an accurate representation of the actual system being studied, that is, whether the model is valid. Conclusions from results derived from non-valid models are of doubtful value. The process of establishing a model's validity and credibility ranges from the development of the conceptual model through the model output analysis. Three primary steps in this process are model specification, verification and validation.

- Specification includes the theoretical framework of the conceptual model along with the application through the model's framework. Specification is also the determination of input data grouping and aggregation to describe the system being modeled (in this case the aggregation of the waterway system data).
- Verification is the determination that proper data has been loaded and that the model's code performs as intended.
- Validation is the determination of whether the model develops an accurate representation of the system under study. Validation often requires calibration, where the description of the system being modeled is fine-tuned to most accurately replicate observed behavior in the system.

K.2.0.1 The Waterway System

The Gulf Intracoastal Waterway (GIWW) extends approximately 1,115 miles along the coast of the Gulf of Mexico from northwestern Florida at Carrabelle to the southern tip of Texas at Brownsville, connecting southern ports with the Midwest, the east, and the Great Lakes region. The GIWW is maintained by the Corps of Engineers at a project depth of 12 feet for a width of 125 feet.

K.2.0.2 The Waterway Model

The Gulf Intracoastal Waterway (GIWW) version of the Navigation Investment Model (NIM) is referred to as GIWW NIM. NIM itself consists of multiple modules, however, the module of interest for the calibration effort is the Waterway Supply and Demand Module (WSDM). WSDM is a fleet sizing and costing model with enhancements which bridge the gap between towing industry operating characteristics and shipping costs and the physical and operational characteristics of the waterway system. WSDM actually serves two tasks: 1) develop and cost the least-cost movement shipping plans; and 2) estimate equilibrium system traffic levels from a bottom-up movement level analysis. The cost characteristics of the shipping plans are needed in the equilibrium traffic process. The focus of this addendum is on the specification, verification, and validation of the WSDM least-cost shipping plans. Specification of the model's equilibrium process is covered in the main attachment (**ATTACHMENT 2** GIWW NIM).

By using detailed data describing the waterways network, the equipment used for towing operations, and the commodity flow volumes and patterns, the model (WSDM) calculates the resources (i.e., number of towboats, trip time, and fuel consumption) required to satisfy the demand on a least-cost basis. Specifically, this means that the shipping characteristics or shipping plan (tow-size, towboat type, re-fleeting points if applicable and empty barge returns if applicable) must be determined for each movement. The model then provides the analyst with the ability to estimate the effects of differences in the cost characteristics associated with different traffic levels and different waterway system definitions; WSDM is a predictive as well as a behavioral model. Before attempts are made to forecast future behavior and system operating characteristics, however, the analyst and reviewers must first be convinced that the model is capable of replicating known shipper behavior and system performance characteristics.

Looking at a historic year, Waterborne Commerce Statistics Center (WCSC) data gives the origin to destination loaded barge flows by commodity, however, information on tow-size, towboat utilization and empty return characteristics[1] are not available at a movement origin to destination level. As a result, a major function of WSDM is to determine the movement level origin to destination shipping plans. To validate that the model is developing accurate shipping plans and is capable of replicating observed shipper behavior and system operating characteristics, the model usually needs to be calibrated. This is a sequential process involving several iterative steps. At each step, certain static components of the model's waterway system description are adjusted or fine-tuned, the model is exercised, and specific results are compared with corresponding target values. The target values are specified by navigation lock project and are often derived from the Lock Performance Monitoring System (LPMS) data for the designated baseline or calibration year(s). The calibration process is designed to ensure that the relevant measures match their corresponding target values as well as possible.

This ADDENDUM discusses the model's input specification and data aggregation, model verification steps, and model validation with intention of supporting model credibility for estimating movement shipping plans and ultimately to support the model's credibility for use in the Calcasieu Lock Replacement Study. The model was calibrated and validated against an average of 2005 through 2009 WCSC and LPMS data. These calibration and validation targets were selected primarily because the rate data was developed using the shipping characteristics for this time period[2], and this averaging also allows for a smoothing of the data to avoid individual year irregularities. This ADDENDUM also discusses the process and results of modification of the model's tow-size limit parameters for the development of shipping plans under an 1,200' x 110' Calcasieu system.

[1] WCSC does track empty barge flows, however, it is not reliable.

[2] Water routing rates were developed using the Barge Costing Model (BCM) using 2006 barge and towboat characteristics. Rail routing rates were developed off Surface Transportation Board (STB) 2008 carload waybill samples.

K.2.2 MODEL INPUT DATA SPECIFICATION AND AGGREGATION

The development of accurate input data, and the appropriate aggregation and classification of the input data to adequately describe the inland waterway system, is essential for correct calibration and operation of NIM. A large part the model's validity and credibility necessitates an adequate number of barge, towboat, port, and commodity classes to represent the existing and future transportation systems.

There are two primary sources of inland waterway transportation flow data: Waterborne Commerce Statistical Center (WCSC) and Lock Performance Monitoring System (LPMS) data, each with their pros and cons. Analyzing the historic system data from these two data sources drives the specification and aggregation of the model's input data for use in the Calcasieu Lock Replacement analysis. Given commonality of traffic between Calcasieu and the GIWW, the Calcasieu study area was defined as, and the GIWW NIM was loaded with, traffic flows in, out, or through one or more of the nine projects listed below:

- Calcasieu
- Leland Bowman
- Old River
- Port Allen
- Bayou Sorrel
- Bayou Boeuf
- Harvey
- Algiers
- Inner Harbor Navigation Channel

K.2.0.3 Waterway Network Specification

The topology of the inland waterway system is defined in GIWW NIM through a network which describes the characteristics of the transportation system's constituent ports, reaches, locks, and other components that affect towing operations and costs. The network is defined based on a set of nodes and links between the nodes, that is, a link-node network. Specifically this link-node network is defined with rivers, sectors, nodes, and links which define continuous stretches of waterway between the various types of nodes. FIGURE 1B.2.1 provides a graphical view of the network data relationships.

GIWW NIM's network is loaded with the nine navigation projects specified along with the loading and unloading nodes necessary to describe the data set traffic flows (which often move outside the GIWW). Navigation projects beyond the specified nine projects, however, were not included since a complete traffic set moving through these projects was not modeled. Additionally the loading and unloading node granularity is thin outside the GIWW given the distance and isolation of these areas of the waterway system with the Calcasieu study area movements.

The extent and location of junctions and ports within the GIWW NIM network is based on 2005 through 2007 Waterborne Commerce Statistics Center (WCSC) movements traversing Calcasieu Lock. The 2005-2007 time frame was chosen because it was the most recent data available after dropping years 2008 and 2009 since they were recessionary years. A three year time frame allows for smoothing of annual variability. As shown in FIGURE 1B.2.2, the extent of the network was extensive since the origins and destination of commodities moving through Calcasieu included St. Paul, MN on the Mississippi River; Pittsburgh, PA on the Ohio River; Chattanooga, TN on the Tennessee River; Brownsville, TX on the GIWW – West; and Panama City, FL on the GIWW – East. However, a few waterways such as the Missouri River, White River, and Kentucky River were not included in the network because they did not send or receive any commodities that traveled through Calcasieu. Port locations within the network were determined by plotting the origins and destination of commodities through Calcasieu in ArcMap 9.2 and identifying locations that would represent a reasonable estimation for all tonnage within a specified area. As expected, waterways which are farther away from Calcasieu received / sent less tonnage through Calcasieu than waterways near Calcasieu. Therefore, ports on the GIWW-W and waterways near Calcasieu required greater granularity and were located closer together than ports on waterways farther away such as the Ohio River.

FIGURE 1B.2.1 – Waterway Network Entities

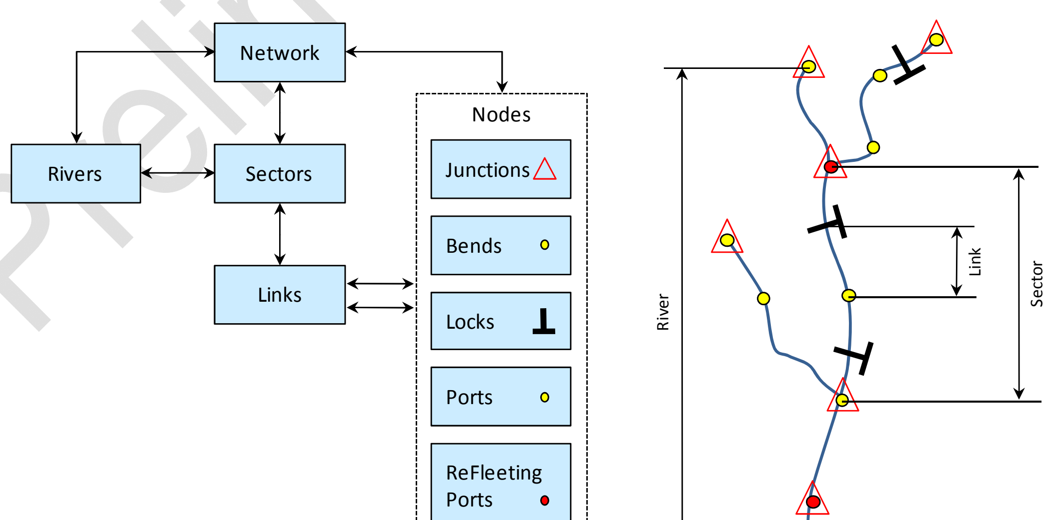
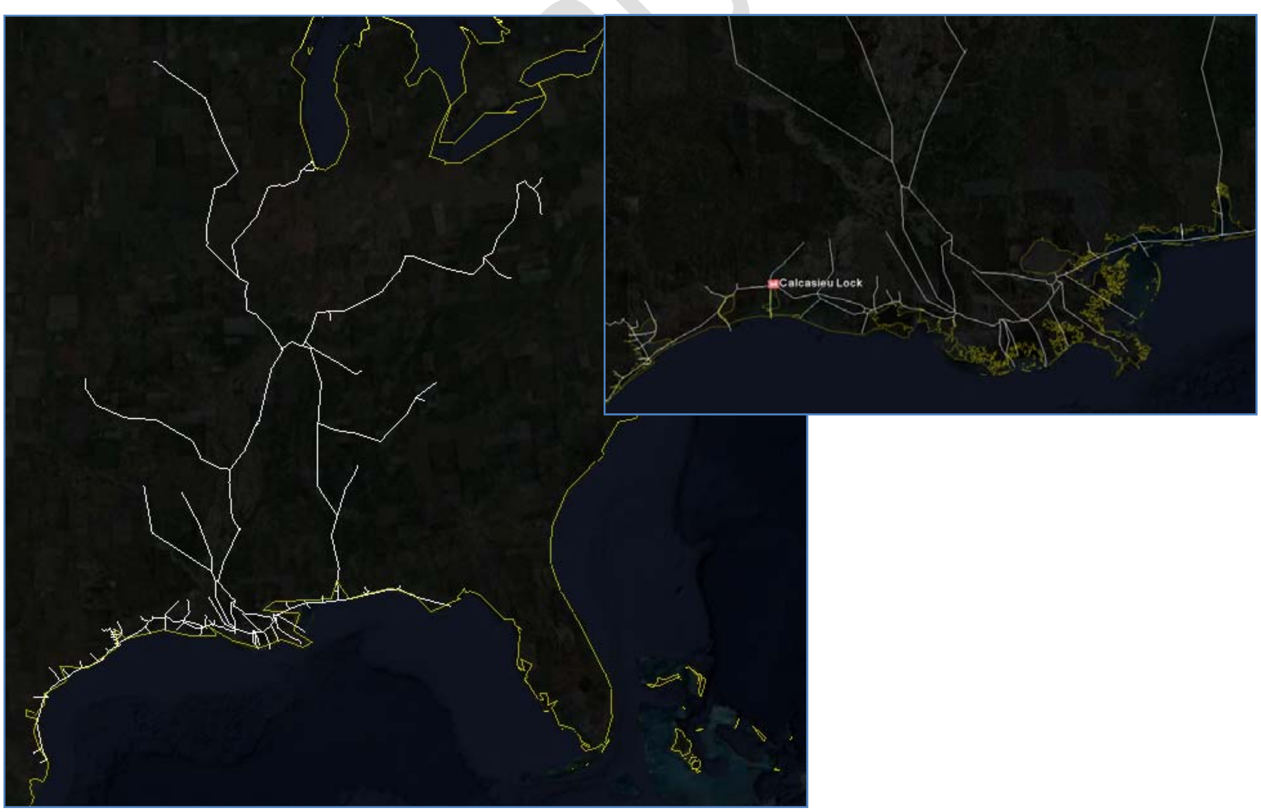


FIGURE 1B.2.2 – The GIWW NIM Waterway Network



K.2.0.0.1 Port Node Specification, Aggregation, and Characteristics

NIM requires at least one loading and unloading node in each navigation pool, however, in longer pools where traffic pickups and drop-offs are diverse, multiple nodes are often specified. The location of the loading and unloading node within a navigation pool is a tonnage weighted centroid.

In the model's identification of the least-cost shipping plans, time in port whether loading, unloading, fleeting, or re-fleeting is considered. The model allows specification of component times shown in TABLE 1B.2.1 for each port, however, in the current database, all ports are currently specified with the values shown. Barge types are designated as carrying one of three handling classes. Each handling class can have its own loading rate, unloading rate, and port delay time. In the Calcasieu study and in this calibration, only handling class 1 and 3 are utilized, where handling class 1 is for dry bulk and handling class 3 is for liquid[3].

TABLE 1B.2.1 – Port Characteristics

[3] In previous usage of NIM handling class 2 was used to track hazardous commodities.

Characteristic	Time *
Average Towboat Wait Time	4.4 hours per tow
Fleeting / Re-fleeting Time Per Tow	20 minutes per tow
Fleeting / Re-fleeting Time Per Barge	5 minutes per barge
Loading Rates	
Handling Class 1	0.13 minutes per ton
Handling Class 2	1.5 minutes per ton
Handling Class 3	0.27 minutes per ton
Unloading Rates	
Handling Class 1	0.22 minutes per ton
Handling Class 2	0.93 minutes per ton
Handling Class 3	0.39 minutes per ton
Port Delay	
Handling Class 1	0 hours per tow
Handling Class 2	0 hours per tow
Handling Class 3	0 hours per tow

** Ports can be specified individually, but all ports currently set with these values.*

As an example, say a 15 barge jumbo tow of dry bulk commodity with an average barge loading of 1,450 tons is being shipped. Origin port time will be calculated as 53.108 hours as shown below:

0.000 hours port delay

47.125	hours loading (15 barges x 1,450 tons/barge x 0.13 minutes/ton)
4.400	hours (waiting for a towboat)
1.583	hours fleeting (15 barges x 5 min/barge + 20 minutes)
53.108	hours at origin port

Similarly the destination port time will be calculated as 81.333 hours as shown below:

0.000	hours port delay
79.750	hours unloading (15 barges x 1,450 tons/barge x 0.22 minutes/ton)
79.750	hours at destination port

The hours at the port, however, should not be confused with the hours of equipment utilization. The model assumes: 1) sequential loading / unloading of the barges; 2) empty barges arrive as needed for loading; 3) towboat wait time starts once all barges are loaded and ready for fleeting; 4) the towboat is immediately released at the destination; and 5) barges are released once empty. As a result, at the origin and destination, each piece of equipment is cost for different times.

In this example, at the origin the first barge will be cost for 53.108 hours (port delay, loading, waiting for 14 other barges to load, waiting for towboat pickup, and fleeting), the second barge will be cost for 49.966 hours (port delay, loading, waiting for 13 other barges to load, waiting for towboat pickup, and fleeting), the third barge will be cost for 46.825 hours (port delay, loading, waiting for 12 other barges to load, waiting for towboat pickup, and fleeting), and so on. At the origin the towboat will only be cost for 1.583 hours (fleeting time).

In this example, at the destination the first barge emptied will be cost for 5.317 hours (port wait and unloading time), the second barge emptied will be cost for 10.633 hours (port wait, unloading time for previous barges and unloading time for the current barge), and so on. The last barge emptied will be cost for 79.750 hours. The towboat will be cost for 0 hours at the destination.

In summary, while total time in port (origin and destination) is 132.858 hours; each piece of equipment is cost with its unique utilization time. At the origin the towboat cost equation at the origin is simply the fleeting time (in this case 1.583 hours) multiplied by the hourly cost for the selected towboat class. The barge cost equation at the origin is:

$$\left[\left[\frac{\left[\frac{\text{no. of barges} \times (\text{no. of barges} + 1)}{2}\right] \times \text{barge loading in tons} \times \text{loading rate in minutes per ton}}{\text{60 minutes per hour}}\right] + \text{port wait time in hours} + \text{towboat wait time in hours} + \text{fleeting time in hours}\right] \times \text{Hourly barge cost} \qquad \text{(1B.2-1)}$$

Where fleeting time is number of barges x min./barge fleeting time + min./tow

At the destination the towboat cost always zero (even with a port delay time). The barge cost equation at the destination is:

$$\left[\left[\frac{\left[\frac{\text{no. of barges} \times (\text{no. of barges} + 1)}{2}\right] \times \text{barge loading in tons} \times \text{unloading rate in minutes per ton}}{\text{60 minutes per hour}}\right] + \text{port wait time in hours}\right] \times \text{Hourly barge cost} \qquad \text{(1B.2-2)}$$

In a re-fleeting situation where the shipping plan is upsized and/or downsized en route, the calculation is fairly similar. Say this shipment trip moves from a major river to a tributary river. At the mouth of the tributary the 15-barge tow is broke into three 5 barge tows for the remainder of the trip. As at the origin port, the towboat wait time starts once all barges are loaded and ready for fleeting, which at a re-fleeting point means that the towboat wait time begins when the tow arrives since all the barges are already loaded. This essentially assumes that the re-fleeting of the single tow into three tows is done simultaneously. There is no unloading and re-loading at the re-fleeting point meaning there is no unloading and re-loading time and as a result no port delay time. The re-fleeting time for a single 5 barge tow will be calculated as 5.150 hours as shown below:

4.400	hours (waiting for a towboat)
0.750	hours fleeting (5 barges x 5 min/barge + 20 minutes)
5.150	hours at the re-fleeting port for one 5-barge tow

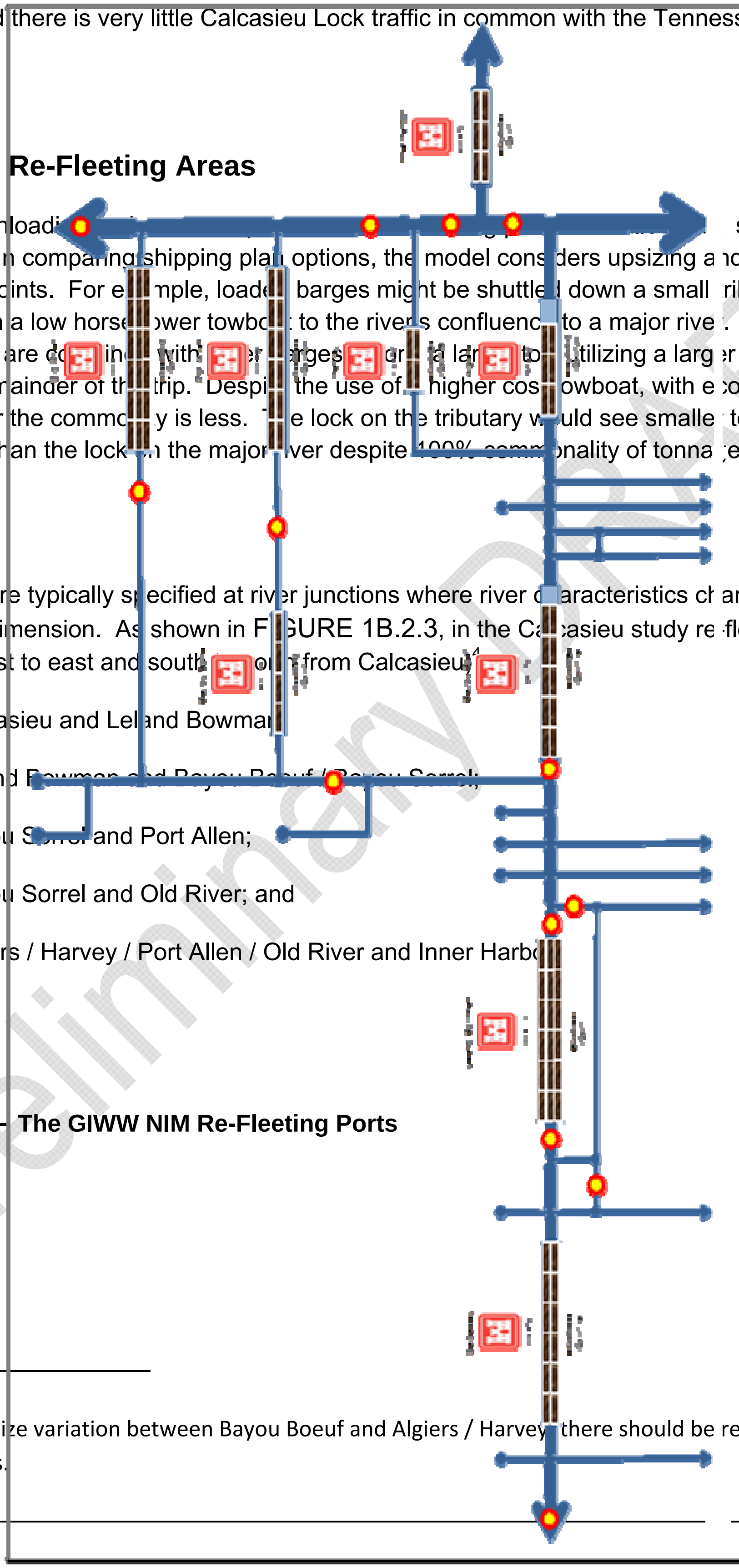
Each of the three new towboats (a smaller towboat than used to initially move the 15-barge tow) will be cost for re-fleeting (in this case 0.75 hours/tow). Each of the 15 barges will be cost for 5.150 hours.

K.2.1.1.2 **Navigation Project Characteristics**

Navigation projects are constraint points in the system and the transit times past these areas are represented by tonnage-transit curves relating an average tow transit time to an annual aggregate traffic level at the project. In the verification, calibration, and validation of the model's movement shipping plans, these tonnage-transit curves are not used. Instead, the model uses the observed transit time in the "*Targets*" database table (section K.2.1.1.1.20) as input for its calculations. Validation of the project tonnage-transit curves are done as part of project level capacity analyses and not part of this model verification, calibration, and validation. No further discussions of the navigation project characteristics are needed in this document.

K.2.1.1.3 **Other System Constraint Points**

A model node can be any constraint area in the waterway transportation system that affects towing operations and costs (e.g., bends). Other than navigation projects, no other significant constraint points are modeled. The lower Cumberland River has significant constraints, however, Kentucky Lock offers an alternate route and there is very little Calcasieu Lock traffic in common with the Tennessee or Cumberland Rivers.



K.2.1.1.4 Re-Fleeting Areas

Any loading and unloadi[illegible] shipping plan to change in route. In comparing shipping plan options, the model considers upsizing and downsizing tows at the re-fleeting points. For example, loaded barges might be shuttled down a small tributary river in a small tow-size with a low horsepower towboat to the rivers confluence to a major river. At the tributary mouth, the barges are [illegible] with [illegible] barges [illegible] a lar[illegible] to[illegible] utilizing a larger horsepower towboat for the remainder of the trip. Despite the use of a higher cost towboat, with economies of scale the cost per ton for the commodity is less. The lock on the tributary would see smaller tow-sizes and smaller towboats than the lock on the major river despite 100% commonality of tonnage between the locks.

Re-fleeting ports are typically specified at river junctions where river characteristics change and between locks of different dimension. As shown in FIGURE 1B.2.3, in the Calcasieu study re-fleeting options are allowed (going west to east and south [illegible] from Calcasieu)[4]:

- Between Calcasieu and Leland Bowman[illegible]
- Between Leland Bowman and Bayou Boeuf / Bayou Sorrel;
- Between Bayou Sorrel and Port Allen;
- Between Bayou Sorrel and Old River; and
- Between Algiers / Harvey / Port Allen / Old River and Inner Harb[illegible]

FIGURE 1B.2.3 – The GIWW NIM Re-Fleeting Ports

[4] Despite little tow-size variation between Bayou Boeuf and Algiers / Harvey there should be re-fleeting allowed between these locks.

K.2.1.4 Commodity Group Specification, Aggregation, and Costs

For modeling, the 269 WCSC data commodity codes have been grouped into nine major groups (TABLE 1B.2.2) reflecting major types of commodities with similar shipping characteristics and patterns.

TABLE 1B.2.2 – Commodity Groupings

Commodity Group	WCS 5-Digit Commodity Code
Coal	32100, 32210, & 32500
Petroleum	33411, 33412, 33419, 33421, 33429, 33430, 33440, 33450, 33510, 33521, 33523, 33525, 33530, 33540, 33590, & 34000
Crude Petroleum	33300
Aggregates	27230, 27310, 27322, 27323, 27330, 27340, 27350, 27910, & 29115
Grains	4100, 4200, 4400, 4520, 4530, 4600, 4700, 4800, 8120, 8130, 8140, 8150, 8190, 22220, 22230, & 22390
Chemicals	27210, 51111, 51112, 51113, 51114, 51119, 51121, 51122, 51123, 51124, 51125, 51126, 51127, 51129, 51131, 51132, 51133, 51135, 51136, 51137, 51139, 51140, 51211, 51212, 51213, 51215, 51216, 51217, 51219, 51221, 51222, 51224, 51229, 51231, 51243, 51299, 51371, 51372, 51373, 51377, 51378, 51379, 51382, 51389, 51391, 51451, 51452, 51454, 51461, 51471, 51473, 51482, 51483, 51484, 51569, 51612, 51614, 51615, 51616, 51617, 51623, 51624, 51625, 51699, 52210, 52221, 52222, 52224, 52226, 52229, 52231, 52232, 52234, 52252, 52253, 52254, 52261, 52262, 52263, 52264, 52266, 52269, 52310, 52322, 52329, 52331, 52332, 52341, 52349, 52359, 52363, 52379, 52381, 52383, 52431, 52494, 56211, 56213, 56216, 56217, 56219, 56221, 56222, 56229, 56231, 56239, 56291, 56292, 56293, 56294, 56296, 56299, 57000, 59110, 59721, 59733, 59771, 59810, 59840, 59864, 59890, & 59990
Ores and Mineral	27700, 27820, 27830, 27850, 27891, 27892, 27893, 27895, 27897, 27898, 27899, 28300, 28500, 28750, 28770, 28780, 28790, 28800, & 28910
Iron and Steel	28100, 28200, 67090, 67120, 67140, 67150, 67200, 67300, 67400, 67600, 67700, 67800, & 67900
All Others	55, 3500, 5420, 6110, 6150, 6190, 9894, 9898, 9899, 11101, 11200, 23100, 24610, 24620, 24700, 24890, 25090, 25120, 27861, 27862, 27869, 29220, 29299, 42000, 41130, 62000, 63400, 63500, 64150, 64200, 65400, 66110, 66120, 66130, 66181, 66183, 66200, 66330, 68200, 68300, 68400, 68600, 68700, 69000, 71100, 71200, 72000, 71600, 74120, 74130, 74180, 74200, 74300, 74400, 74500, 77000, 78100, 78200, 78300, 78400, 78620, 79100, 79200, 79300, 82000, 89100, 89900, 99910, 99920, & 99940

For specification of the shipping plan, the model requires cost data in order to determine the least-cost equipment utilization required to satisfy the demand. In this cost calculation the model considers an inventory holding cost. However, this cost plays very little into the model's selection of the shipping plan. This is primarily because the variation in inventory holding costs between shipping plans is minimal. Commodities transported on the inland waterway are predominately bulk low-value commodities and the costs of the equipment, primarily the towboat, outweigh the inventory holding costs. The inventory cost is calculated as 8% of the commodity value annually. For example a 1,500 ton jumbo barge loaded with the highest valued commodity at $1,056.68 / ton would have an inventory holding cost of $126,801.60 annually, or $14.475 / hour (compared with a towboat costing $200 to $1,000 / hour). Additionally, since the inventory holding cost is based on the time in the barge, the only difference in this time between shipping plans comes from variations in the towboat type and tow-size speed calculations, in re-fleeting time, and route length. The commodity values used in the inventory holding cost calculation are shown in TABLE 1B.2.3. The commodity values are dated, however, a contract is underway to update these values. As noted, these values will play very little in calibration and validation of the movement shipping plans.

TABLE 1B.2.3 – Commodity Group Values

Commodity Group	Value $ / ton (2007 price level)	Holding Cost Factor	Density (lbs / cu.ft.)
Coal	$ 36.40	0.08	62.40
Petroleum	$ 654.75	0.08	58.00
Crude Petroleum	$ 1,056.68	0.08	58.00
Aggregates	$ 9.58	0.08	58.00
Grains	$ 190.65	0.08	56.00
Chemicals	$ 707.91	0.08	58.00
Ores and Mineral	$ 187.79	0.08	57.00
Iron and Steel	$ 324.83	0.08	53.00
All Others	$ 94.56	0.08	53.00

SOURCE: Commodity Valuation Analysis for the Great Lakes, Mississippi-Ohio, and Columbia-Snake Waterway Systems, Upper Great Plains Transportation Institute North Dakota State University, 30 Novemeber 2009.

Additionally, there is a commodity density factor assigned to each commodity group. This density factor is used in an equation to determine the barge loading for each movement if a barge loading is not specified as input (see section K.2.1.25). The factor, expressed in pounds per cubic foot, relates the average density and loading characteristics of cargo in the commodity group to the density of water (62.4 pounds per cubic foot). The value specified is not the commodity density factor for the commodity itself, but represents a value used in calculating barge capacity. The capacity of a barge is a function of the density of the medium (water) displaced by the barge. This displacement depends on how high the cargo can be piled on the barge or on how tightly it can be packed to fully utilize the barge's usable draft. As a result, most bulk commodities should be specified with a density factor equal to the density of water (62.4 pounds per cubic foot). A slightly lower density factor is used for extremely light commodities or commodities with inefficient packing.

As will be discussed in section K.2.1.25, movement barge loadings are calculated externally and supplied as input to the model in the Calcasieu Study analysis. As a result, the commodity density factors are not used.

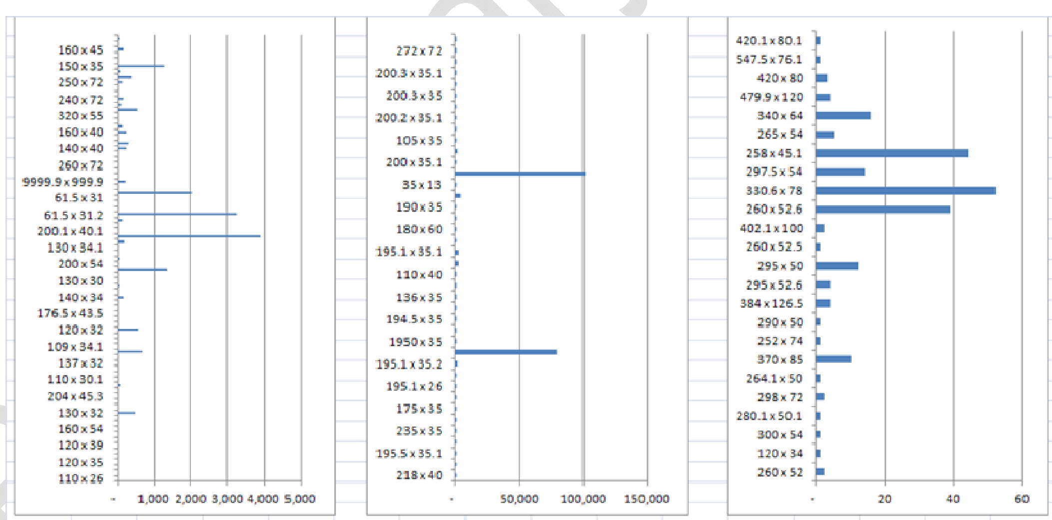
K.2.1.5 Barge Type Specification and Aggregation

NIM allows for a barge type (with its own cost and characteristics) to be specified on each movement. For the current effort, 2000-2010 GIWW WCSC data were summarized, analyzed, and then grouped into the modeling barge types for the Calcasieu study. In this WCS data set there were 145 uniquely dimensioned hopper barges (WCS vessel type 4) and 412 uniquely dimensioned tanker barges (WCS vessel type 2 and 5). The vessel dimension data, however, can be incorrect; e.g., a 1,950' x 35' hopper barge moving an average load of 1,500 tons. As a result the listing of barge dimensions was sorted by average loading for this grouping analysis.

The 145 unique vessel type 4 (hopper) barge length-widths were grouped into 3 hopper barge types as displayed in FIGURE 1B.2.4 (Note: x-axis scale is different for each barge type). The predominant hopper barge type by far is the jumbo barge. The jumbo barge measures 195'-200' x 35' depending upon whether the hopper is a box or has its ends raked. This barge type represents 84% of the hopper barges in the study area. A small hopper and a large hopper barge type were then added to bracket the jumbo hopper.

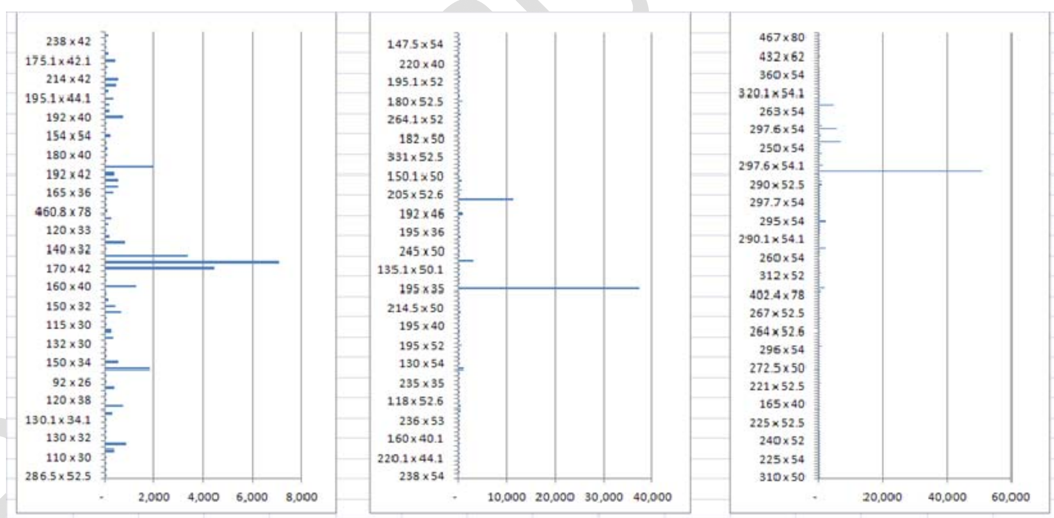
The 412 unique vessel type 5 (tanker) barge length-widths were also grouped into 3 tanker barge types as displayed in FIGURE 1B.2.5 (Note: x-axis scale is different for each barge type). Again, the predominant tanker barge type by far is the jumbo barge (195'-200' x 35'); representing 25% of the tanker barges in the study area. A small tanker and a large tanker barge type were then added to bracket the jumbo tanker.

FIGURE 1B.2.4 – ORS Barge Dimension Distribution Vessel Type 4 (Hoppers) 2000-2010



Barge Type	1	2	3
Mode	61.6x31.2	195-200x35	330.6x78
#Loaded Barges 2000-2010	7,112	180,594	52
Average Load	338	1485-1599	3,383

FIGURE 1B.2.5 – ORS Barge Dimension Distribution Vessel Type 5 (Tankers) 2000-2007



Barge Type	4	5	6
Mode	160x42	195-200x35	297.5x54
# Loaded Barges 2000-2010	7,068	51,594	50,906
Average Load	560	1,372	3,377

For these six barge types the summary data shown in TABLE 1B.2.4 were loaded into the model. The barge capacity, draft, and clearance data are a remnant of the barge loading calculations which are not currently used (since movement barge loading is summarized from the historic data). The blocking coefficient is used to calculate tow speed. Note that all barge types are set with the same blocking coefficient. The handling class allows specification of the loading and unloading rates at the loading and unloading ports (see section K.2.1.1.1).

TABLE 1B.2.4 – Barge Type Data

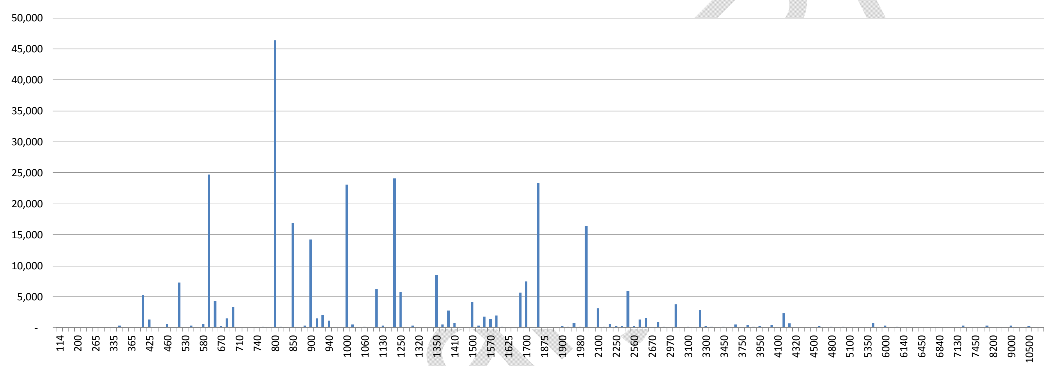
Barge Type	Handling Class *	Loading Capacity (tons)	Dimensions (ft)		Draft (ft)				Blocking Coefficient
			length	beam	Empty	Loaded	Maximum	Clearance	
Small Hopper	1	1,200	105	34	1.5	9.5	12	1	0.98
Jumbo Hopper	1	1,800	198	35	1.5	9.5	12	1	0.98
Large Hopper	1	8,000	267	66	1.5	9.5	12	1	0.98
Small Tanker	3	1,000	166	40	1.5	9.5	12	1	0.98
Jumbo Tanker	3	2,500	202	40	1.5	9.5	12	1	0.98
Large Tanker	3	6,000	295	54	1.5	9.5	12	1	0.98

** Handling class allows specification of different loading and unloading rates.*

K.2.1.6 Towboat Class Specification and Aggregation

A major component in the model's calculation of waterway transportation costs is towboat cost. The towboat fleet is summarized into a user specified number of towboat classes, each with its own cost and usage characteristics. The eight towboat classes were determined in the capacity analysis using LPMS data. A summary of the 2000-2010 Calcasieu study WCS data is shown in FIGURE 1B.2.6.

FIGURE 1B.2.6 – Towboat Horsepower Frequency Distribution 2000-2010



SOURCE: WCSC Detail and Master Vessel data.

For these eight towboat classes the summary data shown in TABLE 1B.2.5 were loaded into the model (also see sections 1A.1.1.1.1 and K.2.1.1.1.10). The dimensions, draft, blocking coefficient, and shaft horsepower are used in the speed calculation(s)[5]. The fuel consumption rates are used to calculate trip fuel consumption and hence trip fuel costs. The maximum tow-size limits the number of barges allowed in the shipping plan for each towboat class.

TABLE 1B.2.5 – Towboat Class Data

Towboat Type (rated HP)	Shaft Horse-power	Dimensions (ft)			Blocking Coefficient	Fuel Consumption Rates (gallons per hour)					Maximum Tow-size (# barges)
						Operating / Line-Haul Rates				Maneuvering Rate	
						Loaded Tow		Empty Tow			
		length	beam	draft		Up	Down	Up	Down		
0 - 800 HP Towboat	800	82	24	5.7	0.75	43	43	43	43	25	4
801 - 1500 HP Towboat	1,151	98	29	7.2	0.75	50	50	50	50	29	6
1501 - 1800 HP Towboat	1,651	115	30	8.0	0.75	64	64	64	64	37	9
1801 - 2400 HP Towboat	2,101	131	31	8.0	0.75	91	91	91	91	53	11
2401 - 3200 HP Towboat	2,801	141	35	7.8	0.75	135	135	135	135	79	14
3201 - 5000 HP Towboat	4,101	146	38	7.9	0.75	198	198	198	198	115	15
5001 - 5600 HP Towboat	5,301	162	42	8.0	0.75	222	222	222	222	129	25
5601 - 8400 HP Towboat	7,001	170	45	8.9	0.75	333	333	333	333	194	30

K.2.1.7 Equipment Costs

For comparison and selection of the least-cost movement shipping plans, the model requires cost data. As such, the equipment costs are critical in the model's determination of towboat type, tow-sizes, re-fleeting points, and ultimately the number of tow trips to move the tonnage. The latest Corps Economic Guidance Memorandum on shallow-draft vessel costs is EGM05-04[6] which has costs at a FY2004 price level. For this calibration effort this FY2004 cost data was indexed to a FY2005-2007 price level, as

[5] *There are actually two different speed functions coded in the model. Currently the original TCM calculation is used because the newer Maynord calculations are too CPU intensive.*

[6] *FY 2006 Shallow-draft vessel costs were completed but have yet to be finalized into an EGM.*

shown in TABLE 1B.2.6 and TABLE 1B.2.7, and discussed in the sections to follow. Note, for the analysis runs of the model, a current cost price level is used.

TABLE 1B.2.6 – Barge Cost Data (FY2005-2007 Price Level)

	Barge Type					
	Hoppers			Tankers		
Cost Category	Small (105' x 34')	Jumbo (198' x 35')	Large (267' x 66')	Small (166' x 40')	Jumbo (202' x 40')	Large (295' x 54')
FIXED COSTS:						
Replacement Cost	$ 196,722	$ 321,054	$ 486,283	$ 985,952	$ 815,956	$ 1,554,749
Utilization (days)	350	350	350	340	340	340
CRF 5.125% 20 yrs	$ 15,953	$ 26,036	$ 39,435	$ 79,956	$ 66,170	$ 126,083
Administration	$ 2,142	$ 4,460	$ 4,359	$ 11,059	$ 9,306	$ 12,975
Fixed Annual Capital Costs	$ 18,095	$ 30,495	$ 43,794	$ 91,015	$ 75,476	$ 139,057
VARIABLE COSTS:						
Maintenance & Repairs	$ 2,239	$ 3,700	$ 5,822	$ 19,161	$ 15,875	$ 30,119
Supplies	$ 172	$ 717	$ 614	$ 622	$ 562	$ 819
Insurance	$ 940	$ 1,424	$ 2,540	$ 10,013	$ 7,261	$ 19,965
Other	$ 489	$ 868	$ 649	$ 7,325	$ 6,877	$ 8,811
Annual Variable Costs:	$ 3,840	$ 6,708	$ 9,624	$ 37,120	$ 30,575	$ 59,714
Total Annual Costs:	$ 21,935	$ 37,203	$ 53,418	$ 128,135	$ 106,051	$ 198,772
HOURLY COSTS:						
Hourly Fixed Costs:	$ 2.15	$ 3.63	$ 5.21	$ 11.15	$ 9.25	$ 17.04
Hourly Variable Costs:	$ 0.46	$ 0.80	$ 1.15	$ 4.55	$ 3.75	$ 7.32
Avg. Hourly Costs:	$ 2.61	$ 4.43	$ 6.36	$ 15.70	$ 13.00	$ 24.36

SOURCE: EGM05-06 FY 2004 Shallow Draft Vessel Costs indexed to CY 2005-2007 using averaged BLS CPI Inflation Calculator and averaged FY 2005-2007 Federal Discount Rate of 5.125%.

The fuel costs shown in TABLE 1B.2.7 are for information only. The annual fuel costs are calculated based on one gallon per horsepower per day and the hourly fuel costs are based on fuel consumption equations defined in the EGM. Neither of these fuel consumption equations are used in NIM. Instead, NIM calculates fuel consumption on a movement basis using the fuel consumption rates shown in TABLE 1B.2.5 and based on movement trip time (differentiated between maneuvering and line-haul time). See section K.2.0.0.7 for a discussion of the fuel cost per gallon.

K.2.1.1.5 **Equipment Base Cost**

Here the base costs refer to the basic fixed and variable costs such as equipment replacement cost, wages, maintenance, etc. To adjust the costs, a 2005-2007 index was averaged using the BLS CPI Inflation Calculator. The Inflation Calculator showed an index of 1.0339 from 2004 to 2005, an index of 1.0672 from 2004 to 2006, and an index of 1.0976 from 2004 to 2007. As a result, the index applied to the FY2004 costs to estimate the costs at an average 2005-2007 price level was 1.06623; a 6.623% escalation in cost.

TABLE 1B.2.7 – Towboat Cost Data (FY2005-2007 Price Level)

	Towboat Hoursepower							
Cost Category	**800**	**1,151**	**1,651**	**2,101**	**2,801**	**4,101**	**5,301**	**7,001**
FIXED COSTS:								
Replacement Cost	$ 1,363,394	$ 1,740,355	$ 2,242,971	$ 2,745,586	$ 3,750,817	$ 5,949,761	$ 6,766,511	$ 10,598,954
Utilization (days)	340	340	340	340	340	340	340	340
Crew Size	5	5	6	6	7	8	9	10
CRF 5.125% 20 yrs	$ 110,565	$ 141,135	$ 181,894	$ 222,654	$ 304,173	$ 482,497	$ 548,732	$ 859,525
Administration	$ 77,409	$ 83,089	$ 90,659	$ 98,228	$ 113,367	$ 146,487	$ 158,787	$ 216,507
Fixed Annual Capital Costs:	$ 187,974	$ 224,224	$ 272,553	$ 320,882	$ 417,540	$ 628,984	$ 707,519	$ 1,076,032
VARIABLE COSTS:								
Wages	$ 311,556	$ 338,727	$ 374,957	$ 411,140	$ 483,644	$ 642,147	$ 701,018	$ 977,265
Fringe Benefits	$ 73,791	$ 80,226	$ 88,806	$ 97,387	$ 114,549	$ 152,088	$ 166,030	$ 231,458
Food & Subsistence	$ 16,397	$ 17,829	$ 19,736	$ 21,642	$ 25,456	$ 33,798	$ 36,897	$ 51,434
Trans. (to and from vessel)	$ 8,200	$ 8,914	$ 9,868	$ 10,821	$ 12,728	$ 16,899	$ 18,449	$ 29,172
Maintenance and Repairs	$ 124,627	$ 130,753	$ 138,921	$ 147,092	$ 163,427	$ 199,166	$ 212,440	$ 304,342
Supplies	$ 39,975	$ 41,940	$ 44,561	$ 47,178	$ 52,420	$ 63,885	$ 68,143	$ 97,619
Insurance	$ 47,030	$ 49,343	$ 52,424	$ 55,505	$ 61,672	$ 75,158	$ 80,168	$ 114,846
Other	$ 23,513	$ 24,669	$ 26,210	$ 27,754	$ 30,836	$ 37,579	$ 40,084	$ 57,423
Annual Variable Costs:	$ 645,089	$ 692,401	$ 755,483	$ 818,522	$ 944,733	$ 1,220,719	$ 1,323,228	$ 1,863,560
Total Annual Costs (less fuel)	$ 833,062	$ 916,625	$ 1,028,036	$ 1,139,404	$ 1,362,273	$ 1,849,703	$ 2,030,747	$ 2,939,592
Annual Fuel Costs ($2.052 / gal)	$ 558,061	$ 802,561	$ 1,151,349	$ 1,465,259	$ 1,953,562	$ 2,860,411	$ 3,697,502	$ 4,883,382
Annual Fuel (Waterway)Tax ($0.2 / gal)	$ 54,400	$ 78,234	$ 112,234	$ 142,834	$ 190,434	$ 278,834	$ 360,434	$ 476,034
~~Deficit Reduction Tax ($0.043 / gal)~~	~~$ 11,696~~	~~$ 16,820~~	~~$ 24,130~~	~~$ 30,709~~	~~$ 40,943~~	~~$ 59,949~~	~~$ 77,493~~	~~$ 102,347~~
Total Annual Costs (with fuel)	$ 1,457,219	$ 1,814,241	$ 2,315,750	$ 2,778,206	$ 3,547,212	$ 5,048,897	$ 6,166,177	$ 8,401,355
per hour --->	$ 178.58	$ 222.33	$ 283.79	$ 340.47	$ 434.71	$ 618.74	$ 755.66	$ 1,029.58
HOURLY COSTS (340 days):								
Hourly fixed costs	$ 23.04	$ 27.48	$ 33.40	$ 39.32	$ 51.17	$ 77.08	$ 86.71	$ 131.87
Variable costs, Labour	$ 50.24	$ 54.62	$ 60.46	$ 66.30	$ 77.99	$ 103.55	$ 113.04	$ 158.01
Other	$ 28.82	$ 30.23	$ 32.12	$ 34.01	$ 37.79	$ 46.05	$ 49.12	$ 70.37
Avg. Hourly Costs less fuel	$ 102.09	$ 112.33	$ 125.98	$ 139.63	$ 166.95	$ 226.68	$ 248.87	$ 360.24

K.2.1.1.6 **Equipment Capital Return**

Equipment capitalization and return on investment are calculated with an interest rate (typically the project evaluation and formulation Federal Discount rate. E.G. EGM 09-01, Federal Interest Rates for Corps of

Engineers Projects for Fiscal Year 2009) amortized over the equipment life (i.e., 20-years). To adjust the capitalization and return on investment costs to a 2005-2007 price level, an averaged FY2005-2007 Federal Discount Rate was used. With discount rates of 5.375%, 5.125%, and 4.875% for FY 2005, FY2006, and FY2007, the average Federal Discount Rate used was 5.125%.

K.2.1.1.7 Towboat Fuel Cost

Price data were obtained from the United States Department of Energy (USDOE) Energy Information Administration. To derive a 2005-2007 average fuel cost, monthly U.S. No. 2 low sulfur diesel fuel prices for Other End Users by All Sellers were averaged from October 2004 through September 2007. The average fuel price for this period was $2.052 per gallon. Adding the $0.20 per gallon waterway fuel tax and the $0.043 per gallon deficit reduction tax yielded a total fuel price of $2.2947 per gallon. A complication in calculation of movement fuel cost is that the waterway fuel tax is not applicable to all waterways, and as a result an additional database table is needed to specify on which waterway segments to collect fuel tax (see section K.2.1.1.1.4).

K.2.1.1.8 Model Input

While the cost data shown in TABLE 1B.2.6 and TABLE 1B.2.7 are quite detailed, only a total fixed annual and total hourly variable cost are needed for each equipment type or class. Cost data entered into the database are shown in TABLE 1B.2.8. It should be noted that the fuel costs are not entered. NIM calculates fuel consumption and fuel cost on a movement basis based on a calculated movement trip time (differentiated between maneuvering and line-haul), the fuel consumption rates shown in TABLE 1B.2.5, the user specified fuel cost (i.e. $2.0517 / gallon), and user specified fuel taxes (i.e. $0.20 / gallon waterway fuel tax and $0.043 / gallon deficit reduction tax).

TABLE 1B.2.8 – Equipment Cost Data

Barge Type	Variable Operating ($/hour)	Fixed Annual (000's)
Small Hopper	$ 0.46	$ 18.095
Jumbo Hopper	$ 0.80	$ 30.495
Large Hopper	$ 1.15	$ 43.794
Small Tanker	$ 4.55	$ 91.015
Jumbo Tanker	$ 3.75	$ 75.476
Large Tanker	$ 7.32	$ 139.057

Towboat Class	Begin Year	Cost: Hourly Costs: Labor Cost	Cost: Hourly Costs: Other Variable	Cost: Fixed Annual (000's)
0 - 800 HP Towboat	2005	$ 50.238	$ 28.817	$ 187,973.503
801 - 1500 HP Towboat	2005	$ 54.620	$ 30.233	$ 224,223.966
1501 - 1800 HP Towboat	2005	$ 60.462	$ 32.122	$ 272,553.141
1801 - 2400 HP Towboat	2005	$ 66.298	$ 34.011	$ 320,882.229
2401 - 3200 HP Towboat	2005	$ 77.987	$ 37.789	$ 417,540.492
3201 - 5000 HP Towboat	2005	$ 103.545	$ 46.052	$ 628,984.148
5001 - 5600 HP Towboat	2005	$ 113.039	$ 49.122	$ 707,518.992
5601 - 8400 HP Towboat	2005	$ 158.006	$ 70.371	$ 1,076,032.292

K.2.1.8 Movement Specification

Movement specification (i.e., origin, destination, commodity, barge type) is dictated by the network, commodity grouping, and barge type groupings discussed above. For the Calcasieu Lock analysis utilizing 2000-2010 historic WCSC data and three traffic forecast scenarios, 20,302 unique model-level movements were needed to define the un-aggregated dock to dock flows to the aggregated model network.

WCSC data, which serve as the source of the model's movement data, exist at a very detailed dock to dock, barge dimension, 5-digit commodity code level. The aggregation of this flow data not only requires aggregation of the origin and destination nodes, commodity groupings, barge types, and tonnages, but also requires weighted averaging of the rate data. Details of the data summarized and loaded into the model are discussed in Section K.2.1.1.10 and in Addendum A, GIWW NIM Movement Input.

K.2.1.9 Movement Barge Loading Specification

As the movement specification is dictated by the network, commodity grouping, and barge type groupings, the movement barge loading specification is dictated by the movement specification discussed above (i.e., which location-dock to location-dock 5-digit commodity code shipments are included in each modeled movement). The model determines the number of loaded barges in the system by dividing each movement's annual tonnage by each movement's average barge loading. The average barge loading for each movement can either be calculated internally to the model (using the barge dimensions and the commodity density factor) or it can be calculated externally and specified as an input.

NIM's barge loading calculation, and calibration, is discussed in section K.2.1.25, however, for the Calcasieu analysis the barge loadings were calculated externally to the model and supplied as an input. Since channel depths and barge loadings were not expected to change through the analysis period, or between the without and with-project conditions, externally calculating the barge loadings was the most straight forward and accurate method.

As the historic 2000-2010 WCSC data are aggregated from their detailed dock to dock levels to the model's network (section K.2.1.8), an average barge loading can also be tabulated. WCSC data include a "*trip*" field which is defined as the "*number of trips represented by one record*". The trip field is basically equivalent to the number of barges, and the movement tonnage can be divided by the movement number of trips to determine an average barge loading. Potentially distorting this barge loading average are partial trips which are coded as zero trips.

Specification of a movement (i.e., movementID in the MovementDetail table) barge loading (field "tonsPerBarge" in the MovementBarge table) is discussed in Addendum A, GIWW NIM Movement Input. Basically, prior to aggregation of the WCS data to the model-level, for each vessel dock-level movement the trips and tons were summed over years 2000 through 2010 and an average loading was calculated. If this loading was more than 10% greater than the vessel's capacity as specified in the NDC MASTER_VESSEL database, the average loading for the vessel dock-level movement was set to the vessel's capacity. Next, as the vessel dock-level movement file was aggregated to model-level movements, a simple average of the movement average loadings was carried forward into the model-level movement definition. In short, through time a weighted average for average barge loading was calculated, then across dock-level movements a simple average was calculated. Modeling level average barge loading (weighted by 2005-2007 tonnage) over the Calcasieu study area is shown in TABLE 1B.2.9.

TABLE 1B.2.9 – Weighted Average Barge Loading (2005-2007) by Modeling Barge Type

ID	Barge Type Name	Coal		Petroleum		Crude Petroleum		Aggregates		Grains		Chemicals		Ores and Mineral		Iron and Steel		All Others	
		Count	Loading	Count	Loading	Count	Loading	Count	Loading	Count	Loading	Count	Loading	Count	Loading	Count	Loading	Count	Loading
1	Small Hopper	*na*	*na*	90	417	*na*	*na*	3	1,486	26	417	1	12	*na*	*na*	369	390	216	230
2	Jumbo Hopper	699	1,600	581	1,651	*na*	*na*	5,255	1,597	321	1,595	575	1,546	5,012	1,551	3,165	1,453	2,449	1,452
3	Large Hopper	*na*	*na*	9	3,589	*na*	*na*	0	1,747	*na*	*na*	0	22,498	*na*	*na*	9	824	19	1,153
4	Small Tanker	*na*	*na*	254	627	2,099	646	*na*	*na*	*na*	*na*	26	1,234	553	522	*na*	*na*	43	443
5	Jumbo Tanker	1	1,443	1,773	1,638	891	1,446	2	1,730	*na*	*na*	4,136	1,611	41	1,060	17	1,475	436	1,413
6	Large Tanker	*na*	*na*	6,003	3,265	1,600	2,977	*na*	*na*	*na*	*na*	2,176	2,928	2	1,680	*na*	*na*	2	3,532

K.2.1.10 Commonality of Traffic Between Study Locks

Determination of the areas of the GIWW System that have the most in common with Calcasieu Lock traffic allows focus of model verification, calibration, and validation to areas that matter. There are two perspectives for quantifying the commonality of Calcasieu Lock traffic with the other river segments and navigation projects: 1) the amount or percentage of Calcasieu Lock traffic reaching these areas; and 2) the amount or percentage of Calcasieu Lock traffic transiting these areas. In other words, the distinction is the importance of these other areas to the Calcasieu Lock traffic versus the importance of Calcasieu Lock traffic to these other areas.

As shown in TABLE 1B.2.10, the majority of Calcasieu Lock traffic transits Leland Bowman Lock, while each of the remaining seven locks handles less than half of Calcasieu's traffic (Harvey Lock only processes only 2% of Calcasieu's traffic). The importance of Calcasieu traffic to the other projects, however, is much more significant. To over generalize, with the exception of Leland Bowman, Calcasieu is insulated somewhat from changes at the other seven locks, but these locks are not insulated from changes at Calcasieu Lock (i.e., over half of their traffic with the exception of Inner Harbor, is in common with Calcasieu Lock).

TABLE 1B.2.10 – Calcasieu Lock Commonality of Traffic Throughout the System

Navigation Lock Project	Project Tonnage	Calcasieu Lock Tonnage		
			Percentage	
		Tonnage	Through	Of
Study Project				
CALCASIEU L&D	39,859,863	39,859,863	100.0%	100.0%
Gulf Intercoastal Waterway				
ALGIERS L & D	24,229,648	14,835,088	37.2%	61.2%
BAYOU BOEUF L & D	25,771,594	16,498,306	41.4%	64.0%
BAYOU SORREL LOCK & DAM	22,247,067	17,258,383	43.3%	77.6%
HARVEY L & D	1,542,487	903,030	2.3%	58.5%
INNER HARDBOR LOCK & DAM	16,561,209	4,136,073	10.4%	25.0%
LELAND BOWMAN L & D	39,710,669	38,794,627	97.3%	97.7%
PORT ALLEN LOCK AND DAM	21,966,349	17,257,124	43.3%	78.6%
Old River				
OLD RIVER L & D	6,924,817	2,648,005	6.6%	38.2%

SOURCE: averaged 2005-2007 WCSC and LPMS data.

K.2.1.11 **Loading the NIM Input Files**

NIM data are stored in Microsoft SQL Server database tables which can be grouped into six broad categories: 1) system network, infrastructure, and equipment characteristics; 2) movement characteristics; 3) system tax and fee characteristics; 4) reliability characteristics; 5) investment options; and 6) analysis summaries. This section is not a complete itemization of all model input, but only the loading of input pertinent to: 1) specification, verification, and validation of the WSDM least-cost shipping plans; and 2) adjustment of the calibrated shipping plans for future lock size and barge fleet changes.

K.2.1.1.9 **System Network, Infrastructure, and Equipment Characteristics**

This category of data includes database tables describing: 1) the topology of the inland waterway network; 2) the characteristics of the system's constituent locks, ports, reaches, and other components that affect towing operations and costs; and 3) the characteristics and costs of towboat classes and barge types used for towing operations. The following eleven tables are used in the specification, verification, and validation of the WSDM least-cost shipping plans.

K.2.1.1.1.1 NetworkDefinition and NetworkVersion Tables

NIM allows storage and analysis of different networks for different river systems (TABLE 1B.2.11), and allows for storage and analysis of variations of each network (TABLE 1B.2.12). The Calcasieu study network is stored under network ID # 3.

TABLE 1B.2.11 – NetworkDefinition Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkName		Network name (e.g., Calcasieu Study GIWW)
baseYear		Year for base cost (e.g. 9999 equals 2005-2007 average)
comments		Additional description if needed (e.g., Network for Calcasieu Lock Replacement Feasibility Report)

The "*networkVersion*" is used to specify changes to the base network at a specified time in the planning period. These changes can occur from scheduled events such as a project already under construction being completed (e.g., Inner Harbor Lock replacement) or from events being analyzed by the model (e.g., 110' wide instead of 75' wide Calcasieu Lock). Currently in the model the nine network versions shown in TABLE 1B.2.13 are defined. Verification, calibration, and validation occurs using "*networkVersion*" 1.

TABLE 1B.2.12 – NetworkVersion Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion		Version ID (a variation of the network)
networkVersionName		Network name (e.g., Calcasieu 75'x1200')
comments		Additional description if needed (e.g., Calcasieu Lock with 75' x 1200' lock chamber)

TABLE 1B.2.13 – Network Versions (NetworkVersion Table Data)

networkID	networkVersion	networkVersionName	comments
3	1	Existing	Existing GIWW system configuration (Calcasieu with 75'x1206'x13')
3	2	Existing Future 1	Existing Calcasieu with Inner Harbor Lock replacement
3	3	Existing Future 2	Existing Calcasieu with Inner Bayou Sorrel Lock replacement
3	4	Existing Future 3	Existing Calcasieu with Inner Harbor & Bayou Sorrel replacements
3	5	Calcasieu 75'x1200'	Calcasieu Lock with 75' x 1200' lock chamber
3	6	Calcasieu 110'x1200'	Calcasieu Lock with 110' x 1200' lock chamber
3	7	Calcasieu 110'x1200' Future 1	Calcasieu 110' x 1200' with Inner Harbor Lock replacement
3	8	Calcasieu 110'x1200' Future 2	Calcasieu 110' x 1200' with Inner Bayou Sorrel Lock replacement
3	9	Calcasieu 110'x1200' Future 3	Calcasieu 110' x 1200' with Inner Harbor & Bayou Sorrel replacements

K.2.1.1.1.2 NetworkVersionSelection Table

Since the applicable network version can change through time, the timing of the network version is specified in the "*NetworkVersionSelection*" table. For example, "*networkVersion*" 1 represents the existing system. If no other projects (e.g., Inner Harbor) are coming online over the analysis period, then the without-project condition would be analyzed over the analysis period using "*networkVersion*" 1. If the with-project condition is replacement of Calcasieu with a 110' wide chamber in 2015, Inner Harbor is replaced in 2020, and Bayou Sorrel is replaced in 2025, then the model would be run with network version 1 to year 2015, network version 6 from year 2015 to 2020, network version 7 from year 2020 to 2025, and network version 9 from year 2025.

Again, in this verification, calibration, and validation exercise the model is exercised against a specific time period (in this case, an average of 2005 through 2007) and only one network version ("*networkVersion*" 1) is utilized.

K.2.1.1.1.3 Rivers Table

A river in the model's waterway network (FIGURE 1B.2.1) is a sequential string of sectors that represent the river. For "*networkID*" 3 105 rivers have been defined and stored in the "*Rivers*" table. The primary use of the data stored in this table is to allow output data rollup for summary reports.

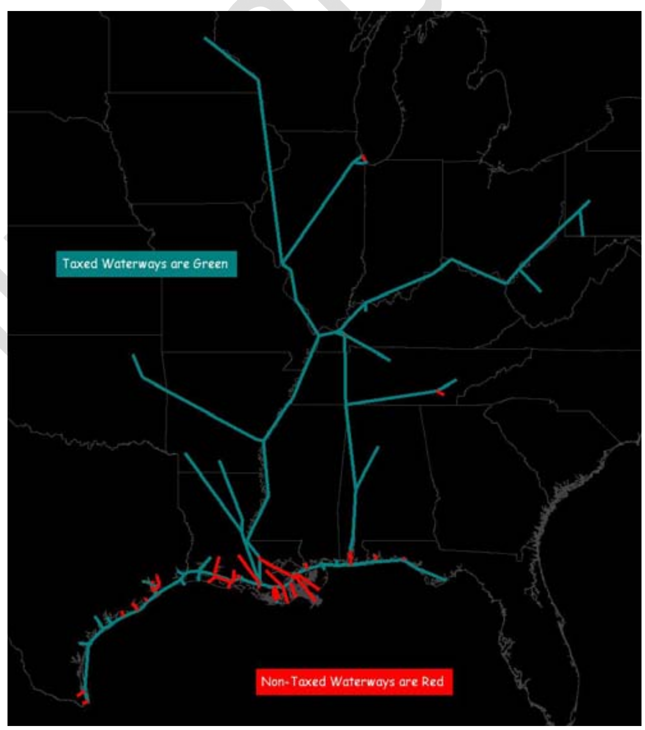
K.2.1.1.1.4 Sectors Table

A sector in the model's waterway network (FIGURE 1B.2.1) is a sequential string of links that represent segments of the waterway system. For "*networkID*" 3 197 sectors have been defined and stored in the "*Sectors*" table. Data stored in this table are shown in TABLE 1B.2.14. As discussed in section K.2.1.1.7 the current waterway fuel tax is not applicable to all waterways. Under existing law (33 U.S.C. 1804), the fuel tax is collected on twenty-seven specified waterways. These fuel tax waterways are identified in the model through the "*collectFuelTax*" field in the "*Sectors*" table. Of the 197 sectors, 56 have been specified as non-tax waterways as shown in FIGURE 1B.2.7.

TABLE 1B.2.14 – Sectors Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
sectorID		Interger ID used as key in other database tables
sectorName		Text name used for output report labeling
riverID		Integer cross reference ID to the Rivers table
collectFuelTax		(TRUE or FALSE) does IWUB fuel tax apply to this water segment
waterwayCode		WCSC WTWY used for summary report generation
Comments		Additional description if needed (e.g.,)

FIGURE 1B.2.7 – Non-Fuel Tax Waterways



K.2.1.1.1.5 Locks Table

NIM allows specification and storage of the navigation projects in the system network through the "*Locks*" table. Data stored in this table are shown in TABLE 1B.2.15. Primarily the table allows specification of a "*lockID*" for each project that can then be referenced as a key in other database tables where project specific data are stored. A text name and GIS coordinates are specified to facilitate report labeling and mapping. Additionally, for the auto shipping plan calibration programs (section K.2.1.1.31), a "*calibrationWeight*" field is specified for each lock in the system network. This lock calibration weight allows the calibration process to focus on projects important to the analysis (as specified by the user). For this Calcasieu Lock analysis, given the commonality of Calcasieu Lock traffic with the other eight locks (section K.2.1.10.):

- Calcasieu and Leland Bowman (which moves 97% of Calcasieu traffic) were set with lock calibration weight of 1.0;
- Bayou Boeuf, Bayou Sorrel, and Port Allen Locks were set with lock calibration weight of 0.8;
- Algiers Lock was set with lock calibration weight of 0.6;

- Inner Harbor Lock was set with lock calibration weight of 0.4; and
- Old River and Harvey Locks were set with lock calibration weight of 0.2.

TABLE 1B.2.15 – Locks Table Description

Database Field		Description
networkID	DB	River system network (3 = Calcasieu Study GIWW)
lockID	DB Key	Interger ID used as key in other database tables (WTWY code with mile point)
waterwayCode		NDC WTWY code
milepoint		WTWY integer mile point
lockName		Text name used for output report labeling
displayLockName		Text name used for output report labeling
lockGroup		Used to consolidate calibration statistics (i.e. Kentucky & Barkley L/Ds)
calibrationWeight		Used to identify primary projects for calibration
latitude		Latitude decimal degrees (used for display maps)
longitude		Longitude decimal degrees (used for display maps)
mainChamberLength		Main chamber length (ft) for output report labeling
mainChamberWidth		Main chamber width (ft) for output report labeling
auxChamberLength		Auxiliary chamber length (ft) for output report labeling
auxChamberWidth		Auxiliary chamber width (ft) for output report labeling
Comment		Additional description if needed (e.g., single lock chmb project)

K.2.1.1.1.6 Junctions Table

Junctions in the model's waterway network (FIGURE 1B.2.1) define sector endpoints, that is, the head and mouth of a river and points where tributaries enter the river. For networkID 3 185 junctions have been defined and stored in the "*Junctions*" table. Data stored in this table are described in TABLE 1B.2.16.

TABLE 1B.2.16 – Junction Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
junctionID		Unique integer junction ID used as key in other database tables
junctionName		Text name used for output report labeling
latitude		Latitude decimal degrees coordinate used for display maps
longitude		Longitude decimal degrees coordinate used for display maps
Comments		Additional description if needed (e.g.,)

K.2.1.1.1.7 Ports and PortsRefleeting Tables

Ports in the model's waterway network (FIGURE 1B.2.1) define the traffic pickup and drop-off nodes in the link-node network. For "*networkID*" 3 303 ports have been defined and stored in the "*Ports*" table. Data stored in this table are described in TABLE 1B.2.17. Additional discussion on the port parameters can be found in section K.2.1.1.1.

These traffic pickup and drop-off nodes are not always the ultimate waterside origin and destination for the traffic flows; the movement might simply re-fleet (switch towboats or re-group into a different tow-size). The definition of which ports allow this re-fleeting operation is handled in a separate "*PortsRefleeting*" table as shown in TABLE 1B.2.18. This is done in a separate table so that the assumptions regarding the re-fleeting points can be changed in an analysis without changing (or duplicating) the underlying port node definitions. As a result, the "*PortsRefleeting*" table contains a "*networkVersion*" ID while the "*Ports*" table does not.

TABLE 1B.2.17 – Ports Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
portID		Unique integer port ID used as key in other database tables
portName		Text name used for output report labeling
latitude		Latitude decimal degrees coordinate used for display maps
longitude		Longitude decimal degrees coordinate used for display maps
fleetTimePerTow		Time per tow to fleet barges to towboat
fleetTimePerBarge		Time per barge to fleet into tow (minutes)
loadRate1		Cargo handling class 1 load rate in minutes per ton
loadRate2		Cargo handling class 2 load rate in minutes per ton
loadRate3		Cargo handling class 3 load rate in minutes per ton
unloadRate1		Cargo handling class 1 unload rate in minutes per ton
unloadRate2		Cargo handling class 2 unload rate in minutes per ton
unloadRate3		Cargo handling class 3 unload rate in minutes per ton
portDelay1		Cargo handling class 1 port delay time in hours per tow
portDelay2		Cargo handling class 2 port delay time in hours per tow
portDelay3		Cargo handling class 3 port delay time in hours per tow
towboatWaitTime		Av. Hours barges wait for towboat pickup once loaded (hours)
comments		Additional description if needed (e.g., Port at Escatawpa RM 26)

TABLE 1B.2.18 – PortsRefleeting Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion		Network version (e.g., 0 = existing)
portID		Movement portID (Ports table) where re-fleeting is considered
comments		Additional description if needed (e.g.,)

K.2.1.1.1.8 Links Table

Links in the model's waterway network (FIGURE 1B.2.1) define the continuous stretches of waterway between the various types of nodes (e.g., ports and locks). For networkID 3 508 links have been defined and stored in the "*Links*" table. Data stored in this table are described in TABLE 1B.2.19.

It can be noted that node types ("*upNodeType*" and "*downNodeType*") are related to network nodes ("*upNodeID*" and "*downNodeID*") in this table since a node can be defined with multiple attributes. For example, the end of a river is often defined as a port where traffic can be loaded or unloaded and also as a junction representing the end of the sector. In this case, both a port node and a junction node would be defined, and the distance between them would be set to 0. River junctions offer an additional example. At a river junction, often traffic can be picked up or dropped off (loaded, unloaded, or re-fleeted) and three sectors merge.

TABLE 1B.2.19 – Links Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
sectorID		Sector ID (from Sectors table)
linkIndex		Link ID (sequentially numbered 1,n within each Sector)
upNodeType		Upstream node type (B=bend , J= junction ,L=lock , or P=port)
upNodeID		Upstream node ID (note, node types B, J, L, and P can all be defined with the same node ID)
downNodeType		Downstream node type (B=bend , J= junction ,L=lock , or P=port)
downNodeID		Downstream node ID (note, node types B, J, L, and P can all be defined with the same node ID)
length		Length in miles of the river segment (link).
currentSpeed		Speed of current (mph).
avgDepth		Average depth of the link in feet (used in speed function).
minDepth		Minimum depth of the link in feet (used in barge loading calculation).
upSpeedCoefficient		Upbound speed coefficient (used in speed function).
downSpeedCoefficient		Downbound speed coefficient (used in speed function).
Comments		Additional description if needed (e.g., Mobile River)

Most of the parameters defined in the "*Links*" table relate to the tow speed and trip time calculations discussed in section K.2.4, which ultimately influence the shipping plan selection.

K.2.1.1.1.9 BargeTypes and BargeTypeCost Tables

The "*BargeTypes*" and the "*BargeTypeCost*" tables (TABLE 1B.2.20 and TABLE 1B.2.21) hold the data discussed in section K.2.1.5 (TABLE 1B.2.4).

TABLE 1B.2.20 – BargeTypes Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
bargeTypeID		Unique barge ID used as key in other database tables.
bargeTypeName		Text name used for output report labeling
handlingClassCode		
capacity		
length		Typical barge length (in feet) in barge type class.
beam		Typical barge width (in feet) in barge type class.
emptyDraft		Typical empty barge draft (in feet) in barge type class.
loadedDraft		Typical loaded barge draft (in feet) in barge type class.
maxDraft		
clearance		
blockCoefficient		ratio of volume to length, width, & draft.
availability		fraction of time available for hauling.
comments		Additional description if needed

TABLE 1B.2.21 – BargeTypeCost Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
bargeTypeID	DB Key	Unique barge ID from BargeTypes table
beginYear	DB Key	First year cost is to be applied
varOpCost		Variable operating cost per hour (dollars)
fixedCost		Fixed annual cost (dollars)

1A.1.1.1.1 *TowboatType and TowboatTypeCost Tables*

The towboat class data presented in TABLE 1B.2.5 are loaded into the "*TowboatType*" table shown in TABLE 1B.2.22. The towboat cost data presented in TABLE 1B.2.7 are loaded into the "*TowboatTypeCost*" table shown in TABLE 1B.2.23. The "*beginYear*" field allows storage and use of different cost data, primarily for calibration to different years. Year "*9999*" was used to signify the 2005-2007 average.

TABLE 1B.2.22 – TowboatType Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
towboatTypeID	DB Key	Network version (1 = existing, 2 = 1200' UpperOH main chambers)
towboatTypeName		Text name used for output report labeling
ratedHorsepower		Rated horsepower of the towboat class
horsepower		Nominal hp reflecting hp delivered to the prop.
maxTowSize		Maximum no. of barges that can be pushed by the towboat class
length		Overall vessel length (feet)
beam		Overall vessel width (feet)
draft		Overall vessel draft (feet)
blockCoeffieient		Ratio of the vol of the hull to the product of the vessel length, width, & draft.
opFuelRateUpLoaded		Operating (line-haul) fuel consumption rate (gallons per hour)
opFuelRateDownLoaded		Operating up-bound loaded barge(s) tow fuel consumption rate (gallons per hour)
opFuelRateUpEmpty		Operating down-bound loaded barge(s) tow fuel consumption rate (gallons per hour)
opFuelRateDownEmpty		Operating up-bound empty barge(s) tow fuel consumption rate (gallons per hour)
manFuelRate		Operating down-bound empty barge(s) tow fuel consumption rate (gallons per hour)
availability		Maneuvering fuel consumption rate (gallons per hour)
displayColor		Proportion of year equipment class is available for towing service
Comments		Additional description if needed (e.g., 50)
propDiameter		Additional description if needed (e.g.,)
propPitch		Propeller diameter (inches) used for NAVPAT file generation.

TABLE 1B.2.23 – TowboatTypeCost Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
towboatTypeID	DB Key	Towboat Type ID (from BargeTypes table)
beginYear	DB Key	first year that the cost is in effect
laborCost		Labor cost ($/hour)
otherVarCost		Other variable costs ($/hour)
fixed Cost		Annual fixed costs
comments		Additional description if needed (e.g., 12/28/2011 VLL indexed EGM05-06 to 2005-2007 av.)

K.2.1.1.1.10 FuelCost Table

Fuel costs discussed in section K.2.1.1.7 are loaded into the "*FuelCost*" table as shown in TABLE 1B.2.24. NIM allows storage and analysis of different fuel costs by networkID by year. For this validation of the WSDM least-cost shipping plans, the existing GIWW network (i.e., networkID 3) is utilized along with the average 2005 through 2007 No. 2 low sulfur diesel fuel price. The "*beginYear*" and "*endYear*" fields allow specification of fuel costs to a specific year or years. Year "*9999*" was used to signify the 2005-2007 average.

TABLE 1B.2.24 – FuelCost Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
beginYear		first year that the price is in effect
endYear		last year that the price is in effect
fuelCost		cents per gallon fuel cost (no tax)
Comments		Additional description if needed (e.g., 12/28/2011 VLL av EIA 2005-2007 diesel #2 low-sulfur)

K.2.1.1.1.11 TowSizeLimits Table

A component of the movement shipping plans is the movement tow-size(s). If movement tow-sizes were set based solely on the physical limitations of the river and equipment, WSDM would tend to produce shipping plans with larger tows than historically observed, since WSDM calculates the resources required to satisfy the demand on a least-cost basis. To account for other factors that are considered in determining the shipping plan tow-size, the model contains a barge type tow-size limit calibration parameter that is specified at a river segment level (rather than at the movement level) and stored in the "*TowSizeLimits*" table as shown in TABLE 1B.2.25. When the model develops a shipping plan for a movement, it considers all the river segment restrictions in its route to find the bottleneck river segment (i.e., the minimum of "*maxTowSize*" along the route), along with the towboat class specific characteristics (e.g., "*maxTowSize*" in TABLE 1B.2.22).

TABLE 1B.2.25 – TowSizeLimits Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion		Network version (1 = existing, 2 = 1200' UpperOH main chambers)
sectorID		Sector ID (from Sectors table)
linkIndex		Link ID (from Links table, 0 specifies Sector level specification)
bargeTypeID		Barge Type ID (from BargeTypes table)
minTowSize		Minimum tow-size in/out/thru the link (number of barges per tow)
maxTowSize		Calibration maximum tow-size in/out/thru the link (number of barges per tow)
origMaxTowSize		
limitTowSize		Maximum tow-size in/out/thru the link (number of barges per tow)
comments		Additional description if needed (e.g., J 199900450 to J 199900030 Mobile River (0.7 miles) on WTWY 1999)

As discussed, river segments in the model network are defined as rivers, sectors, nodes, and links (FIGURE 1B.2.1). The tow-size limits and towboat class efficiency factors can be specified at the link level, however, these factors can also be set at the sector level. The "*linkIndex*" corresponds to the link ID in the "*Links*" table (TABLE 1B.2.19). When "*linkIndex*" is set to zero, the parameters are used for all links within a sector except for any link that is already set. In other words, a link specific specification will override any sector level specification.

While the river segment tow-size limits can be manually set and adjusted by the user, an automated calibration program called the Sector Tow-size Limits Calibrator was developed (see section K.2.1.27).

The user, or the Sector Tow-size Limits Calibrator, adjusts the "*maxTowSize*" field in the "*TowSizeLimits*" table. The "*limitTowSize*" parameter provides an upper bound for the "*maxTowSize*" field. The "*limitTowSize*" field is loaded by the user and is determined by calculating the maximum tow-size for the projects upstream and downstream from the river segment assuming a homogeneous barge type tow. For example, a river segment bounded by 1200' x 110' main chambers would have a "*limitTowSize*" for jumbo barges (195' x 35') of 17 barges per tow; 1,170' long by 105' wide in a knockout configuration with enough room for the towboat in the sixth row of barges.

The "*maxTowSize*" is calibrated by the model to observed data (i.e., 2005-2007 average targets). To develop shipping plans with a system containing larger lock chambers, these "maxTowSize" parameters are adjusted.

When an investment option increases (or decreases) chamber size, a separate "*networkVersionID*" is assigned and the appropriate "*maxTowSize*" adjustments are made. To minimize the duplication of data, only the limits for the changed chamber sizes are assigned a new "*networkVersionID*", all other limits revert to the base network version (i.e., "*networkVersion*" 1).

K.2.1.1.1.12 TowboatUtilization Table

Not only is the tow-size a major component of the movement shipping plans, but so is the towboat class utilized to move the barges. The towboat cost is a major component of the cost of a waterway shipment. If movement towboat types were chosen based solely on the physical capability of the equipment, WSDM would tend to produce tows with smallest towboat that could move the barges (i.e., the "*maxTowSize*" in the "*TowboatTypes*" table). This typically produces utilization of smaller towboats than historically observed, since WSDM calculates the resources required to satisfy the demand on a least-cost basis. To account for other factors that play into the shipping plan towboat class selection, the model contains a towboat efficiency calibration parameter that is specified at a river segment level (rather than at the movement level) and stored in the "*TowboatUtilization*" table as shown in TABLE 1B.2.26. When the model develops a shipping plan for a movement, it considers all of the towboat class specific characteristics including the maximum towboat tow-size and the towboat efficiency factor. Specifically the towboat efficiency factors for each river segment are multiplied by the towboat class maximum tow-size (TABLE 1B.2.25) to develop the river segment tow-size limits by towboat class.

TABLE 1B.2.26 – TowboatUtilization Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
sectorID		Network version (1 = existing, 2 = 1200' UpperOH main chambers)
linkIndex		Sector ID (from Sectors table)
towboatTypeID		Link ID (from Links table, 0 specifies Sector level specification)
networkVersion		Towboat Type ID (from TowboatTypes table)
capUtilFactor		proportion of the towboat's capability that can be utilized on the link
comments		Additional description if needed (e.g..)

Like the tow-size limits, the towboat class efficiency factors are specified at the link level, however, sector level settings can be specified. The "*linkIndex*" corresponds to the link ID specified in the "*Links*" table (TABLE 1B.2.19). When "*linkIndex*" is set to zero, the parameters for all links within a sector are specified the same except for any specific links which are already set. In other words, a link level specification will override any sector level specification.

While the river segment towboat efficiency limits can be manually set and adjusted by the user, an automated calibration programs called the Sector Towboat Efficiency Factor Calibrator was developed (see section **K**.2.1.27). The user, or the Sector Towboat Efficiency Factor Calibrator, adjusts the "*capUtilFactor*" field in the "*TowboatUtilization*" table. The "*capUtilFactor*" parameter specifies the proportion of the towboat class capability that can be utilized on the specified link. For example, if the "*capUtilFactor*" is set at 0.50 for a given link for "*towboatTypeID*" 5 (3,400 BHP) and as shown in TABLE 1B.2.5 the maximum tow-size is 14 barges per tow. Then the towboat would only be allowed to move up to a 7 barge tow through this link.

As with the "*TowSizeLimits*" table, a separate "*networkVersionID*" can be set up for any needed "*capUtilFactor*" adjustments. Again, to minimize the duplication of data, only the changes need to be specified with a new "*networkVersionID*"; all other utilization factors revert to the base network version (i.e., "*networkVersion*" 1). Typically, in adjusting the shipping-plans to a different chamber size the towboat utilization factors are not adjusted (only the tow-size limits are adjusted).

K.2.1.1.10 **Movement Characteristics**

This category of data includes database tables describing shipment data specifying the origin, destination, commodity group, annual tonnage (historic and forecasted), barge type, barge loading, barge transportation willingness-to-pay, shipper river closure response, and river closure response externality cost of existing and projected port-to-port commodity movements.

K.2.1.1.1.13 CommodityTypes Table

The commodity types and costs discussed in section K.2.1.4 (TABLE 1B.2.3) are loaded into the "*CommodityTypes*" table as shown in TABLE 1B.2.27. The data is stored at a "*networkID*" level.

TABLE 1B.2.27 – CommodityTypes Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
commodityID	DB Key	Unique commodity ID
commodityName		Commodity Name
value		Commodity value in $/ton (for inventory holding cost calculation)
holdingCostFactor		Percent of commodity value to charge as holding cost
density		Commodity density in lbs per cubic foot
displayColor		Color to use for output graphs
comments		Additional description if needed (e.g., 2007 NSDU 1-9 Group Av.)

K.2.1.1.1.14 Movement Classification Tables

The movement data discussed in section K.2.1.8 are defined through multiple database tables. Not only does the model's database structure allow for storage and use of various waterway networks and variations of each network, the model also allows for storage and use of multiple forecasted demand scenarios as well as variations of each of these defined forecasted demand scenarios.

1A.1.1.1.1.1 Forecast Table

The forecasted demand scenarios are defined in the "*Forecast*" table shown in TABLE 1B.2.28. As shown in TABLE 1B.2.29, the database contains definitions for three forecast scenarios. The "*forecastID*" of 0 is used to identify historic (observed) data in the database. The annual tonnage is stored by calendar year, but in the case of the historic data a year "*9999*" was generated to store an average of 2005-2007 data.

TABLE 1B.2.28 – Forecast Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
forecastID		Unique forecasted demand ID
forecastName		Forecast name
comments		Additional description if needed (e.g., GEC GIWW Calcasieu Forecasts dated Jan 2011)

TABLE 1B.2.29 – Forecast Scenarios (Forecast Table Data)

networkID	forecastID	forecastName	comments
3	0	na (forecastID for historic/actual flows)	year 9999 represents 2005-2007 average
3	1	Low GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011
3	2	Reference (Mid) GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011
3	3	High GEC GIWW Calcasieu Forecasts	GEC GIWW Calcasieu Forecasts dated Jan 2011

1A.1.1.1.1.2 MovementSet Table

To allow for additional delineation of the movement / forecasted demand scenarios (e.g., induced demand applicable for only certain transportation system configurations), it is further defined by a "*movementSetID*" in the "*MovementSet*" table shown in TABLE 1B.2.30. As shown in TABLE 1B.2.31, no variations in the movement sets have been defined for the Calcasieu analysis. Note, as in the "*Forecast*" table, "*movementSet*" 0 represents observed historic tonnages.

TABLE 1B.2.30 – MovementSet Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
movementSetID		Unique movement set ID
movementSetName		Movement set name
comments		Additional description if needed (e.g., base forecast routings)

TABLE 1B.2.31 – Movement Sets (MovementSet Table Data)

networkID	movementSetID	movementSetName	comments
3	0	Historic/Actual Routings	base forecast routings

Calcasieu study traffic has a routing option between the use of Kentucky and Barkley Locks. Often, if the primary study area has little traffic commonality with an area like Kentucky/Barkley (as is the case of the Calcasieu traffic), the modeling can be simplified by routing all Kentucky and Barkley traffic through one lock (i.e., Kentucky, with the Kentucky Lock tonnage-transit curve representing the capacity of both Kentucky and Barkley if tonnage-transit curves are modeled at those locks). While the Calcasieu study network (networkID # 3) was designed with Kentucky and Barkley routing options, the movement flows have not been simplified through the movement set ID (to date).

K.2.1.1.1.15 MovementDetail and MovementBarge Tables

The basic movement data discussed in section K.2.1.8 is loaded into the "*MovementDetail*" table. The barge type and barge loading information is placed in a separate "*MovementBarge*" table. This separation is done to allow changing of the movement barge type and loading assumptions (section K.2.1.9) by "*networkVersion*". As can be noted in TABLE 1B.2.13, the model is set up with network versions that not only allow for adjustment of tow-sizes in the system at user specified locations and under user specified investment options, but the network version also allows a change in barge types. The "*MovementDetail*" table is shown in TABLE 1B.2.32 and the "*MovementBarge*" table is shown in TABLE 1B.2.33.

When setting up a network version with barge type changes, currently all movements must be listed in the "MovementBarge" table under the specified network version, regardless of whether the barge type specification varies from the base network version ("*networkVersion*" 1). This duplicates data. In the future the model will be modified to allow only specification of the changes under the new network version (similar to the new network version in the "*TowSizeLimits*" and "*TowboatUtilization*" tables).

TABLE 1B.2.32 – MovementDetail Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
movementID		Unique movement ID
Origin		Movement origin portID (Ports table)
Destination		Movement destination portID (Ports table)
ForcedSec		Movement must be routed through this sectorID (Sectors table)
ForcedLk		Movement must be routed through this lockID (Locks table)
AvoidSec		Movement must not be routed through this sectorID (Sectors table)
Commodity		Movement commodityID group (CommodityTypes table)
WWLineHaul		Base waterway line-haul rate in dollars per ton
WWRate		Total base waterway rate in dollars per ton
AltRate		Base least-cost all-overland alternative rate in dollars per ton
WWExternality		Waterway externality cost in dollars per ton
AltExternality		Alternative routing externality cost in dollars per ton
Comment		Additional description if needed (e.g.,)

TABLE 1B.2.33 – MovementBarge Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion		River system network version (1 = Existing Calcasieu with Inner Harbor Lock replacement)
movementID		Unique movement ID
bargeTypeID		Movement bargeTypeID class (BargeTypes table)
tonsPerBarge		Movement average barge loading in tons

K.2.1.1.1.16 MovementTonnage Table

The yearly tonnage data are stored in the "*MovementTonnage*" table under the "*networkID*", "*forecastID*", "*movementSetID*", "*movementID*" (called in this table just "*ID*"), and year. TABLE 1B.2.34 shows the "*MovementTonnage*" database fields.

TABLE 1B.2.34 – MovementTonnage Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
forecastID	DB Key	Unique movement set ID (defined in table Forecasts)
movementSetID	DB Key	Unique movement set ID (defined in table MovementSets)
ID	DB Key	Unique movement ID
year	DB Key	Year
cargoAmount		Annual tonnage (observed for historic, forecasted for future)

K.2.1.1.1.17 Movement Willingness-to-Pay

For movements defined as inelastic, field "*AltRate*" of the "*MovementDetail*" table (TABLE 1B.2.32) defines the movement's willingness-to-pay. For movements defined as elastic, the willingness-to-pay is defined through four database tables which will not be discussed in this ADDENDUM since they do not factor into the specification, verification, and validation of the WSDM least-cost shipping plans or in the adjustment of the calibrated shipping plans for future lock size and barge fleet changes.

K.2.1.1.1.18 Movement River Closure Response

The movement river closure response data will not be discussed in this ADDENDUM since it does not factor into the specification, verification, and validation of the WSDM least-cost shipping plans or in the adjustment of the calibrated shipping plans for future lock size and barge fleet changes.

K.2.1.1.11 **System Tax / Fee Characteristics**

Included in this database table category are data specifying government cost recovery levels and cost recovery options such as lockage fees, barge fees, river segment tolls, and fuel taxes. NIM allows analysis of these various revenue generating policies, however, for this validation of the WSDM least-cost shipping plans, only fuel taxes are applicable. The following two tables are used in the specification, verification, and validation of the WSDM least-cost shipping plans.

K.2.1.1.1.19 FuelTaxPlan and FuelTaxPlanYear Tables

In WRDA 1978 Congress passed the first excise tax on inland waterway users of $0.04 per gallon (taking effect Oct 1980) and rising to $0.10 per gallon in 1986[7]. WRDA 1986 then mandated that the tax increase to $0.20 per gallon by 1995[8]. Fuel taxes actually peaked over 1998 through 2004 at $0.253 per gallon with an additional Deficit Reduction Tax of $0.043 and a Leaking Underground Storage Tank (LUST) tax of $0.01 per gallon. Fuel tax has since dropped to the current $0.20 per gallon after the LUST tax expired 1 January 2005 and the deficit reduction tax expired 1 January 2007. Over the 2005 through 2007 period, the average fuel tax was 22.9 cents per gallon (24.3 cents in years 2005 and 2006, and 20 cents in year 2007).

NIM allows storage and analysis different fuel taxes by year (tax plan) by networkID. In the "*FuelTaxPlan*" table (TABLE 1B.2.35) the various tax plans are assigned an ID so that the yearly tax data can be stored in the "*FuelTaxPlanYear*" table (TABLE 1B.2.36). For this validation of the WSDM least-cost shipping plans, the existing Calcasieu network (i.e., networkID 3) is utilized and the existing tax law is defined and stored under fuelTaxPlanID 1. Data loaded into the "*FuelTaxPlanYear*" table are shown in TABLE

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[7] *Inland Waterways Revenue Act of 1978 (Public Law 95-502, October 21, 1978), Sections 203 and 204. Section 202 specifies the amount of tax and certain exemptions, and Section 206 specifies the waterways where the tax applies.*

[8] *Water Resources Development Act (WRDA) of 1986 (Public Law 99-662, November 17, 1986), Section 1405. Section 1404 amends the two sections in the earlier act to increase the amount of fuel tax and to add the Tennessee-Tombigbee Waterway to the waterways where the tax applies.*

1B.2.37. A "*beginYear*" and "*endYear*" of 9999 is used to identify the average 2005-2007 fuel tax (i.e., 22.9 cents).

TABLE 1B.2.35 – FuelTaxPlan Table

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
fuelTaxPlanID	DB Key	Fuel tax plan ID from FuelTaxPlan table.
fuelTaxPlanName		Description of the fuel tax plan.

TABLE 1B.2.36 – FuelTaxPlanYear Table

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
fuelTaxPlanID	DB Key	Tax plan (1 = existing tax law)
beginYear	DB Key	first year that the cost is in effect
endYear		last year that the cost is in effect
fuelTax		cents per gallon fuel tax
Comments		Additional description if needed (e.g., Av.2005-2007 taxes (VLL 12/30/2011))

TABLE 1B.2.37 – Fuel Tax Plan Year Table (FuelTaxPlanYear Table Data)

networkID	fuelTaxPlanID	beginYear	endYear	fuelTax	Comments
3	1	1990	1990	12	11 cents IWATF + 1 cent Leaking Underground Storage Tank (LUST Tax)
3	1	1991	1991	14	13 cents IWATF + 1 cent LUST
3	1	1992	1992	16	15 cents IWATF + 1 cent LUST
3	1	1993	1993	18	17 cents IWATF + 1 cent LUST
3	1	1994	1994	20	19 cents IWATF + 1 cent LUST
3	1	1995	1995	21	20 cents IWATF + 1 cent LUST
3	1	1996	1997	24.3	20 cents IWATF + 4.3 cents deficit reduction tax (DRT)
3	1	1998	2004	25.3	20 cents IWATF + 1 cent LUST + 4.3 cents DRT
3	1	2005	2006	24.3	
3	1	2007	2070	20	
3	1	9999	9999	24.63333333	

K.2.1.12 Model Calibration Targets

The calibration targets represent lock performance statistics that the model should replicate in order to be considered verified and validated. The model was calibrated and validated against an average of 2005 through 2007 WCSC and LPMS data. This is often done because the rate data survey assumptions (shipping characteristics for this time period analyzed) vary, and this averaging allows for a smoothing of the data to avoid individual year irregularities. Development of the targets, unfortunately, is not straightforward as discussed in the sections below.

K.2.1.1.12 Lock Tonnage Target

As noted, the calibration targets are lock performance statistics. While the movements are loaded as origin to destination traffic, the tonnage past each navigation project is easily tabulated. There are two data sources for target lock tonnage statistics; WCSC and LPMS. Since the model is supplied origin to destination tonnage flows derived from WCSC data, the lock tonnage targets were derived from averaging 2005 through 2007 WCSC origin to destination flows and then tabulating the tonnage past each navigation project. Since the origin to destination traffic data loaded into the model comes from the same data source as the lock tonnage targets, there is no reason that the model will not hit these targets. As a result, this target serves as a verification test (rather than a validation test).

The lock tonnage targets, their comparison to model output, and discussion on how the LPMS lock tonnage statistics are compared against the WCSC data, can be found in section K.2.1.13.

K.2.1.1.13 Lock Number of Loaded Barges Target

The origin to destination tonnage flows in the model are converted to loaded barge trips, which can then be used to tabulate the number of loaded barges transiting each navigation project. The model has the capability to calculate barge loadings for each movement based on depth restrictions enroute, the barge type loading capacity, the commodity density, and a barge draft calculation. However, since the data are available, the model is supplied a barge loading for each movement. As a result, the model calculates the required number of barge trips to move the tonnage by dividing the annual tonnage by the average barge loading.

Again there are two data sources for the target number of loaded barges through each navigation project; WCSC and LPMS. Again, since the model is supplied origin to destination tonnage flows derived from WCSC data, and since the WCSC data includes a number of trips field, the movement average barge loading supplied to the model and the target number of loaded barges through each navigation project were derived from averaging 2005 through 2007 WCSC data. Since the origin to destination tonnage and average barge loading loaded into the database comes from the same data source as the lock number of loaded barge targets, there is no reason that the model will not hit these targets. As a result, this target also serves as a verification test (rather than a validation test). If the barge loading feature is exercised, this comparison test would convert to a validation test.

The loaded barge targets, and their comparison to model output, can be found in TABLE 1B.3.2.

K.2.1.1.14 Lock Number of Empty Barges Target

The derivation of the target number of empty barges through each navigation project is not as straightforward as the tonnage and loaded barge targets. As discussed in section K.2.1.26, a movement level barge dedication factor is set (either manually or automatically) specifying how dedicated the loaded barges are to the movement. As a result, comparison of the model empty barge results against the empty barge target is a true validation test.

The lock number of empty barges target was developed by the equation below. By taking the minimum of either 1 or the LPMS empty to loaded barge ratio, the target is capped to no more than 50% empty. While a percent empty greater than 50% would appear unsustainable in the long-run, it could occur, however it is rare. NIM, however, is not capable of generating empty barge movements for reasons other than supplying barges for loaded flows.

$$\text{Lock No. of Empty Barges} = \text{MIN}\left(1 \;,\; \frac{\text{LPMS No. of Empty Barges}}{\text{LPMS No. of Loaded Barges}} \right) \times \text{Target No. of Loaded Barges} \qquad (1B.2\text{-}3)$$

K.2.1.1.15 Lock Number of Tows Target

The lock number of tows target was developed by the equation below. Since the movement empty back-haul (number of empty barges) and tow-size are estimated by the model, the comparison of the model number of tows results against the tow targets is a validation test.

$$\text{Lock No. of Tows} = \frac{\left(\text{Target No. of Loaded Barges} + \text{LPMS No. of Empty Barges}\right)}{\text{LPMS Av. Barges per Tow}} \qquad (1B.2\text{-}4)$$

K.2.1.1.16 Lock Average Tow Processing and Delay Time Targets

Transit times (processing and delay) past locks in the system are represented by tonnage-transit curves relating an average tow transit time to an annual aggregate traffic level at the project. In the verification, calibration, and validation of the model's movement shipping plans, however, these tonnage-transit curves are not used. Instead, the model uses the observed (target) transit time in the "*Targets*" database table (K.2.1.1.1.20) as input in its calculations. Validation of the project tonnage-transit curves are done as part of project level capacity analyses and not part of this model verification, calibration, and validation. Storage of the transit times in the "Targets" table is a misnomer. The storage of a delay time separate from the processing time is a remnant of older modeling where the processing time was fixed and a tonnage-delay curve (rather than a tonnage-transit time curve) was used. Fixing the processing time was abandoned since processing time can increase as congestion increases at dual chamber projects as a result of chamber interference and in situations where the auxiliary chamber is smaller than the main (and gets increased usage as traffic levels increase).

K.2.1.1.17 Lock Average Towboat Horsepower Target

The lock average horsepower targets were calculated from 2005 through 2007 LPMS data utilizing horsepower data from a 2008 inland vessel directory developed by CEIWR-GW under the NETS program NaSS project. This IWR vessel directory consolidated LPMS Vessels, WCSC Master Vessel, Coast Guard PSix, and Inland River Record data.

As discussed in section K.2.1.6, the model summarizes and simplifies towboats into eight horsepower classes (TABLE 1B.2.5). As a result, since the model averages the horsepower classes rather than the vessel horsepowers themselves, the targets need to be similarly developed. A comparison of the vessel averages (average of all vessel horsepowers) with the vessel class averages (weighted average of the towboat class frequencies) for the nine locks included in the Calcasieu Lock analysis is shown in TABLE 1B.2.38.

TABLE 1B.2.38 – Average Horsepower versus Towboat Class Average Horsepower

Navigation Lock Project	Average Project Rated Horsepower (LPMS)			
	Actual	Towboat Class Av.	Difference HP	Difference Percentage
Study Project				
CALCASIEU L&D	1,495	1,499	4	0.3%
Gulf Intercoastal Waterway				
ALGIERS L & D	1,433	1,463	30	2.1%
BAYOU BOEUF L & D	1,160	1,251	91	7.8%
BAYOU SORREL LOCK & DAM	1,759	1,710	-48	-2.7%
HARVEY L & D	1,033	1,134	101	9.8%
INNER HARDBOR LOCK & DAM	1,492	1,532	40	2.7%
LELAND BOWMAN L & D	1,450	1,471	22	1.5%
PORT ALLEN LOCK AND DAM	1,655	1,622	-33	-2.0%
Old River				
OLD RIVER L & D	1,828	1,802	-25	-1.4%

K.2.1.1.18 Loading the NIM Target Files

NIM target data are also stored in Microsoft SQL Server database tables, as discussed below.

K.2.1.1.1.20 Targets Table

The majority of the target data are stored in the "*Targets*" table shown in TABLE 1B.2.39. The "*year*" field allows storage of different years for calibration. In this verification, calibration, and validation a 2005 through 2007 system average was used and stored as year 9999.

TABLE 1B.2.39 – Targets Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion	DB Key	Network version (0 = existing, 1 = Existing Calcasieu with Inner Harbor Lock repl.)
year	DB Key	Applicable year (9999 = 2005 through 2007 average)
lockID	DB Key	Lock ID (from Locks table)
lockName		Text name used for output report labeling
loadedBarges		Target # of loaded barges (WCSC)
emptyBarges		Target # of empty barges (est from WCSC loaded & LPMS % empty)
delayTime		Target av. tow delay time in min (LPMS av 2005-2007)
processingTime		Target av. tow processing time in min (LPMS av 2005-2007)
tonnage		Target tonnage (WCSC)
tows		Target # of tows (est from target loaded & empty barges, & LPMS barges per tow)
horsepower		Target av. Horsepower (LPMS)
comments		Additional description if needed (e.g.,)

K.2.1.1.1.21 TargetTowSizeDistribution Table

Additional target data on tow-size distributions are stored in the "*TargetTowSizeDistribution*" table shown in TABLE 1B.2.40. The "*year*" field allows storage of different years for calibration. In this verification, calibration, and validation a 2005 through 2007 system average was used and stored as year 9999.

TABLE 1B.2.40 – TargetTowSizeDistribution Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion	DB Key	Network version (1 = existing, 2 = 1200' UpperOH main chambers)
lockID	DB Key	Lock ID (from Locks table)
year	DB Key	Applicable year (9999 = 2005 through 2007 average)
towSize	DB Key	Tow size in number of barges per tow (integer)
distribution		Proportion of tows of tow-size towSize (0-1.0)

K.2.3 INPUT VERIFICATION

While model verification is the determination that the model's code performs as intended, the focus here is more on input data verification to guard against "*Garbage in, Garbage out*" results.

K.2.1.13 Lock Tonnage Verification

Since WCSC data contains waterside origin to destination information, it is used to develop the traffic demand forecasts and is used to develop the GIWW NIM movements. WCSC data are collected from shippers monthly, and contain specific: waterside origin and destination location; routing; commodity type classification; tonnage; number of trips; barge type (hopper or tanker) and barge dimensions. Determination of which navigation projects transited, and total project tonnages, must be deduced. Statistics on the number of loaded barges between the origin and destination locations, and loaded barge counts at the navigation projects must also be calculated. The WCSC movement number of trips is essentially equivalent to the number of barges. However, partial trips are coded as "*0 trips*" and can distort the estimation of the number of loaded barges moving in the system.

LPMS data are collected at the navigation projects, and contain vessel counts by direction and time. Loaded barge counts are considered quite accurate, however, barge tonnages are often rounded and as a result tonnages transiting the locks are only estimates.

These two data sets rarely match. While LPMS barge loadings are often rounded, the discrepancy occurs primarily because of underreporting in the WCSC data.

K.2.1.1.19 Input Tonnage (WCS) Verification Against LPMS Data

For model calibration and for this verification step, an average of 2005 through 2007 WCSC and LPMS data was used. Newer data (2008 and 2009) was considered inappropriate given the December 2007 through June 2009 recession. This averaging allows for a smoothing of the data to avoid individual year irregularities. Additionally, the fleet and shipping characteristics for the time period selected should match as well as possible the time period and assumptions imbedded in the rate data, or more importantly in the demand elasticity estimates.

As shown in TABLE 1B.3.1, the WCSC tonnage data are relatively close to the LPMS tonnage data. Rarely do these two databases match. Even without underreporting in the WCS system, tonnages in LPMS are often estimated and rounded when entered at the lock projects. Still, tonnage differences at Harvey, Old River, and Port Allen Locks are significant. When comparing the number of WCSC loaded barges with the LPMS number of loaded barges, however, the differences between the two databases become more significant. This is particularly true for the Harvey and Inner Harbor projects with 59% to 62% of the loaded barges apparently missing.

TABLE 1B.3.1 – Comparison of Input Tonnage and Loaded Barges to LPMS Data

Navigation Lock Project	Tonnage				Number of Loaded Barges			
	WCSC	LPMS	Difference Tonnage	Difference Pct.	WCSC	LPMS	Difference Number	Difference Pct.
Study Project								
CALCASIEU L&D	39,875,410	41,714,926	-1,839,516	-4.4%	19,284	21,931	-2,648	-12.1%
Gulf Intercoastal Waterway								
ALGIERS L & D	24,233,824	25,325,433	-1,091,609	-4.3%	11,679	14,821	-3,143	-21.2%
BAYOU BOEUF L & D	25,799,444	25,909,708	-110,264	-0.4%	17,262	16,937	325	1.9%
BAYOU SORREL LOCK & DAM	22,247,067	24,122,542	-1,875,476	-7.8%	13,013	13,598	-585	-4.3%
HARVEY L & D	1,542,491	1,783,465	-240,975	-13.5%	741	1,816	-1,075	-59.2%
INNER HARDBOR LOCK & DAM	16,563,062	16,800,271	-237,209	-1.4%	3,622	9,568	-5,946	-62.1%
LELAND BOWMAN L & D	39,726,023	41,777,099	-2,051,076	-4.9%	19,742	22,820	-3,078	-13.5%
PORT ALLEN LOCK AND DAM	21,966,349	25,281,185	-3,314,836	-13.1%	11,802	14,380	-2,577	-17.9%
Old River								
OLD RIVER L & D	6,925,484	8,101,971	-1,176,487	-14.5%	3,622	4,667	-1,045	-22.4%

SOURCE: averaged 2005-2007 WCSC and LPMS data.

Remember that the WCS data defines an origin to destination barge movement, and a not specific number of transits past a specified point. The WCS number of barges past a lock is calculated off the WCS “trip” field. In a WCS record that identifies a movement as having 2 trips, it is assumed that there were 2 barges transiting each point along the origin to destination route.

For barge trips in which the barge is partially emptied midway between the movement’s origin and final destination, the barge movement is recorded as three separate movements: origin to midpoint, midpoint to destination, and origin to destination. The origin to midpoint trip reports the tonnage that was loaded onto the barge at the origin and was unloaded at the midpoint. This counts as one trip. The midpoint to destination trip reports 0 tonnage since no additional tonnage is being shipped from the midpoint to the destination. This counts as a second trip. The origin to destination trip reports the tonnage that was loaded at the origin and unloaded at the destination. This trip is regarded as a "0" trip because the trips from origin to midpoint and midpoint to destination have already covered the distance that this trip does, so including it as a third trip would double-count that distance. The result of this methodology is one trip with partial tonnage, one trip with 0 tonnage, and one non-trip with partial tonnage, which can cause confusion when looking for loaded and unloaded barge data. For example, a loaded barge going from the midpoint to the destination would appear as an empty barge (0 tonnage) going from an origin to a destination if the data is not organized in a way that shows that there is a "0" trip that reports the real tonnage of that barge going from origin to destination.

There are two other "0" trip situations that occur less frequently than the first. One involves loading a barge at the origin, loading more at a midpoint, and then unloading it all at the destination. Here the trip with 0 tonnage is origin to midpoint (no tonnage is dropped off here), the trip with partial tonnage is midpoint to destination (only tonnage loaded at midpoint is counted), and the "0" trip with the remaining tonnage is origin to destination (to prevent double-counting distance traveled). The other "0" trip type involves compartmented barges, where the barge only goes from origin to destination, but the different commodities are separated into different trips. Here the regular trip covers the tonnage of commodity one from origin to destination and the "0" trip covers the tonnage of commodity two from origin to destination (to prevent double-counting distance traveled).

In the dock-level WCS movement file, 8,379 of 541,988 (1.5% of the records) contain a "0" trip.

K.2.1.1.1.22 Output Tonnage Verification Against Input

The initial verification check is to compare the model output against the WCSC input as shown in TABLE 1B.3.2. This verifies network movement routing, correct traffic accounting at the navigation projects, and correct conversion of annual tonnages into loaded barge counts.

TABLE 1B.3.2 – Comparison of Output Tonnage and Loaded Barges to Input Data

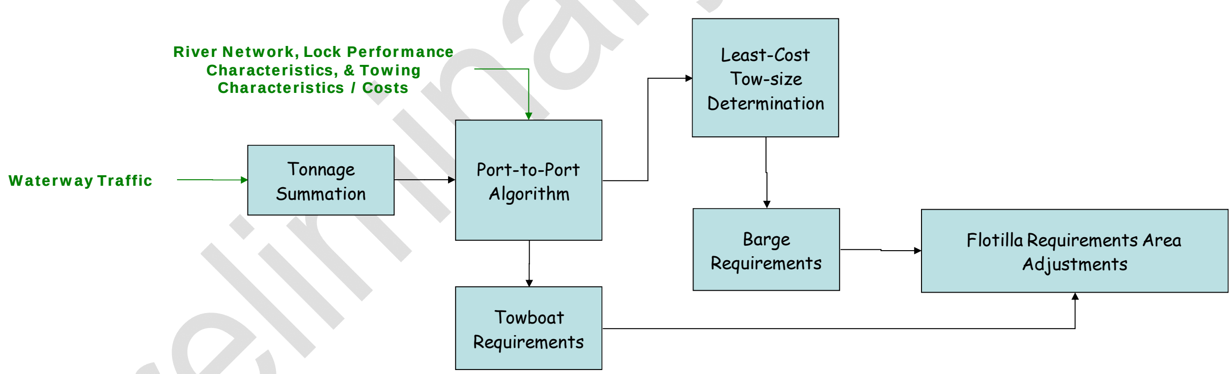
	Tonnage					Number of Loaded Barges			
		Model				Model			
				Difference				Difference	
Navigation Lock Project	Raw WCSC	Input	Output	Absolute	Pct.	Input	Output	Absolute	Pct.
Study Project									
CALCASIEU L&D	39,875,410	39,859,885	39,870,353	10,468	0.0%	19,451	19,470	18	0.1%
Gulf Intracoastal Waterway									
ALGIERS L & D	24,233,824	24,229,658	24,253,138	23,480	0.1%	11,791	11,800	9	0.1%
BAYOU BOEUF L & D	25,799,444	25,771,605	25,883,787	112,182	0.4%	14,740	14,778	38	0.3%
BAYOU SORREL LOCK & DAM	22,247,067	22,247,078	21,751,505	-495,573	-2.3%	12,470	11,878	-592	-5.0%
HARVEY L & D	1,542,491	1,542,497	1,695,858	153,361	9.0%	775	847	72	8.5%
INNER HARDBOR LOCK & DAM	16,563,062	16,561,201	16,543,044	-18,157	-0.1%	7,641	7,634	-7	-0.1%
LELAND BOWMAN L & D	39,726,023	39,710,688	39,729,072	18,384	0.0%	19,696	19,702	6	0.0%
PORT ALLEN LOCK AND DAM	21,966,349	21,966,358	22,050,954	84,596	0.4%	11,965	11,955	-10	-0.1%
Old River									
OLD RIVER L & D	6,925,484	6,924,810	6,764,230	-160,580	-2.4%	3,683	3,621	-62	-1.7%

K.2.4 DETERMINATION OF THE LEAST-COST SHIPPING PLANS

The movement shipping-plan is a specification on how barges are loaded, grouped (tow-sizes) and moved (towboat classes) between the origin and destination ports. The shipping-plan, which ultimately dictates the transportation cost for moving tonnage on the waterway, depends on the commodity shipped, the equipment used, the characteristics and limitations of the waterway system, and the total transportation trip time. As previously noted, the focus of this addendum is ultimately on the specification, verification, and validation of the WSDM least-cost cargo shipping-plans. To completely understand the calibration process, the model's process of analyzing shipping-plans, estimating shipping-plan costs and determining the least-cost shipping-plan must be understood. The model's process to calculate shipping-plans is called the Port-to-Port Algorithm.

The process of determining the least-cost shipping-plans can be described as three phases: 1) summarizing system utilization; 2) analyzing the potential shipping-plans; and 3) selection and storage of the least-cost shipping-plan for the equilibrium process. The general structure of this process is shown in FIGURE 1B.4.1.

FIGURE 1B.4.1 – Process to Determine the Least-Cost Shipping-Plan



The first phase is reading, checking, and storage of the input data describing the waterway system. The system is represented as a network with ports, locks, and river junctions as nodes and connecting waterway links between them. For computational purposes the network is partitioned into sectors which are linear, un-branched sets of links and nodes (FIGURE 1B.2.1). In addition to the network data, the system description includes data on the types of towboats and barges available and cargo characteristics.

While the movement least-cost shipping-plan is based primarily on a movement-by-movement basis, collective information about the system as a whole is needed and used to determine shipment times, etc. The model next reads the list of shipments to be processed, which are characterized by the movements' origin and destination ports, type of commodity, barge type, tonnage, and if applicable, the portion carried by dedicated equipment. The model then calculates a number of parameters needed for the Port-to-Port Algorithm, including total tonnages through various elements of the network, system transit times, and tow speeds.

The following sections describe the Port-to-Port Shipping-Plan Algorithm and many of the computations made by the model. The Port-to-Port Algorithm is the name applied to the collective procedures by which the model evaluates the time and cost required to transport cargo between a given pair of ports using a given towboat class.

K.2.1.14 Analyzing the Least-Cost Shipping-Plans

In this phase the model uses an optimization algorithm to determine the most cost effective way to ship cargo between each pair of ports having traffic between them. The shipping-costs between these port pairs are calculated (the number of towboats and barges required are no longer calculated). Essentially, for each movement, the model tests each possible combination of towboat classes and fleeting between the ports, thereby determining an optimum "*Least-Cost Tow*" routing scenario.

Even though the Port-to-Port Algorithm computes times and costs on a movement-by-movement basis, and most shipping-plan decisions are based on an individual movement basis, there are system-wide interactions to be considered. Most notable of these system-wide interactions are the lock transit times. Higher lock transit times (resulting from higher utilization and increased congestion) encourages larger tow-sizes (with higher HP towboats) as the trip time for each shipment increases. Shippers can lower their total movement transportation costs by minimizing their number of trips through the locks. As a result, the trip time for a movement is dependent upon the shipping-plan decisions of other movements in that movement's path (i.e., the number of lock transits for all movements through the locks in question). This is not an issue in the calibration step because the target lock transit times are known and are used (i.e., the lock transit times are fixed and are not adjusted as movements increase and decrease their number of trips as they decrease and increase their tow-sizes). Transit times are adjusted, however, when the least-cost shipping-plans are re-planned in the middle of an analysis (if the user specifies to do so).

The trip is divided into six activities, or functions, for analysis:

(1) Cargo loading and unloading

(2) Waiting for access to docks (to begin loading or unloading)

(3) Barges waiting for pickup by a towboat

(4) Tow makeup and breakdown

(5) Travel on waterway links

(6) Lockage transit operations (processing and delay)

Shipping costs arise from four sources, or categories, in the model:

(1) Towboat operating costs (including fuel tax and any other towboat level fees)

(2) Barge operating costs (including any other barge level fees)

(3) Cargo inventory costs

(4) Lockage and segment tolls

The results of the Port-to-Port Algorithm can thus be visualized as an array of the time per trip spent in each of the six activities, and a matrix of shipping costs in each of four cost categories arising from each activity (TABLE 1B.4.1). Note that certain functional costs apply only to certain sources. The crossed out cells indicate cost entries which are not used. In agreement with normal operating practice it is assumed that towboats do not wait while barges are loaded and unloaded. Thus the first three activities do not apply to towboats and the average trip time for a towboat is shorter than that for a barge. Physically this occurs because towboats do not simply shuttle the same set of barges back and forth but pick them up and drop them off as available.

Cargo inventory costs are accumulated for the time accounted for by the six listed activities. The time and cost of commodity or towing equipment storage at either end of the trip are not considered (note however, that the cargo is assumed to be waiting during the time that barges are waiting for dock access). The

Port-to-Port Algorithm allows for computation of each of the cost elements for each movement by first computing the amount of towing equipment and the times required for each of the itemized waterway activities.

TABLE 1B.4.1 – Cost Accounts Matrix

	Waterway Trip Activity Time (days / round-trip)					
	Load / Unload *(Activity 1)*	Wait Dock *(Activity 2)*	Wait Pick-Up *(Activity 3)*	Tow Make Up *(Activity 4)*	Link Travel *(Activity 5)*	Lockage Transit *(Activity 6)*
Time						

Shipping Cost Sources	Waterway Trip Activity Costs (mills / ton-mile)					
	Load / Unload *(Activity 1)*	Wait Dock *(Activity 2)*	Wait Pick-Up *(Activity 3)*	Tow Make Up *(Activity 4)*	Link Travel *(Activity 5)*	Lockage Transit *(Activity 6)*
Towboat *(Cost 1)*						
Barges *(Cost 2)*						
Cargo *(Cost 3)*						
User Fees *(Cost 4)*						

The remainder of this section will first discuss some general computational factors used by the Port-to-Port Algorithm, then treat each of the six waterway trip activities individually, and finally consider the conversion of calculated operating times to a shipping-plan cost.

K.2.1.1.20 Shipment Aggregation

As discussed in sections K.2.1.3 through K.2.1.5, individual shipments are aggregated into annual modeling level ports, commodity groups, and barge types; i.e., movements.

The Port-to-Port Algorithm stipulates that for each movement, the most efficient tow-size will be used between each pair of fleeting points along the route (tow-size changes can occur only at specified re-fleeting points). It should be noted that the most efficient tow-size is specified for each trip movement regardless of movement tonnage. For example, if a particular movement consists only of a single barge load per year between ports A and B, a four- or eight-barge tow may still be specified as the optimal and most efficient tow-size. In this case, however, the movement is shown as having a fractional number of trips (employing a fractional towboat). Considering the traffic flow along most portions of the waterway system, such a movement is assumed to be a fractional part of other movements between ports A and B. This assumption is important since the model is not a simulator; it cannot explicitly consider interaction between movements

Of course, by considering movement groupings on a trip basis, in complete isolation of other movements, the model would tend to overestimate equipment and trip requirements since the potential for intermediate backhauls is not considered. For certain ports A and B having freight flows in one direction only, strict adherence to the trip shuttle assumption would ignore potential for backhauls between ports located intermediate to A and B.

In the original Port-to-Port Algorithm (TCM) this was handled by algebraically reducing the number of round trips (and hence reducing the number of barges and towboats) by an additional aggregation to a transportation class (trans-class) and then application of a specific port-to-port-trans-class grouping (percent loaded trips) factor. The model computed a fraction of loaded barge trips for each trans-class combination in the model by considering the up-bound and down-bound tonnage and the percentage of dedicated movements for each trans-class within a single link. This then indirectly considered the back-haul potential for any particular movement.

The current Port-to-Port Algorithm (NIM) is simplified and makes no such adjustment. It is yet to be determined whether this functionality will be re-coded into NIM in future versions.

Once the number of trips and barges is computed, the Port-to-Port Algorithm provides the means for computing various lock and port factors, considering aggregate traffic levels using each lock or port. Furthermore, link travel times and speed, fleeting costs, and various cargo handling costs are accounted for. The following section describes how all of the assumptions and procedures are brought together in the actual tow cost calculations.

K.2.1.1.21 Barge Loading Capacity

The procedures used by the Port-to-Port Algorithm require a movement level barge loading so that equipment resources can be estimated and cost. While the barge type and barge loading are part of the overall shipping-plan, in the model the movement barge type (see section K.2.1.5) and movement barge loading (see sections K.2.1.9 and K.2.1.25) are specified through input data. As a result, only the various movement tow-size and towboat class combinations are analyzed to determine the movement's least-cost shipping-plan algorithm. The model, however, does have the capability to determine movement barge loadings if not specified through input. These model generated barge loadings are done prior to execution of the Port-to-Port Algorithm as discussed below.

A maximum barge capacity by barge type is given by input data (TABLE 1B.2.9). The actual usable capacity for a movement, however, can be reduced by two factors: limited channel depth along the shipping route can restrict the usable draft of the barge, or low density cargo can fill its available volume before the maximum tonnage is loaded (cubing out). If the barge loading is derived from historic data and specified to the model through direct input, this reduction in barge capacity from draft restrictions and commodity density can be accounted for through a barge loading factor e_d as discussed below.

First the barge usable draft "*d*" (in feet) is computed as:

$$\text{Barge Usable Draft} = d = \text{MIN}\left[\left(\text{barge loaded draft} - \text{barge empty draft}\right), \left(\text{controlling channel depth} - \text{Required Barge Clearance} - \text{empty barge draft}\right)\right] \quad (1B.4\text{-}1)$$

The controlling channel depth is the minimum channel depth encountered along the shipping route as input on the Links definition records. The other parameters are derived from barge class input data items (TABLE 1B.2.9).

The maximum barge tonnage which can be carried is equivalent to that obtained by loading the barge to a draft "*d*" with cargo having a density equal to that of water, 62.4 pounds per cubic foot (0.0312 tons per cubic foot). With lower density cargo, fewer tons can be loaded into the barge. The actual tonnage which can be carried is thus:

$$Y_{usable} = MIN \left(p \;,\; 0.0312 \right) \times L \times W \times d \times s \qquad (1B.4\text{-}2)$$

where:

Y_{usable} = *usable barge capacity (in tons)*

L = *barge length (in feet)*

W = *barge width (in feet)*

d = *barge usable draft (in feet)*

s = *barge block coefficient (ratio of actual volume of barge to the product of its length, width, & draft*

p = *cargo density factor (tons per cubic foot)*

Note that the parameter p above is defined as a "*density factor*" which is not the density of the cargo material itself. Also note that the capacity of the barge is a function of the density of the medium (i.e., water) displaced by the barge. This displacement depends on how high the cargo can be piled on the barge or on how tightly packed it is; it is not directly a function of the textbook density of the commodity itself. Since most barges are designed to carry as much bulk material as the controlling channel depth will allow, a density factor of 62.4 (density of water) should be input for most bulk commodities. A slightly lower p would be specified for commodities which are extremely light or which are subject to inefficient packing, such as manufactured goods and certain steel products (see TABLE 1B.2.3 for the current density settings).

K.2.1.1.22 Tow Capacity

The maximum potential tonnage capacity of a tow would be the product of the maximum number of barges in the tow and the maximum capacity of each barge. However, the actual tow cargo tonnage will be reduced by the presence of empty barges in the tow, by the fact that the average number of barges included will generally be less than the maximum permitted, and by barges not loaded to their maximum capacity. The maximum number of barges which can be moved by a towboat of a given towboat class is the minimum of the towing capacity of the towboat and the smallest tow-size limit along the shipping route. In other words, the maximum towboat barge capacity is reduced according to the tow capacity factors input for each network link along the shipping route. The towboat barge capacity factor e_c used for the round trip between two ports is the minimum e_c encountered over the shipping route. The average number of barges in a tow is thus given by:

$$n_{average} = n_{max} e_c \quad (1B.4\text{-}3)$$

where:

n_{max} = *the maximum number of barges which can be moved by the towboat class*

Note that the model does not attempt to intentionally reduce the tow-size in order to obtain higher speeds, reduced lockage times, etc.

Despite the Port-to-Port Algorithm's focus on a movement-by-movement basis, the other system-wide interaction (besides lock transit times which are a function of lock utilization and the shipping-plan decisions of all movements transiting the lock) that is considered is the loaded backhaul potential. In the older version of the Port-to-Port algorithm (TCM),the movement loaded barge backhaul assumption was key in a round-trip cost calculation. Unless commodity shipments are exactly balanced, it will be necessary to move some empty barges in order to balance the barge flows in the system. Empty barge movements also result from the use of dedicated barges which, by definition, return empty and are not available for backhaul tonnage. The presence of empty barges reduces the effective tonnage capacity of a tow.

The current Port-to-Port Algorithm (NIM) is simplified and does not consider barge balancing. As previously noted, it is yet to be determined whether this functionality will be re-coded into NIM in future versions. The lack of this barge balancing has not adversely affected ORS calibration, and application of just the barge dedication factors is sufficient. In short, the movement barge dedication (discussed in section K.2.1.26) was a potential empty barge return probability in TCM while it is an absolute empty barge return in NIM.

The task of the Port-to-Port algorithm is to find the least-cost shipping plan from a shipment's waterside origin to its waterside destination. Recall that there are refleeting ports defined in the network, which are locations where the tow may change size or towboat type along the way. Once a route (series of links to be traversed) has been chosen, the next step is to split this route into sections. The endpoints of a section are either refleeting points or the shipment's waterside origin or destination. In determining the least-cost shipping plan, the sections are considered separately.

There are six categories of cost in a shipping plan:

- Waiting for access to the dock;
- Loading/unloading;
- Waiting for a towboat;
- Making up the tow;
- Travelling along the link; and
- Transiting the locks.

And there are four sources of cost:

- Towboats,
- Barges,
- Commodities, and
- Fees/taxes.

Not all activities will happen in each section. For example, loading activities will only occur in the first section, and unloading activities only happen in the last section. Since these are the only activities that require access to the dock, the first two cost categories will only contribute costs to the first and last sections.

Not all sources are involved in all costs. For example, the towboat is not involved in the loading or unloading activities, so the first three cost categories (loading/unloading, waiting for dock access, and waiting for the towboat) will not have a towboat component.

To derive the cost for a section of the shipping plan, we consider a tow of *n* loaded barges. The costs given below are the cost as calculated for the tow. In WSDM, the objective is to find the lowest cost per ton moved, so the costs as stated would be divided by total tons on the tow for that section.

K.2.1.15 Delay Cost

The delay time is the time that the barges must wait at a loading or unloading port before they are moved to the dock to load or unload cargo.

$$C_p = n * c_b * p + c_m * p \qquad (1B.4\text{-}4)$$

where

c_b = barge cost ($/hour)

c_m = towboat maneuvering cost ($/hour)

p = port wait time (hours)

Note that the last term of the above equation (the term concerning the towboat maneuvering cost) only applies at the unloading port, since the towboat is assumed to remain with the barges until they are ready to be unloaded. At the origin, the towboat joins the tow after loading is completed.

K.2.1.16 Loading Cost

The time required for loading barges depends on the type of cargo and the port facilities available. In the database, commodities are divided into three handling classes based on their loading and unloading characteristics. Although the definition of these classes is left to the user, the normal classifications are (1) dry granular cargo, such as coal or grain, (2) dry bulk cargo, such as steel products, and (3) liquid cargo, such as petroleum. Loading and unloading rates for each cargo handling class are specified for each port in the network and are the basis for calculating loading and unloading times.

To calculate the loading cost, WSDM assumes that each barge appears (and its cost begins accumulating) as it is ready to be loaded. So the cost of the first barge to be loaded will be charged for the loading of all *n* barges; the second barge will be charged for the loading of barges 2 through *n*, etc. Therefore, the total loading cost for the tow is given as:

$$C_l = d * r_l * n * (n + 1) / 2 * c_b \qquad (1B.4\text{-}5)$$

where

d = tons per barge

r_l = load rate (tons/hour)

c_b = barge cost ($/hour)

Note that the only cost contributor for the loading cost is the barges.

K.2.1.17 Wait Cost

After loading of the barges making up a tow is complete, they will normally have to wait to be picked up by a towboat. The waiting time will depend on the scheduling of tows, which is not treated by WSDM. The wait cost is the cost incurred by the barges and cargo as the loaded barges wait for a towboat to pick them up.

$$C_w = n * (c_b + d * c_c) * w \qquad (1B.4\text{-}6)$$

where

c_b = barge cost ($/hour)

d = tons per barge

c_c = commodity cost ($/ton/hour)

w = wait time (hours)

The wait cost is incurred in the first section, as well as any section that has a change of towboat or tow size.

K.2.1.18 Fleeting Cost

Fleeting is the operation of forming a tow out of the barges. When a towboat arrives at a port, time is consumed in dropping off barges which have reached their destination and picking up a new group. The WSDM model assumes that all such activity occurs at the start of the trip, as well as any time refleeting (the changing of towboat types or tow sizes) takes place. The time required is computed from two parameters specified for each port: a fixed delay which is experienced whenever a towboat stops at a port, regardless of the number of barges handled, and an additional delay incurred for each barged picked up.

$$C_f = (f_t + n * f_b) * (c_m + n * c_b + n * d * c_c) \qquad (1B.4\text{-}7)$$

where

f_t = fleeting time per tow (hours)

f_b = fleeting time per barge (hours)

c_m = towboat maneuvering cost ($/hour)

c_b = barge cost ($/hour)

d = tons per barge

c_c = commodity cost ($/ton/hour)

Fleeting occurs in the first section, and in any subsequent section that has a change of towboat type or tow size from the preceding section.

K.2.1.19 Travel Cost

The activity which generally consumes the majority of the trip time of a tow is travelling the links of the waterway system between ports, locks, and junctions. The time spent in link travel Is calculated from a tow speed function described in section K.2.1.1.24. The speed function is applied to each link. The total link travel time is the sum of the link travel time over all of the links included in the section. As the commodity is moved along the links of the route, costs are incurred in proportion to the amount of time the travel requires. (Transiting the locks are treated separately and discussed in section K.2.1.20).

$$C_t = t * (c_l + n * (c_b + d * c_c)) + f * r_o * t_f + n * (d * u + b) * l \qquad (1B.4\text{-}8)$$

where

l = length of section (miles)

t = total travel time (hours)

t_f = taxed travel time (hours)

f = fuel tax ($/gallon)

r_o = towboat operating fuel rate (gallon/hour)

c_l = towboat linehaul cost ($/hour)

c_b = commodity cost ($/ton/hour)

u = river user fee ($/ton/mile)

d = tons per barge

b = barge mile fee ($/barge/mile)

Note that the river user fee and barge mile fees are generally not used in the WSDM. They are included for exploratory analyses, but have never been used in a study.

K.2.1.20 Transit Cost

In WSDM, the time it takes to transit a lock is dependent on the total tonnage at the lock in the year. These transit times are represented by tonnage-transit curves relating an average tow transit time to an annual aggregate traffic level at the project. In the verification, calibration, and validation of the model's movement shipping plans, however, these tonnage-transit curves are not used. Instead, the model uses the target (observed) transit time in the Targets database table (K.2.1.1.1.20) as input in its calculations. The total transit time through all locks in the section is the sum of the individual lockage transit times.

$$C_r = t * (f * r_m + c_m + n * (c_b + d * c_c)) + l_t + n * l_b \quad (1B.4\text{-}9)$$

where

t = transit time through all locks in the section (hours)

f = fuel tax ($/gallon)

r_m = towboat maneuvering fuel rate (gallon/hour)

c_m = towboat maneuvering cost ($/hour)

c_b = barge cost ($/hour)

d = tons per barge

c_c = commodity cost ($/ton/hour)

l_t = sum of per tow lockage fees ($)

l_b = sum of per barge lockage fees ($)

Note that WSDM has the capability of modeling lockage fees at the barge or at the tow level.

K.2.1.21 Unloading Cost

To calculate the unloading cost, WSDM assumes that each barge disappears (and its cost stops accumulating) when it has been unloaded. So the unloading cost of the first barge to be unloaded will only be charged for its own unloading; the second barge to be unloaded will only be charged for the unloading of the first two barges, etc. Therefore, the total unloading cost is given as:

$$C_l = d * r_u * n * (n + 1) / 2 * c_b \quad (1B.4\text{-}10)$$

where

d = tons per barge

r_u = unload rate (tons/hour)

c_b = barge cost ($/hour)

Note that the barges are the only cost contributor for the unloading cost.

K.2.1.22 Empty Barge Tows

WSDM does not combine empty and loaded barges in its tows. After calculation of the least-cost shipping plan for loaded barges of the shipment, if the dedication factor for that shipment is positive (indicating that at least some of the barges will be sent back to the shipment's waterside origin), it then generates a shipping plan for the tow of empty barges. As in the case of the loaded barges, the shipping plan for the empties is generated assuming that a full tow's worth of empty barges will be shipped. This may result in fractions of tows being shipped. The calculation of the cost of the empty barges is the same as the calculation for the loaded barges, except the commodity cost is not included, and no cost is included for loading, unloading, or waiting for the dock. The total cost of the empty tow movements is spread over all of the tons in that shipment.

Note that WSDM does not do any balancing of barges or towboats. The model assumes that barges are available as required and that towboats will appear as they are needed. It is an annual model, and operates under the belief that the equipment flows will balance out over the year.

K.2.1.1.23 Fleeting Operations

The previous discussion has assumed that cargo is carried from its origin to its destination using the same towboat and barges which were selected by the Port-to-Port Algorithm. However, this tow configuration, while being optimum for the total route, is likely to be less efficient for some of the sectors through which it must travel. The model provides an opportunity for the tow to change the number of barges and/or the size (horsepower) of the towboat being used. This is allowed only at re-fleeting ports. For a movement which passes through such ports, the Port-to-Port Algorithm is applied to the individual sections of the route, between an origin/destination and an intermediate fleeting point or between two such fleeting points to determine the best trip plan for each section. The algorithm is also applied to the complete route with no re-fleeting allowed.

When a trip endpoint is a fleeting point rather than a final destination, no cargo loading or unloading takes place. Therefore, the times and costs associated with activities 1 (loading and unloading) and 2 (waiting for dock access) at an intermediate port are zero. The time (and therefore the cost) for waiting for a towboat and tow makeup and breakdown are specified at the port level, and so the intermediate ports are treated in the same manner as the origin port was at the beginning of the trip. Link travel and lock operations are unaffected.

The time and cost of a route involving fleeting is the sum of the times and costs of the individual section trips. Compared to a straight-through route, the fleeting alternative requires extra towboat waiting and tow makeup time at the intermediate ports. However, this may be more than compensated for by the ability to use the most efficient towboat and tow-size on each route selection.

The model does not operate within a time continuum; it is not a dynamic waterway simulator. Instead, the model is a waterway cost accounting tool; it endeavors to account waterway costs primarily by summing the costs of each individual movement, i.e., each origin-destination-commodity combination. Each movement is considered independently of every other movement, even when fleeting is to take place. The model does not explicitly consider interaction between specific movements. Even extremely small movements, such as one or two barge-loads per year are accounted separately. The model often uses fractional “towboats” and fractional “round trips” to consider these movements as portions of larger movements (tows). The model does, however, consider the aggregate traffic levels of each waterway element, and uses these aggregate levels to determine the transit time at locks (and back-haul potential in the case of the original Port-to-Port Algorithm)

The purpose of fleeting in the model is to allow for major changes in tow-sizes, particularly as certain shipments move between waterways having different channel and lock sizes. Thus, fleeting is best accomplished at waterway junctions (port located zero miles from the junction). When the fleeting port is at a junction, the sector assigned to the fleeting port is important. As mentioned previously, the number of fleeting points has a direct effect upon model run costs since all shipments passing through a fleeting point are considered for re-fleeting. Typically, most fleeting points are located in the smaller tributary sector (e.g., Sector 15) at zero miles from the junction with the main-stem waterway. This way only movements passing into or out of the tributary stream will be considered for re-fleeting. Occasionally, however, it may be desirable to locate another fleeting point at the junction in one of the main-stem sectors to allow for further re-fleeting of the non-tributary movements.

K.2.1.1.24 Tow Speed Calculation

In order to calculate the time required to travel between two points in the network it is necessary to estimate the average speed as a function of tow and waterway characteristics.

K.2.1.1.1.23 The Basic Idea

A tow moving through the water at a constant speed is in a state of equilibrium where resistance R of the tow is balanced by an equal and opposite thrust T from the towboat propeller (R = T). The resistance of a vessel tends to increase with the square of the speed so it is useful to define the specific resistance as:

$$r = \frac{R}{v^2} \qquad (1B.4\text{-}11)$$

where:

r = *specific resistance*

R = *tow resistance*

v = *speed (mph)*

In unrestricted water the specific resistance is, to a first approximation, a function only of the vessel size and shape and is independent of speed. Since the range of tow speeds is relatively limited, the thrust is also nearly independent of speed. Combining these results yields the basic formula for tow speed in unrestricted water:

$$v = \sqrt{T/r} \qquad (1B.4\text{-}12)$$

where:

v = *speed (mph)*

r = *specific resistance*

T = *tow thrust*

To estimate the speed of a tow the specific resistance is obtained for each of the component vessels and then combined to produce the resistance of the tow. The thrust is assumed to be proportional to the towboat horsepower. Equation (1B.4-12) is then used to obtain the speed for the influence of shallow water. Adding or subtracting current speed, depending on the direction of travel, completes the calculation.

K.2.1.1.1.24 Vessel Resistance

The remaining sections describe the actual formulas and sequence of computation. The specific resistance of each vessel, towboat, or barge making up a tow is computed from the empirical relation[9]:

$$r = 0.0118\, bd^{2/5} \left(L + 70.5 \left(1 - \frac{L}{328} \right) \sqrt{\frac{\delta}{1 - \delta}} \right) k_c$$

[9] *Fomkinsky, L., Method of Drag Calculation for Flotilla Determination, Transport, Moscow, USSR, 1967.*

(1B.4-13)

where:

r = *specific resistance*

b = *beam (width) of vessel (in feet)*

d = *draft of vessel (in feet)*

L = *length of vessel (in feet)*

δ = *block coefficient (ratio of the actual displacement of the vessel to the product of length, width, & draft)*

k_c = *resistance coefficient (discussed below)*

The resistance coefficient k_c is, in general, a function of the vessel lock coefficient and a quantity known as the Froude Number F_r.

$$F_r = \frac{v}{\sqrt{gL}} \qquad (1B.4\text{-}14)$$

where:

g = *the gravitational acceleration, 32.2 ft / sec*^{2}

The dependence of the Froude number on the speed v means that the specific resistance is also a function of the as yet unknown tow speed. Fortunately, the effect is not strong over the narrow range of speeds encountered in practice and k_c may be approximated by a function of δ only. Specifically, the minimum value of k_c for each value of δ was selected from the empirical derived relationship of the Froude number (F_r) and the resistance coefficient (k_c). The resulting function k_c (δ) was then approximated by the quadratic function:

$$k_c\left(\delta\right) = 2.42\delta^2 - 3.43\delta + 1.34 \qquad (1B.4\text{-}15)$$

The maximum approximation error is about 3%.

The resistance of each towboat class can be calculated and stored for use by the speed function. The same procedure cannot be used for barges because the draft can vary in the analysis. What is done is to calculate and store the resistance r_{empty} of each barge type when empty. The resistance of a loaded barge is then computed whenever needed as:

$$r = r_{empty}\left(\frac{d}{d_{empty}}\right)^{2/5} \qquad (1B.4\text{-}16)$$

where:

d_{empty} = *is the draft when empty*

This follows directly from equation (1B.4-13). In practice the computation of a 2/5 power is replaced by a linear approximation:

$$x^{2/5} \doteq 0.136x + 1.22 \qquad (1B.4\text{-}17)$$

This is a least squares fit over the range 4-8, a typical range of values for the ratio (d/d_{empty}). The maximum error of this approximation on the given interval is about 1%.

K.2.1.1.1.25 Tow Resistance

The resistance of a tow is less than the sum of the resistances of its component vessels. A fastening coefficient k_f is defined as the ratio of the actual tow resistance (not including towboat) to the sum of the individual barge resistances. Hence the tow resistance r_f is given by:

$$r_f = K_f \quad r_i \qquad (1B.4\text{-}18)$$

where:

r_i = *the individual barge resistances*

The value of K_f depends on the configuration of barges in the tow and on the individual barge shapes and types of fastenings, none of which are available in the model. However, by assuming typical conditions it is possible to approximate K_f as a function of only the number of barges in the tow and whether they are loaded or empty. In general a tow may include both loaded and empty barges, though WSDM models tows as being composed of only empty barges or only loaded barges. The value of K_f is then interpolated as:

$$K_f = \frac{n_{empty} K_{f\,empty} + n_{loaded} K_{f\,loaded}}{n_{empty} + n_{loaded}} \qquad (1B.4\text{-}19)$$

where:

n_{empty} = *the number of empty barges*

n_{loaded} = *the number of loaded barges*

$K_{f\,empty}$ = *the empty barge resistance*

$K_{f\ loaded}$ = *the loaded barge resistance*

A similar consideration applies to the towboat. A constant coefficient of 0.6 is applies to the towboat resistance before it is added to the tow resistance computed above. In the special case of a light boat the "*tow*" resistance is just that of the towboat, the full value being used in this case.

K.2.1.1.1.26 Speed in Still and Unrestricted Water

The remaining quantity necessary to apply equation (1B.4-12) is the thrust force produced by the towboat. This is taken to be proportional to the horsepower, specifically:

$$T = 26.4H \qquad (1B.4\text{-}20)$$

where:

T = *towboat thrust (in pounds)*

H = *horsepower*

Although the assumption of proportionality is not strictly correct it is an adequate approximation in view of the fact that thrust is also influenced by various difficult to quantify aspects of boat design, and also in view of the aggregation of towboats into a relatively small set of classes in the model. It is also true that the effective thrust changes somewhat as the speed changes, but within the range of practical towing speeds this is also a secondary effect and is ignored here. Using equation (1B.4-12) the tow speed v_o in still water of unlimited depth is now computed.

K.2.1.1.1.27 Shallow Water Correction

The speed which a tow actually attains is reduced by the influence of restricted waterway conditions. On the inland navigation system the effect of restricted depth is by far the most significant factor and is the only one accounted for in the model.

The shallow water coefficient is determined by an empirical formula:

$$e_h = \left(1 + 2\,\frac{7b}{L}\,\frac{d}{h}\,\frac{V_o^2}{gh}\right)^{-1/2} \qquad (1B.4\text{-}21)$$

where:

h = *is the average depth of the waterway route*

b = *tow width*

L = *tow length*

d = *tow draft*

Since the model does not know the configuration of the barges in the tow a constant ratio of 0.18 is assumed for b/L. b/L is the ratio for a single standard jumbo barge as well as the ratio for a 110' x 600' lock chamber. The draft value used is the average draft of the tow, with the draft of each barge being weighted by its area. When the constant values of b/L and g are inserted, the formula reduces to:

$$e_h = \left(1 + 0.0697\, d\,\frac{V_o^2}{h}\right)^{-1/2} \qquad (1B.4\text{-}22)$$

Multiplying the speed V_o by e_h yields the actual speed of the tow through the water V_w. However, there is an additional physical restriction which must be considered. As the speed of a vessel approaches the speed at which waves travel through the water the resistance increases very sharply. The wave speed in water of depth is SQRT(gh) or 5.67 x SQRT(h) ft/sec. As a practical matter a vessel will not exceed about 70 percent of this critical speed even if it is capable of doing do, because it will be very inefficient. Hence the actual water speed is calculated as:

$$V_w = \text{MIN}\left(e_h V_o\,,\ 3.97\sqrt{h}\right)\ \text{ft/sec} \qquad (1B.4\text{-}23)$$

Under typical navigation conditions, the ratio $A = A_c/A_t$, where A_c is the channel cross-section area and A_t is the tow middle-section area, exceeds 8.0, the influence of channel width on tow speed can be safely ignored. In the case of canals or other restricted channels, however, A can be less than 8.0, and maximum tow speed is a function of both channel depth and channel width, as follows:

$$V_w = 11.2 \sqrt{\cos^3\left(\frac{\pi + \arccos(1 - 1/A)}{3}\right) h} \qquad (1B.4\text{-}24)$$

Tow speeds in canals are nearly always equal to the above limit, and hence equation (1B.4-24) could be used to compute speeds in this situation. Equation (1B.4-24) is not presently used in the model, since the tow middle-section is unknown. However, it could be used as a basis for estimating the factor e_r (discussed below) for channels with restricted dimensions. It would be rather easy to add equation (1B.4-24) to the model later should a need for it become evident.

K.2.1.1.1.28 Final Adjustment

At this point the speed is multiplied by the user specified coefficient e_r (section K.2.1.1.1.8) appropriate to the network reach and direction of travel. This coefficient, which should be derived from empirical data, helps account for the many factors not explicitly considered in the speed calculation. Included here, for example, are the presence of sharp bends or obstacles, narrow channels, and the effect of the water level gradient (a tow moving upstream is also moving uphill). The final travel speed is obtained by adding or subtracting the current speed, c.

$$v = e_r v_w \pm c \qquad (1B.4\text{-}25)$$

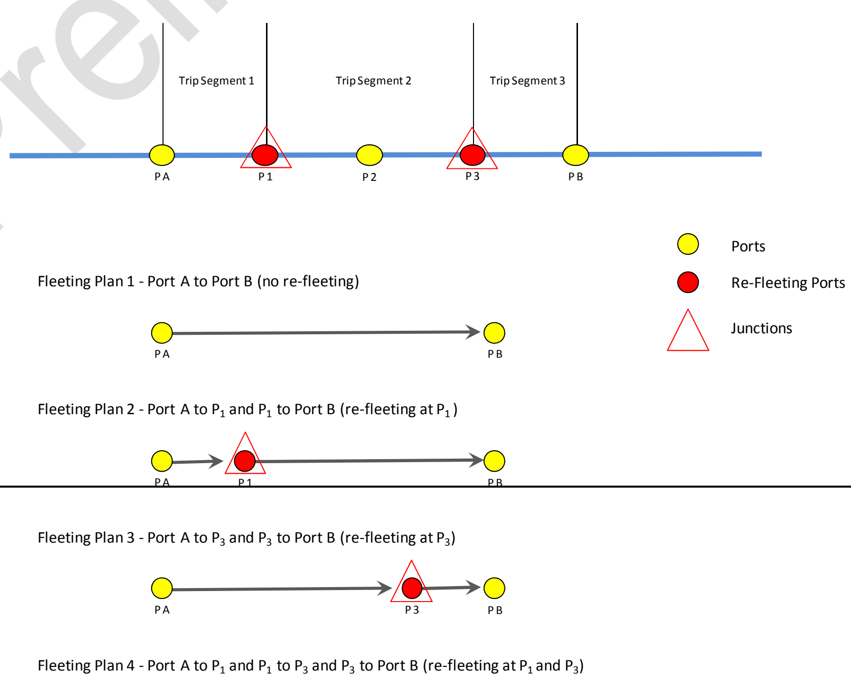
K.2.1.23 Selecting the Least-Cost Shipping-Plan

The shipping plans considered by the model are limited by the characteristics and limitations of the waterway system. The network defined re-fleeting areas (see section K.2.1.1.1.6), river reach tow-size limits (see section K.2.1.1.1.11), and towboat efficiency characteristics (see section K.2.1.1.1.12) reduce the number of shipping plans that must be cost and compared.

In developing the shipping plans, the model's first action is to determine the shipping route of each movement. This step, however, is not needed in the calibration, verification, and validation effort since the historic routings are used to allow comparisons against known targets. Movement routing is controlled through the "*forcedLock*", "*forcedSector*", and "*avoidSector*" fields in the "*MovementDetail*" table (section K.2.1.1.1.15) which are loaded with the historic routing specification. In the calibration model runs, these specification must be adhered to, which reduces the possibilities for shipping routes. In the case where these restrictions have not limited the possibilities to a single route, then the model will choose the shortest route among those satisfying the forced/avoid constraints.

In the second step, the route is then divided into sections called "*trip segments*" defined by the designated re-fleeting points along the route. For example, if the route from Port A to Port B passes through three ports, P_1, P_2, and P_3 of which P_1 and P_3 have been specified as potential re-fleeting points. The movement will be divided into three trip segments: A to P_1, P_1 to P_3, and P_3 to B. If the shipping route under consideration contains more than one trip segment the shipping plan optimization procedure must determine whether or not re-fleeting should actually take place at each fleeting point along the route. A particular choice as to which fleeting points along a route are and are not used is termed a "*fleeting plan*". For the example used previously, there are four possible fleeting plans for traffic between A and B as shown in FIGURE 1B.4.2.

FIGURE 1B.4.2 – Example Trip Segments and Fleeting Plans



Each component of a shipping-plan is called a "*trip*". Fleeting plan 1 consists of one trip segment, fleeting plans 2 and 3 of two trips, and plan 4 of three trips. Of course, in the case where there are no fleeting points on a route, there will be only one shipping plan with a single trip to consider. The model cycles through all possible shipping-plans for each pair of ports. The towboat optimization procedure described below is applied separately to each trip included in a shipping-plan and the trip costs summed to obtain the total shipping cost for the plan. The plan having the lowest total cost is selected as the one that will be used.

Evaluation of the shipping cost for a trip involves selecting the most efficient towboat and tow-size. This is where the Port-to-Port Algorithm comes directly into use. It is applied to determine the cost of shipping cargo using each towboat class in turn. The class which produces the lowest cost per ton is selected.

For the example route the tow optimization procedure would be called upon to find the optimal tow for different trips: A to B, A to P_1, P_1 to B, A to P_2, P_2 to B, and P_1 to P_2. The optimal trip costs would then be combined according to the four shipping-plans to determine the best overall way of moving cargo from A to B.

In addition to the towboat and barge requirements the model also records statistics on tow-size distributions, port and lock utilization, and the costs associated with individual ports, locks, and links of the network. If the appropriate run option switches are specified, information about each trip is saved in the "*ShippingPlan*" table (see section 1.4.8.1.1.1 Optional ShippingPlan and ModeSelection Tables of ATTACHMENT 1 Gulf Intracoastal Waterway Navigation Investment Model Version 5.3).

K.2.1.24 Storage of the Least-Cost Shipping-Plan

The model developed least-cost shipping plans are stored in the "*LinkShippingPlan*" table as described in TABLE 1B.4.2. As can be seen, the database key is quite large allowing storage of different shipping plans for different system configurations (e.g., without-project versus with project). Additionally, the specification of the shipping plan to a sector-link level allows for specification of shipping plan variation along the waterway route. This allows for re-fleeting specification as tonnage moves from one size waterway segment to another. For example, 60 loaded jumbo barges moving from the upper Kanawha River to the Gulf might take 7 trips with an average 8.57 barges per tow (say, six 9 barge tow trips and one 6 barge tow trip) to the mouth of the Kanawha River where it meets the Ohio River. Then it would have 4 trips of 15 barges per tow to the mouth of the Ohio River where it meets the Mississippi River. Then it may have 3 trips of 20 barges per tow to the final waterside destination in the Gulf. Each of these three legs (or tow-sizes) would have its own towboat class specification.

TABLE 1B.4.2 – LinkShippingPlan Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
investmentPlanID	DB Key	Investment plan ID from InvestmentPlan table.
forecastID	DB Key	Forecast ID from Forecast table.
networkVersion	DB Key	Network version ID from NetworkVersion table.
movementSetID	DB Key	Movement set ID from MovementSet table.
movementID	DB Key	Movement ID from MovementDetail table.
sectorID	DB Key	Sector ID from Sectors table.
linkIndex	DB Key	Link ID from Links table (0 specifies Sector level specification).
loadStatus	DB Key	Loading status (F = full or loaded, E = empty).
towboatTypeID		Towboat class ID from TowboatTypes table.
numberBarges		Number of barges per tow on the leg (tow-size).
speed		Tow speed (mph) for the defined towboat class, tow-size, and link direction.
rpm		Propeller RPM.

The actual descriptors of the shipping plans themselves in the "*LinkShippingPlan*" table are only the towboat class ("*towboatTypeID*"), number of barges in the tow ("*numberBarges*"), speed, and rpm. The "*rpm*" field is inconsequential in this discussion since it has no influence on transportation costs and is only a parameter that is passed through the model to the environmental NAVPAT model.

K.2.5 WATERWAY SUPPLY AND DEMAND MODULE CALIBRATION

To validate that the Gulf Intracoastal Waterway Navigation Investment Model (GIWW NIM) Waterway Supply and Demand Module (WSDM) is developing accurate shipping plans and is capable of replicating observed shipper behavior and system operating characteristics, the model requires calibration. Specifically, the model requires calibration of movement empty barge backhaul flows, movement tow-sizes (including towboat type), and movement re-fleeting (if applicable). During this calibration process, the description of the waterway system being modeled is fine-tuned so the model most accurately replicates observed shipping behavior in the system. Unfortunately, movement level targets are not available and the validation is achieved by comparison of the model results against statistics observed and recorded at the navigation projects in the system.

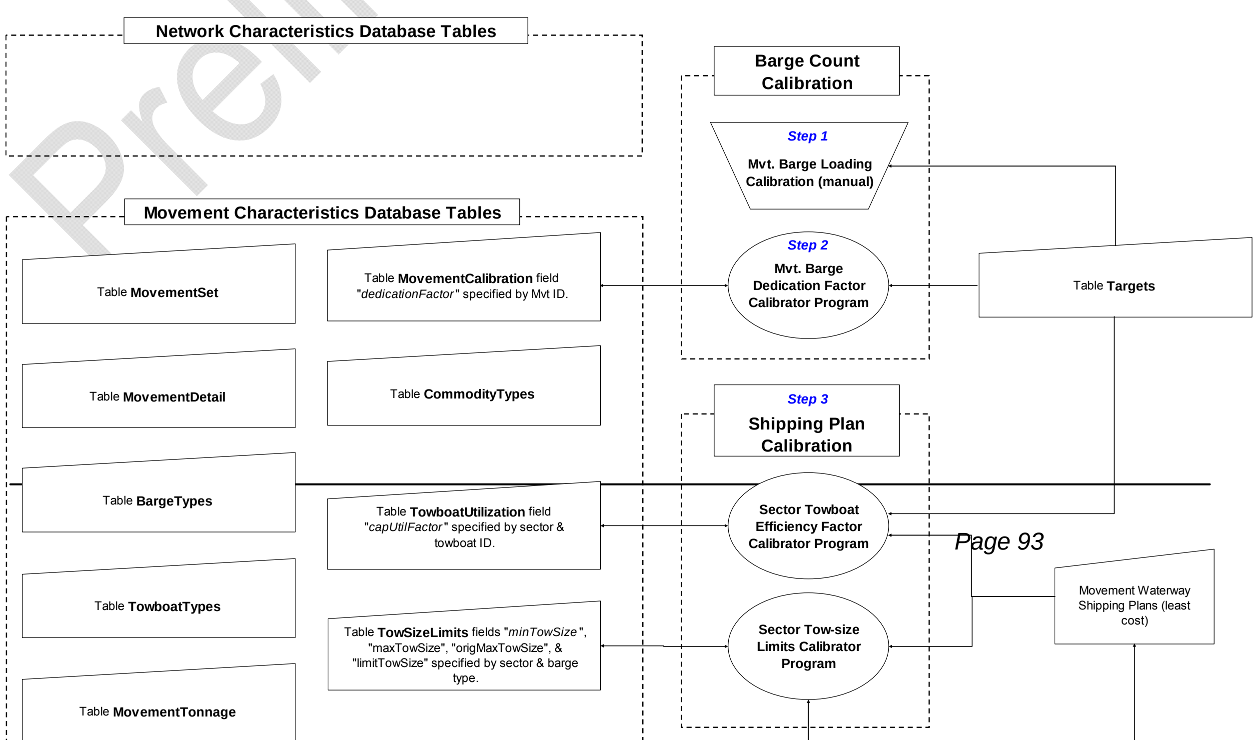
WSDM is a behavioral model and as previously noted WSDM actually serves two tasks: develop least-cost shipping plans and estimate equilibrium system traffic levels from a bottom-up movement level analysis. The focus of calibration is on WSDM movement shipping plan development. By using detailed data describing the waterways network, the equipment used for towing operations, and the commodity flow volume and pattern, WSDM calculates the resources (i.e., number towboats, trip time, and fuel consumption) required to satisfy the demand on a least-cost basis for each movement in the system. These results are then aggregated and summarized at each navigation project in the system and compared with observed behavior.

Calibration is a sequential process involving several iterative steps; at each step, certain static components of the model's waterway system description are adjusted or fine-tuned, the model is exercised, and specific results are compared with corresponding target values. There are three primary calibration steps: calibration of loaded barge flows; calibration of empty barge flows (movement barge dedication); and calibration of the shipping plans. Calibration of the movement shipping plans is further broken into calibration of tow-size and the selection of towboat type (horsepower).

In the past (late 1970's through mid-1990's) these calibrations were completed essentially manually. However, NIM now has three automated routines to fine-tune the calibration parameters to the user specified target statistics for the dedication factors and shipping plans. An automated routine to calibrate the loaded barges has not yet been developed since it is currently not needed. As shown in FIGURE 1B.5.1, the three automated calibration routines are known as: 1) the Movement Barge Dedication Factor Calibrator; 2) the Sector Tow-size Limits Calibrator; and 3) the Sector Towboat Efficiency Factor Calibrator. The yet to be developed calibration routine is the Movement Barge Loading Calibrator. The naming and function of these calibration programs are covered in the following sections.

For model calibration, verification and validation for this Calcasieu Lock analysis, an average of 2005 through 2007 data was used. This was done primarily because the rate data developed for this study assumed the shipping characteristics for this 2005-2007 time period and model costs need to be synchronized with these rates. Additionally, this averaging over several years also allows for a smoothing of the data to avoid individual year irregularities.

FIGURE 1B.5.1 – Calibration Process



K.2.1.25 Calibrating the Loaded Barge Flows

The first calibration step is to determine the loaded barge flows in the system. The model determines the number of loaded barges in the system by dividing each movement's annual tonnage by each movement's average barge loading. The average barge loading for each movement can be either calculated internally to the model or it can be calculated externally and specified as an input.

The movement barge loading is stored in the "*TonsPerBarge*" field of the "*MovementBarge*" table (TABLE 1B.2.32). If there is a record for the movement in the MovementCalibration table, then that record overrides the tonsPerBarge value from the MovementBarge table. If, after looking in both of these tables, the value of the "*TonsPerBarge*" field equals zero, the model will automatically calculate a barge loading for the movement using the equation shown below.

$$\text{Mvt. Barge Loading} = \text{MIN}\left(\text{Barge Type Capacity},\ \left(\text{barge Type Length} \times \text{barge Type Beam} \times \text{barge Type Blocking Coefficient} \times \text{MIN}\left(0.0312, a\right) \times \text{MIN}\left(b, c\right)\right)\right) \qquad (1B.5\text{-}1)$$

where:

a = commodity density in tons/cubic foot (field "density" in table "CommodityTypes")

b = barge draft loaded – barge draft empty

c = min depth of link along path – required barge clearance – barge draft empty

For the Calcasieu Lock analysis the barge loadings were calculated externally to the model and supplied as an input directly into the "*MovementBarge*" table. Since channel depths and barge loadings were not expected to change through the analysis period, or between the without and with-project conditions, externally calculating the barge loadings was the most straight forward and accurate method. The external calculation of the movement barge loading is discussed in section K.2.1.9.

Since studies to date have not needed an analysis of barge loading effects, an automated calibration of the barge loadings (to be called the Movement Barge Loading Calibrator) has not been developed.

Since the movement barge loadings are specified as input in this analysis, and as a result the system loaded barge statistics that the model should produce given this input are known, this calibration step converts to a verification test (TABLE 1B.3.2).

K.2.1.26 Calibrating the Empty Barge Flows

The second calibration step is to determine the empty barge flows in the system, or more specifically, the empty barge backhaul flows associated with each loaded movement. This is done at the movement level so that the loaded front-haul movement can be cost with applicable charges for empty return trips.

Loaded movement empty barge backhauls are determined from a "*dedication*" factor assigned to each movement listed in the "*MovementCalibration*" table, which specifies how dedicated the loaded barges are to the movement. If the dedication factor is 0.0, the barges are totally undedicated, meaning that when they have finished the loaded trip from the movement's waterside origin to its waterside destination, they are free to move to another movement and are no longer part of the movement's cost calculation. If the dedication factor is 1.0, the barges are totally dedicated to the movement, meaning that when they have finished the trip from the movement's origin to its destination, they are required to move empty back to the movement's origin. If the dedication factor is between 0.0 and 1.0, the barges are partially dedicated, and the dedication factor indicates what portion of the set of barges must make the trip back to the movement's origin empty.

K.2.1.1.25 Loaded Back-Haul Potential

The original Port-to-Port Algorithm (TCM) defined the barge "*dedication*" factor as the probability that the back-haul of a movement will be empty if a back-haul potential exists. The current Port-to-Port Algorithm, however, defines the barge "*dedication*" factor as a simple proportion of movement empty barge back-hauls.

K.2.1.1.1.29 Original Barge Dedication Factor Definition

Defining the barge dedication factor as the probability that the back-haul will be empty requires several additional modeling steps. In short, the dedication factor was used as a means to limit potential backhauls even though bidirectional flows of a particular transportation class may exist. And, if a backhaul movement for a particular movement does not exist, there is no other choice than to return empty.

Loaded backhauls are controlled by three factors: 1) the direction of commodity flows carried by the barge; 2) the adaptability of the barge for backhaul (the dedication factor); and 3) the level of towing company efficiency (as affected by institutional and market arrangements, long-term contractual arrangements, imperfect knowledge of potential shippers and consumers, delivery timing, etc.).

As an extreme example, say there is only one movement in the system generating 100 loaded barges from origin port A down-bound to destination port B with a dedication factor of 0.0 transiting one lock project. Simply using the dedication factor in this case would cost the movement for only the loaded shipment(s) and result in 100 loaded barges down-bound and zero barges up-bound through the lock. With this example there is no conservation of barge equipment (there are no loaded backhauls and no empty barge deliveries to port A) and the system is unsustainable. In this example, despite a dedication factor of 0.0, there is no other choice than to return empty. The movement will have to generate, and be cost for, empty return trips in order to supply its own empty barge needs. In effect, the applied dedication factor is 1.0 resulting in 100 loaded barges down-bound and 100 empty barges up-bound through the lock.

As an additional example, say there are two movements in the system. MovementID 1 consists of 100 loaded barges from origin port A down-bound to destination port B with a dedication factor of 0.0 transiting one lock project. MovementID 2 consists of 100 loaded barges from origin port B up-bound to destination port A with a dedication factor of 0.75 transiting the same lock project. While all 100 loaded barges from movementID 1 are released and available for loaded backhaul, movementID 2 has 75% of its loaded barges dedicated to the movement which means that only 25% (or 25) of its barges are released at port A and available for loading by movementID 1. As a result, despite movementID 1 having a dedication factor of 0.0, it will require 75 of its loaded barges to return empty; an effective dedication factor of 0.75.

K.2.1.1.1.30 Current Barge Dedication Factor Definition

The current Port-to-Port Algorithm defines the barge dedication factor as a simple proportion of movement empty barge backhauls (assuming the remaining barges return to the origin as loaded front-hauls of other movements. This simplification avoids specification of transportation classes (section K.2.1.1.20), speeds up the shipping-plan calculations, and simplified the empty barge calibration.

K.2.1.1.26 Movement Barge Dedication Factor Calibrator

Empty trips are recorded by WCSC, however, the data files have been found to be incomplete (although improving through time). As a result, backhaul characteristics between specific origin-destinations can only be estimated. While the movement dedication factors can be manually set and adjusted by the user, an automated calibration program called the Movement Barge Dedication Factor Calibrator (FIGURE 1B.5.1) was developed. In this process, the dedication factor is assigned using a set of linear programming problems. In the first linear program the objective is to minimize the deviation from the target number of empty barges at each navigation project, given the path that each of the movements is taking. Solving this, the program determines a total "*best deviation from targets*" value. In general, there may be several assignments of dedication factors to movements that will achieve this best deviation. Tanker barges are more likely to be dedicated than are hopper barges, due to the nature of the cargo that they carry. The second linear program attempts to maximize the dedication factors for the tanker classes of barges, and minimize the dedication factors for the hopper classes of barges. Using this objective and the added constraint that the total deviation is equal to the "*best deviation*" found in the first linear program, the model determines a final setting of the dedication values which are then stored.

The empty barge flows are then aggregated and summarized at each navigation project in the system and compared against observed behavior. As shown in TABLE 1B.5.1, calibration of movement level dedication factors appears to reproduce system empty barge flows quite well.

TABLE 1B.5.1 – Empty Barge Calibration

Navigation Lock Project	Number of Empty Barges				Percent Empty			
	Estimated Target *	Model Output	Difference Absolute	Difference Pct.	Estimated Target *	Model Output	Difference Absolute	Difference Pct.
Study Project								
CALCASIEU L&D	12,376	12,375	1	0.0%	48%	49%	0	-0.9%
Gulf Intracoastal Waterway								
ALGIERS L & D	8,328	8,328	0	0.0%	40%	40%	0	-0.1%
BAYOU BOEUF L & D	10,984	10,983	1	0.0%	39%	40%	0	-3.0%
BAYOU SORREL LOCK & DAM	7,963	7,963	0	0.0%	39%	39%	0	0.1%
HARVEY L & D	710	709	1	0.1%	39%	39%	0	0.0%
INNER HARDBOR LOCK & DAM	5,324	5,323	1	0.0%	43%	43%	0	0.2%
LELAND BOWMAN L & D	12,725	12,724	1	0.0%	48%	46%	0	4.7%
PORT ALLEN LOCK AND DAM	7,930	7,930	-1	0.0%	41%	41%	0	0.0%
Old River								
OLD RIVER L & D	3,417	3,417	0	0.0%	41%	41%	0	0.0%

** Averaged 2005-2007 LPMS data.*

Since the empty barge flows are generated from loaded movements through the movement's dedication factor, when the model is exercised with a future traffic demand, the empty barge flows automatically adjust as the loaded barge flows adjust to equilibrium. Given that the demand growth and equilibrium mix of movements could, and most likely will be, different than in the calibrated year, the percent empty barges at the projects can, and most likely will, vary from the values shown. For an extreme example, say the demand for movements in the system with 0.0 barge dedication factors declines through time to zero, while demand for movements in the system with 1.0 barge dedication factors increases. Through time the percent empty at all projects will rise to 50% empty as more and more trips in the system require empty barge returns.

If for some reason, a future fleet is needed that assumes different empty barge return characteristics, the dedication factors can be re-calibrated using the anticipated navigation project empty barge count targets. If the empty barge backhaul on individual movements are identified as needing adjustment under a new future fleet, they can be adjusted manually. As shown in FIGURE 1B.5.1, the movement dedication factors are stored in the "*MovementCalibration*" database table summarized in TABLE 1B.5.2. The database contains a "*year*" field in the key allowing for specification of a year specific calibration of the dedication factors, as well as a year specific barge loading. As noted, for model calibration for the Calcasieu Lock analysis an average of 2005 through 2007 data was used, and in this case the calibration parameters and target statistics were stored in the database as year "*9999*".

TABLE 1B.5.2 – MovementCalibration Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
networkVersion	DB Key	Version ID (a variation of the network) defined in NetworkVersion table
movementID	DB Key	Unique movement ID
year	DB Key	Year
tonsPerBarge		Barge loading if not specified in the MovementBarge table
dedicationFactor		Percent of loaded barges returning empty (i.e. dedicated to front flow)

K.2.1.27 Calibrating Tow-sizes, Number of Tows, and Towboat Type

The third component of the calibration process is the calibration of the movement shipping-plans, or specifically movement level tow-sizes and towboat types used between waterside origin to waterside destination. If movement tow-sizes and towboat types were set based solely on the physical limitations of the river and the towing capacity of the equipment, WSDM would tend to produce shipping plans with larger tows and smaller towboats than historically observed. This occurs because WSDM calculates the resources (i.e., number towboats, trip time, and fuel consumption) required to satisfy the demand on a least-cost basis. Because of economies of scale, the smallest towboat to move the largest tow is the least-cost shipping plan, however, the world is not perfect and other factors are considered in the shipping plan determination.

Unlike the calibration of empty barge flows in the system where movement dedication factors are adjusted, calibration of the movement shipping plans involves two sets of calibration parameters specified at the river segment level (rather than at the movement level). When the model develops a shipping plan for a movement, it considers all the river segment restrictions in its route. To account for the factors causing shippers to use smaller tow-sizes than possible, WSDM contains a calibration parameter specifying river segment tow-size limitations. To account for the factors causing shippers to use larger horsepower towboats than possible, WSDM contains a calibration parameter specifying river segment towboat class efficiency limitations. These two calibration parameters are interrelated in their effect on the selection of a movement's least-cost shipping plan and ultimately the fleet distributions observed at each navigation project.

Given the specified river segment tow-size and towboat class efficiency limitations, WSDM calculates the least-cost shipping plan for each movement in the system. Note that this shipping plan might involve multiple waterway legs, each having its own tow-size and towboat characteristics. The shipping plans for all the movements can then be aggregated and summarized at each navigation project in the system and compared against observed behavior (e.g., number of tows and average horsepower).

In addition, each towboat type specified in the model has a maximum limit as to the number of barges that it can tow, regardless of where in the river system it is working. These towboat class towing limits are typically fixed and are not adjusted in the calibration process. However, they limit the ability of calibrating to movement tow-sizes larger than these equipment limits. To summarize, the tow-sizes selected by the model are limited by: 1) river segment barge type tow-size limits along the movement's route; 2) river segment towboat class efficiency factors along the movement's route which are used to determine the towboat type; and 3) the towboat class towing capacity (maximum barges per tow).

As discussed, river segments in the model network are defined as rivers, sectors, nodes, and links (FIGURE 1B.2.1). The tow-size limits and towboat class efficiency factors are specified at the link level, however, sector level settings can be specified. The "*linkIndex*" in the "*TowSizeLimits*" table (TABLE 1B.2.25) corresponds to the link ID specified in the "*Links*" table (TABLE 1B.2.19). When "*linkIndex*" is set to zero, however, the parameters are used for all links within that sector except for any link specific records which will override any sector level specification.

K.2.1.1.27 Tow-Size Limits and Towboat Efficiency Factor Calibrators

While the river segment tow-size limits and towboat efficiency factors can be manually set and adjusted by the user, two automated calibration programs called the Sector Tow-size Limits Calibrator and the Sector Towboat Efficiency Factor Calibrator (FIGURE 1B.5.1) were developed. Because the determination of the shipping plan is a complex process, an analytic procedure similar to that used to set the dedication factors (empty barge flows) could not be used. Instead, the calibration of movement tow-size and towboat type is done in an iterative process, by making a small change to a sector level tow-size limit or towboat efficiency factor (i.e., "*linkIndex*" = 0), running WSDM with the changed value, and noting whether the result is closer to the targets than before the change. This is done for every barge type and for every towboat type on every specified river segment. Once all of the possible changes have been examined, the calibration program chooses the change that will result in the most improvement, changes that value in the database, and then iterates again. When improvements are negligible (less than a .001 change), or the analyst determines the improvements are negligible, the calibration program is stopped.

The Sector Tow-size Limits Calibrator and the Sector Towboat Efficiency Factor Calibrator can be run separately, but are typically run simultaneously. These automated calibration programs are very CPU intensive, especially when run together. To speed up the calibration process in the study area, NIM allows the specification of a sector range (an aggregation of links) to calibrate.

K.2.1.1.28 Determination of the Calibration Network Sectors

As noted, the shipping plan calibration programs adjust the various calibration parameters for every barge type and for every towboat type on every specified river segment. These river segments are referred to in the model as sectors (FIGURE 1B.2.1). Iterating through all 200 sectors in the ORS network and adjusting the tow-size limit and towboat efficiency factors can be very CPU intensive. By focusing calibration on the most important sectors, the two automated shipping plan calibration processes can be sped up. To do this NIM allows the specification of a sector range on which to iterate these two calibration programs.

As discussed in section K.2.1.10, for model verification, calibration, and validation the focus is on the nine locks analyzed in the Calcasieu Lock network.

K.2.1.1.29 Sector - level Tow-size Limits

The Sector Tow-size Limits Calibrator was run to adjust and calibrate the "*maxTowSize*" field in the "*TowSizeLimits*" table (TABLE 1B.2.25) with "*linkIndex*" set to zero. When "*linkIndex*" is set to zero the parameter used is the same for all links within that sector unless overridden by a link specific "*maxTowSize*" entry. Once adjustments to the tow-size limits are made, the model re-estimates the least-cost movement shipping plans which are then aggregated and summarized at each navigation project in the system and compared against observed behavior (the targets) as shown in TABLE 1B.5.3.

TABLE 1B.5.3 – Tow and Tow-size Calibration

Navigation Lock Project	Number of Tows				Average Barges Per Tow			
	Estimated Target *	Model Output	Difference Count	Difference Pct.	LPMS Target **	Model Output	Difference BPT	Difference Pct.
Study Project								
CALCASIEU L&D	11,611	11,592	18	0.2%	2.7	2.7	0.0	-0.2%
Gulf Intracoastal Waterway								
ALGIERS L & D	8,100	8,134	-35	-0.4%	2.5	2.5	0.0	0.4%
BAYOU BOEUF L & D	13,058	13,101	-44	-0.3%	2.0	2.0	0.0	0.2%
BAYOU SORREL LOCK & DAM	5,293	5,175	117	2.2%	3.9	3.8	0.0	0.7%
HARVEY L & D	1,205	1,262	-57	-4.7%	1.2	1.2	0.0	-0.1%
INNER HARDBOR LOCK & DAM	5,878	5,872	6	0.1%	2.2	2.2	0.0	0.0%
LELAND BOWMAN L & D	12,137	11,128	1,009	8.3%	2.7	2.9	-0.2	-9.1%
PORT ALLEN LOCK AND DAM	5,653	6,072	-420	-7.4%	3.5	3.3	0.2	7.0%
Old River								
OLD RIVER L & D	2,080	2,106	-25	-1.2%	3.4	3.3	0.1	2.1%

** Sum of WCSC loaded barges plus estimated empty barges (using averaged 2005-2007 LPMS percent empty) divided by averaged 2005-2007 LPMS barges per tow.*

*** Averaged 2005-2007 LPMS barges per tow data.*

While not a perfect match, it should be noted that the modeling process simplifies tows to one commodity (or empty) and one barge type, while in the real world tows are often comprised of multiple commodities, including empties, in multiple types of barges. Expectation of a perfect match between the observed target data and the model results would be unrealistic.

While the Sector Tow-size Limits Calibrator can adjust the "*maxTowSize*" field up or down, there is also a "*limitTowSize*" field in the "*TowSizeLimits*" table which establishes a cap on the adjustment. This is to ensure that tow-sizes do not exceed the operating policy of the locks (e.g., main chamber single cut).

K.2.1.1.30 **Sector - level Towboat Efficiency Factor**

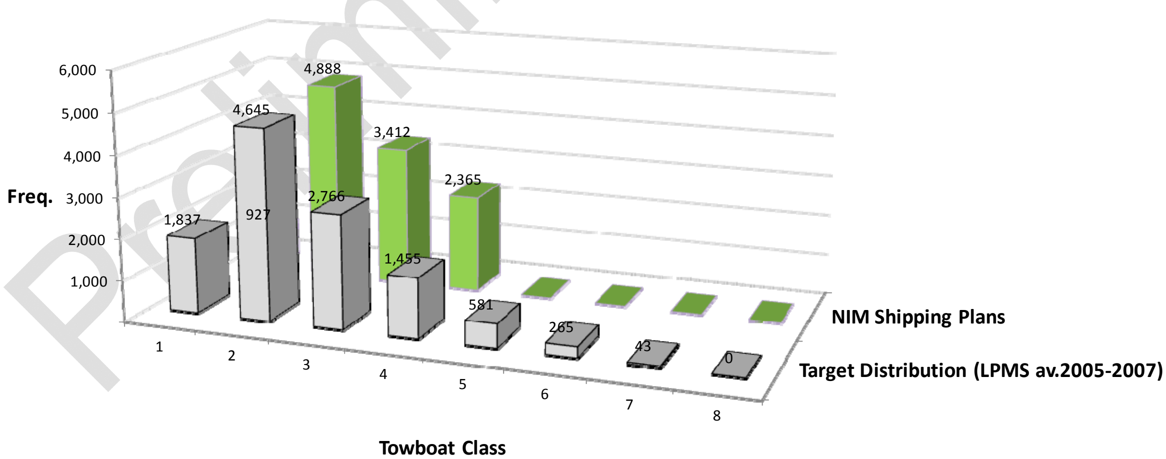
The Sector Towboat Efficiency Factor Calibrator was run to adjust and calibrate the "*capUtilFactor*" field in the "*TowboatUtilization*" table (TABLE 1B.2.25) with "*linkIndex*" set to zero. When "*linkIndex*" is set to zero the parameter is used for all links within that sector unless overridden by a link specific "*capUtilFactor*" entry. Once adjustments to the towboat efficiency factors are made, the model re-estimates the least-cost movement shipping plans which are then aggregated and summarized at each navigation project in the system and compared against observed behavior (the targets) as shown in TABLE 1B.5.4. Additionally, the 2005 through 2007 LPMS towboat class frequencies for Calcasieu Lock are summarized and compared against model output as shown in FIGURE 1B.5.2.

TABLE 1B.5.4 – Towboat Type (Average Horsepower) Calibration

Navigation Lock Project	Average Project Rated Horsepower (LPMS)				Av. Project Rated HP Compared to Model			
	Actual	Towboat Class Av.	Difference HP	Difference Pct.	Class Av. Target	Model	Difference HP	Difference Pct.
Study Project								
CALCASIEU L&D	1,495	1,499	-4	-0.3%	1,499	1,463	36	2.4%
Gulf Intracoastal Waterway								
ALGIERS L & D	1,433	1,463	-30	-2.1%	1,463	1,452	10	0.7%
BAYOU BOEUF L & D	1,160	1,251	-91	-7.8%	1,251	1,247	4	0.3%
BAYOU SORREL LOCK & DAM	1,759	1,710	48	2.7%	1,710	1,576	135	7.9%
HARVEY L & D	1,033	1,134	-101	-9.8%	1,134	1,122	12	1.1%
INNER HARDBOR LOCK & DAM	1,492	1,532	-40	-2.7%	1,532	1,532	0	0.0%
LELAND BOWMAN L & D	1,450	1,471	-22	-1.5%	1,471	1,526	-55	-3.7%
PORT ALLEN LOCK AND DAM	1,655	1,622	33	2.0%	1,622	1,618	4	0.3%
Old River								
OLD RIVER L & D	1,828	1,802	25	1.4%	1,802	1,827	-25	-1.4%

SOURCE: 2005-2007 WCSC and LPMS data.

FIGURE 1B.5.2 – Calcasieu Lock Towboat Class Distributions



K.2.1.1.31 **Auto Shipping Plan Calibration Logic**

The auto tow-size and towboat type calibration programs (Sector Tow-size Limits Calibrator and Sector Towboat Efficiency Factor Calibrator) use a heuristic approach to minimize the difference between the model's least-cost shipping plan tow configurations lock statistics and the target (observed) lock statistics in the system. At a summary level, this heuristic generates a set of potential changes to each sector's tow-size and towboat constraints, regenerates all the movement shipping plans under each changed constraint one at a time, and then chooses the single change that produces the greatest improvement. This process continues until no significant improvement can be made.

K.2.1.1.1.31 Incumbent Calibration Fitness

The calibration process begins by determining summary lock statistics and comparing them to the specified targets. It calculates three "offness" measures based on: (1) difference in the number of tows ("*offTows*"), (2) difference in the number of tows of each size ("*offTowSize*"), and (3) difference in average horsepower ("*offHorsepower*"). In each case, the absolute difference between the model results and the target at each lock is weighted by the lock's "*calibration weight*" which reflects the importance of the lock in the overall analysis.

These offness measures are calculated as:

$$\text{offTows} = \sum_{\text{over all locks}} \text{ABS}\left(\begin{matrix}\text{Target \#}\\ \text{of Tows}\end{matrix} - \begin{matrix}\text{Model \#}\\ \text{of Tows}\end{matrix}\right) \times \begin{matrix}\text{Lock}\\ \text{Calibration}\\ \text{Weight}\end{matrix} \qquad (1B.5\text{-}2)$$

$$\text{offHorsePower} \sum_{\text{over all locks}} \text{ABS}\left(\begin{matrix}\text{Target}\\ \text{Av. HP}\end{matrix} - \begin{matrix}\text{Model}\\ \text{Av. HP}\end{matrix}\right) \times \begin{matrix}\text{Lock}\\ \text{Calibration}\\ \text{Weight}\end{matrix} \qquad (1B.5\text{-}3)$$

$$\text{offTowSize} = \sum_{\text{over all locks}} \left[\sum_{\substack{\text{over all}\\ \text{tow-size}}} \text{ABS}\left(\begin{matrix}\text{Target}\\ \text{Tow-}\\ \text{Size \%}\end{matrix} - \begin{matrix}\text{Model}\\ \text{Tow-}\\ \text{Size \%}\end{matrix}\right)\right] \times \begin{matrix}\text{Lock}\\ \text{Calibration}\\ \text{Weight}\end{matrix} \qquad (1B.5\text{-}4)$$

Where the target number of tows and average horsepower for each navigation project in the system are stored in the "Targets" table discussed in section K.2.1.1.1.20 *and the target tow-size distributions for each navigation project in the system are stored in the "TargetTowSizeDistribution" table discussed in section K*.2.1.1.1.21

These three offness values are measured independently, but they are related. In general, as the number of tows at a lock decreases, the size of the tows going through the lock and the average horsepower of the towboats will tend to increase.

For an overall measure of how well the model parameters have been calibrated to achieve the target values, a single system-wide "*calibration fitness*" value is calculated. To calculate the calibration fitness value these three offness measures are combined with positive weighting factors:

$$\text{Calibration Fitness} \left(\text{offTow} \times \begin{matrix}\text{offTow}\\ \text{Weighting}\\ \text{Factor}\end{matrix} \right) + \left(\text{offTowSize} \times \begin{matrix}\text{offTowSize}\\ \text{Weighting}\\ \text{Factor}\end{matrix} \right) + \left(\text{offHorsePower} \times \begin{matrix}\text{offHorsePower}\\ \text{Weighting}\\ \text{Factor}\end{matrix} \right) \quad (1B.5\text{-}5)$$

The weighting factors are user specified according to the importance of the individual measure in their analysis. In a perfectly calibrated system, the calibration fitness value (and each offness measure) would be zero.

For this Calcasieu Lock analysis, Calcasieu was set with a lock calibration weight of 1.0 and the remaining eight locks were set with a calibration weight of 0.75. These settings were selected based on an analysis of Calcasieu Lock traffic flow commonality as discussed in section K.2.1.10.

The offness weighting factors are primarily used to keep the absolute differences at the same order of magnitude. The offness weighting factors were set as:

offTows weighting factor = 1

offHorsePower weighting factor = 1

offTowSize weighting factor = 500

Once this "*incumbent*" calibration fitness value is calculated, the calibration program examines the effects of small and large changes to the tow-size limit and towboat utilization factor parameters for each sector specified that are inputs to the WSDM model. Recall that the tow-size limits in barges per tow are specified for each combination of sector and barge type, and that the towboat utilization factors are specified for each combination of sector and towboat type. Recall further that for each sector and barge type, there is a user-specified absolute maximum tow-size limit (and an implicit minimum tow size limit of 0 barges), and that towboat utilization factors range from 0.0 to 1.0 (including 0.0 and 1.0) representing a towing capacity utilization of the absolute maximum towing capacity for that towboat class. The calibration process examines modifications to the tow-size limits and towboat utilization factors while staying within these limits. While the user can specify to run the Sector Tow-size Limits Calibrator and the Sector Towboat Efficiency Factor Calibrator, the discussion following assumes both are being run.

The user first specifies a list of sectors the calibration process can modify (K.2.1.1.28) and for each of these sectors, the calibration process first considers modifications to the tow-size limit parameters and then to the towboat utilization factors as discussed below.

K.2.1.1.1.32 Tow-size Limit Trails

For each barge type in each sector in the calibration sector range, the Sector Tow-size Limits Calibrator program determines the calibration fitness that would result if it increased or decreased that barge type's tow-size limit by 5 barges, and if it increased or decreased that barge type's tow-size limit by 1 barge. If the tow-size increase exceeds the absolute maximum tow-size limit for that barge type and sector, the trial is skipped. If the tow-size decrease results in a negative tow-size for that barge type and sector, the trial is skipped. Only one parameter is modified from the original in each of these four trials; the other parameters are left as they were when the incumbent value was determined. As an example, say 2 sectors are specified in the calibration range and there are 6 barge types. In this example there will be up to 48 trials, each with a calibration fitness value based on the unique shipping plans developed under each tow-size limit parameter settings.

K.2.1.1.1.33 Towboat Utilization Factor Trails

For each towboat type in each sector in the calibration sector range, the Sector Towboat Efficiency Factor Calibrator program determines the calibration fitness that would result if that towboat type's towboat utilization factor were increased or decreased by 0.9. If the increase or decrease lies outside of a [0.0 – 1.0] range, the trial is skipped. Note that smaller adjustments to the towboat utilization factors will be considered in subsequent iterations (discussed further below).

A side note: When changing the towboat utilization factor of a towboat on a sector, there is logic in the code that requires that all sectors downstream of that sector have at least that large of a towboat utilization factor for that towboat and similarly that all towboat utilization factors upstream of that sector cannot exceed that sector's towboat utilization factor. The logic behind this is that a towboat operating on a sector should be at least as capable on downstream sectors. Therefore, a towboat class utilization factor change may ripple up or down the river system when a change is considered. Unlike the tow-size limit trial where only one parameter is changed, in the towboat efficiency trial multiple towboat efficiency factors downstream may be increased and multiple towboat efficiency factors upstream may be decreased to maintain the towboat efficiency monotonicity discussed. After this modification's calibration fitness measure is determined, all towboat utilization factors are reverted to their initial values before the next modification is evaluated.

As an example, say 2 sectors are specified in the calibration range and there are 8 towboat class types. In this example there will be up to 32 trials, each with a calibration fitness value based on the unique shipping plans developed under each tow-size limit parameter settings.

K.2.1.1.1.34 Selection of the Best Parameter Adjustment

The calibration process then determines what the best (*i.e.*, lowest) calibration fitness value is among the incumbent calibration fitness value and the (possibly large) set of trials calculated due to parameter modifications. For example, say 2 sectors are specified in the calibration range, with 12 barge types and 8 towboat class types. In this example there are up to 128 trials to compare (assuming no skipped trials from exceeding the adjustment boundaries). If the best fitness value is one of the trials, then that modification is made in the database, and the corresponding fitness value becomes the new incumbent fitness value. If the modification was a towboat utilization factor change, the "*ripple effect*" on towboat utilization factors is imposed upstream and downstream from the sector involved to assure that the towboat utilization factors are non-decreasing as you go from the head of a river to its mouth.

K.2.1.1.1.35 Iteration

If the improvement in the calibration fitness value is greater than 20, the program goes through the list of sectors again to determine the effects on the calibration fitness with modifications (+/- 5, +/- 1) to the tow-size limits and (+/- 0.9) to the towboat utilization factors. As long as the improvement to the fitness value is greater than 20, the calibration process will continue looking at all sectors, at all barge types and towboat types, evaluating up to four (+/- 5, +/- 1) changes to each tow-size limit and up to two (+/- 0.9) changes to each towboat utilization factor.

If the incumbent fitness value was determined to be the best fitness value, or the improvement to the fitness value is less than 20, the Sector Towboat Efficiency Factor Calibrator program reduces the change considered in its towboat utilization factor adjustments. Instead of looking at changes of 0.9, it considers increasing or decreasing the towboat utilization factors by 0.8. The rest of the calibration process remains the same, looking at all sectors, at all barge types and towboat types, evaluating up to four (+/- 5, +/- 1) changes to each tow size limit and two (+/- 0.8) changes to each towboat utilization factor.

Each time the improvement drops below 20 for an iteration, the calibration routine will decrease the towboat utilization factor change by 0.1. Regardless of what the magnitude of the towboat utilization factor is, the program will look at all sectors, at all barge types and all towboat types to determine the possible parameter changes that will be beneficial in decreasing the calibration fitness value. The magnitude of the towboat utilization factor change never increases during a calibration run, and once it is set to 0.1, it remains there for the duration of the calibration run. As long as the calibration fitness value decreases at every iteration, the calibration program will continue to run, each time making the change the resulted in the largest decrease. The program terminates with its best estimate of the tow size limits and towboat utilization factors for all sectors when it cannot find an improvement in the fitness value and the towboat utilization factor change equals 0.1.

K.2.1.1.1.36 GIWW Calibration

For the Calcasieu Lock analysis the calibration focus was on the nine lock projects in the GIWW (given the commonality of Calcasieu Lock flows with these areas of the GIWW) As a result, the calibration process focused most of its time on the GIWW, the Atchafalaya River, and the lower Mississippi River. Specifically, NIM sectors 39, 42-46, 56, 60-61, 126-131, 136-137, 151-174, and 187 were the areas of concentration. However, to ensure that characteristics of sectors further from the area of interest were in the correct range, calibration runs were also made with the entire network. Calibration to an average 2005 through 2007 system resulted in the following calibration offness and calibration fitness measures:

offTows = 1,731.828

offHorsePower = 220.030

offTowSize = 4.247

Calibration Fitness = 1,731.828 + 220.030 + (4.247 x 500) = 4,075.358

Though during the calibration process, the algorithm is guided by the overall amount that the statistics are off from the lock targets, there is a report available that details the statistics at the individual lock projects. Viewing this report is useful in determining whether the calibration process can be terminated.

K.2.1.28 **Movement Cost-to-Rate Delta**

The validated calibration process also allows for the movement's estimated cost to be compared against the movement's base water routed rate to form a cost-to-rate delta. In the equilibrium process when the model is exercised in a cost-benefit analysis, the movement cost-to-rate delta is used to convert the model's waterway line-haul cost calculation to a rate (or price) so that it can be used with the movement's barge transportation willingness-to-pay (which is price-quantity).

These values are not stored in the database, however, but are just regenerated and stored in memory at the beginning of each WSDM (i.e., equilibrium) run.

Calcasieu Lock
Louisiana Feasibility Study

Appendix K Attachment 2

ADDENDUM C

Demand Curve Input

May 2013

Prepared by:

Navigation Planning Center,
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K.2C.1 INTRODUCTION

Movement level barge transportation (annual origin-destination commodity) willingness-to-pay can be defined in NIM as either fixed quantity or price responsive. The waterway transportation willingness-to-pay shows the relationship between the quantity shippers are willing to ship and the price (rate) charges, while holding the rates of alternative modes constant.

For the Calcasieu Lock analysis, all movements in the model were assigned a commodity specific demand curve based on a study of demand elasticity in the GIWW-West system (Attachment 1 Addendum C Barge Transportation Willingness-To-Pay). The Wilson shipper response analysis produced multiple models (briefly summarized in the next section); however, for input into the Calcasieu Lock analysis the revealed choice model was used. These market level demand functions, however, cannot be directly input into GIWW NIM. The sections below describe the application of the Wilson models to generate GIWW NIM price-responsive demand curve inputs.

K.2C.2 THE SHIPPER RESPONSE MODELS

In support of the Calcasieu study, Wes Wilson *et. al.* studied the behavior of shippers on the related waterways and modeled the reaction of the shippers to price increases[1]. Both revealed and stated preference data were collected and analyzed, resulting in a revealed choice and a stated preference choice models. A combined revealed and stated preference model proved to be unachievable.

K.2.0.1 The Stated Preference Models

The stated preference (SP) model is a logit form structured to capture the changes in the rate, time in transit, and reliability attributes with shipper responses of do not switch, switch to another alternative, and shutdown given transportation mode specific price increase. The following five models were developed (The SP model parameters for each of the five models are shown in TABLE K.2C.1):

- Only the percentage rate change (Model 1)
- An alternative specific intercept (Model 2)

[1] Wesley W. Wilson, Mark Campbell, and Wilcox Gleasman. *2010 Shipper Response Models for the Calcasieu Lock and GIWW-West*.

- A model in which mode dummies are added (Model 3)
- A model with commodity dummies (Model 4)
- A model with both mode and commodity dummies (Model 5)

In short, only Model 3 is applicable. Model 1 produced backward sloping demand curves due to a negative coefficient on percent change in price and was deemed an inappropriate model. Model 2 was expanded into Model 3 by adding mode dummies. Models 4 and 5 contained chemical commodity dummy which added insignificant model accuracy.

As noted, Model 3 is an expansion of Model 2 where mode dummies were added. This created a model structured for application to all shippers whether barge, rail, or truck. However, in the Calcasieu Lock analysis only the barge shipper is applicable (i.e., the intercept (switch) and intercept (shut down) parameters which represent the barge intercepts) are applicable in the demand curve equation.

TABLE K.2C.1 – Stated Preference (SP) Choice Logit Model Results

VARIABLES	(1)	(2)	(3)	(4)	(5)
% Change in Price (Switch)	-0.00992	0.0382*	0.0368*	0.0377*	0.0367*
	(0.00881)	(0.0196)	(0.0203)	(0.0201)	(0.0210)
% Change in Price (Shutdown)	-0.0210**	0.0821***	0.0861***	0.0887***	0.0915***
	(0.00825)	(0.0263)	(0.0297)	(0.0286)	(0.0318)
Intercept (Switch)		-1.942***	-2.045**	-2.001***	-2.132**
		(0.719)	(0.932)	(0.727)	(0.958)
Intercept (Shutdown)		-4.573***	-5.149***	-4.979***	-5.339***
		(1.226)	(1.539)	(1.375)	(1.645)
Truck (Switch)			0.130		0.0272
			(1.271)		(1.327)
Truck (Shutdown)			1.781*		1.647*
			(0.953)		(0.986)
Rail (Switch)			0.179		0.231
			(0.720)		(0.736)
Rail (Shutdown)			0.171		0.229
			(0.719)		(0.734)
Chemical (Switch)				0.00578	-0.142
				(1.296)	(1.318)
Chemical (Shutdown)				0.862	0.886
				(1.122)	(1.148)

K.2.0.2 The Revealed Choice Models

The revealed choice (RC) model is also in a logit form, expressed as a ratio of exponential terms. The logit model relates the waterway rate (in $ / ton) to the probability of a waterway movement given an alternative non-water rate (also in $ / ton). Two models were developed (TABLE K.2C.2). Model 1 is presented with rates as the only explanatory variable and the estimation was conducted based on the observed data. Model 2 was based on proxy (stated preference) data.

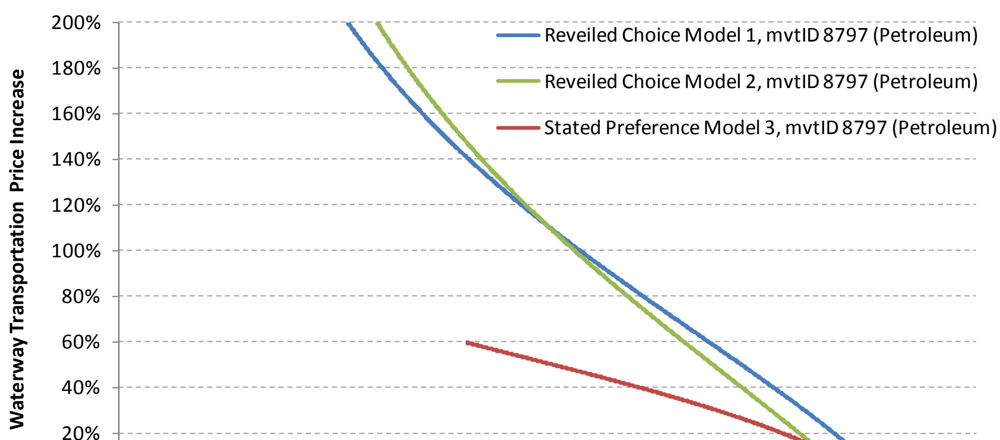
TABLE K.2C.2 – Revealed Choice (RC) Logit Model Results

Variables	Model 1	Model 2
ln(rate)	-2.866	-2.389
	(1.157)	(0.612)
Pseudo R2	0.41	0.42
Ln Likelihood	-9.6204	-19.0889
Likelihood Ratio	12.88	28.02

K.2.0.3 Models Compared

The SP Model (SP Model 3) is fed by the movement's water routed rate and the two RC models (RC Models 1 and 2) are fed by the movement's water routed rate and it's least-cost all-overland rate (next best all land). As shown in FIGURE K.2C.1, the three models produce different demand curves.

FIGURE K.2C.1 – Demand Curve by Shipper Response Model



It was advised that the RC Models were more accurate, and as a result the SP Model was not carried forward. Given the similarity of the results between the RC Model 1 and 2, only Model 1 was carried forward. In subsequent conversations with Wilson, it was advised that the model's shape parameter, the coefficient on lr (-2.866 of TABLE K.2C.2), could and should be varied to capture uncertainty in the demand curve.

K.2.0.0.1 Movement Demand versus Base Waterway Barge Demand

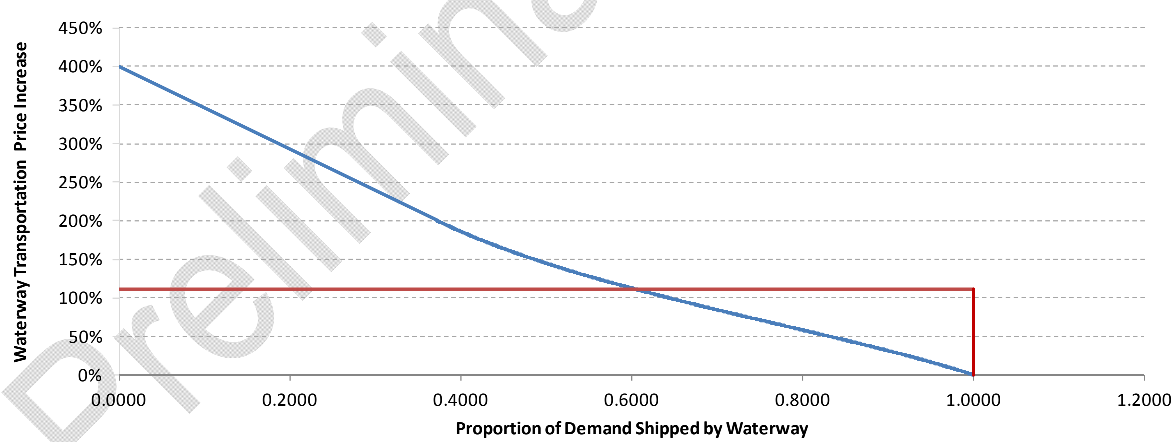
Another observation that can be made from FIGURE K.2C.1, is that the demand curve never reaches 100% of demand. This occurs because the equations are said to capture the full origin to destination demand, and that some of the tonnage is routed overland. To utilize the demand curves as generated the full movement demand tonnage is needed. This information (full demand), unfortunately is not readily available.

As a result, a distinction needs to be made between movement demand and barge transportation demand. NIM is not loaded with a forecasted movement demand, but with a forecasted movement barge transportation demand that assumes that the current transportation prices (in all transportation modes) are in effect throughout the forecast horizon. To apply the shipper response demand curves to barge transportation demand, the curves must be shifted to the 100% water shipped at the 0% water price increase. As a result, if observed tonnage were loaded into the NIM, the demand curve would predict 100% of the observed tonnage moves with no increase in water transportation price. Without shifting of the demand curve before input into NIM, the first increment of waterway transportation price increase (e.g., one cent per ton) would divert a significant portion of demand (e.g., 10%).

K.2.0.0.2 Consumer Surplus versus Rate-Savings

It is also interesting to compare the consumer surplus as defined by the shipper response choice modeling against rate-savings as defined by the rate estimation process. The comparison is certainly highly dependent upon the shape and slope of the demand curve. As shown in FIGURE K.2C.2, for petroleum movement number 8797 which has a base tonnage of 462,635, the integration under the shipper response demand curve results in an estimated consumer surplus of $ 22.9 million while the base rate-savings for the movement is $ 8.6 million.

FIGURE K.2C.2 – Consumer Surplus versus Rate-Savings



K.2C.3 DEVELOPMENT OF THE COMMODITY DEMAND CURVES

To transform the shipper response curves into NIM demand curve format, we must assign a movement to a curve based on its alternative rate and then scale the barge rate axis by the baseline waterway rate. We must also scale the result by the baseline probability of barge use so that the curve begins at the (1,1) point (see FIGURE K.2C.3).

K.2.0.4 The Stated Preference Models

At this time, none of the SP models were converted into NIM input.

K.2.0.5 The Revealed Choice Models

Since the RC models utilize the base water routed rate and the alternative least-costly all-overland rate, the generation of the demand curves for the Calcasieu movements combines the results of the movement rate estimation process and the shipper response modeling effort. Initially the RC shipper response model 1 was applied to each of the 12,481 movements. It quickly became apparent that this level of demand definition was not needed.

Plotting the waterway rate to the probability of a waterway movement curves for a variety of alternative rates for RC Model 1 produces the graphs in FIGURE K.2C.1 where each curve represents a different alternative rate. Given the mathematical form of the RC model for shipper choice the critical factor for a movement is the ratio of the baseline waterway rate to the alternative rate.

Plotting the baseline rates for the 12,481 movements in the study reveals a unique pattern in FIGURE K.2C.2. The points representing movements with the same commodity fall on lines radiating from the graphs origin. This indicates that, for a given commodity, the ratio of the baseline waterway rate to the alternative rate is constant for 12,141 of the 12,481 movements (97%). This consistent ratio of alternative to baseline waterway rates is due to the way the rates were estimated. The GIWW NIM Movement Input (Addendum A to the Economics Appendix) describes the process for estimating the waterway and alternative rates for the movement set based on a survey of a set of waterway movements. Since the transportation rates were estimated based on ton-miles and commodity group, the ratio of the alternative rate to the baseline waterway rate is a constant for each commodity grouping.

FIGURE K.2C.1 – Probability of Barge Use by Alternative Land Rate

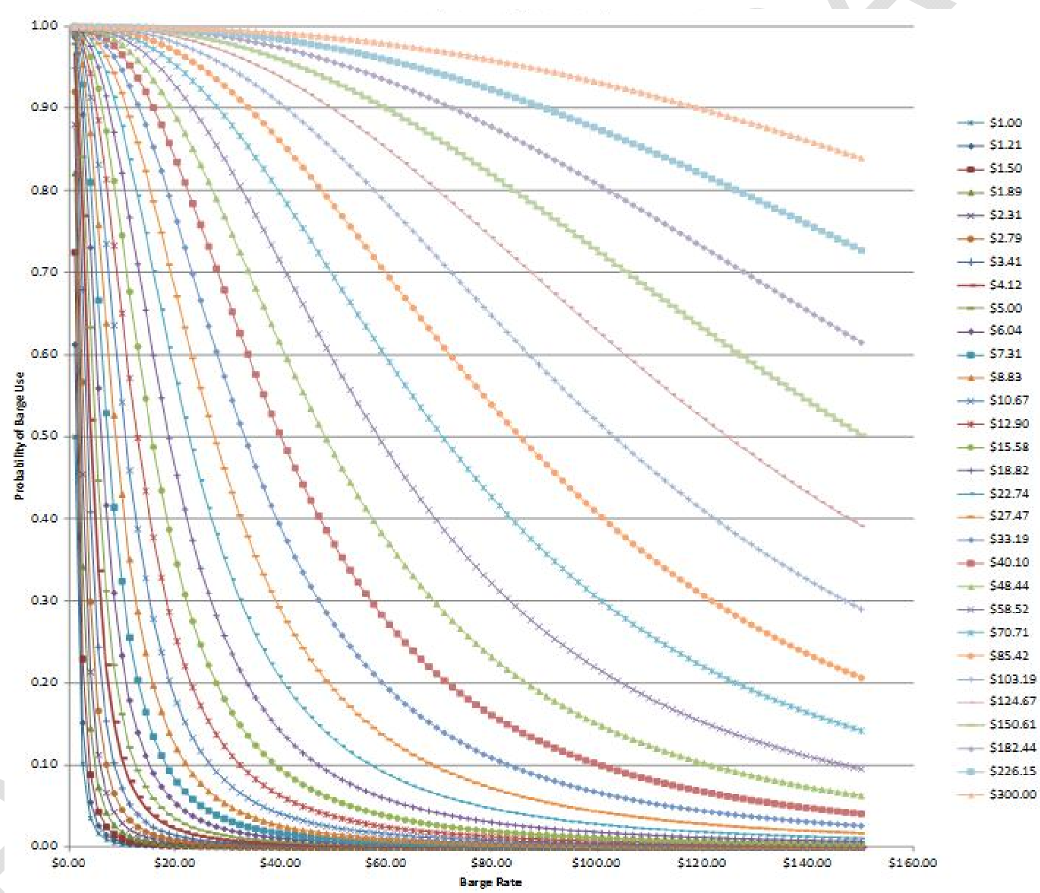
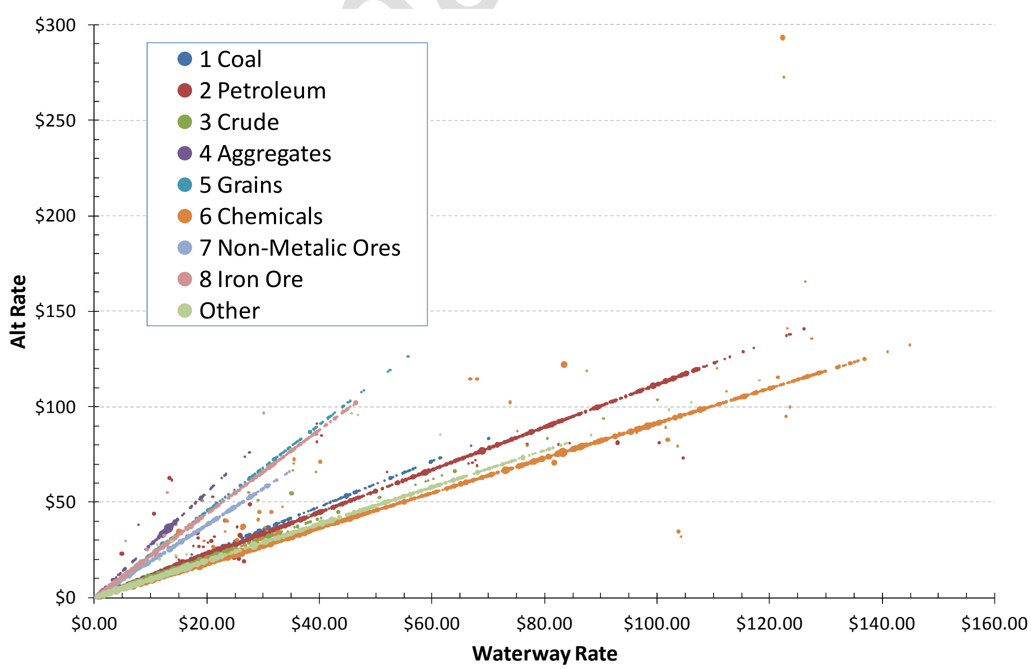


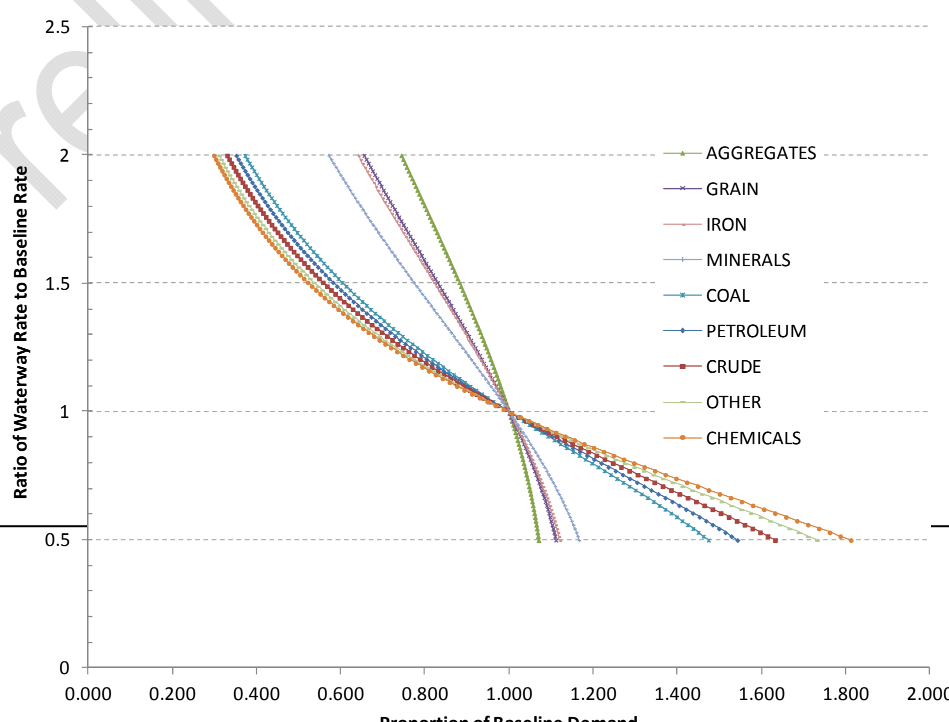
FIGURE K.2C.2 – Movements – Baseline Rates



The 337 movements with distinctly different ratios in FIGURE K.2C.2 arise from movements containing a sampled rate which is averaged into the modeling port level movement. Remember that the raw movement set is at a dock-to-dock level, and that the sample rates and non-sample rating equations were applied at this dock-to-dock level. Next, the 49,141 dock-to-dock level movements were aggregated into the 12,481 modeling port level movements.

Given this relationship between baseline waterway rates and alternative rates, we can show mathematically that the scaling process will produce the same curve for all movements in a commodity group. Thus, the set of demand curves reduces to a curve for each commodity as displayed in FIGURE K.2C.3.

FIGURE K.2C.3 – Demand Curves by Commodity



While NIM is capable of storing a unique demand curve for each movement or for each commodity group. As shown above, defining and storing a unique demand curve for each movement is redundant for 97% of the movements given the structure of the rating equations and the structure of the RC demand models. As a result, for the initial modeling runs, it was decided to each movement with the demand curve for its commodity code regardless of whether the movement contained a rated movement rate.

We note that the commodities such as aggregates, grain, iron and minerals are relatively inelastic and respond less to increases in waterway rates than the other commodities. Of the more elastic commodities, chemicals are the most elastic and coal is the least. These commodity based curves are specified by a set of points (100 points per curve) in the NIM database. While we have generated the initial NIM curves for waterway rates up to twice the baseline, there is not a mathematical limit to calculating the demand for higher rates; however, there is a logical limit when we reduce the tonnage to the level of one barge load for a movement.

Given the mathematical form of the RC model for shipper choice and the format required for the NIM demand curve, the critical factor for a movement is the ratio of the baseline waterway rate to the alternative rate. Since this ratio is determined solely by commodity for almost all of the movements, it was decided to use one demand curve for each commodity derived from the shipper choice model and the ratio of waterway and alternative rates. These curves were generated and entered into the NIM database specified by a set of 100 points for each curve. The curves seem to reflect the intuition that commodities such as aggregates and grain will remain on the waterway in greater percentages than commodities such as chemicals when waterway rates increase.

The revealed choice model uses a logit format which can be written as

$$\text{Probability of Barge} = \frac{e^{\alpha \ln(W)}}{e^{\alpha \ln(W)} + e^{\alpha \ln(R)}}$$

Where W is the waterway rate, R is the alternative rate, and α is the logit parameter for the model (-2.389 in this case). For the NIM demand curve, we express the proportion of the baseline tonnage moved at a given proportional increase in waterway rate. Letting ρ represent the ratio of the increase in waterway rate to the base rate and δ represent the ratio between the baseline waterway rate and the alternative rate, we can express the NIM demand curve as

$$\text{NIM demand curve} = \frac{e^{\alpha \ln(\rho W^*)}}{e^{\alpha \ln(\rho W^*)} + e^{\alpha \ln(\delta W^*)}} \left(\frac{1}{\text{Baseline Prob(barge)}} \right)$$

For $1 \le \rho \le 2$ where W^* is the Baseline Water rate.

Note that the curve is scaled to have a value of 1 when ρ is 1 by dividing by the baseline probability of barge usage, i.e. the value of the shipper choice model at W*. Using the rules of logarithms and exponents, we can transform this expression into

$$\text{NIM demand curve} = \frac{e^{\alpha \ln(W^*)} e^{\alpha \ln(\rho)}}{e^{\alpha \ln(W^*)} \left(e^{\alpha \ln(\rho)} + e^{\alpha \ln(\delta)}\right)} \left(\frac{1}{\text{Baseline Prob(barge)}}\right)$$

noting that the exponential terms with W* cancel out. Simplifying this leaves us with

$$\text{NIM demand curve} = \frac{e^{\alpha \ln(\rho)}}{\left(e^{\alpha \ln(\rho)} + e^{\alpha \ln(\delta)}\right)} \left(\frac{1}{\text{Baseline Prob(barge)}}\right)$$

Looking at the Baseline Prob(barge) term, we see that it is the probability of barge evaluated at W*

$$\text{Baseline Prob(barge)} = \frac{e^{\alpha \ln(W^*)}}{e^{\alpha \ln(W^*)} + e^{\alpha \ln(\delta W^*)}}$$

which reduces in the same logarithm rules to

$$\text{Baseline Prob(barge)} = \frac{1}{1 + e^{\alpha \ln(\delta)}}$$

Thus, the demand curve can be expressed in terms of the logit parameter, the ratio of baseline water and alternative rates, and the proportion of the baseline waterway rate in a given year—that is *α, δ,* and *ρ*.

$$\text{NIM demand curve} = \frac{e^{\alpha \ln(\rho)}\left(1 + e^{\alpha \ln(\delta)}\right)}{\left(e^{\alpha \ln(\rho)} + e^{\alpha \ln(\delta)}\right)}$$

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K.2C.4 NIM TABLES

As previously noted, NIM is capable of either modeling movements as fixed quantity or price responsive. For movements defined as fixed quantity, field "*AltRate*" of the "*MovementDetail*" table defines the movement's willingness-to-pay. For movements defined as price responsive, the willingness-to-pay is defined through four database tables discussed in the following sections. While only one fixed quantity willingness-to-pay value is allowed for each network movement (characterized by networkID and movementID), the model allows any number of price responsive demand curves to be specified for each movement. This was done to allow checking and sensitivity tests on various demand curve specifications.

With a price responsive demand definition (in this case developed from the Wilson revealed choice model 1), NIM allows either input as a constant elasticity function or as a piecewise-linear approximation. A constant elasticity function could be fit to the shipper response choice model results, however, the fitting is not very precise. The piecewise-linear approximation allows replication and loading of any demand curve (without NIM code modification) by defining the curve as a series of XY coordinates defining each price-responsive demand curve.

While the demand curves can be defined uniquely to each movement, the demand curves developed for the Calcasieu Lock analysis were only done at a commodity group level (as discussed in section K.2.1.5).

In such a case, the demand curves do not have to be duplicated for each movement. The movement is linked to the demand curve through a "*demandFunctionRuleID*"; there is a "*demandFunctionRuleID*" for each commodity group. If each movement has a unique demand curve, then each demand curve is placed under its own "*demandFunctionRuleID*" and there are as many "*demandFunctionRuleID*"s as "*movementID*"s.

K.2.0.6 **The DemandFunctionPlan Table**

The "*DemandFunctionPlan*" table lists and names the demand function plans developed for each network (TABLE K.2C.3). As shown in TABLE K.2C.4, "*demandFunctionPlanID*" 0 is used to represent fixed quantity demand.

TABLE K.2C.3 – DemandFunctionPlan Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionPlanID		Unique demand function plan ID
demandFunctionPlanName		Demand function plan name

TABLE K.2C.4 – Demand Function Plans (DemandFunctionPlan Table Data)

networkID	demandFunctionPlanID	demandFunctionPlanName
3	0	none (i.e., fixed quantity demand)
3	1	constant elasticity curves
3	2	piecewise-linear elasticity curves, Wilson Revealed Choice Model (2011)

K.2.0.7 **The DemandFunctionRule Table**

The "*DemandFunctionRule*" table (TABLE K.2C.5) is used to indentify the demand curve to be defined (either as a constant elasticity or as a piecewise-linear). As previously noted, there can be a one-to-one correspondence between the "*demandFunctionRuleID*" and the "*movementID*" when there is a demand curve defined for each movement. In the Calcasieu Lock analysis the price responsive demand curves are defined at a commodity group level as shown in TABLE K.2C.6.

TABLE K.2C.5 – DemandFunctionRule Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionRuleID		Unique ID for the demand function
demandFunctionRuleName		Movement set name
demandFunctionType		Additional user description if needed

TABLE K.2C.6 – Demand Function Rule (DemandFunctionRule Table Data)

networkID	demandFunctionRuleID	demandFunctionRuleName	demandFunctionType
3	0	inelastic	none (fixed quantity demand)
3	1	coal piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	2	petroleum piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	3	crude piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	4	aggregates piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	5	grain piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	6	chemicals piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	7	minerals piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	8	iron piecewise linear	piecewise linear (Wilson revealed choice model, 2011)
3	9	other piecewise linear	piecewise linear (Wilson revealed choice model, 2011)

K.2.0.8 The MovementDemandFunction Table

The "*demandFunctionRuleID*" is linked to the "*movementID*" through the "*MovementDemandFunction*" shown in TABLE K.2C.7. The model allows for re-specification of the demand curve through time through the "*beginYear*" and "*endYear*" fields. This option was not used in the Calcasieu Lock analysis..

TABLE K.2C.7 – MovementDemandFunction Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionPlanID	DB Key	Demand function plan ID from DemandFunctionPlan table.
ID	DB Key	movementID from MovementDetail table.
beginYear	DB Key	First year of demandFunctionRuleID
endYear		Last year of demandFunctionRuleID
demandFunctionRuleID		ID from DemandFunctionRule table.

K.2.0.9 The DemandFunctionRuleParameter Table

The "DemandFunctionRuleParameter" table stores parameters that characterize the demand curve (i.e., the "*demandFunctionRuleID*").

TABLE K.2C.8 – DemandFunctionRuleParameter Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
demandFunctionRuleID	DB Key	ID from DemandFunctionRule table
parameterName	DB Key	Parameter name (x1 … xn or y1 …yn, or elasity for constant)
parameterValue		Proportion of demand (x) or base price (y), or elasticity value for constant

Calcasieu Lock
Louisiana Feasibility Study

APPENDIX K

ATTACHMENT 3

Gulf Intracoastal Waterway (GIWW) Willingness-To-Pay for Barge Transportation

May 2013

US Army Corps of Engineers

Prepared by:

Navigation Planning Center,
Huntington District

Prepared for:

CEMVN-PDE-N

List of APPENDIX K Attachments

2010 SHIPPER RESPONSE MODELS FOR THE CALCASIEU LOCK AND GIWW-WEST

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Executive Summary

The U.S. Army Corps of Engineers (ACE) is currently evaluating the costs and benefits of upgrading the Calcasieu Lock located on the GIWW West. This report describes the system and examines the responsiveness of shippers, which are necessary inputs to assessing the benefits of alternative investments in the Lock over time. The research follows much of the methodology developed under the Navigation and Economic Technologies (NETS) program, which was developed by the Army Corps of Engineers. Under this program, a set of economic tools, methods, and techniques were developed and evaluated with an express purpose of aiding the evaluation of long-term investment decisions.[1]

The research was conducted two major phases. Phase I consists of four major parts, which comprise Sections 2, 3, 4, and 5 of this report. First, in Section 2, a descriptive review of the region and the associated transportation network is provided. This review includes a discussion of the geography, the economic base of the region, and a description of the waterway and the rail networks. Interviews with barge companies, shippers, trade associations, industry analysts, and others were conducted to document current practices, problems, and issues. But also to identify the major users of the system, and issues related to the waterway's use. Third, the Army Corps and other government agencies e.g., the Surface Transportation Board collect massive amounts of information. These data were procured and processed to describe and document flows over the system, and this information is presented in Section 4. Finally, on the basis of the interviews and previous research, a survey instrument and survey design was developed and is described along with the survey responses in Section 5. There are multiple versions of the survey instrument, developed for completion on the Internet as well as a mail version). The mail version is provided in Appendix A. In addition, while the instrument was

[1] The objectives of the NETS program and a wide variety of research are reported on www.corpsnets.us.

designed to be completed on-line, in practice, over 2300 shippers were contacted either by telephone, by mail, and/or by email. Further, during the telephone solicitations, respondents provided a number of comments discussed later in the report with all comments available provided in Appendix B.

Phase II consists of two major Sections. First, Section 6 summarizes descriptive statistics that were collected from the Survey. These include the availability of shipper options in transportation, the characteristics of shippers in terms of size, age, etc, and the characteristics of shipment options e.g., rate, time in transit, reliability. Second, Section 7 presents a variety of econometric models that allow for the responsiveness of shippers to shipment to characteristics to be estimated. These include analyses of stated preference models, revealed preference modes, and combined stated preference and revealed preference models. The stated preference models focus on shipper responses to hypothetical changes in rates, transit times and reliability. These are conducted for both mode and location (origin or destination) decisions of shippers as well as for changes in the annual volumes shipped. The revealed choice models are based on the actual decisions made and actual data. That is, shippers choose the location (either the origin or destination of a shipment) along with the mode. For each alternative, information was collected on prices received (or paid) for the product shipped, the transportation (mode specific), transit times, and reliability. Based on these data, various logit models were estimated to gauge the responsiveness of shippers to rates, transit times, and reliability. Finally, the revealed and the stated preference data were combined. This can allow for a richer set of data to estimate the choice model.

Primary Findings

1. ***Regional Summary:*** *The Calcasieu Lock is located in Louisiana on the Gulf Intercoastal Waterway (GIWW). The navigation project prevents salt water intrusion in the Mermentau River Basin but also facilitates navigation on the GIWW, and is a floodway for the Mermentau Basin. The Mermentau basin encompasses about 4.2*

million acres. Primary products in the region are rice and crawfish farming, totaling about $150 million dollars. The waterway is dominated by petroleum and chemical goods, with petroleum accounting for 49 percent and chemical products accounting for 28 percent of the total movement. Transportation is hampered by substantial delays, which complicate interconnections with further barge movements, but also with other modes of transportation.

2. *Interviews:*

   a. *Barge Operators:* A set of seven different barge operators provided considerable information of the industry and business practices. A central issue raised by the barge companies is that the project is designed for water control not for navigation. They need safe tie-off areas, but have teamed with other tugs to, at least, partially resolve the issue. Further, there are significant delays in the system. Some of this, however, is due to the BP oil spill, and that cleanup crews and construction had priority. Perhaps, a notable finding from the barge companies is that the shipments on the waterway are dominated by relatively few very large shippers, many of whom have located on the waterway to take advantage of low cat barge rates.
   b. *Petroleum and Chemical Shippers:* Shippers were also interviewed; however, direct contact with decision-makers was very difficult, owing to non-disclosure rules and the sheer size of the companies. Contact was attempted with both large and small firms. Often shipments from the smaller tended to be to and from the larger companies in the region, and that the larger companies tended to handle the details of the shipments.
   c. *General Findings.:* Most shipments are handled and logistics set up by large integrated firms with multiple locations at which they can access the network. A large proportion of traffic moves under contract, with demurrage charges and fuel charges as part of the contract. Shippers use barge, rail, truck, ocean barge and pipelines to move the products, but access varies across shippers. Barge is the "cheapest" way to move goods, but delays from weather, mechanical issues or congestion at the locks hampers their use. Rail is more expensive, and it is sometimes difficult to get cars.

3. *Available Data:* USACE and Other government agencies collect considerable amounts of information. These data include the Waterborne Commerce Data (USACE) and the Waybill Sample Collected by the Surface Transportation Board. Each of the datasets provides considerable information on commodity movements, including origin and destination. These data were combined to describe flows over the system and when combined with supplemental data from the Texas Transportation Institute on barge rates, the Waybill data on rail, and a truck costing model developed by the Upper Great Plains Transportation Institute various rate proxies were developed to supplement the statistical analysis. From these data, there are a number of points to be made.
   a. There are three general commodity groups including petroleum, chemicals, and other. Petroleum, and to a lesser extent, chemicals tend to have far fewer origin-destination pairs relative to other commodities, despite the fact that they dominate the tonnages in the data.

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b. *Petroleum movements represent the largest movements in the data. For barge, both origins and destinations tend be located along the Gulf Coast, but there are large quantities that both originate and terminate in the interior. For rail, the quantities are again large, but major origins tend to be in the interior, but less concentrated along the Gulf Coast. Destinations are much more geographically dispersed, with major destinations outside of the Gulf Coast.*
c. *Chemical movements represent the 2nd large movements in the data. As with petroleum move of the origins and destinations are along the Gulf Coast, but there are some important origins and destinations along the interior waterways. Again, for rail there are large concentrations of origins throughout the region of analysis, and the destinations are very numerous and distributed seemingly uniform throughout the region of analysis.*
d. *Other commodity movements, as might be expected, are quite diffused. For barge, the major origins and destinations are in the Gulf Coast, and in the Northern part of the Lower Mississippi. The same is true for rail, but there is a greater degree of geographic diversity in origins, while destinations tend to be very disaggregated.*

4. ***Survey:** The survey was designed following a long line of research under the Navigation and Economic Technologies Program. This research is summarized in www.corpsnets.us.*
   a. ***Survey Form:** The survey form was adapted from previous studies. This form was adapted for an Internet survey, with an interactive from placed on a website (www.transportationinfo.us).*
   b. ***Survey Targets:** Initially, 2000 potential survey targets were identified from a list of shippers provided by Dun and Bradstreet. A total of 2000 were contacted (1000 were contacted by telephone and another 1000 by mail) and solicited to fill out the survey. A large number of the shippers were found to be not germane to the study. This is consistent with our interviews with barge and shipper companies. However, we supplemented this list through the use of the Waybill and direct internet searches. In addition, a supplemental list was obtained with the help of a major trade organization. In total, another 254 contacts were tempted. The process of contacting relevant shippers was very difficult. From the interviews conducted as well as the telephone contacts made, not only were the number potential shippers relevant to the survey small (most decisions are made by the large integrated firms), the decision-makers were very difficult to contact. It sometimes took several phone calls before contact was made.*
   c. ***Survey Responses:** In total, information was obtained for 108 shipments made. Both the response rate and the quality (completeness of the form) was better by telephone. When contact was made, there were 41 completions and 39 refusals. This represents a 51 percent response rate. Yet, there were large numbers that were not relevant and where contact was not made. By mail, the same issues resulted and the estimated response rate of 14 percent is lower. All told, there were 42 forms from the phone, 33 from the mail survey, 16 from the internet and trade association list, and 17 that did not provide information to allow the source to be identified.*

d. *Summary Statistics: The survey contains information on availability, modal utilization and characteristics, and stated responses to changes in rates, time in transit, and reliability.*
   i. *Availability: In general, about 38 percent of all shippers have access to only one mode (32% are truck only and 7 percent are barge only). This means that about 68 percent have access to multiple modes. Some of the shippers, indeed, 34 percent have access to all modes (rail, truck and barge), not including pipeline, and this is the most frequent response.*
   ii. *Modal Utilization: All three modes are represented in the responses. Barge is used in 42 percent of shipments, Rail is used in 33 percent, and Truck is used in 25 percent of shipments. While the instrument is designed to capture substitution among both modes and locations (origins/destinations), most of the substitution is among modes, with only nine that switch origins or destinations. There are a large number of shippers that have no options, and report that they would shutdown if the option they used were not available.*
   iii. *Shipment Characteristics: As expected, barge rates per ton are considerably lower than for rail and truck. In general, barge costs less than rail, which costs less than truck. Transit times are affected by shipment distances, but miles per hour by barge is about the same as by rail, and both are considerably lower than by truck (shipment times include waiting for equipment). Barge and truck movements are about 412 miles, while rail movements are considerably longer at 787. All three modes tend to be "reliable" in the sense that over 80 percent of shipments are expected to arrive on-time.*
   iv. *Stated Preference Responses: There are a host of stated preference questions designed to gauge the sensitivity of shippers to rates, transit times and reliability. Shippers were prompted with varying levels of percentage changes in attributes (rates, transit times, and reliability). At small changes, shippers do not change from the options they choose, but as the percentage changes shippers do state that they will switch to an alternative or they will shutdown. This measure of responsiveness is more marked with rates than for reliability and much more than for transit times. In terms of volumes, shippers do report their annual volumes are affected by percentage changes in their rates, as well as rates that apply to themselves as well as competitors. However, there seems to be no clear relationship between the level of the prompt (the percentage change in the attribute) and whether annual volumes are affected. Respondents either report a zero effect (if annual volumes were not affected or a percentage effect if they were). From this, the results suggest that the changes in annual volumes, regardless of whether rates, time or reliability are very modest (less than one percent).*

5. *Econometric Models: Two types of data were collected in the survey. These include stated preference (SP) data and revealed preference (RP) data. From these data, the responsiveness of shippers to changes in attributes can be estimated, using choice models. Choice models*

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were estimated using SP data alone, RP data alone, and a combination of both SP and RP data. In all cases, there is evidence to support the idea that demands are responsive to changes in rates. In none of the models estimated were significant differences found among shippers of petroleum, chemicals and other commodities. There is mixed evidence on whether there are statistical differences between estimates applicable to barge, rail and truck. The effects of transit times and reliability were much less clear. Indeed, in all models estimated, there was no clear evidence that transit times have a clear and significant effect. And, only in a few cases, were statistically important effects of reliability found. The results on transit times are consistent with the shipper discussions. They treat the transit times as an inventory management problem. And, while there are costs associated with the inventory, they are small. Reliability is a much more important factor to the shippers. Yet, in the survey, all modes tended be quite reliable and, as such, there is little variation in the data.

6. ***SYNOPSIS:*** *The final section summarizes and concludes. The primary issue in this report is the use of survey methods and small numbers of observations that result from a limited population. While there is strong evidence that shipper demands depends on rates, the general results are confined to models that are relatively modest in terms of the number of explanatory variables. The limited sample size emanates from a limited population. Such cases are not infrequent in barge markets. In this last section, there is some discussion of alternative techniques that could be developed that may ameliorate this issue.*

1.0 Introduction

Transportation is a central component of trade and of economic development. Investments are necessary to build and maintain transportation infrastructure. In the case of waterway transportation, the Army Corp invests and maintains the transportation infrastructure and is mandated to examine the costs and benefits of major transportation investments. Examination of the benefits requires information on the role of the infrastructure, but, in particular, of transportation demand. In this study, we provide:

- a review the role of the Calcasieu Lock, located in the Mermentau River Basin in Louisiana;
- the results of a series of interviews with key decision-makers in the region;
- a description of relevant flows over the transportation network;
- the results of a survey of shippers that provides key components of shipper decision-making that give a foundation for estimating demand structures; and
- estimates of the decision process and the related demand functions along with the associated responsiveness of demands to changes in attributes afforded by investments.

Louisiana is a major maritime transit zone in the nation's waterway network, and 83 percent of total waterborne commerce occurs along the lower Mississippi and the Calcasieu Ship Channel (Shaw, 2007). Many of these flows emanate from a much wider region, and as such the quality, reliability, and usefulness of Louisiana's waterway systems has a substantial impact to the overall function of the national waterway network. Petroleum is a major commodity relevant to this study, and Louisiana's waterway network facilitates 20% percent of the national import and export of petroleum related commodities (Shaw, 2007). This role is partially explained by its proximity to the drilling operations in the Gulf of Mexico, but also well the transportation infrastructure linking it to other parts of the Nation. But, the waterways and ports are also very important to other commodities as well. For example, these waterways and ports also account for 53% of the national export of grain products based upon value occurs through the Louisiana waterway network (Shaw, 2007).

The intensity of the national transportation network's reliance upon the Louisiana transportation system creates the need for maintenance and investments in the network. Such studies are based on transportation systems where associated forecasts of traffic, demands, and costs are considered. The forecasts point to physical as well as economic constraints on the system, while demand structures point to how demanders respond to changes in economic conditions caused by the constraints, and of equal import, how they respond to removing the constraints through investments.

According to Shaw (2007), the Calcasieu lock is a gateway that has imposed constraints on the system. The constraint manifests itself as substantial vessel delays which occur 92% of the time. While these delays alone maybe a credible reason to lay out an investment in the upgrade of the Calcasieu Lock, the lock when compared to other segments of the local water-system surprisingly performs better than other locks in the same "high priority" bin. An example of a lock with a higher critical capacity constraint then the Calcasieu Lock is the Bayou Sorrel Lock. The Bayou Sorrel Lock is the oldest in Louisiana, its poor state of operation results in delays 100% of the time (Shaw, 2007).

The traffic through the Calcasieu lock is dominated by Petroleum and, to a lesser extent, Chemical products. Based on Waterborne Commerce Data from 1994-2008, Petroleum accounts for 49 percent of the waterborne traffic through the lock, while Chemical Products account for about 38 percent. The remainder includes Crude Materials (11 percent), manufactured products (6 percent), and a host of others (6 percent).[2]

[2] These figures are based on mean values calculated from Waterborne Commerce data from 1994-2008.

Based on the tonnage figures along with interactions with USACE, the study focus is on shipments of Petroleum and Chemicals. In the early work, we interviewed key decision-makers in the industry. These include barge firms, the shippers of high volume commodities, and a variety of others (trade associations, Army Corps, industry analysts, etc.). Almost immediately, it became evident that shipments relevant to these commodity groups in this region tend to be dominated by relatively few decision makers representing very large firms.

Interviews with shippers point to a number of items. First and foremost most shipments are handled by large integrated firms with multiple locations where they can access the network. Smaller shipping firms that do exist have the primary function of augmenting the operations of the larger firms. One reason for this is that smaller firms often do not have access to the scale/scope needed, to negotiate large volume or time frame contracts. This occurs for rail and barge modes where contracts are often exclusively designed between the large shippers and the rail and barge companies. Second, the shippers use (ship, barge, rail, truck, and pipeline), each of these modal options comes with its own set of concerns. For ship these are volume issues and destination, ocean ships can't operate on inland water navigation and thus when they do operate they tend to load large volumes to the destination. For trucking it is also a volume issues and vertically integrated companies, most of the firms don't deal in hiring truck companies to move their product it is just shipped to a terminal location and other companies deal with shipping to the end user or the company is vertically integrated and has its own trucks. For barge these are mostly delay issues, barge is the cheapest inland way to move large amounts of product to the destination but with that mode comes delays from weather, mechanical issues or just pure volume of traffic at the locks. For rail these are car availability, if you don't contract with the railroad companies to ship often enough then rail cars aren't available to you with enough reliability to even consider the mode. For pipeline these are high cost of construction which leads to a higher cost than other modes, but has the reliability and safety advantages over all other modes to justify using it to the locations when possible. So, the real factor in pipeline is it's availability to locations and given it doesn't serve a desired location. The costs of building, however, are substantial with the cost by one company projected it to cost $2,000,000 a mile to construct.

Barge firms have hands on perspective of the day-to-day working of the GIWW-West waterway as well as the Calcasieu Lock. They point to a range of issues. First, the Calcasieu Lock is a substantial constraint to barge movements. The lock has a dual role as facilitating both navigation as well as water control. In performing water control, barge operators often have difficulty transiting the lock. Second, a less general but general but still common issue/concern was the need for barge tie-off piers. Tie-off piers are seen by the barge firms as being critical to a well-functioning system. Third, there are delays that may run up to two days. Many of the delay issues were asserted to be due to the oil spill clean-up traffic, which receive priority for lock use.

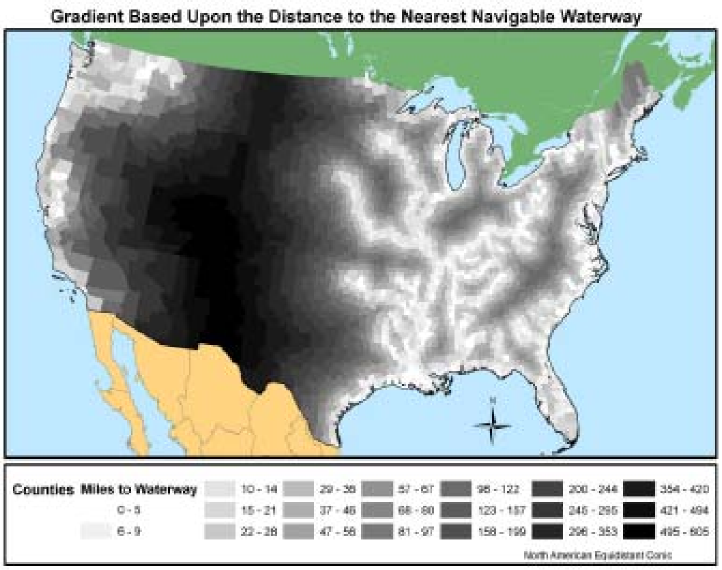
Interviews with shippers and barge companies were useful to understand some of the issues in the market. In addition, to develop an understanding of the role of the Calcasieu Lock and the transportation system, we received and used the Waterborne Commerce data to document traffic patterns by barge, and the Surface Transportation Board's (STB) Waybill data to document traffic patterns by rail. For barge movements, the data consisted of annual flows by commodity group from 1994-2008 conditioned on traveling through the Calcasieu Lock. These data point to the dominance of petroleum and chemical products for the lock, with most origins and terminations in the Gulf Coast, but with important inland destinations as well. Of course, shippers can also use rail. The STB contain very detailed information on origins and destinations by commodities. We defined the relevant region as any movement that originated or terminated within 100 miles of the waterways relevant to the Calcasieu. As with the barge data, the origins were concentrated in the Gulf Coast region, but the destinations were disaggregated throughout the study region. While, in principle, these data can be developed and used to estimate demand functions, it is a daunting task given that the Waterborne data do not have rate information (as well as other attributes potentially important to shippers) and the available data in the waybill data are potentially masked if under contract. While proxies for rates may be option, the role of these data in this study was to document traffic flows, and to supplement the survey data.

The overriding purpose of the study is to develop estimates of shippers to changes in the attributes central to their decisions. We adapted a survey instrument from previous studies. Dun and Bradstreet identified over 5200 potential shippers in the region, and from that list we drew a sample of 2000 firms form their list. After executing the survey, we augmented the sample with auxiliary lists from inspection of alternative data and Internet searches as well as correspondence with a trade association. In total, 2254 shippers were contacted, by telephone, mail and email. A very high proportion of shippers were not relevant to the survey. Consistent with the interview information, the transportation of the bulk of these products is handled by a handful of large firms. Nevertheless, a total of 108 survey forms were either fully or partially completed. They were completed on a web-based interface and/or filled out and returned by mail.

The survey instrument was designed for a choice framework. The mode and location (i.e., origin or destination) along with the attributes of the movement (rate, transit times, and reliability measures) were solicited for the shipment made and alternative shipments that could have been made. The survey also contained information on the access shippers have to modes, size of firm, etc. that can influence decisions. In addition, information was also solicited on the sensitivity of choices to changes on rates, transit times, and reliability. These data are commonly called stated preference data. Various models were estimated using both sets of data separately and together. The results, based on the data, provide evidence that shippers to respond to rates, little evidence that transit times matter, and mixed evidence for reliability. The findings are rates are then translated to elasticities as a measure of responsiveness. While elasticities vary across the range of the data, the results tend to support relatively inelastic demands.

In general, the survey evidence, while limited, does allow for estimates as well as a multitude of descriptive statistics and comments, which to provided an understanding the demand for transportation, and the role of waterways in the region. Indeed, transportation involves several major modes and locations. The inter-relationships which exist between these modes become very important. A common relationship is the difference in costs of transport for the different modes available to shippers. Barge is typically the lowest cost option, yet often has slow transit times. As well as having slow times, the barge network has the least extensive 'penetration.' Rail movements have traditionally been a mid-cost option with quicker delivery times then barge movements. Rail networks have a higher degree of penetration yet need specialized facilities to load and unload. Lastly the highest cost option which shipper face, is to move the shipment by truck. Truck is the most flexible of any of the shipment options, and has similar delivery times as rail, yet by far is the highest cost option. Truck movements have by far the highest degree of penetration and effectively have no limitation to the locations which they can access. This is underscored by a map in Figure 1.1, which is a gradient map of the network with progressively darker colors pointing to growing distances to the waterway network in the U.S. It indicates as does our analysis, the role of the three modes, and the importance of access.

Figure 1: Distance to the Nearest Navigable Waterway



As the distance to the waterway grows shippers face fewer options to move large volume shipments. Many times the distance to the waterway is so great given the truck mode distance having too high of a cost, that effectively a shipper may only be able to ship by rail. Many times the shippers are further constricted by only being served by a single rail firm.

This study does consider the spatial dimensions of the network as it explores the issues and realities facing the Calcasieu Lock and the traffic that most commonly transits the lock. While severe network constrictions such as the Calcasieu Lock are individually important; how they nest into the greater network as a whole is also explored in this study.

7

2.0 Background

2.1 Relevant Structures, Waterways and Control Systems

The Calcasieu Lock is an inland navigation project located in Louisiana on the Gulf Intracoastal Waterway (GIWW) near the Texas border. The navigation project has several distinct purposes. These purposes are: preventing salt water intrusion from the Gulf of Mexico into the Mermentau River Basin, providing a route for inland navigation, and serving as a floodway for draining flood waters from the Mermentau River Basin. These purposes are accomplished by two interconnected systems: The Mermentau River Basin flood control system and The Gulf Intracoastal Waterway system.

2.1.0 The Mermentau River Basin flood control system

The Mermentau basin encompasses a total area of about 4.2 million acres and contains highly productive agricultural lands interwoven into a variety of intrinsically valuable natural environments. Located between the Teche-Vermilion and Calcasieu basins, the Mermentau river basin is a controlled waterway system. Control exists for the drainage of the Mermentau River and its tributaries. Maintaining optimal water levels, helps secure a freshwater reservoir for agricultural use while preserving the basin's sensitive environments which are kept from the detrimental effects of saltwater intrusion from the Gulf. Catfish Point, Schooner Bayou Control Structures, the Calcasieu, the Freshwater Bayou, and Leland Bowman Locks are all features which control the impoundment of winter runoff for irrigation use in the summertime. The target water level inside the basin is 2.0 feet above the mean low gulf. These five features are operated in unison to achieve this target level.

The principal agro/aqua cultural products of the Mermentau Basin are rice and crawfish. There are approximately 300,000 acres of rice farming, as well as 35,000 acres devoted to crawfish farming. The average annual economic values of the rice and crawfish production equates to $160 million dollars. The rice and crawfish farming both require ample supplies of fresh water, as well as similar terrain. Also dependent upon the fresh water supply is the surrounding natural ecosystem. The basin provides a home to upwards of a half a million ducks and well over 300 species of birds as well as large commercial sport fishing use. It is crucial for these reasons for the basin to have adequate freshwater. While quantity is important, the quality of the water is of equal importance. A collection of reports show that due to agricultural runoff the water quality has suffered in the local watershed. (USACE/New Orleans District)

2.2.1 The Gulf Intracoastal Waterway

The Gulf Intracoastal Waterway (GIWW) is a 12 ft. deep by 125 ft. wide navigation channel that extends from Brownsville, Texas to Apalachicola, Florida following for the most part the shape of the coastline. The Mississippi River provides a midpoint between the GIWW East and the GIWW West. The Calcasieu lock is located on the GIWW West segment. The GIWW segment that crosses through the Mermentau Basin between Calcasieu and Leland Bowman locks is heavily used by commercial shippers. These commercial shippers are primarily concerned with petroleum products, chemicals, aggregates, agricultural products and manufactured goods.

2.1.2 Structures in the Mermentau Basin (USACE/New Orleans District)

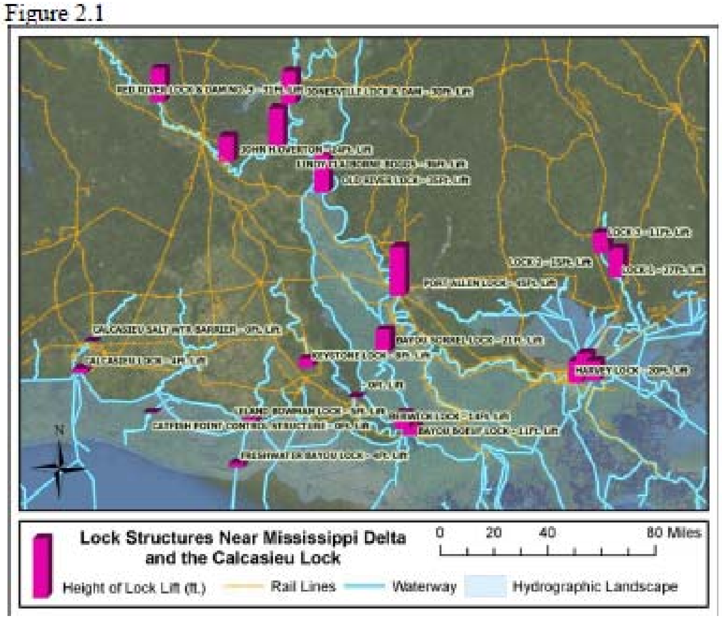
There are a set of structures in the Mermentau Basin which provide for flow control and prevention of saltwater intrusion. Table 2.1 contains descriptive information on each of these structures.

Table 2.1: Structure Characteristics

Structure Characteristics							
Structure	**Completed**	**Width (ft.)**	**Length (ft.)**	**Mean low gulf**	**Hours operated**	**Annual tons passed**	**Annual lockages**
Calcasieu Lock	1950	75	1200	(-13) ft.	24 hours a day	46,000,000 tons	6,558
Leland Bowman Lock	1986	110	1200	(-13) ft.	24 hours a day	43,000,000 tons	5,311
Freshwater Bayou Lock	1968	75	600	(-16) ft.	24 hours a day	5,000,000 tons	15,826
Catfish Point Control	1951	56		(-13) ft.	Daily 6 am to 8 pm	288,000 tons	1,058
Schooner Bayou Control	1951	75		(-13) ft.	Daily 6 am to 8 pm	80,000 tons	1,195

These structures all have relatively small lifts as is graphically portrayed in Figure 2.1. While the lifts are relatively small, they are necessary for the overall functioning of the waterway system as well as providing for the substantial aquaculture in the region. These functions often conflict with the regional barge transportation as it is necessary that movements then transit these structures. Indeed, in many cases these structures are cause for delays in barge shipments through the region.

Figure 2.1



2.1.3 The Calcasieu Lock and Calcasieu Ship Canal

The Calcasieu Lock is located on the Gulf Intracoastal Waterway (GIWW) near the intersection of Highway 384. A primary function of the Lock is to prevent salt water from entering the basin through the Calcasieu Lake. The Leland Bowman and the Freshwater Bayou Lock structures are used to release floodwaters from the basin by opening both sets of lock gates. The Catfish Point and Schooner Bayou control structures were constructed to release floodwater from the Grand and White Lakes and reduce tidal inflow (USACE/New Orleans District). Construction on the Calcasieu was completed in 1950. At that time, the U.S. looked forward to an extended period of growth, and construction of these locks was not only to control water, but also in anticipation of the long-run changes in navigation on the system.

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The extensive waterway and hydrological features which exist in the Gulf Coast and more specifically in Louisiana have a long tradition of being used for waterborne transportation. Investments by the Army Corps of Engineers in water control structures have increased the ability to manage the waterway system as a whole. The local region has extensive aquaculture, such as rice farming, crawfish farming, as well as a diverse natural ecosystem. Preventing saltwater intrusion as well as allowing excess water to drain drives the need for such structures. The drainage function shares usage of the lock with the traffic which also transits the lock.

The Calcasieu Lock is known to be subject to substantial delays. It is the connection ends which are most affected by the delay. Time cycles in many of the support industries such as the dock loading or train switching operations, adhere to a structured schedule. If a shipment is delayed then it can miss its timing window for loading or unloading. Because there can be several time sensitive components to the life of a shipment a compounding effect occurs when large scale shipments become delayed.

Direct impact of delays from structures such as the Calcasieu Lock reaching maximum capacity is common to the tug operators.

Some of the tugs own the barges. Yet, often barges are owned as an asset of a shipping firm. Performance has been historically tied to speed of delivery. They have the need to "explain" to their customers who are leasing or committing the barges to 'on-hire' status. Lease periods can vary and range from 15 days up towards two months long. During this time the barges are either moving through the water column or 'making money,' being loaded or unloaded or they are stalled. Stalls can occur in various segments of the waterway network. Yet, there are locations where there are obvious bottlenecks. The Calcasieu Lock being one of these obvious network constrictions.

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3.0 Interviews

To gain an understanding of the system from the perspective of the users, we interviewed a set of barge companies, shippers, and others. In this section, we describe the information gained from the interviews.

3.1 Barge Company Contacts

Barge companies were contacted for information on traffic movements and needs in relation to the GIWW. Calls were prefaced by stating that this was a study for the Army Corps of Engineers to assess the benefits of waterway investments, specifically oriented towards the improvement of the Calcasieu Lock located north of Lake Calcasieu. The following list of barge companies were contacted and participated: American Commercial Lines (ACL), AEP River Operations (Memco), Canal Barge, Florida Marine, Marquette Transportation, Ingram Transport and McKinney Fleet and Barge Services.

The barge companies shared common opinions about the GIWW issues, such as the needs of different types of traffic traveling along the GIWW. The barge industry is comprised of three different operations; fleet services, tramp towers, and dedicated or line haulers. The fleet services such as McKinney Fleet act as holding locations that speed up flows and efficiency. The service may hold three barges while a tugboat goes north to pick up an additional three barges to haul further east or west together coupled together with the original three. Fleet companies such as McKinney operate locally, helping to get the barges through local locks, speeding up the transport flow. The tramp towers like Marquette Transportation are working with primarily overflow movements, they may pick up two barges at one location and drop off three a few miles later as they make their way up and down the GIWW mainly working off a spot rate which is the highest priced movements. The dedicated services or line haulers account for most of the traffic through the lock. As almost all petroleum movements are assembled in large movements, these moves are contracted and represented by large barge companies like ACL, AEP, Canal, Florida Marine, Blessey, Ingram and Kirby.

The primary problem illuminated by the conversations with the barge companies was that the Calcasieu Lock is designed for and in place primarily for flood control and not water traffic flows. There are no safe tie-off areas, so a barge company pulls up with six barges and can't push through the lock due to water release; they are forced to team up with three other tugboats in the same predicament. This problem is centered around the fact there is nowhere to tie three barges safely and push through three on either end of the lock. Such problems are not unique to the Calcasieu. For example, one barge company stated that at the Bayou Coral Lock and the Industrial, they had a barge that is 33 in lock number at the Industrial or 1.5 days out from passing. It was said that some tramp towers are also affected by this same issue and have responded with a pricing mechanism. In particular, if they sit for more than 12 hours, they begin to charge for the holding and add delay costs into the rate they charge. At the time of the interviews, the Industrial structure was said to be always queued for two days. Much of that backlog was attributed to the wall construction crews and oil clean-up crews, which have priority. Further, this is exacerbated by the fact that if a storm is projected all the equipment has to be evacuated, due to the new regulations since Katrina. While these issues occur with the Calcasieu, some of the other structures also have these issues. For example, one noted that the Industrial is a structure that is 100 years old, and that "the Calcasieu is a Cadillac compared to Industrial". The most repeated comment about the Calcasieu was that the structure's primary function is for water control and not for water traffic.

As noted elsewhere, the traffic on this GIWW is composed of 80-90% petroleum/chemicals and the remaining being sugar, scrap, iron, coal and empty barges. From the interviews, th majority of the flows are coming out of the Texas region to New Orleans and Port Arthur. Additionally traffic is organized in Baton Rouge and is moved north to Pittsburgh, St. Louis, Chicago and Louisville. Depending on the size of the barge company, some major flows are from Houston to New Orleans or Baton Rouge and others work a lot of water traveling from Houston to the northern states via the GIWW and Mississippi River. These flows are forecasted 30 days in advance to meet demand needs in the north. The average tugboat going along the GIWW is pushing 2-6 barges and a north bound boat/s may be pushing 6-35 barges. An exception is the traffic flowing to Chicago, due to the shallow Illinois River, barges can't sit lower than 9 feet in the water. On the lower Mississippi, with no locks, the barges being pushed could number 15-35 with 10,000 - 25,000 barrels each. These shipments run on a schedule of every six days with 15-20 barges going north bound 24 hours a day and 7 days a week, as well as not stopping for holidays. The rate structure of such services was not clearly outlined by the barge companies.

Some of the companies conveyed information on the rate structures of the average move. For petroleum, the minimum rate is based off 1400 tons per barge and an average barge going to Chicago area may have 10,000 barrels and others may have as many as 25,000 barrels per barge. One thing noted is that a 1400 ton barge doesn't cost any less to move than a 1600 ton barge, and, it would be to the shipper's advantage to ship the most tons per barge they could ship.

In general, the barge companies noted that the primary shipments were made by only a few major shippers on the GIWW. These include Shell, Marathon, Conoco, Oxidental, Exxon-Mobil, Chevron, Holson and LaFarge. They noted that often these companies have positioned their facilities to operate on the waterway; this is due to the sheer volume that they are shipping and the fact that a barge is the most cost effective way to move tons per gallon of fuel. When asked about what do these shipper companies values as attributes of the barge companies they choose to ship with, they most notably replied safety requirements and then secondly rates. They report that for these shipping companies, bad press is a concern and reliability of on-time shipments takes a secondary role to safety of the shipment. The rates that the barge companies offer as a whole are centered on this preference of safety.

All parties agree the Calcasieu lock is vital and that improvements to the waterway are needed throughout the GIWW. As a final note, a major barrier to collecting information from shippers (as discussed below) is quite difficult. Indeed, it is quite difficult to even locate the decision-maker in the large companies. While such contact information was solicited from the barge companies, we were not able to receive very much usable contact information.

3.2 Shipper Contacts

In general, the barge companies were very useful to identify issues, practices, and the setting of the GIWW and the Calcasieu lock. Interviews were also conducted with shippers, but some of this was hampered by non-disclosure agreements and the about very sensitive information that hits their bottom line and competitiveness (rate and movement information).

As noted earlier, the barge companies routinely indicated that there are about 10 large firms that handle virtually all of the barge movements, both receiving goods and shipping goods. The larger companies including Shell, Marathon, Exxon, Conoco, Valero, BASF, BP, Chevron, and Lyondell were each contacted and given the opportunity to participate. It is noted that in this process, it was very difficult to determine, locate, and make contact with the relevant decision-maker. A common experience was a chain of conversations of "you need to talk to so and so," then being redirected through 8 people to at last find the correct contact is "out till next Tuesday." Even when the correct contact was found within the organization, many times the person needed to check with the corporate headquarters, as to check for any disclosure issues. In addition to these large firms, we also contacted shippers from the Dun and Bradstreet list. From this list, we contacted shippers with less than 100 million but more than 10 million in sales. This effort was centered on the line of thought that large firms may have a strong incentive to not give out any information and that knowledgeable individuals may not have the authority to release information. While the same problem existed with the barge industry, it was not as compounded as some did respond although it might take up to a week after initial contact to complete the interview.

In general, we found that large companies work off of 3-5 year contract for a base amount of barges to use and it is typically paid on a daily rate. The small companies contacted typically work with the larger companies who arrange the transportation. Large petroleum companies such as Shell, Marathon, etc., handle all the freight to the terminal and coordinate any barge/rail movements. The same practice is followed by chemical companies, although there were some that reported they did their own logistics decisions.

One logistics manager was particularly helpful. He was in charge of all the excess capacity that his firm may have. Firms often contract only about 85 percent of capacity, and, depending on market conditions, demand, the decisions of competitors, and the specific amount of production that the company only contracts, there arises a need to find a buyer for the non-contracted capacity. The companies often do not contract out for the full production to keep a reserve stock in the event of shut down for maintenance or plant failure. Sometimes, however there are times when the refinery/company does purchase barrels from other refineries when the refinery needs to be switched over. The logistics manager stated that most of the leg work on the contracted gas/diesel shipping decisions is already done and that more than likely the product was contracted to ship by pipeline or possibly barge. His job is to deal with the excess and or shortage scenarios of gas/diesel while looking for profit-maximizing potentials. When he is dealing with a demand for a specific product, he contacts other refineries both within/out of the company to fill the contract. In cases of excess supply, the potential markets which this surplus can be sold to, range from local, national, and foreign. The modes used, range from barge, pipeline, truck, railroad, or ships and prices follow the trends and demand of the economy and, in the case of foreign markets, the currency exchange rates.

From the discussion with this manager, he noted that in the 20 years, there has been a progression within the petroleum industry from rail to barge to pipeline. While pipeline may cost more, there is a lower potential for negative publicity than for the other modes. This underscores the discussions with barge operators. The goods they continue to ship on rail service are propane and butane, and he states "the rail traffic is a mess and it is too congested and unreliable". They use barges and ships to meet demand for the oil and prefer pipeline when feasible. This fact suggests that attributes such as safety and rates important, at least for this shipper, but that transit times and reliability are important in mode decisions as well. Finally, the shipper also noted that their company continues to expand in the New Orleans area to meet higher future demands, and underscores the import of an efficient transportation system.

3.3 Synopsis

Together, the shipper and barge interviews point to a number of items. A typical shipper may have a contract for 1-2 years for a rate that allows them to use about 2 barges a day. Often such contracts specify a fuel rate and if fuel prices rise above the contracted maximum, then a fuel surcharge are added to the daily rate. At the time of the interviews, the average rate is $6,500 a day per 2 barges that have a capacity of 50,000 barrels, at about $80 a barrel that is $6,500 a day to move about $4 million of product. This works out to be about $0.26 a barrel per day of shipment. Firms pay more for any spot rate shipments that they may have. For example, in 2000-2008, there was high demand for barges. Getting a barge was tough and contract negotiations were in favor of the barge industry. Since the recession, barge contracts in 2009 are easier to acquire, serving as a less costly mode of transportation because of the low demand. Consequently the spot price for the industry has fallen and traffic for the company has been almost always supplied within the contract or time charter.

Finally, pipeline is often lamented as a preferred mode to ship Gas or Diesel products, and it is usually owned by a third party. However, access is quite limited, and building of access is quite expensive. One of the interviews was very detailed of the issues that arise in shipping by pipeline. This company reported that they use a pipeline owned by J.P. Morgan and the main pipeline they use is operated by Bengal Pipeline Co. LLC. In using a pipeline, the shipper typically has a window to pump their product into the pipeline e.g., 2-3 days in early July. They pay a fee per batch that might be 200,000 barrels. One company stated that they pump 1,000,000 barrels a month, and the price is between $0.40 and $0.60 a barrel. The reason the pipeline is higher priced and preferred is twofold. First, it serves markets that are further from the waterway which have higher prices for fuel and the pipeline is safe. Second, if there is a leak it can be detected easily and fixed. The company is committed to moving their product by pipeline mainly and would prefer to send excess product that the pipeline can't handle by ship to other foreign markets. However, the capacity of the pipeline has been reached, and the company is considering with another group of investors the idea of developing a new pipeline. But, their analysis suggested that there were downward pressure on market demand from financial conditions, the demand for more fuel efficiency, etc. which point to lower demands for gas in the domestic market. Given the high cost of building pipelines, the pipeline would be not worth the initial cost.

While pipelines are seemingly an attractive modal option, construction of a new pipeline is difficult because of "right of way" issues, construction costs, and environmental concerns. That is, if land owners provide right of way, the construction costs are enormous. A new pipeline might cost $2 million per mile depending on the area. Of course, this number may vary widely owing to differences across alternative sites with different levels of environmental concerns. As an alternative to construction, the person pointed to the difficulties of capacity expansion by increasing pipeline pumping rates. Yet, pipelines have physical limits imposed upon by the strength of the pipeline. It might cost less than construction, but the incremental increase might not be that much. When this occurs, the pipeline may seek higher fees to recoup the added costs and/or upgrades to the pipeline. This shipper reported that all and all pipeline upgrading and or construction is much more complicated than just going out and finding a barge that could accommodate needs almost immediately.

4.0 Available Data and Traffic Flows

4.1 Introduction

There are a variety of datasets that are commonly used and useful in assessing demands, costs and prices in transportation. The bulk of the data used are gathered by the Army Corps (who collect and manage the Waterborne Commerce data) and the Surface Transportation Board (who collect and manage the Waybill data). These data are used in the study for four different purposes. First, the data were used along with Geographic Information System (GIS) to develop relevant markets and counties for the survey discussed in the Section 5. Second, the data were useful to the development of rate proxies used in conjunction with the survey data. Third, these data provide the best information on traffic flows available and are used in this section to document flows relevant to the region of analysis. Finally, with added effort and development, the data could serve as a foundation for doing studies with limited numbers of shippers and/or where survey data are not plausible or as an alternative to survey based methods. These data represent a cross-section of transportation movements by commodity over time. While the two datasets differ substantially, they each contain attributes of individual movements. Technically, when combined, the data can be considered as multi-modal panel dataset with spatially focused and described markets. This possibility is described in Section 8.

4.1.0 STB Masked-Waybill

The STB collects and manages a widely used rail dataset called the Waybill. The Waybill has been collected as a yearly ongoing process over an extended length of time. The Waybill is a dataset of interest to not just the rail firms and the STB, but also a matter of public policy in relation to future transportation investment decisions across all modes of freight transportation, barge, rail, truck, and air.

The Waybill is a stratified sample of rail movements across the U.S. network and through time. It provides detailed information on railroad movements from one location to another along with shipment characteristics including revenues, weight, interchanges, miles traveled, car-type, etc. for each railroad involved. This allows for the STB to use the Waybill as one source of input for its Uniform Rail Costing System, which costs individual movements, and the data are also widely used to examine traffic flows, rates, etc. These data contain very sensitive information, and as such, falls under the classification of 'controlled' sensitive industry data. This sensitive nature of the Waybill therefore drives the creation of several different versions of the dataset, the *Unmasked, Masked,* and the *Public Use.* The unmasked data are available only to the STB in its regulatory mission; the masked Waybill is available to federal agencies, but the revenues are masked; and the public use data are have detail removed that impinge confidentiality, but are available to the public. This study uses the Masked-Waybill version.

4.1.1 U.S. ACE Waterborne Commerce Movement observations and Waybill Data

The second source corresponds to waterway movements. The Waterborne Commerce Data of the U.S. (WBC) that were made available contains dock to dock flows by commodity *given that it passed through the Calcasieu Lock.* These data are collected and maintained by the U.S. ACE. The Waterborne data are traffic movements reported to ACE by vessel operators. Reports are submitted on the basis of individual vessel movements. These include origination, destination, commodity, barges and tons. A major shortcoming of the WBC in developing shipper response functions is that it does not contain rate data as well as the other attributes that affect shipper. As discussed later in this report, rate proxies can be developed to supplement the data and have promise to provide shipper responses, but the approach (discussed in Section 8) is, at this point, developmental. For the immediate purpose, these data are used to outline a region of analysis for drawing survey data and for describing flows in the region.

The WBC data was merged with dock directory data (provided by USACE) by waterway and river mile. This allowed the locations (geography) to be identified by county. The data were then merged with Army Corps commodity files to identify the commodities in the file. The result then contains detailed information on traffic flows (county to county) for each commodity and location from 1994-2008. In the working file, we construct the total county to county flow (aggregate) across commodities and the commodity specific county to county flow.

Using the counties represented in the Waterborne Commerce Data, a study area was established using ArcGIS. This region represented the counties along the water that were in the Waterborne Commerce Data and a bandwidth of counties 100 miles wide. That is, the Waterborne Commerce Data reflect the total tons that originate and terminate on the waterway. The actual origin or termination point may and quite likely is off-river. This approach is an approach to identify the bulk of area in which shippers may be located that potentially use or consider the waterway. The resulting list of counties is then used as the universal set of counties. It contains all counties from which waterway movements and rail movements originate or terminate in the region. The water and rail data span the years 1994-2008. The Waterborne Commerce data set has all the observations or recorded shipments that traveled through the Calcasieu Lock on the GIWW. The Waybill Records is a sample of rail movements across North America, but also contains an estimate of the total flow by rail (which is used in the analysis).

In order to compare the Waterborne Commerce data to the Waybill records a few constraints were placed on the Waybill Records. First, the buffer zone established to create the study region is derived from the water data's originating and terminating counties. Second, from the list of terminating counties rivers were isolated as locations that traffic that flows through the Calcasieu Lock travels to or along on the way to the terminating locations. Then to capture a market zone the 100 mile line was placed around the rivers to isolate the potential counties off the river.

To compare the water data to the rail data, only the rail data that originated from counties from which the water data originated from was selected and it had to terminate within the buffer zone or in other words 100 miles from the relevant waterways. As discussed above, we cannot identify the water traffic from originating on the water from those moves that originate 20-50 miles away and then travel to and on the waterway. In order to compare the two modes with the water data, market areas are defined as the set of counties within 100 miles of the waterway. To develop market boundaries within the buffer region, we used the existing Bureau of Economic Regions. By doing so, the region can be identified without dividing up the countries. This is critical for the analysis of market flows and BEA demand shifters in the alternative analysis.

4.2 A Description of the Market Connected to the Calcasieu Lock

Data from both the sources described above were combined and synthesised to create a description of the market connected to the Calcasieu Lock. The general description is broken into the two primary commodities transiting the lock. These were petroleum related commodities (designated by STCC 29), and chemical related commodites (designated by STCC 28). The remaining set of traffic transiting the lock was grouped into the alias of 'Other'. Other traffic is all movements transiting the lock which was neither petroleum or chemical designated. The reason for doing this was that the commodities which transited the Calcasieu Lock were primarily petrolem and chemical.

Figure 4.1 contains the number of origin-destination county pairs over time in the Waterborne data. The number of origins and destination pairs is far less numerous for Petroleum than for Chemicals, and other commodities are much more diffused with the greatest number of origin-destination pairs in the data. Given Peteroleum and then Chemicals have the largest tonnages, it points to a greater geographic concentraion of flows than for other commodities. Figure 4.2 contains the locations of the origins and destinations of water movements geographically and also identifies the study region. Rail origins and termination points are excluded from this figure simply to highlight the waterway origins and destination and to clearly present the study area. As is immediately evident the study region covers a broad geographic area from the Gulf Coast to the Great Lakes, but most of the origins and destinations are concentrated in the Gulf Coast.

Figure 4.1

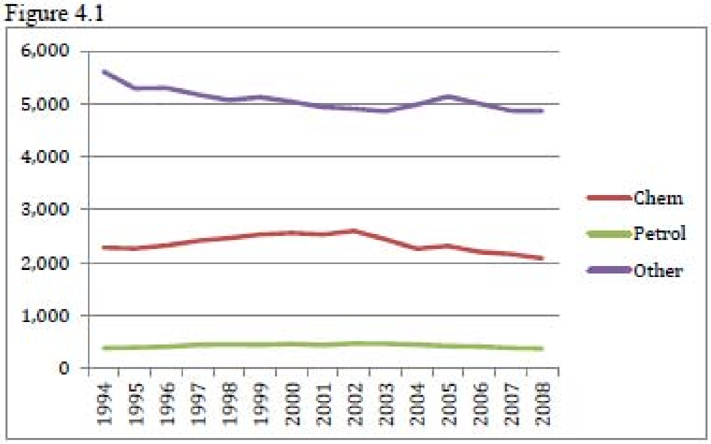
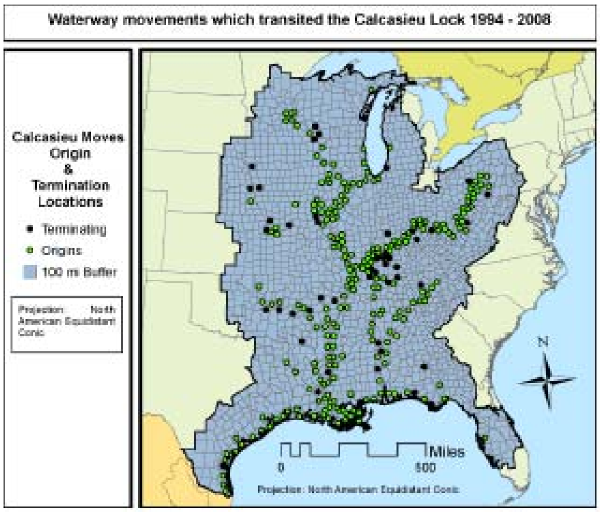


Figure 4.2



25

For the remainder of this section a series of figures re provided to identify major origins and destinations, and the largest county to county traffic flows for each commodity and mode. The data are also presented for 1994 and 2008 to identify any major changes in the origins, destinations and flow patterns.

4.2.0 Petroleum Origins, Destinations and Flows

Petroleum represents the largest total waterway movement in the study region. Again, the waterway data are confined to movements that travel through the Calcasieu Lock. Figures 4.3 and 4.4 contain tonnages for the origins and destinations for Barge and for Rail in 1994 and 2008. As indicated in Figure 4.3, regardless of year, origins are concentrated along the Gulf Coast in Texas and Louisiana. There are, however, important origins along the Ohio River, Chicago, Alabama and Oklahoma. The data also suggest that there have been some changes over time, with greater concentrations of tonnages along the Gulf Coast, and in particular, in Louisiana. Terminations follow similarly, with concentrations in the Gulf Coast, but important markets along the Mississippi and Ohio Rivers, and Chicago Area. Over time, the location of terminating tons largely remains along the Gulf Coast, but the termination points in 2008 appear to have become more concentrated, with a lower presence through much of the interior locations.

Figure 4.4 contains the same information for railroads. Railroad origin tonnages are less concentrated in the Gulf Coast, and more concentrated in the interior, relative to barge. There are a large tonnages that originate in Texas, Louisiana, Minneapolis, along the Ohio and in Alabama. There are marked changes between 1994 and 2008, not in terms of the locations, but in terms of the relative size of the origins. The termination points are much more geographically diffused for rail than for barge. The primary termination points in 1994 were in Chicago, Ohio, Minnesota, and to a lesser extent the Gulf Coast. In 2008, there are some marked changes. Probably the most marked change is a lower concentration in Ohio, and growth in Alabama.

Figure 4.3 Originating and Terminating Barge Petroleum Tons in 1994&2008

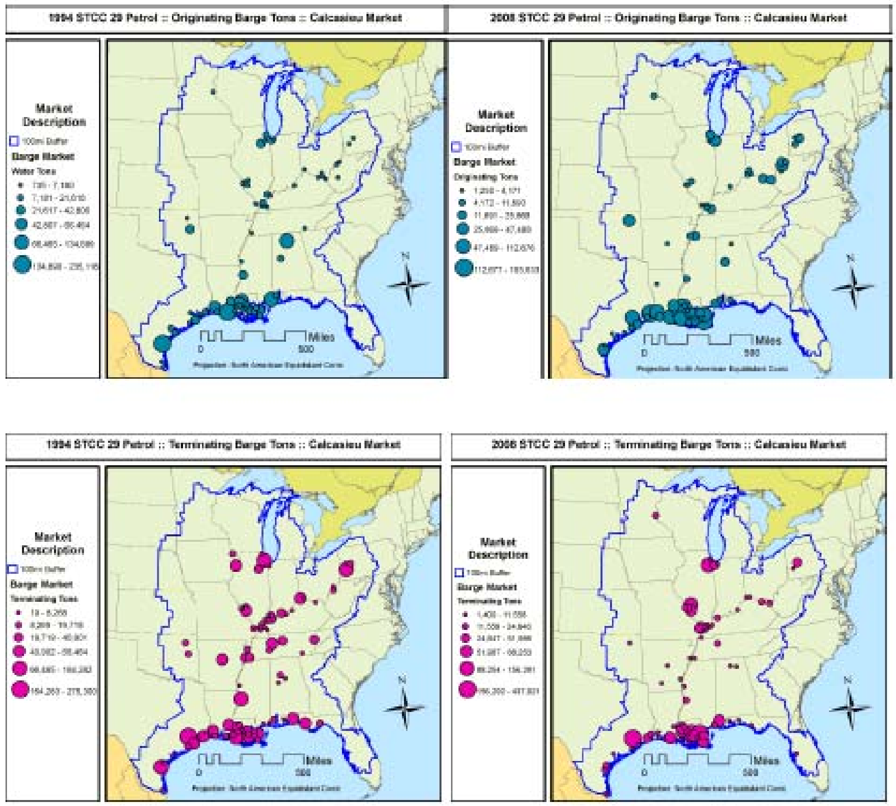


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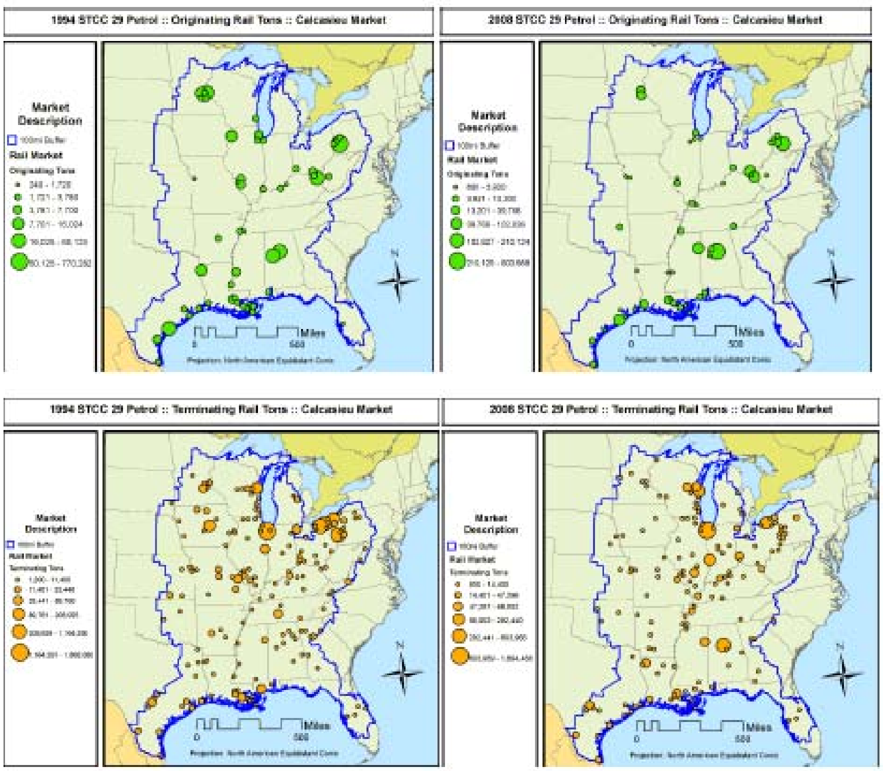
Figure 4.4: Originating and Terminating Rail Petroleum Tons in 1994&2008



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The figures point to the locations of major origins and terminations over time, but do not identify the major flows. In Table 4.1, we present the top ten flows for Water, and in Table 4.2, the same information is presented for rail. Major waterway flows originate and terminate in three states, each along the Gulf Coast. Indeed, except in one case all major origins are in Louisiana or Texas, and all major terminations are in Texas and Louisiana. Further, five of the leading ten flows in 1994 remain in 2008, pointing to some stability of the major flows. However, tonnages in 2008 are generally lower than in 1994. Rail movements are presented in Table 4.2 and are much different from that of barge. First, major origins and destinations involve a number of different states. Second, from 1994-2008 tonnages ten to larger, and that of the leading flow in 2008 is about 60 percent larger than in 1994. Third, only 2 of the top 10 flows in 1994 remain in the top 10 for 2008, pointing to significant changes in the rail market.

Table 4.1

1994 Top 10 Petroleum commodity moves by Water (tonnages)				
O State	O County	T State	T County	Tons
LA	PLAQUEMINES	TX	GALVESTON	1,095,827
LA	ST CHARLES	TX	HARRIS	1,064,532
TX	HARRIS	LA	ST CHARLES	606,884
TX	JEFFERSON	LA	ST CHARLES	591,253
LA	EAST BATON ROUGE	TX	HARRIS	469,563
LA	EAST BATON ROUGE	TX	JEFFERSON	402,743
TX	HARRIS	LA	PLAQUEMINES	351,669
TX	HARRIS	LA	EAST BATON ROUGE	351,639
LA	ST MARY	TX	GALVESTON	342,822
MS	JACKSON	TX	JEFFERSON	279,384
2008 Top 10 Petroleum commodity moves by Water (tonnages)				
O State	O County	T State	T County	Tons
LA	ST CHARLES	TX	JEFFERSON	731,468
LA	ST CHARLES	TX	HARRIS	706,744
LA	EAST BATON ROUGE	TX	HARRIS	512,839
TX	JEFFERSON	LA	ST CHARLES	456,644
AL	MOBILE	TX	HARRIS	437,921
TX	HARRIS	LA	ST CHARLES	401,233
LA	ST BERNARD	TX	HARRIS	363,766
LA	PLAQUEMINES	TX	HARRIS	359,061
LA	ST CHARLES	TX	GALVESTON	323,867
TX	HARRIS	LA	EAST BATON ROUGE	311,563

Table 4.2

1994 Top 10 Petroleum product movements by rail				
O_State	O_County	T_State	T_County	Tons
TX	JEFFERSON	TX	JEFFERSON	1,109,180
PA	ALLEGHENY	IN	LAKE	1,040,640
PA	ALLEGHENY	OH	CUYAHOGA	881,730
PA	ALLEGHENY	WV	HANCOCK	762,462
PA	ALLEGHENY	OH	LORAIN	554,012
AL	JEFFERSON	IN	LAKE	319,132
IN	MARION	IN	LAKE	293,044
KY	BOYD	OH	CUYAHOGA	290,456
AL	JEFFERSON	IL	ST CLAIR	179,948
IL	CRAWFORD	IN	POSEY	168,516
2008 Top 10 Petroleum product movements by rail				
O_State	O_County	T_State	T_County	Tons
PA	ALLEGHENY	IN	LAKE	1,694,488
TX	BRAZORIA	TX	HARRIS	1,080,548
TX	JEFFERSON	TX	JEFFERSON	1,036,416
VA	BUCHANAN	IN	LAKE	499,059
AL	JEFFERSON	AL	JEFFERSON	456,876
PA	ALLEGHENY	OH	BUTLER	332,648
MN	DAKOTA	IN	VIGO	272,730
OH	SCIOTO	OH	CUYAHOGA	260,244
PA	WESTMORELAND	OH	CUYAHOGA	210,124
IL	CRAWFORD	KY	HENDERSON	174,996

4.2.1 Chemical (STCC 28) Movements Description

Chemicals represent the second largest total waterway movement in the study region. Again, the waterway data are confined to movements that travel through the Calcasieu Lock. Figures 4.3 and 4.4 contain tonnages for the origins and destinations for Barge and for Rail in 1994 and 2008. As indicated in Figure 4.5, regardless of year, there is a concentration of chemical origins along the Gulf Coast in Texas, Louisiana, and Mississippi. There are, however, important origins along the Ohio River, Chicago, and Alabama. Unlike petroleum, the data do not suggest major changes in the distribution of origins over time. Terminations follow

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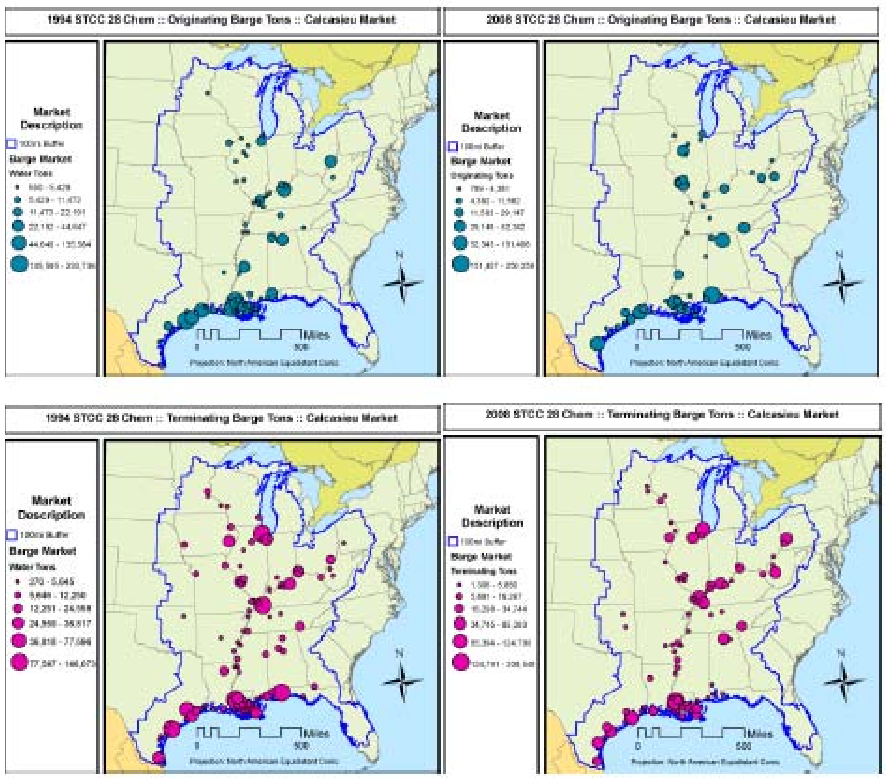
similarly, with concentrations in the Gulf Coast, but important markets along the Mississippi and Ohio Rivers, and Chicago Area. Again, over time, the location of terminating tons largely remains along the Gulf Coast, with little change in the relative distribution of tonnages over time.

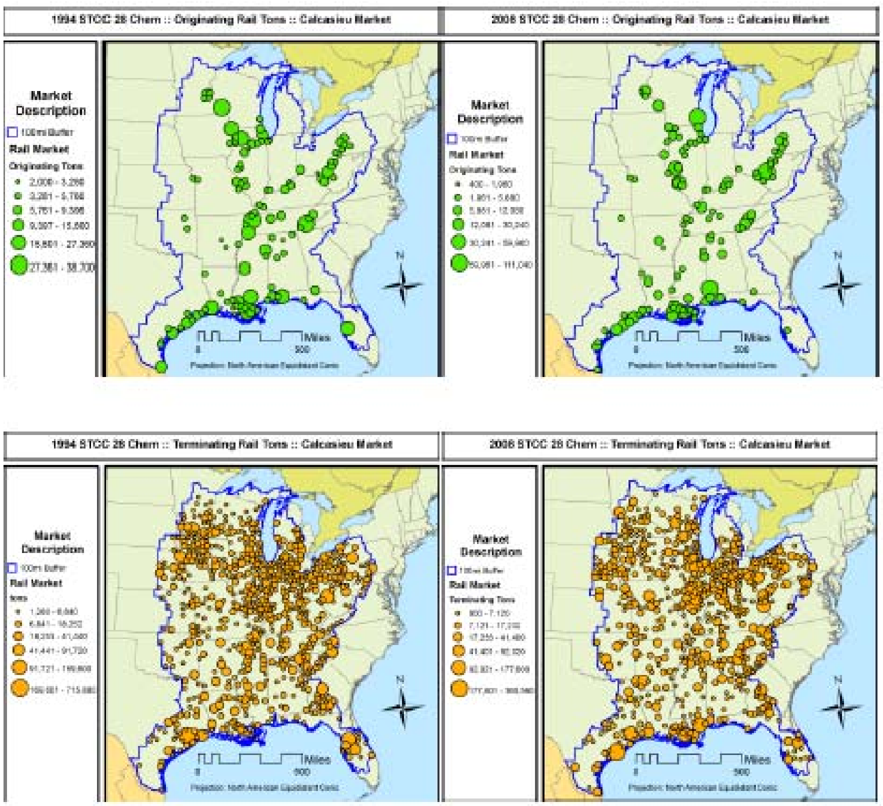
Figure 4.6 contains the same information for railroads. Railroad origin tonnages are less concentrated in the Gulf Coast, and more concentrated in the interior, relative to barge. There are large tonnages that originate in the Gulf, but also along the Mississippi and Ohio Rivers, as well as a variety of other locations. As with origins, there are only modest differences between 1994 and 2008 in the relative distribution of tonnage origins.

Figure 4.5


1994 STCC 28 Chem :: Originating Barge Tons :: Calcasieu Market
2008 STCC 28 Chem :: Originating Barge Tons :: Calcasieu Market
1994 STCC 28 Chem :: Terminating Barge Tons :: Calcasieu Market
2008 STCC 28 Chem :: Terminating Barge Tons :: Calcasieu Market
Market Description
Barge Market
N
Miles

34

Figure 4.6


1994 STCC 28 Chem :: Originating Rail Tons :: Calcasieu Market
2008 STCC 28 Chem :: Originating Rail Tons :: Calcasieu Market
Market Description
Rail Market
Originating Tons
Miles
1994 STCC 28 Chem :: Terminating Rail Tons :: Calcasieu Market
2008 STCC 28 Chem :: Terminating Rail Tons :: Calcasieu Market
Market Description
Rail Market
Terminating Tons
Miles

35

Again, the figures point to the locations of major origins and terminations over time, but do not identify the major flows. In Table 4.3, we present the top ten flows for Water, and in Table 4.4, the same information is presented for rail. Major waterway flows originate and terminate in three states, each along the Gulf Coast. Indeed, except in one case all major origins are in Louisiana or Texas. Unlike petroleum, however, there are a number of major termination points in the interior. These include Ohio, Illinois, and Alabama. Four of the leading ten flows in 1994 remain in 2008, again, pointing to some stability of the major flows. Tonnages in 2008 tend to be only modestly different from those in 1994. Rail movements are presented in Table 4.4 and are much different from that of barge. First, major origins and destinations involve a number of different states, but again tend to be located on the Gulf Coast. Second, in 2008, tonnages are much larger than in 1994, pointing significant growth in the rail sector. Finally, the leading three flows in 1994 remain in the top 10 in 2008, and four of the top ten remain in the top 10 in 2008.

Table 4.3

1994 Top 10 Chemical commodity moves by Water				
O State	O County	T State	T County	Tons
LA	ST CHARLES	TX	GALVESTON	422,263
TX	NUECES	OH	WASHINGTON	336,994
LA	ASCENSION	TX	HARRIS	313,114
LA	ST CHARLES	TX	HARRIS	310,592
TX	HARRIS	LA	IBERVILLE	308,429
LA	WEST BATON ROUGE	TX	BRAZORIA	233,738
TX	BRAZORIA	AL	MORGAN	222,849
LA	ST JAMES	TX	HARRIS	216,887
LA	IBERVILLE	TX	HARRIS	207,437
TX	HARRIS	IL	MASSAC	207,046
2008 Top 10 Chemical commodity moves by Water				
O State	O County	T State	T County	Tons
LA	ST CHARLES	TX	HARRIS	447,604
TX	NUECES	OH	WASHINGTON	411,375
TX	HARRIS	LA	IBERVILLE	279,988
AL	MOBILE	TX	HARRIS	250,358
TX	BRAZORIA	AL	MORGAN	225,593
TX	BRAZORIA	LA	WEST BATON ROUGE	201,727
LA	EAST BATON ROUGE	TX	HARRIS	158,931
TX	HARRIS	LA	ASCENSION	158,805
TX	JEFFERSON	FL	ESCAMBIA	154,011
TX	NUECES	AL	MOBILE	151,406

Table 4.5

1994 Top 10 Chemical/Allied product movements by rail				
O_State	O_County	T_State	T_County	Tons
FL	POLK	FL	HILLSBOROUGH	4,542,500
FL	POLK	FL	MANATEE	754,136
TX	HARRIS	TX	HARRIS	655,080
FL	HILLSBOROUGH	FL	HILLSBOROUGH	546,587
TX	BRAZORIA	TX	HARRIS	482,120
TX	CHAMBERS	TX	HARRIS	252,880
TX	JEFFERSON	TX	JEFFERSON	191,960
TX	CALHOUN	TX	HARRIS	189,680
MN	WASHINGTON	MN	WASECA	158,800
MN	RAMSEY	MN	BROWN	139,000
2008 Top 10 Chemical/Allied product movements by rail				
O_State	O_County	T_State	T_County	Tons
FL	POLK	FL	HILLSBOROUGH	1,822,815
TX	HARRIS	TX	HARRIS	1,033,620
TX	HARRIS	IL	COOK	836,480
TX	HARRIS	LA	ORLEANS	630,200
TX	HARRIS	IL	ST CLAIR	594,520
FL	POLK	FL	MANATEE	449,685
TX	CALHOUN	TX	HARRIS	373,000
TX	CALHOUN	IL	ST CLAIR	371,400
TX	HARRIS	TX	LIBERTY	371,148
LA	IBERVILLE	TX	HARRIS	360,920

4.2.2 'Other' (All STCC codes, excluding 28 and 29) Movements Description

The final set of figures and tables relates to "other" i.e., non-petroleum and non-chemical commodities. In total, these commodities account for approximately 23 percent of total waterway tonnages. Figures 4.7 and 4.8 contain tonnages for the origins and destinations for Barge and for Rail in 1994 and 2008. As indicated in Figure 4.7, regardless of year, origins are concentrated along the Gulf Coast, along the Mississippi and the Upper Ohio. The data also suggest that there have been some changes over time, with reduced greater concentrations of tonnages along the Gulf Coast and Lower Mississippi. Terminations follow similarly, with concentrations in the Gulf Coast and the Lower Mississippi and Ohio. Over time, there is apparent greater concentrations of the tonnages, with major changes along the Upper Mississippi and the Ohio River.

Figure 4.8 contains the same information for railroads. Railroad origin tonnages are less concentrated in the Gulf Coast, and more concentrated in the interior, especially along the Mississippi and Ohio rivers with little change from 1994 and 2008 (in terms of relative changes). The termination points are much more geographically diffused for rail than for barge. Indeed, the distribution of termination points is seemingly uniform over the region, with no major changes between 1994 and 2008.

Figure 4.7

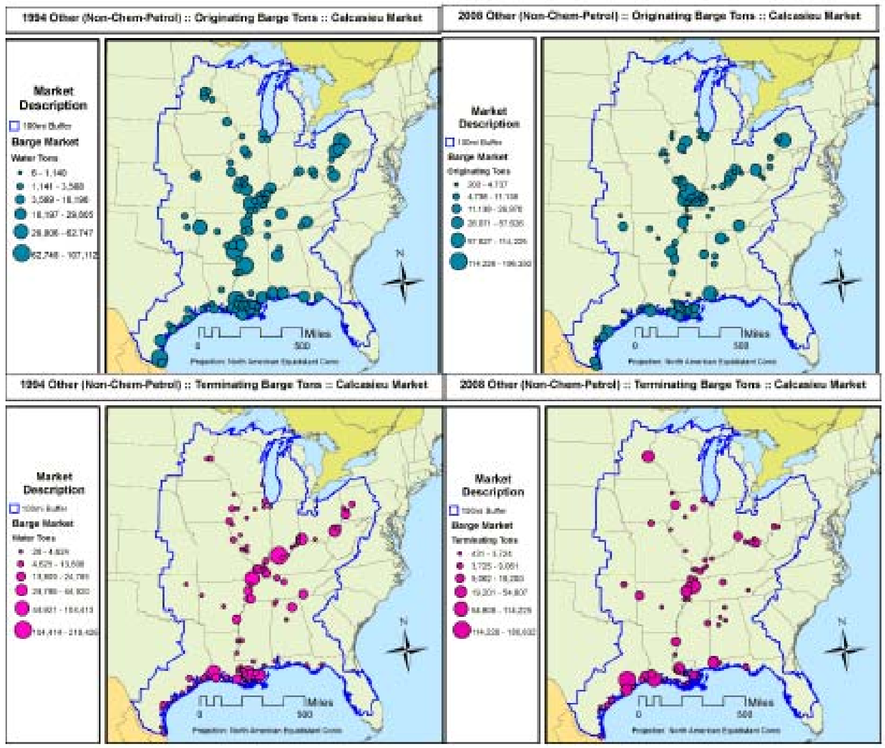
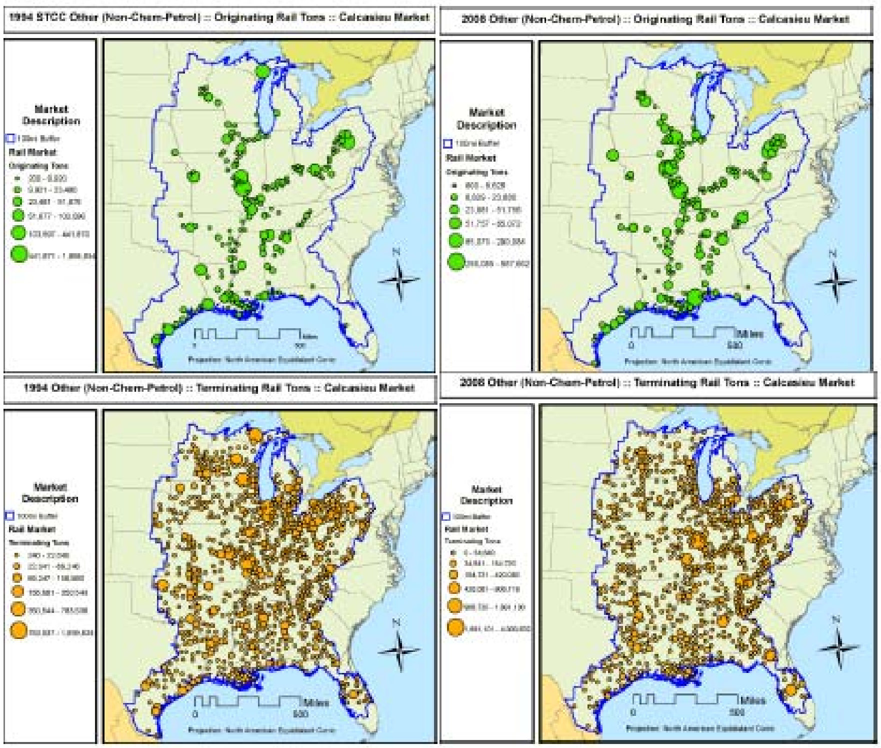

1994 Other (Non-Chem-Petrol) :: Originating Barge Tons :: Calcasieu Market
2008 Other (Non-Chem-Petrol) :: Originating Barge Tons :: Calcasieu Market
1994 Other (Non-Chem-Petrol) :: Terminating Barge Tons :: Calcasieu Market
2008 Other (Non-Chem-Petrol) :: Terminating Barge Tons :: Calcasieu Market
Market Description
Barge Market
Miles

Figure 4.8


1994 STCC Other (Non-Chem-Petrol) :: Originating Rail Tons :: Calcasieu Market
2008 Other (Non-Chem-Petrol) :: Originating Rail Tons :: Calcasieu Market
1994 Other (Non-Chem-Petrol) :: Terminating Rail Tons :: Calcasieu Market
2008 Other (Non-Chem-Petrol) :: Terminating Rail Tons :: Calcasieu Market
Market Description
Rail Market
Originating Tons
Terminating Tons
Miles

41

As with petroleum and chemicals, the figures point to the locations of major origins and terminations over time, but do not identify the major flows. In Table 4.5, we present the top ten flows for Water, and in Table 4.6, the same information is presented for rail. As with these other commodities, most of the origins and destination are in Texas and Louisiana, but there are other origins in Missouri, Arkansas, Alabama, and Kentucky and destinations in Arkansas, Alabama and Indiana. Only two of the top ten flows in 1994 remain in the top 10 in 2008, suggesting that more than for the other commodities, the traffic patterns are less stable. Further, in eight of the top ten flows, the tonnages are larger for 2008 than for the corresponding position in 1994, pointing to geographic dispersion in growth. Rail movements are in table 4.6. As with the other commodities, and as expected, the leading origins and destinations are more geographically dispersed. Major origins and destinations tend not to be located along the Gulf Coast. Similar to waterway movements, only 2 of the top 10 in 1994 remain in the top ten in 2008.

Table 4.5

1994 Top 10 'Other' commodity moves by Water				
O State	O County	T State	T County	Tons
LA	ASCENSION	TX	JEFFERSON	260,723
TX	CALHOUN	IN	SPENCER	219,426
LA	ORLEANS	TX	HARRIS	209,191
LA	ST MARY	TX	JEFFERSON	168,029
MO	ST LOUIS IC	TX	HARRIS	166,390
AR	MISSISSIPPI	TX	HARRIS	128,251
LA	PLAQUEMINES	TX	JEFFERSON	123,520
TX	NUECES	IN	SPENCER	121,111
TX	WILLACY	LA	ORLEANS	107,112
TX	HARRIS	LA	ST JOHN BAPTIST	104,413
2008 Top 10 'Other' commodity moves by Water				
O State	O County	T State	T County	Tons
TX	HARRIS	LA	ST JOHN BAPTIST	568,979
TX	HARRIS	AR	MISSISSIPPI	214,644
MO	CAPE GIRARDEAU	TX	ORANGE	196,350
LA	VERMILION	TX	JEFFERSON	186,311
AL	HALE	TX	HARRIS	180,632
TX	HARRIS	AL	MOBILE	179,870
AL	MOBILE	TX	HARRIS	154,323
LA	PLAQUEMINES	TX	JEFFERSON	149,415
KY	LIVINGSTON	TX	JEFFERSON	141,401
MO	ST LOUIS IC	TX	HARRIS	134,204

Table 4.6

1994 Top 10 'Other' product movements by rail				
O_State	O_County	T_State	T_County	Tons
AL	JEFFERSON	AL	JEFFERSON	7,207,072
KY	PERRY	GA	BARTOW	5,889,399
FL	PINELLAS	FL	POLK	4,213,140
WV	BOONE	WV	CABELL	4,044,671
WV	BOONE	WV	PUTNAM	3,544,812
FL	POLK	FL	POLK	3,055,389
WV	LOGAN	WV	CABELL	3,040,682
KY	HOPKINS	KY	JEFFERSON	2,963,728
VA	BUCHANAN	WV	WAYNE	2,930,628
IL	CLINTON	IN	GIBSON	2,876,600
2008 Top 10 'Other' product movements by rail				
O_State	O_County	T_State	T_County	Tons
OH	BELMONT	OH	BELMONT	7,420,654
FL	POLK	FL	POLK	7,074,897
IN	GIBSON	IN	GIBSON	5,945,060
AL	JEFFERSON	AL	MOBILE	5,247,088
PA	GREENE	PA	INDIANA	4,797,823
FL	POLK	FL	HILLSBOROUGH	4,738,812
IL	ST CLAIR	IL	JASPER	3,448,304
KY	PERRY	GA	BARTOW	2,912,088
IL	COOK	IN	JASPER	2,828,880
PA	GREENE	PA	FAYETTE	2,778,959

4.2.3 Descriptive Statistics of Data

As a final examination of the data, we processed the data over time, and calculated the average waterway tonnages over the entire time period (Table 4.7). And, to compare over time we calculated three year averages at the beginning and end of the time periods available (Table 4.8). Petroleum is the number one commodity over time, and both the early (1994-6) period and the later period (2006-8). It captures about 49 percent of all the traffic on average over the time period. Since the mid-1990s tonnages have fallen slightly, it remains the top commodity.

Chemicals account for about 28.5 percent of the total flow over the time period, and again has fallen over seven percent from the mid-1990s the last three years of data. In contrast, there are a number of other products with more modest tonnages e.g., crude, primary manufactured which account for 11 and 6 percent of tonnages, but also have experience tremendous growth. Food and farm products, accounting for only 2 percent of the total, have fallen dramatically.

Table 4.7

Commodity	Average Annual Tons 1994-2008	Market Share	Cumulative
Petroleum and Petroleum Products	19,027,605	49.03%	49.03%
Chemicals and Related Products	11,089,543	28.57%	77.60%
Crude Materials, Inedible Except Fuels	4,306,532	11.10%	88.70%
Primary Manufactured Goods	2,371,466	6.11%	94.81%
Food and Farm Products	803,718	2.07%	96.88%
Waste Material; Garbage, Landfill and Waste	632,617	1.63%	98.51%
Coal, Lignite& Coal Coke	279,131	0.72%	99.23%
All Manufactured Equipment and Machinery	115,439	0.30%	99.53%
Unknown or Not Elsewhere Classified	963	0.00%	99.53%
Units (Ferried Autos, Passengers, Railway Cars)	0	0.00%	99.53%

Table 4.8

Commodity	94-96 Mean Annual Tons	06-08 Mean Annual Tons	% Chg.
Petroleum and Petroleum Products	20,068,660	19,976,822	-0.46%
Chemicals and Related Products	11,484,380	10,622,341	-7.51%
Crude Materials, Inedible Except Fuels	4,023,858	5,388,551	33.92%
Primary Manufactured Goods	1,896,664	2,950,183	55.55%
Food and Farm Products	852,002	417,183	-51.03%
Waste Material; Garbage, Landfill and Waste	505,892	635,236	25.57%
Coal, Lignite& Coal Coke	192,852	400,400	107.62%
All Manufactured Equipment and Machinery	99,816	119,958	20.18%
Unknown or Not Elsewhere Classified	0	0	0.00%
Units (Ferried Autos, Passengers, Railway Cars)	0	0	0.00%

Both the Waterborne and the Waybill data contain shipment from location to location along with distances and, in the case of the waybill, some rate information. Tables 4.9 through 4.20 contain a summary of "route" statistics by commodity and by mode. The routes for comparison purposes are all the routes present in the waterborne data and only the routes in the rail data that originate at a water-originating county and then terminate within the 100 mile buffer region. Further, to aid in comparisons, we use a water rate proxy (discussed in greater detail in Appendix C). In short, we used data, provided by ACE and prepared by the Texas Transportation Institute, which approximate rates for 150 water moves. We regressed these rates on distance and a commodity dummy variable, and used the coefficients to approximate a rate for each of the barge movements in the Waterborne data.

In both rail and water data sets the revenue dollar amounts are in 2000 dollars. The first set of tables 4.9 and 4.10 provide descriptive statistics for the 1994 rail routes. There are more chemical routes in the selected region than petroleum routes. However, the mean tons being shipped on those routes are two times greater for petroleum. The revenue per ton between the two modes is very close as are the distances of hauls, which would be expected given the region is constrained to the buffer region. Comparing these tables to the next set of tables 4.11 and 4.12 there remains a very similar pattern in between the two commodities being transported via railroad. For chemicals there is an increase in the mean tons being shipped whereas petroleum has seen a reduction in tons being shipped by rail in that region. For both commodities there has been a reduction in the rate being charged over these routes. A comparison of the last set of rail tables, Tables 4.13 and 4.14, indicate that both average distance and tons is about the same, but rates have increased for both commodities to levels higher than in 1994.

Table 4.9 1994 Waybill Railroad Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	2,121	12,919	102,972	200	4,542,500
Rev/Ton	2,056	35.88	23.04	5.40	143.32
Miles	2,121	703	482	0.73	1,984

Table 4.10 1994 Waybill Railroad Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	359	26,823	108,729	240	1,109,180
Rev/Ton	350	35.21	22.33	5.63	147.02
Miles	359	684	442	1	1,784

Table 4.11 2000 Waybill Railroad Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	2,388	15,850	105,839	400	4,935,489
Rev/Ton	2,305	32.38	20.70	5.74	138.76
Miles	2,388	700	469	1	2,197

Table 4.12 2000 Waybill Railroad Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	421	27,305	96,676	400	1,025,404
Rev/Ton	413	26.91	15.26	5.74	90.74
Miles	421	668	448	1	1,872

Table 4.13 2008 Waybill Railroad Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	1,944	18,156	63,769	1	1,822,815
Rev/Ton	1,859	42.86	28.57	8.50	193.66
Miles	1,944	684	454	1	2,048

Table 4.14 2008 Waybill Railroad Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	354	29,285	128,042	320	1,694,488
Rev/Ton	342	43.29	24.85	8.56	162.78
Miles	354	702	455	1	1,951

Tables 4.15 - 4.20 describe the Waterborne Commerce data routes for petroleum and chemicals the same years 1994, 2000, and 2008. Between the commodities the differing of tons was known in the previous tables describing the traffic passing through the Calcasieu lock. As is evident, the number of chemical routes is somewhat larger than for chemicals than petroleum,

and the tonnages per route are larger for petroleum than for chemicals. In both cases, the number of routes is falling through time as are the average distances traveled, while the average tonnages remain approximately the same.

Table 4.15 1994 Waterborne Commerce Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	364	28,441	55,201	253	422,263
Rev/Ton	293	63.36	33.79	10.06	136.94
Miles	293	1,030	607	130	2,391

Table 4.16 1994 Waterborne Commerce Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	324	52,387	115,632	19	1,095,827
Rev/Ton	287	37.49	23.42	5.37	92.98
Miles	287	894	622	98	2,422

Table 4.17 2000 Waterborne Commerce Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	323	30,966	64,263	207	547,823
Rev/Ton	323	56.53	29.86	17.27	121.07
Miles	323	1,015	594	262	2,349

Table 4.18 2000 Waterborne Commerce Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	277	46,503	93,211	76	1,057,011
Rev/Ton	277	34.72	21.61	4.82	82.67
Miles	277	921	635	97	2,383

Table 4.19 2008 Waterborne Commerce Route Statistics for Chemical Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	246	32,698	58,040	789	447,604
Rev/Ton	246	44.90	24.35	10.93	95.87
Miles	246	969	586	178	2,205

Table 4.20 2008 Waterborne Commerce Route Statistics for Petroleum Shipments

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tons	275	53,206	101,621	773	731,468
Rev/Ton	275	26.57	17.01	4.87	71.02
Miles	275	841	600	121	2,400

5.0 Survey Implementation

5.1 Survey Overview

The survey was designed and implemented with a goal of collecting information on both shipments made and alternatives to the shipments made, a set of characteristics on firms, and a notion of how sensitive decisions are to changes in key attributes. This approach has been used in previous ACE studies and the current studies survey is targeted at the petroleum and chemical industries that potentially ship through the Calcasieu Lock. More specifically, we identified a study region as all locations within 100 miles of the waterways over which tonnages that travel through the Calcasieu Lock are located. A list of about 5500 shippers of petroleum and chemical products was identified by Dun and Bradstreet in the region, and attempts were made to gather data from a sample of 2254 firms through a variety of methods. The survey instrument adapted from previous studies and developed for on-line completion. Shippers were contacted by telephone, mail and email. The survey form and design was and submitted and approved by the Office of Management and Budget prior to be implementation.

In implementing the survey, 1000 companies were contacted by telephone and another 1000 companies were contacted by mail and solicited to participate in the survey. In making telephone calls, companies were called up to five times, and in some cases, multiple calls were made to find the decision-maker. In the mail portion, shippers were sent a solicitation letter, and a few weeks later a follow up letter was sent to non-respondents.

All the companies were given an ID number for survey purposes and also to retain the possibility of verifying and/or using data with files from Dun and Bradstreet. In all cases, a printed version of the survey form could be downloaded from the web page containing the survey form (www.transportationinfo.us) developed for the purpose of entering an ID number to take the respondent to a corresponding survey specially designed for their setting.

The telephone side of the survey mode gave the best response rates. Further, in many cases, the telephone call was accompanied with the shipper filling out the form during the telephone call. When the interviewer(s) were not in contact, the responses were incomplete. Further, the telephone approach allowed for an introductory screen to determine relevance of the shipper to the survey and also allowed for a discussion on open-ended comments of the shipper. The following subsections describe the design, development, approval steps and implementation.

5.2 Questionnaire Design

In adapting previously used survey forms, several papers were consulted. These are readily available on www.corpsnets. Aiding in the content was the information collected in the interviews summarized detailed in Section 3. The paper survey design was created first and located in Appendix A of this report. The paper design was seven pages in length, and designed to collect information on the choices made by the shipper. The survey was accompanied with a burden statement and an Office of Management and Budget (OMB) control number, required on federal survey forms. The burden statement expressed the time to complete the survey, which was estimated at 10-15 minutes, and stated that the responses captured from the survey instrument would be held confidential.

From the approved paper version of the survey, an online form was developed for the purpose of the mail and phone respondents to fill out. The online form was developed and data was collected using Survey Monkey. The online survey followed the paper version with a tree like pattern to develop the path of the questions. The survey started with general background questions and then asked if they were a shipper or receiver of the commodity specified. Given that answer they went to a set of questions framed to gather information in the right format (for example, Where did you last ship from? versus. Where did you last ship to?) The basic concept and questions of the paper version were asked in expanded versions without all the subjective tenses to be completed.

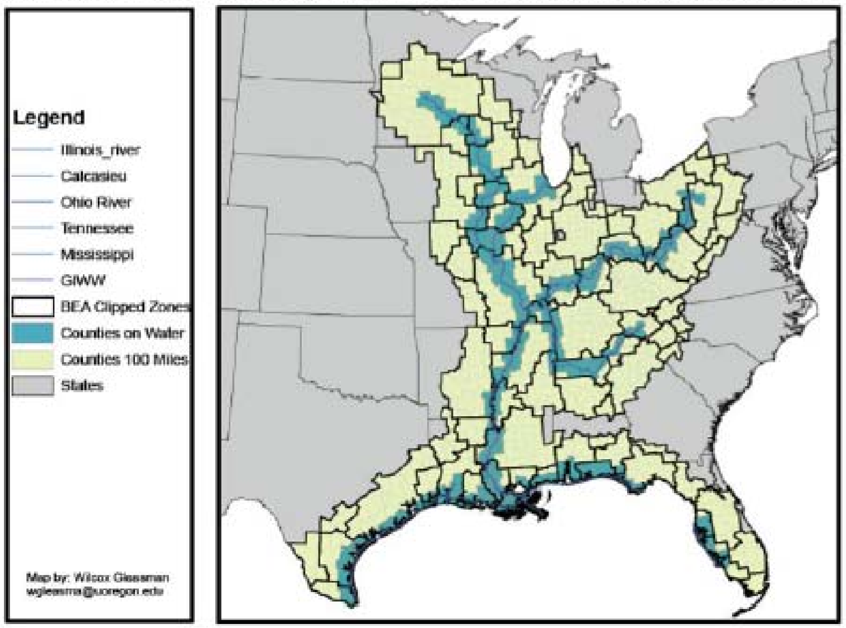
5.3 Sample Design

The type of survey was a mixed mode survey of shippers that for which shipments used or potentially could have used the Calcasieu Lock. The Waterborne Commerce Data, received from Huntington District, captured the traffic that passed through the Calcasieu Lock with a "Calcasieu flag" variable.[3] In the data, there is information on location (waterway, miles, dock etc.). Using county/state all the originating and terminating locations were read into ArcGIS. ArcGIS was used to identify counties within 100 miles of the waterways to capture traffic that has the option of moving on the water through the Calcasieu Lock (figure 5.3.1 below). The light blue spaces are counties that touch the waterway and the yellow region are counties that are within 100 miles of the dark blue line i.e., the major waterways.

3 We also summed the expanded tons of the waybill to identify major shipment counties (origin/destinations) and did internet searches for major shippers as well as to compare with the Dun and Bradstreet list. All of the internet searches were in the local region (GIWW).

Figure 5.3.1

Market Zones Produced Using 100 Mile Buffer Including BEA regions and Counties



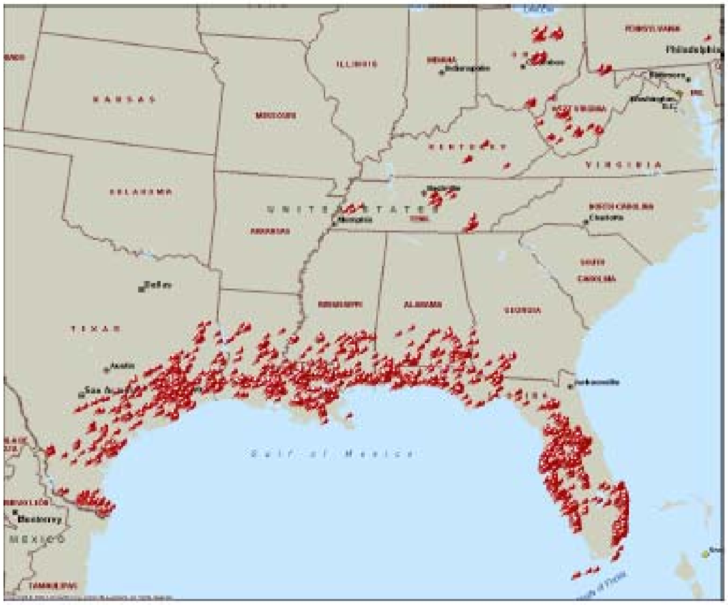
These counties along with specific North American Industry Classification System (NIACS) codes to identify petroleum and chemical products were sent to Dun and Bradstreet who maintains a business directory of firms by commodities. The specific NIACS codes are in Table 5.3.1. We also had a series of discussions with the Dun and Bradstreet representative on the types of firms we needed to get the best list we could.

Table 5.3.1

NIACS Number	Description
213	Support Activities for Mining
237	Heavy and Civil Engineering Construction
324	Petroleum and Coal Products Manufacturing
325	Chemical Manufacturing
331	Primary Metal Manufacturing
3313	Alumina
3241	Cement
4246	Chemical and Allied Products Merchant Wholesalers
4247	Petroleum and petroleum Products Merchant Wholesalers

Dun and Bradstreet sent a list of 5250 firms with locations as indicated in (Figure 5.3.2 below). From the figure, the majority of the firms involved with shipping or receiving the NAICS codes listed above, are located along the Gulf Coast. While generally consistent with the information discussed in Section 3, there are some discrepancies in the interior. Dun and Bradstreet was contacted several times, without success, to verify that the list that was generated from the counties in Figure 5.3.1 and commodity codes in Table 5.3.1, and that is was truly a random sample of the companies located in the selected region. It is plausible, however, the majority of the products being shipped through the Calcasieu Lock, emanate from petroleum and chemicals shippers with headquarters in these regions. It is likely that a large portion of these products are imported/exported and that the majority of the companies are setup on the Gulf Coast to produce domestic goods and easily import/export supplies.

Figure 5.3.2 D&B Full List (5250)



The Dun and Bradstreet data was sorted by firm size measured by sales revenue and two lists were developed for the purpose of the mixed mode survey strategy. The first list contains the top 1000 firms by sales revenue, and they represent our phone list (our experience in the personal interviews suggests that it can be difficult to find the right person within the largest organizations, this is the purpose of the telephone/mixed mode strategy). With the remaining 4250 firms, the list was sorted to keep only the companies with chemicals and petroleum as their primary NAICS code. From that a random sample of 1000 companies was drawn from that list to create the mail list. In Figure 5.3.3, the black represent these random 1000 drawn and the blue represents the top 1000 by sales revenue.

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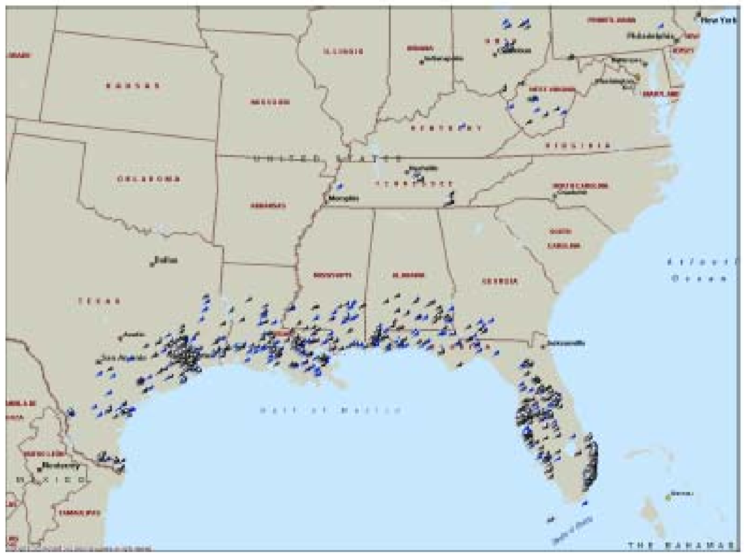
Figure 5.3.3 Telephone and Mail List Locations (Black is mail, Blue is phone)



5.4 OMB Approval

The survey phone and mail sample was completed and the survey instrument was now developed and the next step was to submit to the Office of Management and Budget (OMB) approval. On August 4, 2010 we submitted the mail version of our survey with the website page that directed the respondent to the corresponding survey. The strategy of contacting the largest 1000 by phone and the other random 1000 by mail was explained along with how the sample was drawn.

The total public burden hours for these surveys was estimated at 250 hours. Each successful telephone contact should last approximately 15 minutes, and each negative contact no more than 5 minutes. The total telephone burden would be (with a 30 percent response rate) approximately ((50.7)+(150.3))*1000=133. The mail solicitation follows similarly, but with a

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lower response rate (20 percent). The total mail solicitation burden is (50.8) + (150.2))*1000=117.

Upon first submission, OMB requested some modification to the survey design. The Statement of Purpose (SOP) was added to the cover page or in our case the website page that directed the user to the survey and, the OMB reference number was added to the top page of the survey along with the expiration date. OMB also suggested revisions to the survey instrument, sample design and sampling methods. These concerns were received on September 10, 2010 and resolved with OMB with a responde on September 13, 2010. On September 16, 2010, OMB approved the survey.

5.5 Implementation

With OMB approval of the survey, there were a variety of steps to accomplish before implementation. The survey forms were formatted both a paper version (Appendix A) and an on-line version. The hosting of a survey instrument on-line involved a number of steps. The survey was hosted on SurveyMonkey. Several different versions of the survey forms were developed specifically for petroleum and chemical companies. In addition, for each commodity type, there were multiple versions of the form to accommodate stated preference questions. Specifically, the survey form solicits information on the shipper's revealed choice and alternatives. These are the origin/destination, the price, the rate, transit times, and reliability. This information is symmetric across the survey forms. However, the survey forms also solicit information on the sensitivity of choices. For example, one type of question is: "If the transportation rate increased by 30 percent, would you switch to an alternative, not switch, or shutdown." The percentage prompt differs across survey form and questions. In prior studies, the prompt was randomly drawn by the interviewer during the interview process. However, with on-line and mail survey forms, this was not tractable.[4] However, in this study, we developed six different versions of the form for each commodity. The six different survey forms contained prompts of 10%, 20%, 30%, 40%, 50%, and 60% as percentage changes in the attributes (rate, time and reliability) which differed across stated preference questions. The survey was then applied such that sampled shippers would receive any of the forms with a one in six chance. This approach provides for adequate variation in the stated preference prompts, which is required for estimation.

The survey monkey on-line form was accessed through our webpage www.transportationInfo.us.[5] The webpage was constructed and hosted through GoDaddy.com. The webpage has a picture of the Calcasieu Lock and states the need for the information and the confidentiality ce of their responses. It also provides an option for the respondent to download a survey form that could be filled out by hand and mailed or scanned and emailed to an email account set up for the purpose of the survey. It lists the contact information for a variety of individuals for follow up contacts. These contacts include the project leader (USACE) and two of the authors of this report. The OMB control number is located on the page with statement of burden also being expressed within the boxed script. There are also hyperlinks to letters of support from USACE and a trade association.

An important feature of the webpage is an ID identifier. Each shipper contacted was given a unique ID number. This number was required to enter into the survey page. The shipper received the number by telephone or by mail solicitation letters. The respondent enters their corresponding ID which directs the respondent to the appropriate chemical or petroleum survey forms. The number is also used to insure that the respondents, within each commodity group,

[4] While there is an approach to allow the shipper to generate a random prompt, it was too cumbersome to use.

[5] The on-line form remains active and will remain so until July 1st of 2012. To inspect one version, the reader can use ID=500.

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receive one of the six forms of the survey form (delineated by the stated preference prompts) with a one in six probability. This was not tractable with the printable form, and to accomplish variation in the stated preference questions, the printable survey instrument was replaced on the webpage every other day to allow for changes in percentages within those questions from respondents that chose that method. With the webpage intact, the basics for the differing modes of implementing the survey were finished.

5.5.1 Phone Solicitations

Using the Dun and Bradstreet list, the top 1000 companies by sales revenue were chosen for telephone solicitation. The interviewer(s) attempted to locate the decision-maker(s) within each firm and solicited the decision-maker to take part in the survey. In the case of multiple locations, the interviewer(s) tried to get multiple responses from the firm. Attempts were made to contact each shipper on this list up to five times before giving up (This did not include the phone calls to make contact with the relevant decision-maker). If contact was made with a willing respondent, either the interviewer or the respondent filled out the on-line form. Often the interviewer filled out the form, while on the phone with the respondent, while in other cases, the respondent filled out the form either with or without contact with the interviewer(s).

An excel spreadsheet was created to record responses and dates of contact, update individuals names that were the last contact and record emails and phone numbers for the individuals involved in the shipping decisions. The Dun and Bradstreet list lacked detail information as to the shipping or logistic department and only supplied a main number to be contacted. With the phone number leading to a front desk receptionist, it was both challenging and time consuming to convince the chain of individuals of the need to speak with an individual(s) who makes the decisions on how to ship products or receive them. In the table below, the numbers refer to the actual phone interview results, as some phone solicited companies may have filled out the survey online or by using the downloaded printable survey on their own. The sent email responses were individuals who either needed to have the questions reviewed by a company legal department or were too busy to fill out the survey and wished to do it on their own time. For the most part, without repetitive emails, the individuals usually just ignored the survey, and the email surveys were completed at a low rate outside exclusive barge shippers. The exclusive barge only shippers were either passionate to report the need for infrastructure updates and explain their current situation that usually involved the ACE.

Table 5.3.1

Response Outcome	Freq.	Percent	Cum.
Always Busy	8	0.8	0.8
Completed Survey	41	4.1	4.9
Disconnected #	21	2.1	7
Fax Line	2	0.2	7.2
Left Message	56	5.6	12.8
No Answer	34	3.4	16.2
Not relevant to study	758	75.8	92
Partial Complete	1	0.1	92.1
Please Call Back	3	0.3	92.4
Refusal	39	3.9	96.3
Sent Email	37	3.7	100
Total	**1,000**	**100**	

During the interview process, there were a significant number of companies that expressed that the customer decides their shipping mode. Among the companies, the majority preferred modes in the following order barge, rail then truck with pipeline superseding if available. However, the modal choice depends first on the customers' availability to receive and then the amount being shipped. Thus, there were a handful of times when the company shipped by multiple modes but claimed they didn't have options to the different modes and that the customers' availability decided the modes chosen. Along those similar lines, a number of the companies stated that they didn't organize any of the contractual agreements in shipping their product to the customers. They were only involved in the scheduling and all the agreements were between the customer and the shipping company.

There were a significant number of companies that used freight forward companies in organizing their shipping. They ship such a small amount by rail or barge that the freight forwarder company gets a better rate and in some cases the company wasn't even able to get in contact with the rail or barges companies. Repeated inquires of the freight forwarder companies were unsuccessful as these companies usually have a strict policy of revealing information about their customers' shipments and the contractual rates they receive amongst the shipping industry.

The relevant decision maker within the companies could range from a single decision-maker to entire departments with several members that specialized in a specific mode. The majority of the time the one person logistic coordinator would be willing to walk through a move and give his opinion on how he would react to the alternate options. On the other hand, the larger organizations, with departments of specialized logistic coordinators, may only have information on a single mode. Often, these people were willing to coordinate with the study, and they either request the email to fill out online or do so over the phone. The others, however, would refuse and/or redirect to the company's legal or public affairs division. One company redirected to the legal affairs office as they ship hazardous material, and they were mandated due to the anti-terrorism act to follow protocol when requests shipping information about their products. Except for the list, which is consistent with our interviews presented in Section 3, when contact was made, the response rate was reasonable, albeit still low. There were 1000 phone calls made, but 758 were not germane to the study, there were another 23 with bad contact information, and others where there was no contact made. Of the 242 that remained, successful contact, with an outcome, was made for 81 of the shippers. Of those, 42 either partially (1) or completely participated (41), while 39 refused to participate. Based on these latter numbers, the response rate was about 52 percent (42/81)

5.5.2 Mail Survey

In addition to the telephone solicitation, a solicitation was also sent to 1000 shippers. This solicitation also used the Dun and Bradstreet list. A total of 1000 shippers were drawn randomly from the D&B list and inspected for obvious shippers not relevant to the study. A P.O. Box was established to receive the returned mail from wrong addresses along with mailed in responses from those who chose not to fill it out online. The first mailing occurred in the first week of October, 2010. The second mailing occurred in the last week of October. The solicitation letters sent informed the recipients of the import of the study, the type of information needed for the study, instructions on how to use the website described earlier, and a statement from the Office of Management and Budget Office (OMB).[6] The solicitation letters are provided in Appendix D.

Over the course of the survey a total of 33 survey forms were completed, another 79 different envelops were returned address unknown, and there was one refusal. The status of the remainder is not known. Given the list was taken from the D&B list given earlier; it is likely that a number of irrelevant shippers were sent the letter. Using the 758/1000 irrelevancy number and extending it to the mail survey, the response rate is estimated as 33/236=14 percent.

6 OMB approval of the survey is required as is the inclusion of this paragraph. It states that participation is voluntary, identifies the OMB con control number, the estimated time to complete, and provides contact information for the OMB.

5.6 Supplemental Survey

In total, the telephone and email yielded only 75 observations, primarily due to the small population, alternative lists of shippers were compiled. First, a trade association provided a list of 138 shippers. The second list was identified using the Waybill. Locations of major shippers were identified in these data by summing the tons from 2006-8 for chemicals and petroleum by cities. An internet search was done to locate the large relevant corporations located within those areas that hadn't been contacted yet. In total, these gave 116 companies. but lacks the individual names located in the GICA list but does compose of 116 different companies. This gave a total of 254 added contacts. who were contacted initially by mail with a follow up telephone call a week or so later. From these efforts, there were a total of 28 completed survey forms. The supplemental survey lists yielded a lower percentage of "No Shipping" responses, but due the fact that the companies were contacted via mail and only received 1-2 phone call attempts, there is a high percentage of "Left Message". With the letters going out before the holiday and calls occurring after the first of the year the timing may have been of a bit, but with the GICA mailing information there was some old information with names of individuals that don't work there anymore and addresses for facilities that don't exist. Controlling for these factors, there were a total of and 7 refusals. Table 5.3.3 contains the Trade Association results.

Table 5.3.3

Response Outcome	Freq.	Percent	Cum.
Always Busy	3	0.02	2.07
Completed Survey	8	0.06	7.59
Disconnected #	20	0.14	21.38
Left Message	68	0.47	68.28
Mailed Survey	1	0.01	68.97
No Answer	11	0.08	76.55
No Shipping	8	0.06	82.07
Please Call Back	2	0.01	83.45
Refusal	7	0.05	88.28
Sent email	11	0.08	95.86
Wrong #	6	0.04	100.00
Total	**145**	**100**	

5.7 Survey Respondents Comments

As part of the survey and the phone interview process additional information was recorded in the form of notes or comments written in the end of the survey. The comments are summarized in the following bullets by responses to rates, time in transit, and reliability changes, availability of modes and items related to mode choice, such as volumes and demand modeling. These comments were collected from individuals within the companies surveyed and their identity was reinforced to be confidential, thus the comments are specific to the record but not be attributed to a specific company. In Appendix B, the comments are provided by ID number (without an identity provided).

Response to Rate Changes:

- For most companies the order of prioritizing a shipment decision was focusing on cost, then time in transit and finally they deal with reliability.
- Given that the most cost effected way to ship is barge/ocean ship, then rail, then pipeline and lastly truck.
- However the mode option choice primarily is dependent on the options the customer has available to receive by, thus the focus is on the most cost effective way to ship to that customer given his abilities.

- Often large vertically integrated shippers setup their locations to ship by a specific mode to terminals operated by the customer. Thus, companies may ship millions of barrels a year from a location only by barge, rail or pipeline and changes in rate have to be absorbed or passed on to the end user due to the infrastructural fixed cost in establishing that modal option.
- One company stated that in the last 5 years the barge cost has increased by 20%.
- Another company stated they had two options rail and truck and truck was 20% more to use than rail.
- As far as actual costs for the given modes, few companies were willing to share that information, but some companies were willing to give out approximations. For ocean ship going internationally it was about $20,000 a day, barge it was about $6,500-10,000 a day plus $1000 a day for the tug or about $55-60 a ton, rail was around $60 a ton, pipeline is about $.40-.60 a barrel or roughly $75 a ton and truck was around $120-$200 a ton.

Response to Time in Transit Changes:

- Time in Transit is a very sensitive topic to the companies being interview due to the fact that for most of these companies their whole production is synchronized with shipping and receiving products.
- Given that time in transit is usually accounted for in the day to day operations with the exceptions of unexpected issues arising from natural disasters, catastrophic events or delays due to overwhelming volumes. During the survey time period, the oil spill from the oil rig located in the gulf had just occurred, so companies definitively expressed issues with the barge traffic being secondary to the cleanup efforts. For example, if a storm was reported to be entering the Gulf area then the response crews involved in the cleanup would have priority on the GIWW as they were ordered to evacuate the area. Thus, they would have priority in returning also shutting the barge traffic down for days in some occurrences.
- Some of the chemical company's products are essential to their customer's production and without it would mean shutting down. For example, refineries need certain chemicals in order to refine the crude oil and with the refining industry operating near capacity a shutdown would affect supply to the whole country. Thus, if it appears that they need a product immediately it would be shipped by truck in the amounts needed to hold them over till their shipment arrived by the usually scheduled mode arrived.
- In general, time in transit is very important and tracked very carefully over the long-run that in the short-run without an unexpected event there is leeway built in dependent on the modes being used. In terms of the survey, without using a specific example of a hurricane hit or an oil rig spilled in the Gulf the common answer to a change in time of transit was that they would ship more often or sooner i.e., it was part of their inventory management.

Response to Reliability Changes

- Reliability fell into a similar category as time in transit changes, in that it is heavily tracked over the long-run.
- There is however a twofold meaning to reliability, one being the percentage of time a shipment arrived within the stated time in transit and the other being the percentage of time the shipment arrives without an event occurring during shipping. Of the companies interviewed by phone 95% of them took it to mean percentage of shipments that arrive within the allotted time period.
- Given that, the 5% of the interviewed companies that expressed that they took reliability to be the first measure of concern in shipping products and that they would prefer a higher cost if there was a reduction of mishaps that occur in the differing modes. One company noted that they would always choose to serve locations with petroleum by pipeline if that mode of shipping was available even though it cost more to use than rail or barge. The risk of a pipeline having a negative event was so small that they preferred it over any other modal option.
- With the majority of the companies perceiving the reliability questions as what would they do if a shipment that is stated to arrive in a certain time period is less likely to arrive in that time period, they would ship more often or more product at a time, similar to the responses for changes in time in transit.
- It was noted that those companies that use both rail and barge that barge was more reliable given no unexpected circumstances than using rail.

Availability of Different Modes / Items Related to Modal Choice

- As stated earlier, companies have a tendency to have set their operations up to ship with a preferred mode and end up shipping by the most cost effective way the customer can receive.
- Given that, because the companies have a preferred mode of shipping they may use 90% of the time the other 10% of the time it may not have as many options and may result in truck being their only alternative to their preferred choice.
- One company stated they used barge to ship but have the ability to ship rail or truck, but if an order comes in for a large shipment to be shipped by rail, it may take some time. Specifically, because their use of rail is infrequent, they aren't on the railroads priority list and might have to wait for cars, then wait longer to have them pulled to a hub where they can be combined into a unit train, thus if there is a urgent demand the product would have to be trucked to the customer.
- In cases where a company doesn't use a mode very often but has the ability to ship by rail, barge or truck may opt for the infrequent mode. This tends to occur based on customer needs for delivery. In such cases, the shipper often does not contract and

instead pays a spot price or uses a freight forwarder to set up the load. Each of these comes at higher costs.

- The other issue with mode choices is volumes and concentration of shipments to the receiver. For instance, for small shippers, rail and barge may not be an option especially for small shipment sizes. As such, volumes can be an important factor in mode choice.
- Other modal choices are driven by demand for their products, the company that indicated it prefers pipeline to all markets served by that option looked into the costs associated with building a pipeline to serve other regions to which they ship. In their opinion, oil has peaked, the costs to build a pipeline are significant, and they chose instead to set their production on river to use barge and/or to use rail. But, given low demands for high volume moves they won't be concerned in optimizing their location to serving a high volume mode like barge, rail or pipeline.

6.0 Results

The output from the survey was located on the web amongst the different surveys, paper responses received by mail, and a few scanned forms sent by email. The mailed and scanned forms were entered into the on-line system. The total responses tabulated were 108 survey forms with varying levels of completion. However, there were a number of cases with little or no information provided, and a variety for which the information was incomplete. While the number of observations is somewhat small, they do provide information and that information is summarized in this Section. The summaries include three sections on shipper characteristics, revealed choice data, and stated preference data.

6.1 Shipper Characteristics

Table 6.1 provides a summary of commodities. These were established by ID number and Dun and Bradstreet NAICS codes applied to the contact information. For the supplemental list, information was gained through interviews and from the source list. The sample was dominated by Petroleum shippers (72/108=67%), followed by Chemical (21/108=19%). There were 15 (15/108=14%) that filled out the survey form(s) but for which commodity identifiers could not be determined.

Table 6.1: Commodity Representation

Commodity	Frequency	Percent
Chemicals	21	19
Petroleum	72	67
Other	15	14
Total	108	100

Table 6.2 contains the locations of the shippers. These shippers are located primarily in the South, including AL (9), FL (15), LA (21), MS(5), and TX (51), but there are also shippers in IL (1), OH (1), TN (2) and WV (1).[7] There were two respondents for which location was not identifiable.

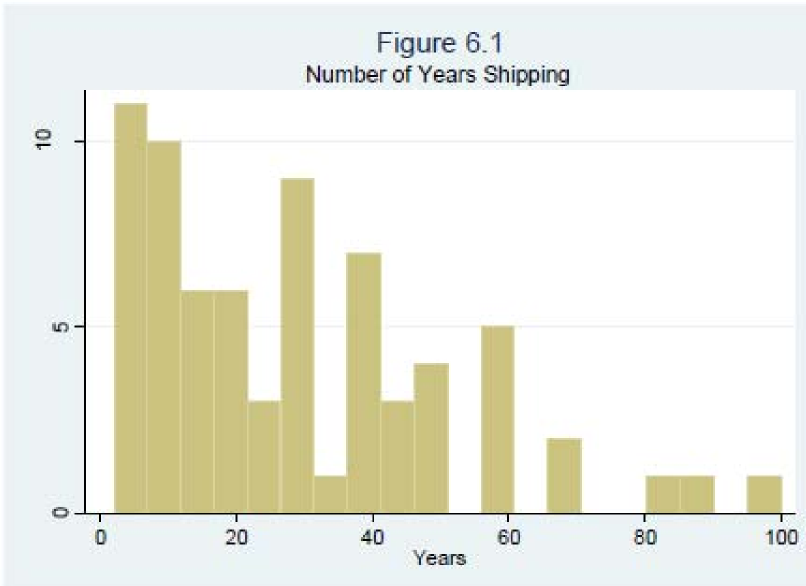
Table 6.2: Shipper Locations

State	Frequency	Percentage
AL	9	8.49
FL	15	14.15
IL	1	0.94
LA	21	19.81
MS	5	4.72
OH	1	0.94
TN	2	1.89
TX	51	48.11
WV	1	0.94
	106	100

Annual volumes shipped average nearly 900,000 tons (51 observations) with a median value of 50,000 tons, and 95 percent of the 51 respondents ship between 8700 and about 120,000 tons per year. Yet, there are also 11 of the 51 shippers that ship in excess of 500,000 tons per year.

In terms of other characteristics, there were a total of 70 firms that reported how long they have been shipping. On average, shippers have been shipping 29 years, with a range from 2 to 100 years, and a median value of 25 years. A frequency distribution is in Figure 6.1. It is noted that, while skewed, there is a good representation of experience and longevity in the sample.

[7] Throughout this section, the number In () represents frequencies of responses.



As is evident throughout the report, the number of firms involved in or potentially in shipping through the Calcasieu, they can be quite large. This is indicated by the information on annual shipments, but also by the number of facilities operated. Again, while heavily skewed, there are a number of shippers with 10 or more facilities. This is underscored by Figure 6.2 below which points to the number of facilities held by companies. Finally, a number of shippers have import or export facilities. This is consistent with the interviews and is represented in the data. There were 36 of 69 shippers (52%) that reported they had import or export facilities.

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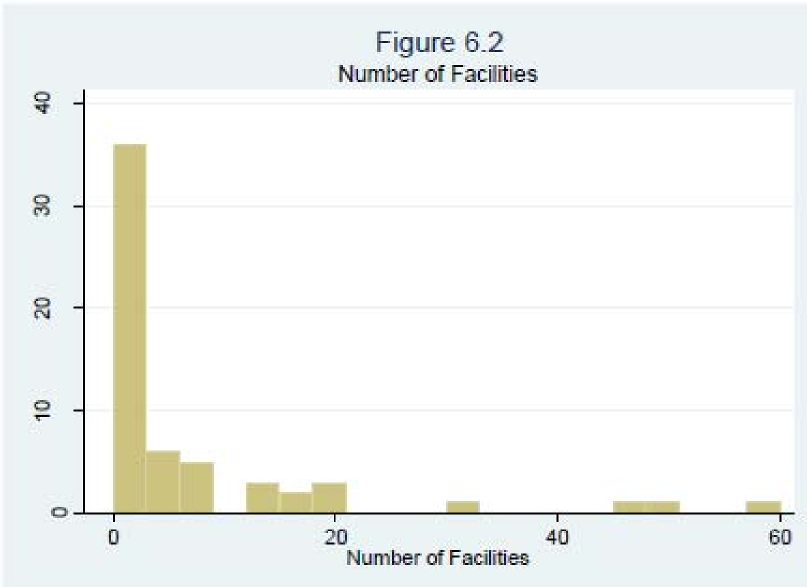

6.2 Modal Availability

In the survey instrument, questions were posed of the modes that were available to shippers. Of course, the access that shippers have to modes is central to the level of flexibility in making mode choices. These are summarized in Table 6.3. There were 98 respondents to this question. Eighty-eight shipper had access to truck, 54 had access to barge (without transshipment), and 53 had access to rail. Only six reported access to pipeline.

Surprisingly, 39 percent reported access to only one mode, and the bulk of these were truck-only shippers. The remaining 61 percent had access to two of more modes—21 percent had two modes, 35 percent had access to three modes, and 4 percent had access to all four modes. From this information, the only substitution, without transshipment, open to 38 percent of the shippers is to switch locations (either origin or destination) of the shipment.

Table 6.3: Modal Availability

Mode(s)	Frequency	Percent
T	31	31.63
B	7	7.14
T-R	12	12.24
T-B	6	6.12
R-B	3	3.06
T-R-B	33	33.67
T-R-P	1	1.02
T-B-P	1	1.02
T-R-B-P	4	4.08
Total	98	100

Note: T=Truck, B=Barge, R=Rail, and P=Pipeline.

However, these shippers can tranship to another location and use barge, rail or pipeline. The survey instrument provides some information on the distance of the shippers from barge and rail (given they have no direct access). Table 6.4 summarizes this information. Generally, about 70 percent of the shippers have direct access to rail and barge. The remaining shippers have access, but must do so through transshipment. Most of these are within 25 miles of rail and/or barge.

Table 6.4: Distance to Available Mode				
Distance	Rail	%	Barge	%
0	53	68	54	72
≤10	71	91	61	81
≤25	74	95	65	87
≤50	76	97	70	93
≤100	77	99	74	99
≤150	78	100	75	100
Average (not direct)	19 Miles		33 Miles	
Overall Average	6 miles		9 miles	
N (All shippers)	78	100	74	100
N (without direct access)	25	100	20	100
Note: Each cell contains the frequency of responses. There are two averages presented, one conditioned on non-direct access and the other for all observations.				

6.2 Mode Use and Options

Tables 6.3 and 6.4 denote options available to shippers. In this subsection, modal use is documented. Table 6.5 presents the observed choices, Table 6.5 presents the response of shippers if the choice they made were no longer available, and table 6.6 presents a cross-tab of the choice made and the options if that choice was not available. There were 76 shippers that provided modal choices. There were 32 barge shippers, 25 rail shippers and 19 truck shippers.

To uncover the next relevant alternative, shippers were queried what they would do if the option they chose was no longer available. It is important to note that shippers can (if available) switch to another mode, ship from or to another location, or shutdown. In Table 6.6, the responses are summarized. There were a total of 81 responses, and overwhelmingly, shipper substation is modal. Only 11 percent switch locations (origin and/or destination) of the shipment; 59 percent would switch to an alternative mode. Finally, it is noteworthy, that there are a number of shippers that are captive to the service they receive and the origin/destinations served in that 25 (31%) report that they would shutdown if the (origin/destination-mode) chosen option were taken away.

Table 6.5: Observed Mode Choices		
Mode Choice	Freq.	Percent
B (Barge)	32	42.11
R (Rail)	25	32.89
T (Truck)	19	25
Total	76	100

Table 6.6: Observed Options		
Alternative	Frequency	Percent
Mode	47	58
Location	8	10
Mode&Location	1	1
Shutdown	25	31
Total	81	100

There were a total of 76 respondents for whom choices and alternatives were available. The results are summarized in Table 6.7. There are 32 barge shippers whose alternatives are barge (2), rail (12), truck (6) and shut down (12); there are 25 rail shippers whose alternatives are barge (3), rail (0), truck (22) and shutdown (0); and 19 truck shippers whose alternates are barge (0), rail (2), truck (7), and shutdown (11). There are 8 cases where the switch is within the same mode. This suggests switching the origin/destination or alternatively, another barge, rail, or trucking firm.[8] It is noteworthy, however, that the switching that occurs for barge is to rail, for rail is to truck, and for truck is to shutdown.

[8] This latter comes from the fact that only 6 stated they would ship from or to another location (Table 6.4). The only other option is that they switch companies.

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Table 6.7: Switching Options					
Choice\Option	B	R	T	No Option	Total
B	2	12	6	12	32
R	3	0	22	0	25
T	0	2	6	11	19
Total	5	14	34	23	76

6.3 Choice Model Attributes

The remainder of the survey instruments solicited responses on key variables that determine mode choice and sensitivity of mode choice and annual volumes to changes in these variables. Generally, mode choice is the result of an optimizing decision that rests on the price of the product transported, the transportation rate, time in transit and reliability of the mode.[9] In the survey instrument, the chosen option (mode and location) along with the alternative options that could have been chosen were solicited. There was considerable variation in the data, owing primarily to measurement error, as well as a considerable number of missing values. Given the relatively small number of observations and the noise in the data, median values are used, and in the empirical work, we developed proxy variables (discussed later), and we also used the data in logarithmic form.[10]

Median values are summarized in Table 6.8 overall and by the chosen and non-chosen options of the shipper, while Table 6.9 provides the median values in terms by mode. The

[9] Only a scant number of respondents provided any information on the price of the product transported (received or paid). Further, in terms of commodities, there was only 1 chemical respondent and 2 others without a commodity identifier. The remaining 18 respondents were petroleum shippers. For the remainder, this shipment characteristic is ignored, and as such enters into the error term. Given that most shippers tend to switch modes or modal suppliers and not origin/destination, this term largely is without consequence since in a choice model, it would fall out of the estimation (given a shipper has options).

[10] Our inspection of the data suggests that the measurement error was roughly consistent across modes. In the econometric work, the difference in logs is equivalent to the log of the ratio in which case conversions of rates per barrel, per mile, etc. factor out and leave the ratio in tact.

median value of rate per ton was about $30, the median transit time was about 3 days, and, generally, the service levels were ranked high with about 90 percent of similar shipments arriving on time, the median distance was 461 miles, and the rate per ton-mile was about 5.99 cents. The chosen option gives a median rate per ton of $20.25, while the non-chosen option (option 2) was considerably higher at about $45.36 per ton. However, the alternative shipment also travels faster (both hours and miles per hour) and travel longer distances.

Table 6.8: Median Values of Shipment Characteristics

Variable	Overall		Chosen		Option 2	
	N	Centile	N	Centile	N	Centile
Rate ($/ton)	63	30	39	20	22	39.4
Hours	113	96	67	168	44	72
% On-time	111	90	66	90	43	98
Distance (miles)	120	461	67	420	51	577
Rate (Cents/Tonmile)	61	5.88	37	5.42	22	6.81
Miles per Hour	111	5.76	64	3.78	44	9.93

Note: The N refers to the number of respondents, and the centile is the median value. There were a maximum three options in the survey instrument. There were only three respondents on the third option. Each of these was a truck movement and excluded in this table.

These same data also developed by mode. The results are in Table 6.7. The rate per ton by barge is about $19.91 per ton and about 3.27 cents per ton-mile. The corresponding figures for rail are 38 and 6, and for truck are 62 and 10. However, the median shipment distances are quite different, as expected, with 415, 787 and 461 for barge, rail and truck. In general, the rates per ton-mile are about as expected. Barge and rail miles per hour (distance/shipment time) are about the same (3.57 and 3.27), and much higher for truck (14.2). [11]

[11] While these number do seem somewhat small, it is noted that they include the time to schedule, wait for equipment and actual transit time. The former two are largely not related to distance, while the latter depends directly on distance.

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Table 6.9: Median Values of Shipment Characteristics by Mode								
Variable	Overall		Barge		Rail		Truck	
	N	Centile	N	Centile	N	Centile	N	Centile
Rate ($/ton)	63	30	26	13.91	17	38	20	52.54
Hours	113	96	34	120	37	240	42	48
% On-time	111	90	33	85	36	80	42	99
Distance (miles)	120	461	33	412	39	787	48	422
Rate (Cents/Tonmile)	61	5.88	25	3.71	17	6	19	9.80
Miles per Hour	111	4.76	32	3.33	37	3.27	42	13.4

Note: The N refers to the number of respondents, and the centile is the median value. There was one respondent who did not identify the alternative mode and is excluded from this table.

6.4 Stated Preference Responses (mode choice)

Stated preference type questions are often used to solicit information. A typical approach is to confront the respondent with hypothetical questions in which they are confronted with a choice. Such an approach is routinely criticized in that the option that are used to confront the individuals may not be relevant and, hence, the choice very inaccurate. To overcome this issue, we tied the stated preference to the choice that was made. We then ask the respondent if they would switch to an alternative for different percentage increases in the shipment attributes (rate, time in transit, and reliability). The responses are summarized in Tables 6.10, 6.11 and 6.12.

The overwhelming majority in all three cases (changes in rates, transit times and reliability) is that shippers generally do not respond to changes. For the three different attributes, they are somewhat more responsive to rates than to transit times or reliability. Of 73 shippers, a total of 45 (62 percent) do not change regardless of the level of the rate change. Of the other 28, 17 (61 percent) would switch to an alternative), while 11 (39 percent) would shutdown. For transit time changes, there were 56 of 73 (76 percent) that reported they would not switch at any level offered. Of the remaining 17, 9 reported they would switch options, while 8 reported they would shutdown. For reliability changes, the responses are similar. There were 52 of 73 (71 percent) that reported they would not switch at any level offered. Of the remaining 21, 16 reported they would switch options, while 5 reported they would shutdown. It is, however, noteworthy, that even though overall switching seems somewhat low, the percentage of changes (switch or shutdown) increases with the percentage change in rates and reliability. While transit times are also changing, the pattern appears much weaker.

Table 6.10: Sensitivity of Chosen Option to Rate Changes

Percentage	No Change	Switch	Shutdown	Total	%
10	12	1	0	13	8
20	11	3	2	16	31
30	7	3	0	10	30
40	7	6	1	14	50
50	5	0	3	8	38
60	3	4	5	12	75
Total	45	17	11	73	38

Note: The cells of the table are frequencies of responses unless otherwise indicated.

Table 6.11: Sensitivity of Chosen Option to Transit Changes

Percentage	No Change	Switch	Shutdown	Total	%
10	7	0	1	8	13
20	4	2	2	8	50
30	11	2	1	14	21
40	16	1	1	18	11
50	10	2	0	12	17
60	8	2	3	13	38
Total	56	9	8	73	100

Note: The cells of the table are frequencies of responses unless otherwise indicated.

Table 6.12: Sensitivity of Chosen Option to Changes In Reliability					
Percentage	No Change	Switch	Shutdown	Total	%
10	15	1	0	16	6
20	11	2	1	14	21
30	8	2	0	10	20
40	6	3	1	10	40
50	3	1	2	6	50
60	9	7	1	17	47
Total	52	16	5	73	29

7. CHOICE MODELING

There are a number of approaches that can be used with the available data. Given the shortness of the data, we present a set of different models and elasticities to provide a range of estimates for the planning models. As discussed in the last section, there are both revealed and stated preference data. We first provide a short summary of results using the stated preference data in the form it was collected. We then present a choice model based on the revealed data and observed data as well as based on the revealed data and constructed data. Finally, we close with a discussion of a model that contains both revealed and stated preference data.

7.1 Stated Preference Data

As discussed in Section 6, there were three specific questions intended to capture the sensitivity of the choice made to changes in the attributes (rates, time in transit, and reliability). In each case, respondents were confronted with a percentage change in the attributes (that made things worse) and asked if they would stay with the original option, switch to a second option, or shutdown. Associated with the change in rate is a change in payoffs of each alternative. In advantage of stated preference data is that all else is held constant. The summary responses of the dependent variable were discussed in section 6, and these responses can be directly estimated and the results used calculate probabilities and elasticities.

In this model, the dependent variable has categories. In this case, the categories are: do not switch, switch to another alternative, and shutdown, which represent the options available to the shipper when rates change. In some of the data, shippers report that they do not have an option other than to shutdown. These are estimated with a logit model, where the number of options is allowed to vary across options i.e., some shippers state that they have no options than that chosen with the result that the only other option is to shutdown.

The specific question asked is as follows (for rates).

> For your last shipment, if the transportation rate increased *Percent change1*%, would you continue with the original mode and destination or switch to your best alternative choice?
> - ❑ Continue to use Original mode
> - ❑ Switch to Best Alternative Choice (Skip to Q26)
> - ❑ Go out-of-business (Skip to Q26)

In this question, each of the targets (respondents) was confronted with varying percentage changes in rates, which ran from a 10 percent increase in rate to a 60 percent increase in price. The stated preference is based on the options solicited and the response to this question (for rate).

Shippers are taken to respond to the question in terms of optimal behavior. This can be modeled as follows. Let P_{ic} be the payoff for shipper choosing option *c*. The payoff is written as: $P_{ic} = \beta_0 + \beta_1 R_{ic} + \sum_k \beta_k X_{ic} + \varepsilon_{ic}$, where R_{ic} is the rate faced by shipper *i* for option *c*, and X_{ic} is a set of control variables which are taken as invariant across options e.g., shipper characteristics, distance to the location (if a mode choice), etc., ε_{ic} is a random component for shipper *i* and alternative *c*.

An advantage of the stated preference approach is the ability to control the experiment generating the response. Stated differently, when confronted with a change in rate, *the response is observed given all of the other variables remain unchanged.* In the present context, let $P_{ic'} = \beta_0 + \beta_1 R_{ic'} + \sum_k \beta_k X_{ic} + \varepsilon_{ic}$ be the payoff attached to an alternative given that the only change is from an increase in rates of a given percentage i.e., $R_{ic'} = (1 + \lambda R_{ic})$ *where* λ is the percent change in rate (.1, .2, .3, …, .6). Payoffs are not observed, but rather the outcome of a comparison of the payoffs i.e. they do not switch, they choose an alternative option. In the present context, the outcome is probabilistic and generated by:

$$P_{ic} \geq P_{ic}$$

$$\Leftrightarrow prb(do\ not\ change) = prb(\beta_0 + \beta_1 R_{ic} + \sum_k \beta_k X_{ic} + \varepsilon_{ic} \geq .\beta_0 + \beta_1 R_{ic'} + \sum_k \beta_k X_{ic} + \varepsilon_{ic'})$$

which reduces to

$$prb(\beta_1 (R_{ic} - R_{ic'}) \geq -(\varepsilon_{ic} - \varepsilon_{ic'}))$$

In Table 7.1 there are five models presented. These include a model with only the percentage rate change (Model 1), an alternative specific intercept (Model 2), a model in which mode dummies are added to the model (Model 3), a model with commodity dummies (Model 4), and a model with both mode and commodity dummies (Model 5). In applicable cases, barge and petroleum are the "base" dummies and, as such, are excluded from the models. We also estimated the same model for changes in transit times and reliability, and for whether annual shipments are affected. The results of these models are given in Appendix E.

In each of the models presented in Table 7.1, the results suggest that there are adjustments to price changes. Further, with the exception of model 1 – the model with no constants, the estimated parameters are numerically similar.[12] The alternative specific dummies are also statically important at all levels and (except for model 1), the estimates are numerically similar. The Chemical and other commodity dummies do not point to important changes from petroleum. The rail dummies do not point to differences in responsiveness from barge, while there is limited support for the inclusion of truck dummies in that shippers by truck tend to respond more by shutting down. It is noted that as indicated in Section 6, in many cases, truck shippers are more

[12] We also estimated the model with the continuous explanatory model in natural logs, which gave qualitatively similar results.

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likely to not have options and if confronted with price increases, they may need to shutdown if rate increases are large enough.

In this model, the coefficients are the change in the natural logs of the relative odds of the option (do not switch, switch, shutdown) in response to the change of a variable e.g., % change in price relative to a base. To more directly assess the effects, we present in Figures 7.1 and 7.2 probability plots against the percentage change in price. In Figure 7.1, this is the probability that the shipper does not change their mode and/or their location choice (i.e., where they are shipper to or from). As indicated earlier, the barge and rail shipper behavior is quite comparable, while truck shippers tend to adjust more rapidly. In Figure 7.2, the probability of switching to another mode or location is plotted against the percentage change in price, where again barge are rail are comparable, but truck shippers tend to switch faster.

In Table 7.2, we present the elasticities by mode. These are the probability of a switch divided by the percent change in prices. In this Table, the percentage change in price, the probability of a switch and the associated elasticities are provided. Generally, the elasticities are smallest for barge, and largest for truck. The numbers range from .96 to 1.98, and generally point to relatively elastic demands i.e., economists typically point to inelastic (elasticities are less than one in magnitude) to elastic (elasticities are greater than one in magnitude.

This information can be used to model the effects of rate changes as follows for specific changes in rates. That is, suppose that he beginning "base" rate is given by R_{ic}. Congestion increases rates, and the new higher rate is given by $R_{ic'}$. For each change in rates, the percentage change in rates can be directly calculated and applied to the formula to calculate the probability that a shipper does not switch to an alternative and/or the probability that a shipper "shuts down" using the logit formula. In the present model i.e., model 3, the calculations are specific to the initial choice the shipper made i.e., barge, rail or truck and to the options that a shipper has i.e., whether they have an alternative mode/location option or whether the only option is to "shut down" both are observed in the data, but GULFNIM typically uses the closest non-barge option. For this reason, each shipper has three options – no switch, switch to an alternative, or shutdown.

A spreadsheet is used to illustrate how the model can be used. In this spreadsheet, the input to the model is the "base rate" and the parameters of the particular logit model used. These are marked in "bold". The base rate is changed by arbitrary increments, and any level of granularity can be used. For the present case, model 3 of Table 7.1 are used in the calculations. In the choice data collected (for barge), the median value of base rate per ton was 14.55 and the mean value was 17.3 per ton. For illustration purposes, a base of 14 was used. Higher rates may cause the shipper to switch (either to another mode or location or by shutting down). In the spreadsheet, there are 1000 different barge rates which run from 14 to 24, in increments of .01. The percentage change in rates is calculated for each rate. The specific formula used is:[13]

$$\%Change = \frac{(rate - baserate)}{baserate} * 100 .$$

To map into the estimation results, the negative of the percentage change is used i.e., it is the percentage decrease (in magnitude) to keep consistent with the estimation.

Column A gives the rate and Column B gives the percentage change in rate. Columns K, L and M calculate components of the logit formula. That is, the logit formulas for each option (indexed by 1=no switch, 2=switch, and 3=shutdown) are:

$$prb(no\,switch) = \frac{e^{xb_1}}{e^{xb_1} + e^{xb_2} + e^{xb_3}}$$

[13] Each of the changes is, therefore, negative and in percentages.

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$$prb(switch) = \frac{e^{xb_2}}{e^{xb_1} + e^{xb_2} + e^{xb_3}}$$

$$prb(shutdown) = \frac{e^{xb_3}}{e^{xb_1} + e^{xb_2} + e^{xb_3}}$$

where the xb_i reflects the parameter estimates and data.[14] Columns K, L and M in the spreadsheet calculates each of the numerator components, while N calculates the denominator. Each of the three probabilities are in columns O, P and Q. Column C is simply a replicate of column K. Hence, the primary features are captured in columns A, B, and C, which contain the rates, the percentage rate change from the base, and the associated probability of not switching to an alternative.

Figure 7.3 illustrates the results. With a small change in price, the probability of not switching (staying with barge) is quite high (about .88). With progressively larger increases in rates, the probability of not switching falls, and with rate increases of about 70 percent ((24-14/14)*100=71.43), the probability of not switching falls to about 18%. Figure 7.4 provides the same information graphed against rates. As rates fall from 14 to 24, the probability of not switching increases to about 18%. Also included in these figures are the probabilities of switching to an alternative and the probability of shutting down. The probability of switching to an alternative or shutting down increases with increases in rates (or percentage changes in rates). For smaller changes, shippers tend to switch to alternatives, but for larger rate changes, the probability of shutting down dominates. It is noteworthy, that in both cases, there are very large percentages of shippers who are not affected even by very large increases in rates.

[14] It is noted that in multinomial models, such as this, variables that do not vary across options require that one set of parameters

Table 7.1: Stated Preference Results - Rates

VARIABLES	(1)	(2)	(3)	(4)	(5)
% Change in Price (Switch)	-0.00992	0.0382*	0.0368*	0.0377*	0.0367*
	(0.00881)	(0.0196)	(0.0203)	(0.0201)	(0.0210)
% Change in Price (Shutdown)	-0.0210**	0.0821***	0.0861***	0.0887***	0.0915***
	(0.00825)	(0.0263)	(0.0297)	(0.0286)	(0.0318)
Intercept (Switch)		-1.942***	-2.045**	-2.001***	-2.132**
		(0.719)	(0.932)	(0.727)	(0.958)
Intercept (Shutdown)		-4.573***	-5.149***	-4.979***	-5.339***
		(1.226)	(1.539)	(1.375)	(1.645)
Truck (Switch)			0.130		0.0272
			(1.271)		(1.327)
Truck (Shutdown)			1.781*		1.647*
			(0.953)		(0.986)
Rail (Switch)			0.179		0.231
			(0.720)		(0.736)
Rail (Shutdown)			0.171		0.229
			(0.719)		(0.734)
Chemical (Switch)				0.00578	-0.142
				(1.296)	(1.318)
Chemical (Shutdown)				0.862	0.886
				(1.122)	(1.148)
Other (Switch)				1.018	0.511
				(1.068)	(1.135)
Other (Shutdown)				-0.331	-0.634
				(1.348)	(1.328)
Observations	191	191	191	191	191
log-likelihood	-65.49	-50.37	-47.71	-49.43	-46.97

Notes: The standard errors are in (). A *, **, *** indicate statistical significance at the 1, 5, and 10 percent levels. The dependent variable takes a value of 1, if the respondent chooses to not switch from their current mode/location choice (base option), if the respondent chooses to switch to another mode and/or location

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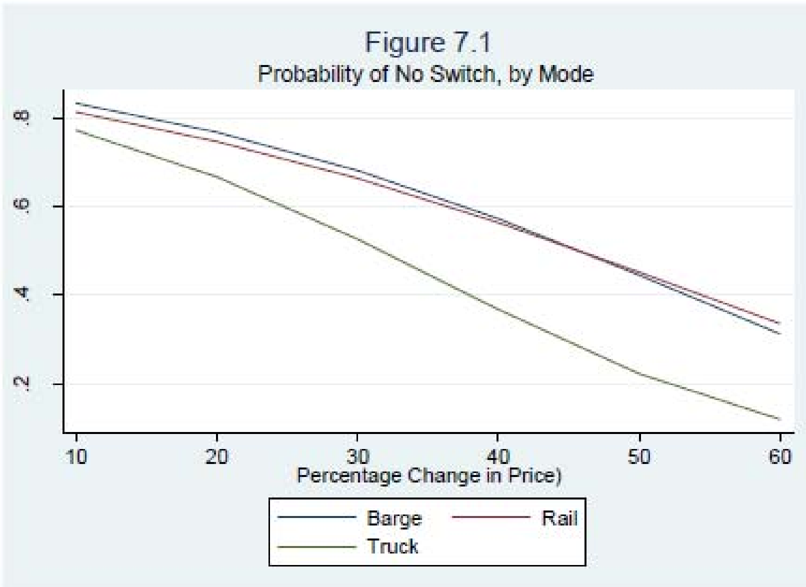


Figure 7.1
Probability of No Switch, by Mode
.2
.4
.6
.8
10
20
30
40
50
60
Percentage Change in Price)
Barge
Rail
Truck

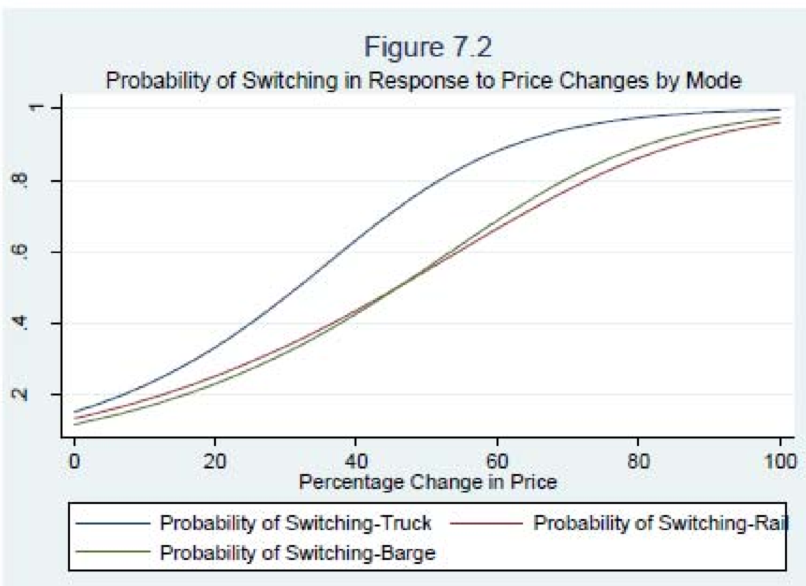


Figure 7.2
Probability of Switching in Response to Price Changes by Mode
.2
.4
.6
.8
1
0
20
40
60
80
100
Percentage Change in Price
Probability of Switching-Truck
Probability of Switching-Rail
Probability of Switching-Barge

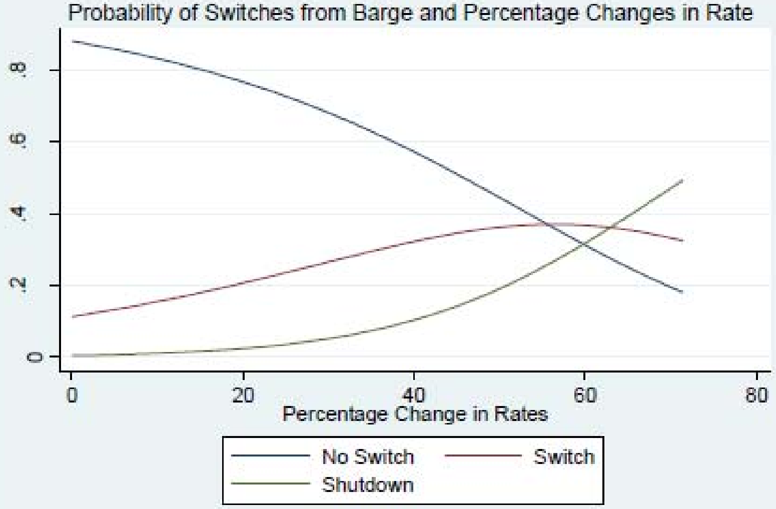
Table 7.2: Probabilities of Switching and Elasticity Estimates by Mode for Various Percentage Changes in Prices.

	Truck		Rail		Barge	
% Change in Price	Probability	Elasticity	Probability	Elasticity	Probability	Elasticity
10	0.2275	2.2749	0.1868	1.8682	0.1672	1.6715
20	0.3336	1.6682	0.2533	1.2667	0.2324	1.1619
30	0.4740	1.5801	0.3366	1.1221	0.3186	1.0619
40	0.6327	1.5818	0.4363	1.0907	0.4274	1.0686
50	0.7770	1.5540	0.5484	1.0967	0.5549	1.1097
60	0.8808	1.4680	0.6646	1.1076	0.6873	1.1455
70	0.9420	1.3457	0.7727	1.1038	0.8045	1.1493
80	0.9734	1.2168	0.8607	1.0759	0.8909	1.1136
90	0.9883	1.0981	0.9226	1.0252	0.9446	1.0496
100	0.9949	0.9949	0.9605	0.9605	0.9737	0.9737

Note: These are estimated values of the probability of a switch, either to another mode, to/from another location, and shutdown. The elasticity is the probability divided by the percent change in price.

Figure 7.3

Probability of Switches from Barge and Percentage Changes in Rate



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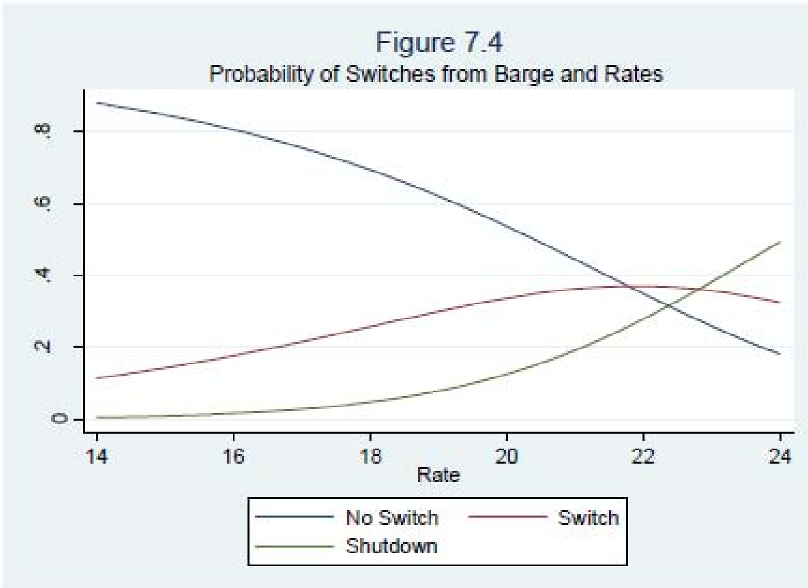
Figure 7.4
Probability of Switches from Barge and Rates
0
.2
.4
.6
.8
14
16
18
20
22
24
Rate
No Switch
Switch
Shutdown

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7.2 REVEALED PREFERENCE CHOICE MODELING

A second approach to estimating the responsiveness of shippers to rates, time in transit and reliability is to use revealed preference data. In this approach, the econometric model is based on the actual decisions made by shippers. In particular, we solicit information on the last shipment made as well as shipments that could have been made in lieu of the choice actually made. The former is the choice *(c)*, and the latter are alternatives. Together, they form the choice set *(C)*.

The empirical model(s) are built of the observe decisions of different shippers. That is, different shippers may use different modes and/or ship between different locations. The actual decision made is taken as the result of an optimizing process. In particular, shippers are assumed to make decisions that maximize payoffs e.g., utility or profit. We do not observe the actual payoffs, but we do observe the discrete choice made e.g., barge to a specific location and the alternatives to the choice e.g., rail to another or the same location. For each alternative in the choice set, there is a payoff, which consists of two components (a deterministic component and a random component), written as $\Pi_c = \pi_c + \varepsilon_c$. For a specific option to be chosen it must dominate other options i.e., let $\delta_c = 1$ if option *c* is chosen, and zero otherwise. Since the payoff has both deterministic and random elements, the actual decision becomes probabilistic. For example, in the case of two options *c* and *c'*, the probability that *c* is chosen is given by:

$$prb(\delta_c = 1) = prb(\Pi_c \geq \Pi_{c'}) = prb(\pi_c + \varepsilon_c \geq \pi_{c'} + \varepsilon_{c'}) = prb(\pi_c - \pi_{c'} \geq \varepsilon_{c'} - \varepsilon)$$

While the payoffs are not observed, the choice is observed (as above) and the deterministic component of payoffs is taken as a set of observables (X_c) e.g., rate, transit times, reliability, etc., with a set of unknown coefficients that are estimated (β). The equation then becomes estimable with a distributional assumption e.g., logistic, normal. In the present case, only logit is considered. In the case of two options, the probability of a given option c is written as:

$$\begin{aligned} prb(\delta_c = 1) = prb(\Pi_c \geq \Pi_{c'}) = prb(\pi_c + \varepsilon_c \geq \pi_{c'} + \varepsilon_{c'}) &= prb(\pi_c - \pi_{c'} \geq \varepsilon_{c'} - \varepsilon) \\ &= prb((X_c - X_{c'})\beta \geq (\varepsilon_{c'} - \varepsilon_{c'}) \\ &= \frac{e^{X_c}}{e^{X_c} + e^{X_{c'}}} \end{aligned}$$

This model is estimated with a logit model for the data described in section 6. Table 7.3 contains the results. In column (1), the model is presented with rates as the only explanatory variable and the estimation is conducted based on the observed data. It is noted that there are precious few observations used i.e., the model requires that a firm has a choice between different options and in the observed data there are only 21 such cases. Nevertheless, in this simple model, the effect of rate is the correct sign and statistically important. We also estimated the model based on the proxy data discussed in Appendix E. These results are presented in column (2). These results are approximately the same magnitude and are statistically important. In this case, there are 46 usable observations used to estimate the model. We also introduced commodity and modal dummies to the model. In no case did the model yield statistically significant effects. As a final model, we estimated a mixed logit. This allows differences in the coefficient to be random (the responses to rate follow a distribution). In this model, a mean and a standard deviation in the distribution of responses to rates is estimated. Neither model pointed to statistically significant effects. Finally, we also incorporated measures of transit time and reliability. Transit times are measured in hours, while reliability is the percentage of time that a shipment is expected to arrive "on-time".[15]

[15] Several models were estimated with variations in commodity, modal, and rates in which one or both hours and reliability measures were introduced. Hours usually comes in with the correct sign, but is not precisely estimated, while reliability is consistently the incorrect sign. It is noted that, respondents queried a lot in the interviews to the

Based on the model in column 2, elasticities are presented in Table 7.4. In this, the calculations are made based on the rates in the data, and rate increases of 10 to 100 percent. These are calculated for each observation and the sample mean is presented for all observations, and then conditioned on barge, rail and truck. Based on the results, there are a number of items to note. First, overall demands tend to be relatively inelastic. Second, the elasticities vary only modestly with the level of the change in rates, regardless of the mode. Third, the elasticities for barge are quite small; this may reflect the fact that barge shippers do so primarily for rate considerations.

In the Table of elasticities, the other option is not fixed. Of interest is the responsiveness of a barge shipper with rail as an option. Indeed, as discussed in Section 6, most barge shippers (if they switch), switch to rail, while most rail shippers (if they switch) switch to truck. Elasticities for a given *barge* shipper with an option of rail has a history of use in Army Planning Models. Therefore, we calculate elasticities for a prototype shipper who has rail as an option at a price of $24 (to be consistent with Section 7.1). Rates are generated for 1000 points, with a minimum value of $5 and a maximium value of $65 per ton. Probabilities were calculated and graphed against rate. Figure 7.5 provides this mapping of the probability of using barge against the barge rate, given that rail is the alternative and rail has a rate of $24 per ton. The associated elasticities are summarized in Figure 7.6. The result is intuitive and as expected. Namely, as barge prices increase, the probability of using barge falls. Further, even at rates greater than the rail rate, the probability of using barge is not zero. This is due to the random nature of the choice model. The error terms contain unobserved factors that influence choices.

transit question (measurement error may have resulted), and most reported very good reliability measures (for all modes) and as a result there is not much variation in the data.

Table 7.3: Logit Model Results		
Variables	Model 1	Model 2
ln(rate)	-2.866	-2.389
	(1.157)	(0.612)
Pseudo R2	0.41	0.42
Ln Likelihood	-9.6204	-19.0889
Likelihood Ratio	12.88	28.02

Table 7.4: Elasticities				
% Rate Change	Overall	barge	rail	truck
10	-0.499	-0.270	-1.070	-0.474
20	-0.503	-0.282	-1.062	-0.465
30	-0.504	-0.291	-1.048	-0.453
40	-0.503	-0.300	-1.029	-0.439
50	-0.500	-0.306	-1.007	-0.423
60	-0.495	-0.311	-0.984	-0.406
70	-0.489	-0.315	-0.959	-0.388
80	-0.482	-0.318	-0.933	-0.371
90	-0.475	-0.319	-0.908	-0.355
100	-0.467	-0.320	-0.882	-0.339

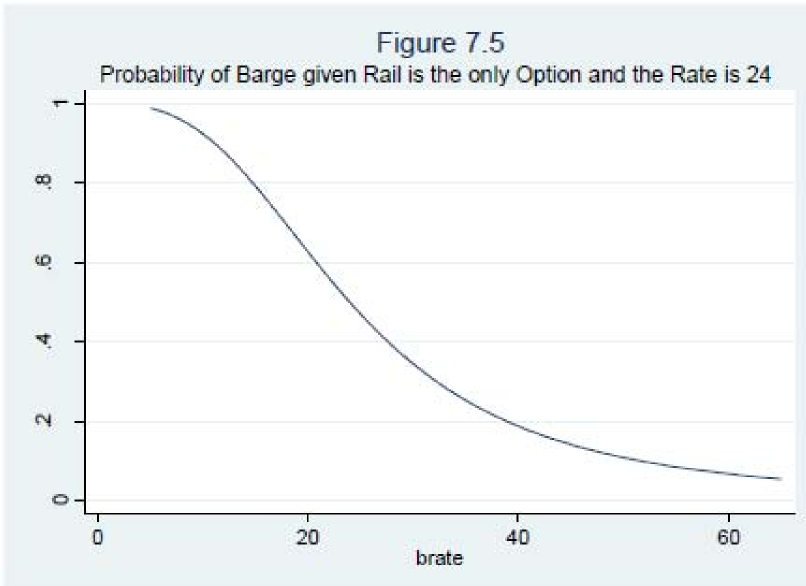
Figure 7.5
Probability of Barge given Rail is the only Option and the Rate is 24
0
.2
.4
.6
.8
1
0
20
40
60
brate

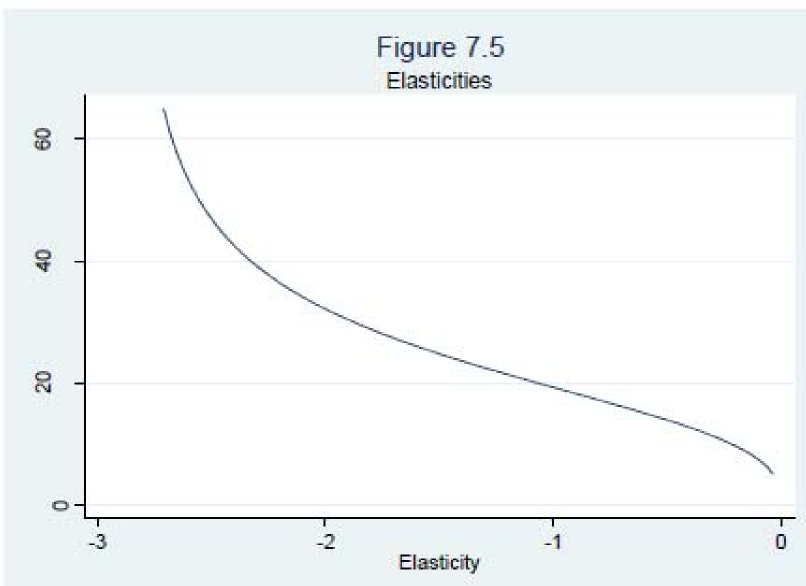
Figure 7.5
Elasticities
0
20
40
60
-3
-2
-1
0
Elasticity

Finally, these same calculations are provided in an accompanying spreadsheet. As with the model in Section 7.1, the numbers in bold need to be entered. This includes the estimated coefficient presented in Table 7.3, the rail rate reference value, and the range of barge rates (this includes the minimum rate titled base rate in the spreadsheet) and the maximum rate (which is used to calculate the rate of change in rates). In the spreadsheet, there are 1000 data points, with 1000 different barge rates and probabilities based on these rates and a *given rail rate of $24 per ton* in this example and a range of barge rates from $5 per ton to $65 per ton.

8. Summary, Conclusions and Suggestions

This study contains an examination of demand for transportation for commodities that travel through the Calcasieu Lock. The Calcasieu Lock is part the GIWW is located in Southern Louisiana and is near the Texas border and the Mermentau river basin. The area is rich in agricultural production of rice and crawfish. Transportation through the lock is important not just to Louisiana but also to the nation. It handles a total of about 35 million tons per year. Petroleum and Chemicals account for substantive portions of the tonnage. Petroleum goods account for about 49 percent of the tonnage, while Chemical goods account for about 28 percent of tonnages.

The study conducted a series of interviews. These interviews point to a variety of factors. The Calcasieu was built for water management, and, in particular to prevent salt water to enter the Mermentau river basin. The barge companies point to a need for tie-offs to aid in navigation. Both shippers and barge companies note the delays in the system and at Calcasieu, with delays that might run up to two days. A second factor suggests that the number of decision-makers i.e., number of shippers is relatively small. Indeed, the interviews point to about ten major integrated firms that handle the bulk of the traffic on the waterway, and for that matter, for rail shipments. A third factor is that making conduct with decision-makers was very difficult, and contact was hampered with Corporate disclosure rules. A fourth factor was that smaller companies typically supported larger firms in the industry, and that the major companies typically setup the transportation.

Analysis of Waterborne Commerce Data and Rail Waybill data points to the origins and terminal locations of flows. In both Petroleum and Chemicals, locations along the Gulf Coast dominate the transport flows, but there are important origins and destinations outside the region and tend to be located near the waterway. For both Petroleum and Chemical products, there are some minor changes over time, but by-and-large, the traffic flows appear to be reasonably stable.

A major part of the study was to conduct a survey. From Dun and Bradstreet, a list of 5250 shippers were provided. From this list, a stratified sample of 2000 shippers were selected, and contacted with a mixed mode survey design. The largest 1000 shippers were directly contacted by telephone, while the remaining 1000 firms were contacted by mail. Most of the shippers contacted were not germane to the survey, and there was a relatively low response rate.

From the survey, a total of 108 survey forms were received. The sample was dominated by petroleum shippers of varying sizes and longevity in the industry. While there were a number of shippers that had access to only one mode, most had access to a variety of modes. Indeed, the most common response was by firms with access to all three of these modes. The shippers provided information on the choice (location of the origin in the case of a receiver and location of the destination in the case of an originator) and the mode used. They also reported optional shipments that could have been made. As is common in surveys of this ilk, there were substantial numbers of shippers that stated they had no options. We also examined the switching of choices. In general, barge shippers tended to switch to rail, rail shippers tended to switch to truck, and truck shippers tended to have no options. The survey also queried shipper responses to hypothetical changes in shipment attributes such as rate, time in transit and reliability. Except for rate, there was only limited switching. For rates, the level of switching to alternative options was limited.

Choice models were estimated using the stated preference data, the revealed choice data and both. Generally, the models yielded evidence that shippers are responsive to changes in rates. In the revealed choice data, there appeared to be limited variability in transit times (given distance) and in reliability. As such, the models did not yield statistically important effects for these variables. Further, in using the stated preference data, the level of switching was relatively small; a finding that suggests shippers are not heavily influenced by transit times and reliability. From the results, elasticities were calculated by mode. The elasticities tended to be relatively inelastic. Together, the results suggest that demands tend to be relatively inelastic. Finally, spreadsheets accompany this report that calculate the probability and elasticities for inputted barge (and rail rates) using the results. These spreadsheets can easily be adapted to consider different levels of responsiveness. As such, it is our recommendation that, if used, sensitivity analysis is used to examine different response parameters.

In these markets, the number of shippers is limited, and they tend to be very large corporations. These firms tend to have strict limits on disclosure. Further, as has become evident through time, transportation and the information necessary to estimate these models is very sensitive to firms and hits directly on their ability to compete. As such, they tend to have serious concerns and issues in releasing information.

In markets with a lot of shippers, the sampling issues can be overcome through larger sample sizes, in markets such as those analyzed in this study points to a need for alternatives. In the present case, the Federal Government collects a voluminous amount of information. The USACE collects the Waterborne Commerce Statistics which contain dock to dock information on waterflows by commodity over time. The STB collects the rail waybill statistics which contain detailed information on the origin and destination by commodity.

These data provide considerable information to model demands for waterway and for that matter rail. There are three shortcomings. First, the waterway data do contain only the origin and destination of the waterway portion of a movement. It does not contain direct information on the origin or the destination of non-waterway portion. Second, the waterway data do not contain information on the rates that apply to the movement. Finally, there are multiple versions of the waybill data. While the data available to USACE to do the analysis have information necessary to construct a measure of rates, a very high proportion of rates move under contract, and as such are commonly masked.

As part of the research conducted in this study, we have overcome much of these deficiencies of the waterway and waybill data, and have found an approach to define origin-destination markets that, conceptually, contain most, if not all, of the traffic that is relevant to a specific location. Our approach uses the waybill and waterway data along with the National Transportation Atlas database along with ArcGIS. We first to define each county along the waterway in which traffic originates as part of a unique market area, and connect the counties across counties for each no waterway traffic originates. We then identify all counties within 100 miles of the waterway (The 100 mile distance is easily changed) and then associate each off-water county to the associated waterway market on the basis of distance to the nearest port. These counties, the waterway county and the off water counties nearest to the waterway county form a market area.

Rates are available in the waybill data (but some are masked), but there are no available rates available for the waterway. Rates or rates proxies can be developed using data such as that provided to use in our study by the Texas Transportation Institute and/or based on the barge costing model. Truck rate proxies can be analogously developed using a truck costing model. Our use of that model and comparisons with survey data suggests that it can be used, with adjustments to capture truck rates.

The data then consist of a set of receiving market areas. A specific market area can receive all or a portion of its needs from an array of supplying market areas. The empirical model treats the receiving area as a representative demander. In previous work, Train and Wilson developed such a procedure to model the decisions of a coal-fired electricity plant on whether to purchase its coal. In that study, the average number of coal sources used was 10 out of a possible of 1000 options available, with a minimum of one and a maximum of 74 different coal sources used. In the present market, a demanding market area has many different options, and typically, the product transported to the destination emanates from only a subset of these origins. The model estimated is similar to that used in the present analysis with the exception that instead of a single choice, a demander can use a multiplicity of options.

The advantages of the approach discussed above are that it rests on data available to USACE, is rigorous and provides demand models that emanate from well defined theory. However, the data steps necessary to conduct the analysis is relatively sophisticated and some of it involves ArcGIS, including the identification of routes for all available options (water and rail) including those not used. Finally, the history of transport demands points to transit times and reliability, which are not generally available in these data. In general, the choice models used in this analysis and previous analyses have a long history in transport demand modeling, and with sufficient data, provide for detailed and rich analyses of demand decisions. It is the accepted approach and allows for very detailed analyses of demand that easily incorporate rates, transit times, reliability and litany of shipper attributes. However, the data necessary to use these data are not generally available and must be collected through survey methods of establishments.

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Appendix A

SURVEY INSTRUMENT

SHIPMENT INFORMATION

Q1. What is the primary commodity you ship? ___________ commodity

Q2. At your location, do you have loading capabilities for…

	YES	NO
a. Trucks...	❑	❑
b. Rail Cars.......................................	❑	❑
c. Barges...	❑	❑

Q2b. If YES to rail loading capability, what is your rail car loading capabilities?

________# of cars

Q2c. If NO to rail loading capability, how close is the nearest rail loading facility to your company?

________ miles

Q2d. If NO to Barge loading capability, how close is the nearest barge loading facility to your company?

________ miles

YOUR LAST FREIGHT SHIPMENT

Q3. What commodity was shipped in your last shipment? __________ commodity

Q4. Where was this commodity shipped to: _______________________ city ____ state

Q5. How large was this shipment (payload weight)?

____________________________ payload weight, in

❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Other (Specify): _______________

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Q6. What type of transportation was used for this shipment, approximately what distance did each travel (in miles), and what was the approximate transportation rate?

Mode (check if used)	Distance traveled	Transportation rate	Per Unit Type for Commodity (CIRCLE) Tons	Cwt.	Gallons	Bushels	Shipment	Other
❑ Truck	_______ miles	_________ rate	❑	❑	❑	❑	❑	❑
❑ Rail	_______ miles	_________ rate	❑	❑	❑	❑	❑	❑
❑ Barge	_______ miles	_________ rate	❑	❑	❑	❑	❑	❑

What were the *total* transport costs? ________ ❑ ❑ ❑ ❑ ❑ ❑

What was the *total* shipment distance in miles? ____________

Q7. What do you estimate was the shipment time (include scheduling time, wait for equipment and transit time)?

____________ days + ____________ hours.

Q8. How reliable is the service? That is, for shipments like this one, what percent of the time do you expect them to arrive on time?

____________ % on-time arrivals.

Q9. What price did you receive for your commodity at the destination terminal?

____________ dollars per

❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ____________

SHIPPING ALTERNATIVES

We want to know what options you could take if the mode and destination you used for your last shipment had not been available and would never be available. For example, if the rail system were shut down, shippers who used rail could truck instead of rail, or could use barge with truck access to a barge loading facility, or could have sent the shipment to a different destination. We need to know what these alternatives are for you. Nearly everyone has some kind of shipping alternative. If not, then the only alternative is to shut down and go out of business. Please provide us with information on these alternatives for you.

Q10. If the mode and destination you used for your last shipment had not been available and would never be available, then you would …

❑ Shut down and go out of business. **Skip to Q25**

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❑ Continue your operations but in a different, perhaps more costly way.

FIRST SHIPPING ALTERNATIVE

Q11. Where you ship to? ____________________ city _____ state

Q11b. What type of destination is this?

❑ River terminal ❑ Railroad terminal ❑ Processing Plant
❑ Other (please specify): ________________________________

Q12. What type of transportation would be used for this shipment, what distance would traveled traveled, and what would be the approximate transportation rate?

Mode (check if used)	Distance traveled	Transportation rate	Per Unit Type for Commodity (circle) Tons	Cwt.	Gallons	Bushels	Shipment	Other
❑ Truck	_______ miles	________ rate	❑	❑	❑	❑	❑	❑
❑ Rail	_______ miles	________ rate	❑	❑	❑	❑	❑	❑
❑ Barge	_______ miles	________ rate	❑	❑	❑	❑	❑	❑

What would be the *total* transport costs? ________ ❑ ❑ ❑ ❑ ❑ ❑

What would be the *total* shipment distance in miles? ____________

Q13. What do you estimate would be the shipment time (include scheduling time, wait for equipment and transit time)?

___________ days + ___________ hours.

Q14. How reliable is the service? That is, for shipments like this one, what percent of the time do you expect them to arrive on time?

___________ % on-time arrivals.

Q15. How large would this shipment be (payload weight) e?

______________________________ payload weight, in

❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Other (Specify): _______________

Q16. What price would you receive for your commodity at the destination terminal?

___________ dollars per

❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ___________

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OTHER SHIPPING ALTERNATIVE

Please complete the table below for your other shipping alternatives. <u>If you have no other alternatives, skip to Q24.</u>

	Second Alternative	Third Alternative
Q17. Where would it be shipped to?	___________ city _____ state	___________ city _____ state
Q18. What type of destination is this?	❑ River terminal ❑ Railroad terminal ❑ Processing Plant ❑ Other (please specify): ____________	❑ River terminal ❑ Railroad terminal ❑ Processing Plant ❑ Other (please specify): ____________
Q19. What type of transportation modes would be used for this shipment?	Mode (check) / Distance traveled / Transportation rate ❑ Truck _______ miles ________ rate ❑ Rail _______ miles ________ rate ❑ Barge _______ miles ________ rate ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ____________	Mode (check) / Distance traveled / Transportation rate ❑ Truck _______ miles ________ rate ❑ Rail _______ miles ________ rate ❑ Barge _______ miles ________ rate ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ____________
Q20. What do you estimate would be the shipment time?	_________ days + _________ hours	_________ days + _________ hours
Q21. How reliable is the service?	______ % on-time arrivals	______ % on-time arrivals
Q22. How large would the shipment be?	_________ payload weight, in ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Other (Specify): ____________	_________ payload weight, in ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Other (Specify): ____________
Q23. What estimated price would you receive for your commodity at the destination terminal?	___________ dollars per ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ___________	___________ dollars per ❑ Tons ❑ Cwt. ❑ Gallons ❑ Bushels ❑ Shipment ❑ Other (specify): ___________

BEST ALTERNATIVE CHOICE

Q24. Of the alternative shipments, if any, what is your "preferred alternative"? That is, if you could make the shipment you made, what shipment would you have made given the way you made your last shipment isn't available?

❑ First Alternative
❑ Second Alternative
❑ Third Alternative
❑ Other Alternative (please specify): ________________________

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TRANSPORTATION RATES

In each of the next three questions relating to rate and service changes, please regard the changes as **permanent** changes. Also, **if you marked no alternative in Q10, please consider "out-of-business" as your alternative.**

Q25. For your last shipment, if the transportation rate increased *Percent change1*%, would you continue with the original mode and destination or switch to your best alternative choice?

- ❑ Continue to use Original mode
- ❑ Switch to Best Alternative Choice **(Skip to Q26)**
- ❑ Go out-of-business **(Skip to Q26)**

Q25b. If you would continue to use your Original mode, what percent increase in transportation rate would be necessary to cause you to switch to the Alternative transportation mode?

_________ % increase

TRANSIT TIME

Q26. For your last shipment, if the transit time (including scheduling and wait for equipment) for the original option increased *Percent change2*%, would you continue with the original mode and destination or switch to the alternative at this location?

- ❑ Continue to use Original mode
- ❑ Switch to Best Alternative Choice **(Skip to Q27)**
- ❑ Go out-of-business **(Skip to Q27)**

Q26b. If you would continue to use your Original mode, what percent increase in the transit time would be necessary to cause you to switch to the Alternative transportation mode?

_________ % increase

RELIABILITY

Q27. For your last shipment, if the reliability (percentage of time shipments arrived on-time) for the original option decreased *Percent change3*%, would you continue with the original mode and destination or switch to the alternative at this location?

- ❑ Continue to use Original mode
- ❑ Switch to Best Alternative Choice **(Skip to Q28)**
- ❑ Go out-of-business **(Skip to Q28)**

Q26b. If you would continue to use your Original mode, what percent decrease in the reliability would be necessary to cause you to switch to the Alternative transportation mode?

_________ % decrease

VOLUME

Q28. If the average transportation rate you pay increased by *Percent change4*%, would your annual volume shipped decrease (assume the rate increase applies to BOTH you and to your competitors)?

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❑ Yes
❑ No (Skip to Q29)
Q28b. If YES, by how much would the volume decrease (assuming the rate increase applies to BOTH you and to your competitors)?
__________ volume decrease

Q29. If the average transportation rate you pay increased by *Percent change5*%, would your annual volume shipped decrease (assume the rate increase applies ONLY to your firm and NOT to your competitors)?

❑ Yes
❑ No (Skip to Q30)
Q28b. If YES, by how much would the volume decrease (assuming the rate increase applies to ONLY your firm and NOT to your competitors)?
__________ volume decrease

Q30. If the average time in transit increased by *Percent change6*%, would your annual volume decrease?

❑ Yes
❑ No (Skip to Q31)
Q30b. If YES, by how much would the volume decrease?
__________ volume decrease

Q31. If the average time in transit increased enough such that shipments arriving on-time decreased by *Percent change7*%, would your annual volume decrease?

❑ Yes
❑ No (Skip to Q32)
Q30b. If YES, by how much would the volume decrease?
__________ volume decrease

SHIPPER CHARACTERISTICS

Q32. How long has your company been engaged in the current shipments?
________ years

Q33. What are the commodities shipped by your company and their annual units shipped? (If more than 5 different commodities are shipped, list the top 5)

Commodity	Amount	Unit
___________	_______	❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Shipment ❑Other (specify): ____________
___________	_______	❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Shipment ❑Other (specify): ____________
___________	_______	❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Shipment ❑Other (specify): ____________
___________	_______	❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Shipment ❑Other (specify): ____________
___________	_______	❑Tons ❑Cwt. ❑Gallons ❑Bushels ❑Shipment ❑Other (specify): ____________

Q34. Does your firm (or parent firm) own export or import facilities?
❑ Yes
❑ No

Q35. How many facilities such as this one does your firm own and/or operate?
__________ number of facilities

Q36. Finally, if we have any questions and wish to follow up, may we contact you?
❑ Yes
❑ No (Skip to Q37)

Q36b. Name: ___________________ Telephone: ___________________
Email: ___________________

Q37. Would you like a copy of the results?
❑ Yes
❑ No (Skip to Q38)

Q37b. Yes, please email the website for the report. Email: _______________
Yes, please send a hard copy to:
Name: ___________________________
Address: ___________________________
City, State Zip: _____________________

Q38. Thank you for you help with this study. We would welcome any additional comments you would like to provide about shipping.

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APPENDIX B

SHIPPER COMMENTS ON SURVEY FORMS

ID Number	Comment
25	The company ships from New Orleans, LA to rigs in the Gulf. Sometimes they barge to Houston and then load on a ship to the rig, 70% of their shipping is from LA by ship to the rig.
26	They procure oil, petroleum and diesel, which they handle the shipping of the product. Trouble finding the right person to talk to though.
27	Rail is their preferred method to ship to the customers. Order of decisions is cost, then speed and finally they calculate the reliability. Didn't want to talk about a specific lane or route, so the location is hypothetically speaking. He gave me a proxy that bulk truck is about $0.05-.06 a lb, box truck is $0.08-.10 and rail is about $0.03 a lb.
49	They send boats out to drills located in the Gulf but other than that they don't engage in shipping.
52	Very informative individual, their company ships but not for hire, they own all the ships and barges. Mentioned that the going rate for a barge was $10,000 a day and $1000 for the tug boat. Mentioned that all vessels have a reporting beacon that is recorded by AIS and we could maybe use that information. Said the main barge companies are Kirby, Florida Marine, Blessey, Canal Barge and CBG. Their main business is to fuel ships on the water as they are shipping.

57	They truck to Houston and then ship by boat to the rigs in the ocean.
70	They ship 1.5 million barrels by barge and 5.5 million barrels by rail. In the next couple of years their barge demand will triple as they are in the process of expanding. They are already using all their barge capacity. They ship 48,000 rail cars annually.
74	Crude is a small portion of their business and it is moved with trucks. The Natural Gas makes up the majority of their business and it is moved via pipeline.
75	They receive large barge shipments of Sulfuric Acid from companies like DuPont, BASF, Martin and Rhodia in the Gulf region. The large chemical companies organize the moves.
89	Spoke with operations, they move the crude between barge, rail and customers but don't handle the logistics of the moves. They dispatch for Shell and Conoco refineries.
100	They move NRLM Diesel from the Baton Rogue Exxon Mobil plant to either Pine Bluff or Little Rock AR. Ships up the Mississippi to the Arkansas River to the terminal locations by barge.
103	They don't ship but they drill for Plains, Shell and Conoco who use pipeline, barge and truck the product.
140	Refused to release details beyond: Use Truck, Rail and Barge to receive products and they ship out by truck and rail but is customer driven as to which mode to ship by.

144	No water routes for their domestic shipments, their rail route takes 3-4 weeks compared to 5 hours by truck.
147	They move barge and truck, but rather not participate.
209	Industrial lock is the only intracoastal way to ship and the ACE closed it off to their access. Now they use sea going barges and ship around to Houston from New Orleans.
211	A while back they used to fill tanks off the intracoastal, but now they don't store anything, just run 18-wheelers.
226	They move rail and truck shipments daily and prefer to use rail. A lot of the time rail is more expensive but the work in loading more trucks makes rail more appealing.
256	They use barge, rail and truck but own the all the equipment and move the entire product for themselves. So rate fluctuations and time in transit is on their crews and not an outside company.
257	They used to ship years ago on the intracoastal but dues to delays they have switched to ocean going barges. In the long run the switch has saved them money.
276	They are a barge moving service for Placid, Pure, Chevron and Shell when dealing with Chemicals and Petroleum.
285	Mentioned that the large companies like Murphy, Marathon and Conoco were the companies to contact.

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320	Mentioned that the large companies like Murphy, Marathon and Conoco were the companies to contact.
328	Mentioned that the large companies like Shell, Exxon, and Valero were the companies to contact.
350	The oil is on site and they don't ship anything, all the products are picked up from that location.
358	They are a trucking firm that picks up Chevron oil at the terminal locations. The ACE was a touchy subject, as it seems a dam in their area has caused the river to be in bad shape.
365	Have 2 domestic mills that ship by barge to him or oversea shipments will come into New Orleans then be loaded onto a barge to be shipped to them. But all the shipping is done through a broker.
378	They have situated themselves to receive Ocean liners through the Port of St. Charles and all the way up the channel to be offloaded at their port. Years ago they used barges to transport incoming material from another port but don't plan on doing that any time soon.
385	They use brokers to make all their shipping decisions, Trans Place or C.H. Robinson.
411	They are a trucking firm for Murphy and Chevron Oil. Gave 2 contacts for the people at the terminal locations that they load the product from.
	They are an oil transporter that owes large oil tanker ships.

453 They have the capacity to ship 100 trucks a day, 3 trains with 30/40 cars through UP and 3 barges a day. They co-own the barges so they only pay for the tugboat.

461 They receive barges from Holland a couple of times a year, then mix it to form their product that is only trucked domestically.

469 Demand is slow for the last couple of years and they have almost no shipments right now.

480 They have tanker trucks supply their storage tanks, and then load up pedal trucks to transport out. They haven't done rail in a very long time.

483 They ship 3 million gallons annually and that is a barge every 8 days. If barge weren't available it would triple their cost. They aren't fully satisfied with the intracoastal and have waited up to 35 hours on occasion to push through locks.

492 They import by ocean ship and outgoing domestic shipments went on trucks and barges.

497 There are 60 different products in their storage tanks. Some are 1000-gallon tanks and others are 40000 gallon and dependent on the products tank size determined the modal option.

519 Transport a lot from overseas and then their freight forwarder handles the domestic transport to their facility. Over the last few years rail has really gone up (CSX).

542 In the future they plan on getting a rail spur but currently everything is shipped by truck.

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568	They receive by barge and rail; barge is the more reliable of the two. In the past 5 years barge cost has increased by 20% and rail reliability is too spotty.
584	They use rail, truck and barge but Star Brite organizes everything they ship.
591	Receive by rail, truck and barge; outgoing barge and truck.
605	They are a 3rd party shipper; shipping for customers who have already made the decision to ship and they organize it.
612	Use rail, truck and barge; business is down and 2008 was the last barge move.
636	Receive via rail and ship dry van. The rate difference between rail and truck is less than 20%.
666	They use Ocean ship to receive and ship and some quick "Hot Shot" truck moves. If domestic moves aren't appealing they ship by ocean ship to Brazil.
693	They were engaged in barge moves but 09 and 10 the economy has shut them down and they are idling currently.
716	90% truck and use freight forwarder for their rail or barge moves. (lotrading.com)
755	They are a middleman shipper for Shell or Marathon. They ship to the barges and rail terminals and offload onto a Kirby barge usually.
784	Receive by Ocean ship and sometimes barge and truck involved in getting it to their facility that is organized by a broker. They only organize the trucking of their product outgoing.

788	Demand is down and they don't use rail anymore due to the downturn.
790	They are familiar with all modes; rail, truck and barge. They move 15-40,000 barrels a month. They operate a recycling vessel system where they own the barges and tugs that move up and down the GIWW collecting recyclable oil products.
811	Mentioned that the price of a ocean ship is $20,000 a day and they move them to Brazil every 3 weeks. They have a rail capacity of 54,000 tons a month and normally move 24 cars with 90 tons each every 4 days. If they export the product then they ship their entire product through Houston.
821	They receive by rail car from Chevron, Dow, and Westlake who organize all the routing and build the transportation cost into the product cost. They then package the products into a container and export the products on ocean ships.
822	They receive 2 rail cars a week and 5 tanker trucks a week. Annually they ship 20 million lbs of the refined raw materials they receive from companies that organize the moves for them.
855	They are a broker firm for their customers, taking the desired modes and find the best price and time for moving the products. They don't make the decisions for which mode to use, they just offer the different choices. Confidential.

APPENDIX C

CONSTRUCTION OF RATE PROXIES

Most interviewed shippers were willing to describe a representative shipment's distance, payload, origin, destination, mode(s) and product. Of those shippers fewer were willing to share rate information for the different modes used in transport. The missing rates were proxy for using three external sources: (1) The Surface Transportation Board (STB) 2008 Masked Waybill Record, (2) The Texas Transportation Institute Waterborne Rate Sheets and (3) The Upper Great Plains Transportation Institute Truck Model.

The STB provided access to the masked 2008 Waybill records to create a proxy for the railroad rates of the representative movements. The revenue variable was divided by tons to form revenue per ton and then the natural log was taking of the value. The distance variable, miles, was also converted into natural log and two dummy variables were created for chemical and petroleum movements. The results are summarized below, the proxy rates are constructed using the exponential of the predicted values from this regression and the survey observations on shipment distances and commodity.

Variable	Coefficient Estimates	Standard Errors	t-ratio
Ln(distance)	0.4949	0.0010	492.2800
Petroleum Dummy	-0.2001	0.0105	-19.0300
Chemicals Dummy	-0.1890	0.0046	-41.0600
Intercept	0.4791	0.0069	69.7000
N=621274			
R2=28.87			

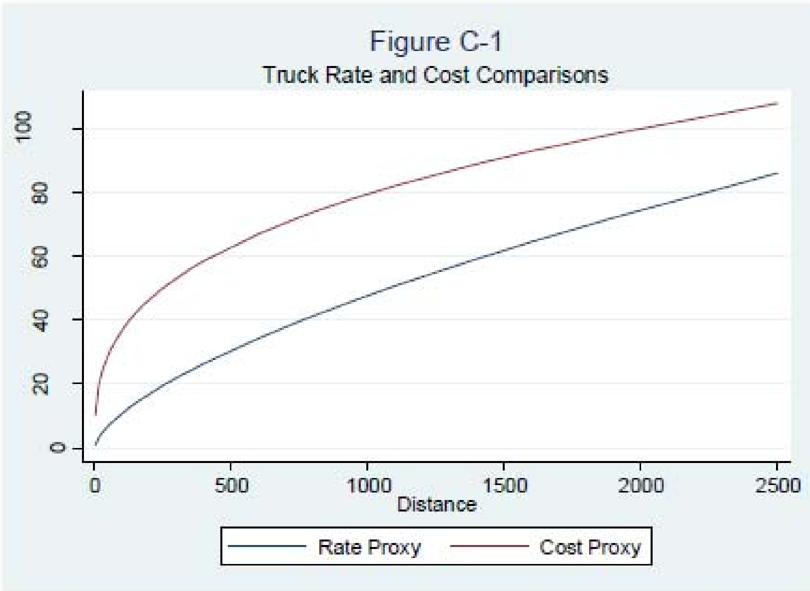
The Texas Transportation Institute supplied us with barge rate sheets for 150 barge shipments they gathered. The rate and distance variables were converted to natural log form and dummy variables were created for other, chemical and petroleum was the base. The survey data miles and commodity information was used to create a proxy for the rate of the shipment. The number of observations was 150 and the r-squared was .7970.

Variable	Coefficient	Standard Error	t-ratio
Ln(distance)	0.8878	0.0505	17.5900
Other Dummy	-0.7772	0.0798	-9.7400
Chemicals Dummy	0.3935	0.0766	5.1400
Intercept	-2.4880	0.3096	-8.0400
N=159			
R2=79.28			

The Great Plains Transportation Institute has a truck cost model program that provides estimates of truck costs. We used this model to generate cost information based on shipment characteristics. There were 22 observations in the survey that used truck as a mode and provided shipment characteristics allowing these cost estimates. The survey itself yielded 12 observations and 10 missing rates so as a check two regressions were ran. First regression was run on the 22 observations that the truck model generated and it had an R-Square of 58.34. The second regression took the 12 observations from the survey that provided rates, and ran the same regression, yielding an R-Square of 38.43. The results are given below:

Cost Model	Coefficient Estimates	Standard Errors	t-ratio
Ln(distance)	0.6440	0.1217	5.2900
Intercept	-0.5818	0.7167	-0.8100
N=22			
R2=58.34			
Rate Model			
Ln(distance)	0.6440	0.1217	5.2900
Intercept	-0.5818	0.7167	-0.8100
N=12			
R2=38.43			

As a check, we graphed the rate and the cost proxies against distance. The two, by construction, correlate well and compare favorably.



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Appendix D

Solicitation Letters

Two different letters follow. Each was individually addressed, but contained the same script and OMB paragraph.

Transportation Information Services
P.O. Box 1111 • Marcola, OR 97454-1111
TransportationInfo@gmail.com • (502) 645-4588

Company Name
Logistics/Shipping Manager
Address

To whom it may concern:

Efficient transportation is central to businesses in order to be competitive. We are conducting a survey on behalf of the Army Corps of Engineers to examine the choices that shippers make, the options they have, and the sensitivity of the choices they make to changes in rates, transit times etc. This information is central to evaluating the efficiency of transportation infrastructure and investment needs.

We invite you to participate in this regional survey of transportation needs. Your participation and identity will be held in the strictest confidence. For our record keeping, we have assigned your survey an ID number. This ID number is **XXX,** and it used only for our records. If you have multiple locations you ship or receive from, then please fill out the first location with the provided ID number and fill out any other locations using 1, 2, 3, 4,..., 10 (up to 10) as the corresponding ID numbers. Please log on to the survey at **www.TransportationInfo.us.** If you prefer to complete the questionnaire by hand rather
than on-line, there exists a downloadable version and return address at the website listed above.

We would be happy to answer any questions that you might have about this study or yourparticipation. Please contact Wesley W. Wilson at (541) 346-4690, Mark Campbell at (502) 645-4588, or Daniel Whalen at the Army Corps of Engineers, New Orleans District at (504) 862-2852. You can also contact us by email at TransportationInfo@gmail.com if you prefer.

According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it has a valid Office of Management and Budget (OMB) control number. The valid OMB number for this information collection is OMB 0710-0001. The time required to complete this information is estimated to average 10-15 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Your participation is voluntary and all responses will be kept confidential. Send comments regarding this burden estimate or any other aspect of this data collection, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Executive Services Directorate, Information Management Division, and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503, Attn.: Desk Officer for U.S. Army Corps of Engineers. Respondents should be aware that notwithstanding any other provision of law, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Please DO NOT RETURN your completed form to either of these offices.

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Transportation Information Services
P.O. Box 1111 • Marcola, OR 97454-1111
TransportationInfo@gmail.com • (502) 645-4588

«company» ID:«contactid»
Attention: Logistics/Shipping/Transportation Manager
«mailcity», «mailstate»» «mailzip»

To whom it may concern:

About three weeks ago, we wrote to you about the 2010 Transportation Needs Survey. As of today, we have not received your completed questionnaire. Your input is important to the study, and we would appreciate hearing from you. The purpose of the survey is provide information to plan investments in transportation facilities in the South.

The survey asks questions related to your business, the decisions you make and the options you have. Your input is important to represent the operations, needs and opinions of all shippers in the region inclusive of barge, rail and truck shipments to or from barge or rail facilities. We are writing to you again because your questionnaire(s) is important to study and is central to the mission of the Army Corps and others in planning transportation investments.

Your participation and identity will be held in the strictest confidence. For our record keeping, we have assigned your survey an ID number. This ID number is **«contactid»**, and it used only for our records. If you have multiple locations, we invite multiple responses. To do so, use the given ID number for the first, and from there on use the numbers 1, 2,.....

Please log on to the survey at **www.TransportationInfo.us**. If you prefer to complete the questionnaire by hand rather than on-line , there exists a downloadable version and return address at the website listed above or you can call the phone number given and we will take the information over the phone. All of the information you provide will be kept strictly confidential.

We are happy to answer any questions that you might have about this study or your participation. Please contact Wesley W. Wilson at (541) 346-4690, Mark Campbell at (502) 645-4588, or Daniel Whalen at the Army Corps of Engineers, New Orleans District at (504) 862-2852. You can also contact us by email at transportationinfo@gmail.com if you prefer.

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APPENDIX E

Stated Preference Models of Transit Times, Reliability, and Annual Volumes

In this appendix, we report the results of stated preference models pertaining to:

1. Do increases in transit times affect location/mode choice (Table E.1)
2. Do decreases in reliability affect location/mode choice (Table E.2)
3. Do increases in the market rate affect annual volumes (Table E.3)
4. Do increases in the shippers own rate affect annual volumes (Table E.4)
5. Do increases in transit times affect annual volumes (Table E.5)
6. Do decreases in reliability affect annual volumes (Table E.6)

Items 1 and 2 are setup and estimated using the same procedures as for rates reported in Section 7.1. In this, the base is do not switch from the revealed choice, switch means that the prompt (a percentage increase in transit times and a percentage decrease in reliability) causes the shipper to switch to another location and/or mode, while shutdown means that the prompt causes the shipper to shutdown. In the models, estimated for transit times, this effect is not observed except in the simplest model. For reliability, there is evidence that changes in reliability affect location/mode choices.

Items 3, 4, 5, and 6 are the yes/no responses to the whether the prompts affect volumes. A yes is coded as a 1 and a no as a 0. Logit models are run on the size of the prompt, modal and commodity dummies, with barge and petroleum as the base dummies. While in some of the models estimated, the dummies may or may not be statistically important, but in none of the models estimated does the size of the prompt matter.

Table E.1: Stated Preference Results – Transit Times

	(1)	(2)	(3)	(4)	(5)
VARIABLES			r		spr
Switch-Intercept		-2.705**	-2.525*	-2.607*	-2.524
		(1.332)	(1.378)	(1.433)	(1.538)
Switch % Change in Time	-0.0370***	0.0247	0.0241	0.0258	0.0278
	(0.0100)	(0.0300)	(0.0308)	(0.0325)	(0.0337)
Switch-Truck			0.144		0.783
			(1.334)		(1.392)
Switch-Rail			-0.396		-0.490
			(0.890)		(0.901)
Shutdown-Intercept		-1.946**	-1.650*	-2.096**	-1.702*
		(0.972)	(0.990)	(0.992)	(1.033)
					-
Shutdown % Change in Time	-0.0464***	-0	0.00111	-0.00972	0.00840
	(0.0101)	(0.0239)	(0.0234)	(0.0243)	(0.0249)
Shutdown-Intercept			-0.00189		-0.567
			(0.917)		(1.048)
Shutdown-Rail			-1.437		-1.299
			(1.135)		(1.169)
Switch-Chemicals				-16.37	-15.21
				(4,968)	(2,099)
Switch-Other Commodities				-16.54	-15.41
				(4,581)	(1,999)
Shutdown-Chemicals				2.019**	1.994**
				(0.930)	(1.003)
Shutdown-Other Commodities				0.818	0.704
				(1.215)	(1.248)
Observations	193	193	193	193	193
Log-Likelihood	-48.65	-44.15	-42.96	-40.61	-39.45

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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Table E.2: Stated Preference Results – Reliability

VARIABLES	(1) spr	(2) spr	(3) spr	(4) spr	(5) spr
Switch-Intercept		-2.699***	-2.589***	-2.781***	-2.683***
		(0.841)	(0.924)	(0.877)	(0.947)
Switch % Change in Rel.	-0.0150*	0.0450**	0.0471**	0.0456**	0.0487**
	(0.00820)	(0.0193)	(0.0203)	(0.0196)	(0.0205)
Switch-Truck			-0.0901		-0.334
			(1.272)		(1.364)
Switch-Rail			-0.366		-0.373
			(0.761)		(0.774)
Shutdown-Intercept		-3.980***	-3.548***	-4.464***	-4.674***
		(1.278)	(1.297)	(1.409)	(1.660)
Shutdown % Change in Rel	-0.0502***	0.0444	0.0499*	0.0474*	0.0641*
	(0.0129)	(0.0277)	(0.0288)	(0.0286)	(0.0330)
Shutdown-Intercept			-15.29		-17.39
			(1,455)		(2,089)
Shutdown-Rail			-1.335		-1.205
			(1.207)		(1.255)
Switch-Chemicals				0.142	0.386
				(1.303)	(1.378)
Switch-Other Commodities				0.543	0.667
				(1.273)	(1.369)
Shutdown-Chemicals				1.311	2.052
				(1.314)	(1.537)
Shutdown-Other Commodities				1.379	2.487
				(1.338)	(1.574)
Observations	189	189	189	189	189
Log-Likelihood	-55.03	-40.84	-38.98	-40.00	-37.26

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table E.3: Logit of whether Changes in Industry Rate Affect Annual Volumes

Variables	(1)	(2)	(3)	(4)
Percentage Change in Industry Rate	0.0141	0.0237	0.0130	0.0191
	(0.0139)	(0.0156)	(0.0144)	(0.0161)
Rail		-0.588		-0.614
		(0.593)		(0.598)
Truck		1.615**		2.107**
		(0.714)		(0.891)
Chemicals			0.904	0.0594
			(0.787)	(0.909)
Other Commodities			-0.603	-1.826
			(0.883)	(1.132)
Constant	-0.790	-1.260*	-0.795	-1.005
	(0.534)	(0.659)	(0.591)	(0.701)
Observations	71	71	71	71
Log-likelihood	-47.84	-43.00	-46.77	-41.28

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table E.4: Logit Model of whether Changes in Own Rates Affect Annual Volumes.

Variables	(1)	(2)	(3)	(4)
Percentage Change in Own Rate	-0.00487	6.47e-05	-0.00548	-0.00399
	(0.0152)	(0.0164)	(0.0155)	(0.0173)
Rail		-0.547		-0.693
		(0.581)		(0.598)
Truck		1.507**		2.261**
		(0.751)		(0.960)
Chemicals			-0.461	-1.813*
			(0.787)	(1.082)
Other Commodities			0.0307	-1.127
			(0.771)	(1.013)
Constant	0.0496	-0.210	0.120	0.178
	(0.575)	(0.636)	(0.623)	(0.697)
Observations	68	68	68	68
Log-Likelihood	-46.96	-42.89	-46.78	-40.95

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table E.5: Logit Model of whether Changes in Transit Times Affect Annual Volumes

Variables	(1)	(2)	(3)	(4)
Percentage Change in Transit Times	-0.00758	0.00261	-0.00245	0.00552
	(0.0169)	(0.0193)	(0.0180)	(0.0207)
Rail		-1.825		-1.846
		(1.146)		(1.152)
Truck		1.376*		1.309*
		(0.707)		(0.749)
Chemicals			1.062	0.368
			(0.858)	(0.977)
Other Commodities			0.699	-0.0815
			(0.914)	(1.021)
Constant	-1.110*	-1.464**	-1.521**	-1.582*
	(0.637)	(0.734)	(0.740)	(0.809)
Observations	69	69	69	69
Log-Likelihood	-34.70	-28.91	-33.80	-28.82

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table E.8 Logit Model of whether Changes in Reliability Affects Annual Volumes

Variables	(1)	(2)	(3)	(4)
Percentage Change in Reliability	0.00778	0.00267	0.00754	0.00184
	(0.0188)	(0.0216)	(0.0191)	(0.0222)
Rail		-1.260		-1.118
		(1.155)		(1.170)
Truck		2.497***		2.279***
		(0.774)		(0.796)
Chemicals			1.945**	1.158
			(0.819)	(0.986)
Other Commodities			1.611*	0.961
			(0.868)	(1.031)
Constant	-1.651**	-2.003**	-2.181***	-2.249**
	(0.716)	(0.927)	(0.773)	(0.975)
	70	70	70	70
	-34.94	-25.24	-31.21	-24.33

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Calcasieu Lock
Louisiana Feasibility Study

APPENDIX K

ATTACHMENT 4

Maintenance, Construction, and Unscheduled Event Input

May 2013

Prepared by:

Navigation Planning Center,
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Prepared for:

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1E.1 INTRODUCTION

Life-cycle maintenance assumptions, and in particular the lock service disruptions they can create, are often critical in the analysis of lock investment decisions. Not only are scheduled maintenance needs applicable, but also service disruption risk from unscheduled repairs.

In the case of the Calcasieu Lock study, while requiring regular maintenance, the lock's structural, electrical, and mechanical systems have either been determined reliable, or to have insignificant consequence to navigation service if a failure is experienced. In short, unscheduled failures and repairs are not expected and not included in this Calcasieu Lock analysis. In the gulf region, however, hurricane events can impact Calcasieu Lock performance. As a result, unscheduled lock closure resulting from hurricane events have been included in this analysis.

This attachment discusses the organization and input of the scheduled maintenance and unscheduled service disruption data into the Gulf Intracoastal Waterway (GIWW) Navigation Investment Model (NIM).

1E.2 WITHOUT-PROJECT SCHEDULED MAINTENANCE

The Calcasieu Lock existing / without-project scheduled maintenance was received in workbook "*Calcasieu Cost and Closure Matrix Final.xlsm*" and transformed into **TABLE 1E.1** through **TABLE 1E.4**. The scheduled maintenance data included the following maintenance cost categories, maintenance work items, and lock service disruption type (which will be defined in section 1E.2.2):

- No Impact to Navigation Work Items
    - Security Maintenance
    - ED Instrumentation
    - Routine Maintenance
    - Periodic Inspection
    - A/E Instrumentation (Pre-PI)
- Annual Fair Wear and Tear / Reimbursable Repairs (13-day 12/12 disruption)

- Minor Closures
    - SE Guide Wall Face (7-day 12/12 disruption)
    - SW Guide Wall Face (5-day 12/12 disruption)
    - NW Guide Wall Face (7-day 12/12 disruption)
    - NE Guide Wall Face (5-day 12/12 disruption)
    - W Chamber Wall Rehabilitation (69-day 12/12 & 9-day 12/12 disruption)
    - E Chamber Wall Rehabilitation (69-day 12/12 & 9-day 12/12 disruption)
- Major Closures
    - SW Guide Wall and Dolphin Rehab (69-day 12/12 disruption)
    - SE Guide Wall and Dolphin Rehab (61-day 12/12 disruption)
    - NE Guide Wall and Dolphin Rehab (69-day 12/12 disruption)
    - NW Guide Wall and Dolphin Rehab (61-day 12/12 disruption)
    - Dewatering & Monitoring / Major Gate Repair (18-day 24 12/12 disruption)
- Hurricane (10-day 24 disruption)

TABLE 1E.1 – Without-Project, No Impact to Navigation Work Items

Summarized from "*Calcasieu Cost and Closure Matrix Final.xlsm*"

Period		No Impact to Nav Work Items														
		Security Maintenance			ED Instrumentation			Routine Maintenance			Periodic Inspection			A/E Instrumentation (Pre-PI)		
	From		Closure			Closure			Closure			Closure			Closure	
Year	2010	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days
2012	2	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2013	3	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2014	4	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2015	5	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2016	6	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2017	7	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2018	8	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2019	9	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2020	10	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2021	11	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2022	12	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2023	13	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2024	14	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2025	15	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2026	16	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2027	17	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2028	18	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2029	19	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2030	20	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2031	21	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2032	22	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2033	23	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2034	24	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2035	25	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2036	26	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2037	27	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2038	28	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2039	29	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2040	30	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2041	31	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2042	32	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2043	33	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2044	34	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2045	35	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2046	36	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2047	37	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2048	38	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2049	39	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2050	40	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2051	41	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2052	42	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2053	43	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2054	44	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2055	45	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2056	46	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na
2057	47	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na	$ 55,000	-	na		-	na
2058	48	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2059	49	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2060	50	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na		-	na
2061	51	$ 30,000	-	na	$ 20,000	-	na	$ 250,000	-	na		-	na	$ 25,000	-	na

TABLE 1E.2 – Without-Project, Annual Fair Wear and Tear Reimbursable Repairs

Summarized from “*Calcasieu Cost and Closure Matrix Final.xlsm*”

Period		Annual Fair Wear and Tear Reimbursable Repairs		
			Closure	
Year	From 2010	Cost	Hrs	Days
2012	2	$ 675,000	150	13
2013	3	$ 675,000	150	13
2014	4	$ 675,000	150	13
2015	5	$ 675,000	150	13
2016	6	$ 675,000	150	13
2017	7	$ 675,000	150	13
2018	8	$ 675,000	150	13
2019	9	$ 675,000	150	13
2020	10	$ 675,000	150	13
2021	11	$ 675,000	150	13
2022	12	$ 675,000	150	13
2023	13	$ 675,000	150	13
2024	14	$ 675,000	150	13
2025	15	$ 675,000	150	13
2026	16	$ 675,000	150	13
2027	17	$ 675,000	150	13
2028	18	$ 675,000	150	13
2029	19	$ 675,000	150	13
2030	20	$ 675,000	150	13
2031	21	$ 675,000	150	13
2032	22	$ 675,000	150	13
2033	23	$ 675,000	150	13
2034	24	$ 675,000	150	13
2035	25	$ 675,000	150	13
2036	26	$ 675,000	150	13
2037	27	$ 675,000	150	13
2038	28	$ 675,000	150	13
2039	29	$ 675,000	150	13
2040	30	$ 675,000	150	13
2041	31	$ 675,000	150	13
2042	32	$ 675,000	150	13
2043	33	$ 675,000	150	13
2044	34	$ 675,000	150	13
2045	35	$ 675,000	150	13
2046	36	$ 675,000	150	13
2047	37	$ 675,000	150	13
2048	38	$ 675,000	150	13
2049	39	$ 675,000	150	13
2050	40	$ 675,000	150	13
2051	41	$ 675,000	150	13
2052	42	$ 675,000	150	13
2053	43	$ 675,000	150	13
2054	44	$ 675,000	150	13
2055	45	$ 675,000	150	13
2056	46	$ 675,000	150	13
2057	47	$ 675,000	150	13
2058	48	$ 675,000	150	13
2059	49	$ 675,000	150	13
2060	50	$ 675,000	150	13
2061	51	$ 675,000	150	13

TABLE 1E.3 – Without-Project, Minor Closures

Summarized from “Calcasieu Cost and Closure Matrix Final.xlsm”

Period		Minor Closures																	
		SE Guidewall Face Timber Rehab			SW Guidewall Face Timber Rehab			NW Guidewall Face Timber Rehab			W Chamber Wall Rehab			NE Guidewall Face Timber Rehab			E Chamber Wall Rehab		
	From		Closure			Closure			Closure			Closure			Closure			Closure	
Year	2010	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days
2012	2																		
2013	3																		
2014	4																		
2015	5																		
2016	6																		
2017	7																		
2018	8																		
2019	9																		
2020	10																		
2021	11	$ 300,000	75	7															
2022	12																		
2023	13				$ 150,000	50	5												
2024	14																		
2025	15							$ 300,000	75	7									
2026	16										$ 5,000,000	825	69						
2027	17																		
2028	18																		
2029	19													$ 150,000	50	5			
2030	20																		
2031	21																$ 5,000,000	825	69
2032	22																		
2033	23	$ 300,000	75	7															
2034	24																		
2035	25				$ 150,000	50	5												
2036	26																		
2037	27							$ 300,000	75	7									
2038	28										$ 600,000	100	9						
2039	29																		
2040	30																		
2041	31																		
2042	32													$ 150,000	50	5			
2043	33																$ 600,000	100	9
2044	34																		
2045	35	$ 300,000	75	7															
2046	36																		
2047	37				$ 150,000	50	5												
2048	38																		
2049	39							$ 300,000	75	7									
2050	40										$ 600,000	100	9						
2051	41																		
2052	42																		
2053	43																		
2054	44													$ 150,000	50	5			
2055	45																$ 600,000	100	9
2056	46																		
2057	47																		
2058	48	$ 300,000	75	7															
2059	49				$ 150,000	50	5												
2060	50																		
2061	51							$ 300,000	75	7									

TABLE 1E.4 – Without-Project, Major Closures

Summarized from "*Calcasieu Cost and Closure Matrix Final.xlsm*"

Period		Major Closures ... less hurricane event														
		SW Guidewall and Dolphin Rehab			SE Guidewall and Dolphin Rehab			NE Guidewall and Dolphin Rehab			NW Guidewall and Dolphin Rehab			Dewatering & Monitoring / Major Repair		
	From		Closure			Closure			Closure			Closure			Closure	
Year	2010	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days	Cost	Hrs	Days
2012	2															
2013	3	$ 6,000,000	825	69												
2014	4				$ 4,000,000	725	61									
2015	5															
2016	6													$ 1,000,000	500	18
2017	7							$ 6,000,000	825	69						
2018	8															
2019	9															
2020	10															
2021	11															
2022	12															
2023	13															
2024	14															
2025	15													$ 1,000,000	500	18
2026	16													$ 1,000,000	500	18
2027	17															
2028	18															
2029	19															
2030	20															
2031	21															
2032	22															
2033	23															
2034	24															
2035	25													$ 1,000,000	500	18
2036	26													$ 1,000,000	500	18
2037	27															
2038	28															
2039	29															
2040	30															
2041	31															
2042	32															
2043	33															
2044	34															
2045	35										$ 4,000,000	725	61	$ 1,000,000	500	18
2046	36				$ 4,000,000	725	61							$ 1,000,000	500	18
2047	37															
2048	38	$ 6,000,000	825	69												
2049	39															
2050	40															
2051	41															
2052	42							$ 6,000,000	825	69						
2053	43															
2054	44															
2055	45													$ 1,000,000	500	18
2056	46													$ 1,000,000	500	18
2057	47															
2058	48															
2059	49															
2060	50															
2061	51															

1E.2.1 Fixed Versus Cyclical Maintenance

Three of the five maintenance actions listed under the "*No impact to navigation work items*" were constant through the analysis period. These cost items were loaded, and handled by the model, slightly different than the cyclical maintenance as will be discussed in section 1E.4.2. The remaining two maintenance actions listed under the "*No impact to navigation work items*", while having no navigation impact, were loaded into the model similarly to the other cyclical maintenance work items containing navigation impacts.

Of the seventeen items in the engineering Calcasieu cost and closure matrix, fifteen generate navigation impacts. A tonnage-transit curve has been developed for each of these service disruption descriptions as discussed in the capacity analysis documentation and summarized below.

1E.2.2 Lock Service Disruption

The thirteen items with navigation impacts were defined with nine different service disruption definitions. One item was a hurricane event, and the other twelve items were for maintenance work items.

1E.2.2.1 Hurricane Event, the 10-Day 24 Event

The engineering cost-closure workbook contained a hurricane event every five years. This probabilistic 10-day 24 event is defined in the engineering maintenance matrix as the 156-hour hurricane disruption event reflecting storms of 5-year intensity or higher (top of lock is at a 5-year level of protection). Per USN Hurricane Havens Handbook for Houston/Galveston (closest listed port to Lake Charles), there were 92 systems of tropical storm strength or higher in the 111-year period 1886 to 1996. Of these, 33 were hurricane-strength with 29 of 92 tropical storms occurring in September. For hurricane-strength storms, however, 11 of 33 occurred in August, and as such August was identified as the most likely month for a hurricane-related drainage events. Post-1996 data has not been added to the online Handbook.

Lock will be closed 3 days from the time lock operators evacuate until they return, for actual storm duration and aftermath. Next 7 days all 4 gates will be open to drain floodwaters, and flow rate will exceed safety limits for navigation. After 7 days of drainage, normal lockage will resume. During 7-day drainage period, repairs to flooded electrical and hydraulic components will also occur.

1E.2.2.2 Work Item Service Disruptions

The other twelve items creating lock service disruption were for maintenance work items which were defined with eight service disruption definitions described in the following sections.

1E.2.2.2.1 69-Day 12/12 Event

The 69-day 12/12 event is defined in the engineering maintenance matrix as the 828-hour event reflecting 69-days of 12 hours open and 12 hours closed per day. Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption was assumed for the west chamber wall rehabilitation, east chamber wall rehabilitation, south-west guide wall / dolphin rehabilitation, and north-east guidewall / dolphin rehabilitation.

1E.2.2.2.2 61-Day 12/12 Event

The 61-day 12/12 event is defined in the engineering maintenance matrix as the 732-hour event reflecting 61-days of 12 hours open and 12 hours closed per day. Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption was assumed for the south-east guide wall / dolphin rehabilitation, and north-west guide wall / dolphin rehabilitation.

1E.2.2.2.3 18-Day 24 12/12 Event

The 18-day 24 12/12 event is defined in the engineering maintenance matrix as the 252-hour event reflecting two cycles of 3-days of 24-hour closures to set cofferdam and dewater with 15-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption was assumed for each dewatering & monitoring / major gate repair event.

1E.2.2.2.4 15-Day 12/12 Event

The 15-day 12/12 event is defined in the engineering maintenance matrix as the 180-hour event reflecting 15-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption was to be assumed for rewiring and machinery rehabilitation, however, this maintenance was not scheduled in the cost-closure matrix. This service disruption definition was not used in the analysis.

1E.2.2.2.5 13-Day 12/12 Event

The 13-day 12/12 event is defined in the engineering maintenance matrix as the 156-hour event reflecting 13-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption is for fair-wear-and-tear or reimbursable repairs to guide walls, once per year, every year. In a year that a dewatering occurs, will be contiguous with dewatering, however, separate curves were not developed to reflect this.

1E.2.2.2.6 9-Day 12/12 Event

The 9-day 12/12 event is defined in the engineering maintenance matrix as the 108-hour event reflecting 9-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption was assumed for the east and west chamber wall rehabilitation.

1E.2.2.2.7 7-Day 12/12 Event

The 7-day 12/12 event is defined in the engineering maintenance matrix as the 84-hour event reflecting 7-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption is for south-east and north-west guide wall face repairs.

1E.2.2.2.8 5-Day 12/12 Event

The 5-day 12/12 event is defined in the engineering maintenance matrix as the 60-hour event reflecting 5-days of 12-hour closures to perform repairs (12 hours open and 12 hours closed per day). Note, that drainage events could occur during the open 12-hour shift (limiting vessel passage). This service disruption is for south-west and north-east guide wall face repairs.

1E.3 WITH-PROJECT CONDITION ALTERNATIVES

In the formulation process, "*drainage alteration*", "*new lock efficiency*", and "*existing lock efficiency*" measures were considered, however, the "*new lock efficiency*" and "*existing lock efficiency*" measures were screened out. The five drainage alteration alternatives are defined below.

1E.3.1.1 Alternative 1 South 75' Gate

Alternative 1 consists of dredging a new channel south of the Calcasieu Lock with construction of a 75 ft. Sluice gate structure. The outfall and intakes will need to be excavated. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. This alternative eliminates all drainage events from Calcasieu Lock. Periodic dredging is required.

1E.3.1.2 Alternative 2 South 3,700 CFS Pumping Station

Alternative 2 consists of dredging a new channel south of the Calcasieu Lock with construction of a 3,700 CFS pumping station. The outfall and intakes will need to be excavated. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. This alternative eliminates all drainage events from Calcasieu Lock. Periodic dredging would be required.

1E.3.1.3 Alternative 3 Black Bayou Supplemental Culverts

Alternative 3 consists of construction of supplemental culverts added to the Black Bayou NRCS structure to increase its capacity. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). This alternative eliminates all drainage events from Calcasieu Lock. Periodic Black Bayou Dredging to the east and west of the NRCS structure will also occur.

1E.3.1.4 Alternative 4 Black Bayou 2,000 CFS Pumping Station

Alternative 4 consists of construction of a 2,000 CFS pumping station adjacent and north of the existing Black Bayou NRCS structure. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). This alternative eliminates all drainage events from Calcasieu Lock. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require USACE to take over O&MRRR of the structure once its 20 project life under CWPRA ends.

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1E.3.1.5 Alternative 5 Black Bayou 3,700 CFS Pumping Station

Alternative 5 consists of construction of a 3,700 CFS pumping station adjacent and north of the existing Black Bayou NRCS structure. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 MLG (Mean Low Gulf). This alternative eliminates all drainage events from Calcasieu Lock. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure.

1E.3.2 WITH-PROJECT CONSTRUCTION COSTS

Construction costs received for the analysis are summarized by year in **TABLE 1E.5**.

TABLE 1E.5 – Alternative Construction Cost Assumptions
(FY2013 dollars, Av.Ann. 3.75% discount/amort rate, with 2018 base year)

Year	Alt. 1-South 75' Gate	Alt. 2-South 3,700 CFS Pump	Alt. 3-Black Bayou Culverts	Alt. 4-Black Bayou 2,000 CFS Pump	Alt. 5-Black Bayou 3,700 CFS Pump
2015	$0	$27,610,277	$0	$16,448,396	$26,091,011
2016	$10,433,565	$46,017,129	$9,415,000	$27,413,994	$43,485,018
2017	$4,880,677	$18,406,851	$4,035,000	$10,965,597	$17,394,007
TOTAL	$15,314,242	$92,034,257	$13,450,000	$54,827,987	$86,970,036
IDC	$391,259	$3,835,240	$353,062	$2,284,785	$3,624,204
Present Value	$15,705,501	$95,869,497	$13,803,062	$57,112,772	$90,594,240
Av.Ann.	$700,060	$4,273,308	$615,261	$2,545,757	$4,038,167

1E.3.3 WITH-PROJECT SCHEDULED MAINTENANCE

Given these alternatives are separate from the Calcasieu Lock facility, the Calcasieu Lock maintenance costs as discussed in the above sections will remain, however, these alternatives have their own maintenance costs. The normal O&M costs are summarized in **TABLE 1E.6** and the cyclical maintenance costs are summarized in **TABLE 1E.7**. The scheduled maintenance data included the following maintenance cost categories, and maintenance work items:

- Culvert Structure/Sluice Gate
    - Routine Maintenance (annually $50,000)
    - Rewiring and Machinery Replacement (every 20-years $100,000)
    - Maintenance by Hired Labor Units (every 5-years $250,000)
    - Dewatering and Monitoring / Major Repairs (every 10-years $1,000,000)
    - Periodic Inspection (PI) Program (every 5-years $60,000)
    - Sluice Gate Replacement (every 25-years $3,000,000)
- Black Bayou Culverts
    - Routine Maintenance (annually $20,000)
    - Maintenance by Hired Labor Units (every 5-years $250,000)
    - Dewatering and Monitoring / Major Repairs (every 10-years $1,000,000)
    - Periodic Inspection (PI) Program (every 5-years $60,000)
    - Flap Gate Replacement (every 20-years $1,000,000)
- Pump Station
    - Routine Maintenance (annually $250,000)
    - Rewiring and Machinery Replacement (every 30-years $750,000)
    - Maintenance by Hired Labor Units (every 3-years $675,000)
    - Pump Replacement (every 30-years $5,000,000)
    - Periodic Inspection (PI) Program (every 5-years $60,000)

TABLE 1E.6 – Normal O&M Costs

(FY2013 dollars)

Maintenance Item	Without-Project Condition	Alt. 1 South 75' Gate	Alt. 2 South 3,700 CFS Pump	Alt. 3 Black Bayou Culverts	Alt. 4 Black Bayou 2,000 CFS Pump	Alt. 5 Black Bayou 3,700 CFS Pump
Lock	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000
South Gate	$ -	$ 50,000	$ -	$ -	$ -	$ -
Pump	$ -	$ -	$ 250,000	$ -	$ 250,000	$ 250,000
Black Bayou	$ -	$ -	$ -	$ 20,000	$ -	$ -
TOTAL	$ 300,000	$ 350,000	$ 550,000	$ 320,000	$ 550,000	$ 550,000

TABLE 1E.7 – Alternative Construction Costs

(FY2013 dollars, Av.Ann. 3.75% discount/amort rate, with 2018 base year)

	Without-Project Condition	Alt. 1 South 75' Gate		Alt. 2 South 3,700 CFS Pump		Alt. 3 Black Bayou Culverts		Alt. 4 Black Bayou 2,000 CFS Pump		Alt. 5 Black Bayou 3,700 CFS Pump	
Year	Lock	Lock	South Gate	Lock	Pump	Lock	Black Bayou	Lock	Pump	Lock	Pump
2018	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2019	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2020	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2021	$1,000,000	$1,000,000	$0	$1,000,000	$675,000	$1,000,000	$0	$1,000,000	$675,000	$1,000,000	$675,000
2022	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2023	$825,000	$825,000	$310,000	$825,000	$60,000	$825,000	$310,000	$825,000	$60,000	$825,000	$60,000
2024	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2025	$1,975,000	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0	$1,975,000	$0
2026	$6,700,000	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0	$6,700,000	$0
2027	$730,000	$730,000	$0	$730,000	$675,000	$730,000	$0	$730,000	$675,000	$730,000	$675,000
2028	$675,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$60,000
2029	$825,000	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0
2030	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2031	$5,700,000	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0
2032	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2033	$975,000	$975,000	$310,000	$975,000	$735,000	$975,000	$310,000	$975,000	$735,000	$975,000	$735,000
2034	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2035	$1,825,000	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0	$1,825,000	$0
2036	$1,700,000	$1,700,000	$0	$1,700,000	$675,000	$1,700,000	$0	$1,700,000	$675,000	$1,700,000	$675,000
2037	$1,030,000	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0	$1,030,000	$0
2038	$1,275,000	$1,275,000	$1,410,000	$1,275,000	$60,000	$1,275,000	$2,310,000	$1,275,000	$60,000	$1,275,000	$60,000
2039	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2040	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2041	$700,000	$700,000	$0	$700,000	$0	$700,000	$0	$700,000	$0	$700,000	$0
2042	$880,000	$880,000	$0	$880,000	$675,000	$880,000	$0	$880,000	$675,000	$880,000	$675,000
2043	$1,275,000	$1,275,000	$3,310,000	$1,275,000	$60,000	$1,275,000	$310,000	$1,275,000	$60,000	$1,275,000	$60,000
2044	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2045	$5,975,000	$5,975,000	$0	$5,975,000	$675,000	$5,975,000	$0	$5,975,000	$675,000	$5,975,000	$675,000
2046	$5,700,000	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0	$5,700,000	$0
2047	$880,000	$880,000	$0	$880,000	$0	$880,000	$0	$880,000	$0	$880,000	$0
2048	$6,675,000	$6,675,000	$1,310,000	$6,675,000	$6,485,000	$6,675,000	$1,310,000	$6,675,000	$6,485,000	$6,675,000	$6,485,000
2049	$975,000	$975,000	$0	$975,000	$0	$975,000	$0	$975,000	$0	$975,000	$0
2050	$1,275,000	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0	$1,275,000	$0
2051	$700,000	$700,000	$0	$700,000	$675,000	$700,000	$0	$700,000	$675,000	$700,000	$675,000
2052	$6,730,000	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0	$6,730,000	$0
2053	$675,000	$675,000	$310,000	$675,000	$60,000	$675,000	$310,000	$675,000	$60,000	$675,000	$60,000
2054	$825,000	$825,000	$0	$825,000	$675,000	$825,000	$0	$825,000	$675,000	$825,000	$675,000
2055	$2,275,000	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0	$2,275,000	$0
2056	$1,700,000	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0	$1,700,000	$0
2057	$730,000	$730,000	$0	$730,000	$675,000	$730,000	$0	$730,000	$675,000	$730,000	$675,000
2058	$975,000	$975,000	$1,410,000	$975,000	$60,000	$975,000	$2,310,000	$975,000	$60,000	$975,000	$60,000
2059	$825,000	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0	$825,000	$0
2060	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$0	$675,000	$675,000	$675,000	$675,000
2061	$1,000,000	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0	$1,000,000	$0
2062	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2063	$675,000	$675,000	$310,000	$675,000	$735,000	$675,000	$310,000	$675,000	$735,000	$675,000	$735,000
~~2064~~	~~$675,000~~	~~$675,000~~	~~$0~~	~~$675,000~~	~~$0~~	~~$675,000~~	~~$0~~	~~$675,000~~	~~$0~~	~~$675,000~~	~~$0~~
2065	$675,000	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0	$675,000	$0
2066	$700,000	$700,000	$0	$700,000	$675,000	$700,000	$0	$700,000	$675,000	$700,000	$675,000
2067	$730,000	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0	$730,000	$0
2068	$675,000	$675,000	$4,310,000	$675,000	$60,000	$675,000	$1,310,000	$675,000	$60,000	$675,000	$60,000
Av.Ann.	$1,949,459	$1,949,459	$182,115	$1,949,459	$298,114	$1,949,459	$158,153	$1,949,459	$298,114	$1,949,459	$298,114

1E.4 NIM TABLES

NIM input, output, and execution data is stored in Microsoft Sequel (SQL) Server 2008 R2 database. The model's 130 database tables can be grouped into ten broad categories. Database tables used to load the scheduled maintenance and unscheduled service disruption events fall under the following table groups:

- system operating and budget assumptions;
- maintenance characteristics; and
- reliability characteristics.

Calcasieu Lock is a salt water barrier that is also utilized to flush flood waters from the Mermentau River and Basin. Depending on the gage differentials, vessels may be locked or they may transit the structure under an "*open pass*". When the east (inland) gage is above 2.5' and the west (coastal) gage is lower than the east gage, the lock gates are opened to flush water; a drainage event. Vessel transit under an open pass, however, can be restricted depending upon the head differential and the resulting current velocities. While it is quicker for a vessel to transit the project under an open pass when velocities are low (the vessel doesn't have to lock), at higher velocities vessels must wait[1]. The primary inefficiency at Calcasieu Lock comes from delays resulting from these high velocity drainage events.

In the formulation process, "*drainage alteration*", "*new lock efficiency*", and "*existing lock efficiency*" measures were considered, however, the "*new lock efficiency*" and "*existing lock efficiency*" measures were screened out. With only "*drainage alteration*" alternatives being considered, and with each of these alternatives eliminating all high velocity drainage events, only the existing condition (the without-project condition or WOPC) and the existing condition without drainage events (WOPC without drainage events) required analysis with NIM. The differences between these two scenarios identify the benefits of eliminating the high velocity drainage events.

In short, the five Calcasieu Lock with-project condition "*drainage alteration measures*" only differ from the WOPC without drainage event scenario in construction and maintenance costs. As a result, the with-

[1] Whether a vessel waits depends upon its size and direction (upbound or downbound).

project condition alternatives were not loaded into NIM and a discussion on how to load the data will not be included.

1E.4.1 Lock Service Disruptions Defined, the ClosureTypes Table

Under the reliability characteristics table grouping, the service disruption events described in section 1E.2.2 are entered into the "*ClosureTypes*" table (**TABLE 1E.8**).

TABLE 1E.8 – ClosureTypes Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
closureID		Unique service disruption ID
closureName		Service disruption name (e.g., 15Day12-12)
affectedChamber		Chamber ID from ChamberTypes table.
opSpeedLevel		Operating speed (1=1/2 speed, 2 = normal speed)
period		Service disruption duration (days)
comments		Additional description if needed (e.g., Rewiring and machinery Rehabilitation)

1E.4.2 Fixed Annual Costs, the GeneralCost Table

Fixed project costs, including fixed cyclical costs, are loaded into database tables under the system operating and budget assumptions, and maintenance characteristics table groupings. As previously mentioned, three of the five maintenance actions listed under the Calcasieu Lock "*No impact to navigation work items*" were constant through the analysis period. Information on the costs that are constant through the analysis period and associated with nodes, but not with particular components (e.g., normal O&M), are stored in the "*GeneralCost*" table (**TABLE 1E.9**).

TABLE 1E.9 – GeneralCost Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
nodeType	DB Key	Node type (B = bend, L = lock)
nodeID	DB Key	Node ID (if nodeType = L, nodeID=lockID. If nodeType=B, nodeID=bendID)
year	DB Key	Fiscal (or calendar) year.
costType	DB Key	C=cyclical, U=unscheduled, I=improvement, T=transit, M=random, O=operations
costCode	DB Key	GI, CG, OD=Op.Dam, OM=O&M, OR=Op.Rehab., TF=IWWTF.
cost		Dollars in specified year for specified cost code at specified node.
comments		Additional description if needed (e.g., Unexplained "No Impact to Nav Work Items" ($300K), ACE-IT Sec.Maint. ($30K), & ED Instrumentation ($20K).)

Only costs for Calcasieu Lock were entered; $300,000 annually which includes $250,000 for routine maintenance, $30,000 for ACE-IT security maintenance, and $20,000 for ED instrumentation.

1E.4.3 Cyclical Maintenance

Data on the cyclical scheduled closures for each lock are stored in the "*ScheduledClosure*" table (**TABLE 1E.13**). A set of scheduled closures is indexed by maintenance plan ID. Maintenance plans are changed through alternatives. Since these cyclical maintenance cycles can shift as investments are implemented, the year field is defined with an offset rather than a calendar (or fiscal) year. The offset is from the "*startYear*" defined in the "*InitialClosurePlan*" table.

1E.4.3.1 AlternativeMaintenanceCategory Table

Data on how implementing an alternative modifies the maintenance plan at a lock are stored in the "*AlternativeMaintenanceCategory*" table (**TABLE 1E.10**).

TABLE 1E.10 – AlternativeMaintenanceCategory Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
alternativeID	DB Key	Alternative ID from Alternative table.
lockID	DB Key	Lock ID from Locks table.
chamberID	DB Key	Chamber ID from ChamberTypes table.
maintenanceCategory	DB Key	Unique maintenance category ID.
daysClosed		Number of days of closure.
absoluteDaysClosed		Whether the change to days closed is absolute (yes) or relative (no).
daysHalfSpeed		Number of days of half-speed.

1E.4.3.2 InitialClosurePlan Table

. The only intent of the “*InitialClosurePlan*” table is to specify the “*startYear*” for the “*closurePlanNumber*” referenced in the “*ScheduledClosure*” table. For convenience, “*startYear*” has been set in all cases to year 2010. The “*InitialClosurePlan*” table is shown in **TABLE 1E.11**.

TABLE 1E.11 – InitialClosurePlan Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID		Lock ID from Locks table.
chamberID		Chamber ID from ChamberTypes table.
closureType		Closure type ID from ClosureTypes table.
closurePlanNumber		Cyclical clousre plan ID from ScheduledClosure table.
startYear		First fiscal (calendar) year to start the cyclical closure plan.
comments		Additional description if needed (e.g., existing)

1E.4.3.3 ScheduledClosureType Table

The scheduled closure types are given a "*scheduledClosureType*" code of long, moderate, short, or painting in the "*ScheduledClosureType*" table (**TABLE 1E.13**)

TABLE 1E.12 – ScheduledClosureType Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
scheduledClosureType		Unique scheduled closure type ID (L, M, P, S)
scheduledClosureTypeName		Scheduled closure type name (e.g. long, moderate, painting, & short).

1E.4.3.4 ScheduledClosure Table

Data on the cyclical scheduled closures for each lock are stored in the "*ScheduledClosure*" table (**TABLE 1E.13**). A set of scheduled closures is indexed by maintenance plan ID. Maintenance plans are changed through alternatives. Since these cyclical maintenance cycles can shift as investments are implemented, the year field is defined with an offset rather than a calendar (or fiscal) year. The offset is from the "*startYear*" defined in the "*InitialClosurePlan*" table.

TABLE 1E.13 – ScheduledClosure Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID		Lock ID from Locks table.
chamberID		Chamber ID from ChamberTypes table.
closurePlanNumber		Closure plan ID (set in this table).
year		Year (1-n).
scheduledClosureType		Scheduled closure type from ScheduledClosureType table.
closureNumber		Sequence # when multiple events scheduled within the same year (typically set = 1)
comments		Additional description if needed (e.g., Original Sched Closures (periodic inspection, 5yr cycle))
maintenanceCategory		Maintenance category ID from AlternativeMaintenanceCategory table.
daysClosed		Number of days as specified in the "period" field of the "ClosureTypes" table.
daysHalfSpeed		Number of days the specified chamber is operating at half-speed for the specified closureID.
cost		Dollars in specified year for specified maintenance category.

1E.4.4 Unscheduled Service Disruption Events

Lock service disruption events not only occur from scheduled maintenance events, but can also occur from probabilistically driven events (risk). These unscheduled service disruption events are typically generated by unreliable lock components, and as such the NIM tables and field names are biased toward modeling lock parts. The structure for modeling of unreliable components, however, is applicable for any probabilistic event. In the case of the Calcasieu Lock study, the lock's structural, electrical, and mechanical systems have either been determined reliable, or to have insignificant consequence to navigation service if a failure is experienced. In the gulf region, however, hurricane events can impact Calcasieu Lock performance. The hurricane probability and its lock service disruption consequence can be loaded and modeled in NIM.

In the model, unscheduled service disruptions are defined probabilistically. As a result, the adjustment of equilibrium traffic levels, transportation costs, and waterway transportation surplus for unscheduled service disruptions is different than for scheduled service disruptions. Probabilistic events are described through a probability of unsatisfactory performance (PUP) and event-tree. While PUPs and event-trees can change through time from continued degradation and from failure and repair reliability adjustment, in the case of a hurricane event a flat PUP and a single branch event-tree was used. The probabilistic service disruption data are stored under the reliability characteristics database table grouping in the model in the nine database tables discussed in the following sections.

1E.4.4.1 Component and ComponentName Tables

Components that have engineering reliability data (or a definable probabilistic service disruption event such as a hurricane event) are initially defined through the "*Component*" and "*ComponentName*" tables (**TABLE 1E.14** and **TABLE 1E.15**). In the "*Component*" table field "*yearFailuresStart*" is set to the base year so that the reliability is only simulated through the analysis period and not through the complete planning period. This assumes survivability of all components to the decision point (i.e., base year). While there is risk during the study and construction periods, it is inappropriate to incorporate this risk in the planning decision since it could under estimate project benefits and skew the selection of the NED plan. In the case of a hurricane event, the setting of the "*yearFailuresStart*" is unimportant since the PUP is flat and events do not affect future probabilities.

TABLE 1E.14 – Component Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID	DB Key	Lock ID from Locks table (e.g., 624202385 for Calcasieu Lock).
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Unique component ID.
yearNew		Calendar year of age = 0.
yearFailuresStart		Year to start reading the PUP function.
initialStateID		State (or version) of the PUP and event-tree.
comments		Additional description if needed (e.g., hurricane event 5yr or greater)

TABLE 1E.15 – ComponentName Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Component ID from Component table.
componentName		Component name
comments		Additional description if needed (e.g., Hurricane 5yr or greater)

1E.4.4.2 ComponentState Table

NIM has the capability to branch to a different PUP function and event-tree from any of the second-level branches in the model's simulation of the unscheduled events. These variations of a components reliability data (PUP and event-tree) are tracked through a "*stateID*" defined in the "*ComponentState*" table (**TABLE 1E.16**). For a hurricane event where the repair from the event does not change either the future PUP or the future repair costs, only one "*stateID*" is needed and defined.

TABLE 1E.16 – ComponentState Table Description

Database Field	DB Key	Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Component ID from Component table.
lockID	DB Key	Lock ID from Locks table.
stateID	DB Key	Unique state (or version) ID of the PUP and evet-tree.
stateName		State ID name.

1E.4.4.3 HazardFunction Table

The engineering reliability, or unscheduled service disruption, PUP (also known as a hazard function) data are stored in the "*HazardFunction*" table (**TABLE 1E.17**). This table is structured to hold both period based and fatigue based PUPs. For the Calcasieu Lock hurricane event, only the period based PUP is required. Only one "*stateID*" is required for the hurricane event since the hurricane event probability does not change in response to previous hurricane damage and repair (i.e., multiple PUPs are not defined). For the hurricane constant PUP, only the initial year is needed (the model will use this PUP until a later year is encountered in the database table).

TABLE 1E.17 – HazardFunction Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID		Lock ID from Locks table (e.g., 624202385 for Calcasieu Lock).
chamberID		Chamber ID from ChamberTypes table.
componentID		Component ID from Component table (e.g., 60 for the hurricane event).
stateID		State (or version) ID from ComponentState table.
year		Component age (1-100)
tonnageLevel		Low, medium, or high (L, M, or H).
yearlyTonnage		Tonnage level for fatige driven components (enter 0 for time dependent)
probFailure		Failure probability (0-1.0)
comments		Additional description if needed (e.g., 5yr or greater hurricane event)

1E.4.4.4 Event-Trees

An event-tree is used to display the consequences of unscheduled service disruptions (e.g., component failure or hurricane event): probabilities of different failure levels, probabilities of different fix levels, service disruption type, service disruption duration, and post-repair reliability changes. Storage of these data in the model requires four tables as discussed in the following sections. As defined in the engineering cost-closure matrix received for the Calcasieu Lock study, the hurricane event was defined as having only one service disruption duration and one repair fix.

1E.4.4.4.1 ComponentBranchProbability Table

The model allows two layers of branches, the first of which is referred to as the failure-level branch which has the functionality of storing the branch probabilities by year, thus allowing the user to change the branch weights through time (provided they still sum to 1.0). The failure-level branch data is stored in the "*ComponentBranchProbability*" table (**TABLE 1E.18**). Since the model has the capability to branch to a different PUP function and event-tree from any of the fix-level branches, the data also requires a "*stateID*" designation. For entry of the Calcasieu Lock hurricane event, only one branch is needed with its branch "*probability*" set to 1 (or 100%).

TABLE 1E.18 – ComponentBranchProbability Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID	DB Key	Lock ID from Locks table (e.g., 624202385 for Calcasieu Lock).
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Unique component ID.
stateID	DB Key	State (or version) ID from ComponentState table.
yearTreeEffective	DB Key	Calendar year prob becomes effective (can be superceeded by subsequent yr)
failureLevel	DB Key	Branch level (0-n).
probability		Branch probability (0-1.0).
comments		Additional description if needed (e.g., single branch tree for 5yr or > hurricane event)

1E.4.4.4.1 ComponentRiskDetail Table

The model allows two layers of branches, the second of which is referred to as the fix-level branch (**Error! eference source not found.**). This branch does not have the functionality of storing the branch probabilities by year like the failure level branch does. The fix-level branch data is stored in the "*ComponentRiskDetail*" table (**TABLE 1E.19**). Since the model has the capability to branch to a different PUP function and event-tree from any of the fix-level branches, the data also requires a "*stateID*" designation. Again, as with the failure-level branch, for entry of the Calcasieu Lock hurricane event, only one branch is needed in the fix-level branch and only one "*stateID*" since the hurricane probably and repairs are not altered after an event.

TABLE 1E.19 – ComponentRiskDetail Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID	DB Key	Lock ID from Locks table (e.g., 624202385 for Calcasieu Lock).
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Unique component ID.
stateID	DB Key	State (or version) ID from ComponentState table.
failureLevel	DB Key	Failure branch level from ComponentBranchProbability table.
fixLevel	DB Key	Branch level (0-n).
probability		Branch probability (0-1.0).
extendLife		Set-back PUP function n-years.
zeroOutHazardFunction		Is component 100% reliable post failure repair (Y or N)?
replaceComponent		Is component replaced (Y or N)?
newStateID		State ID after failure repair
comments		Additional description if needed (e.g., Hurricane repair)

1E.4.4.4.1 ComponentRepairDetail Table

The repair action resulting from the fix-level branch is stored in the "*ComponentRepairDetail*" table (TABLE 1E.20). The repair action defines a protocol for repair that may stretch over several years (e.g., emergency repair in year 1, replacement in year 2) and defines the cost and service disruption. The service disruption however is not defined with a "*closureTypeID*" from the "*ClosureTypes*" table, but instead is defined with a "*daysClosed*" and "*daysHalfSpeed*" fields (which is then used to identify the "*closureTypeID*"). For the hurricane repair, the repair cost was set as $1,500,000 and resulting in a "*10-*

day 24" event which is coded in this file as "*daysClosed*" = 10 which is matched to the "*closureTypeID*" field in table "*ClosureTypes*".

TABLE 1E.20 – ComponentRepairDetail Table Description

Database Field		Description
networkID	DB Key	River system network (3 = Calcasieu Study GIWW)
lockID	DB Key	Lock ID from Locks table (e.g., 624202385 for Calcasieu Lock).
chamberID	DB Key	Chamber ID from ChamberTypes table.
componentID	DB Key	Component ID from Component table.
stateID	DB Key	State (or version) ID from ComponentState table.
failureLevel	DB Key	Failure branch level from ComponentBranchProbability table.
fixLevel	DB Key	Fix branch level from ComponentRisk table.
yearIndex	DB Key	Repair year (1-n).
repairChamberID	DB Key	Repair chamber ID (from ChamerTypes table).
daysClosed		Days of service disruption (closure).
daysHalfSpeed		Days of service disruption (slowed processing)
repairCost		Repair cost (dollars)
comments		Additional description if needed (e.g., 5 year Hurricane event)

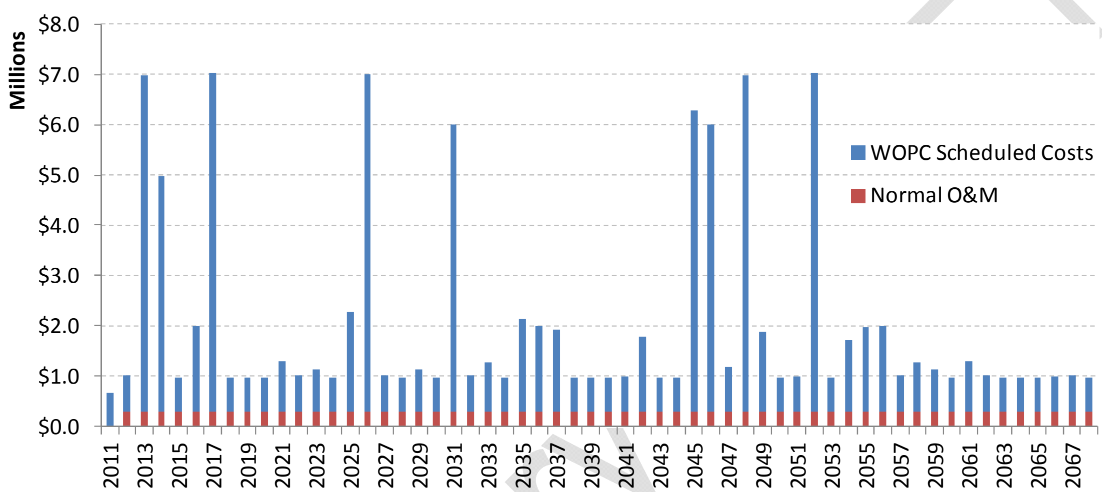
1E.4.5 Input Tests

To test for proper model input of the scheduled and unscheduled data, NIM is exercised and output is reviewed as discussed in the following sections.

1E.4.5.1 Scheduled Maintenance Events

Out of NIM's investment plan report the scheduled maintenance costs used in an analysis are echoed out. As shown in **FIGURE 1E.1** these costs match the input costs shown in **TABLE 1E.1** through **TABLE 1E.4**.

FIGURE 1E.1 – NIM IP Scheduled Costs

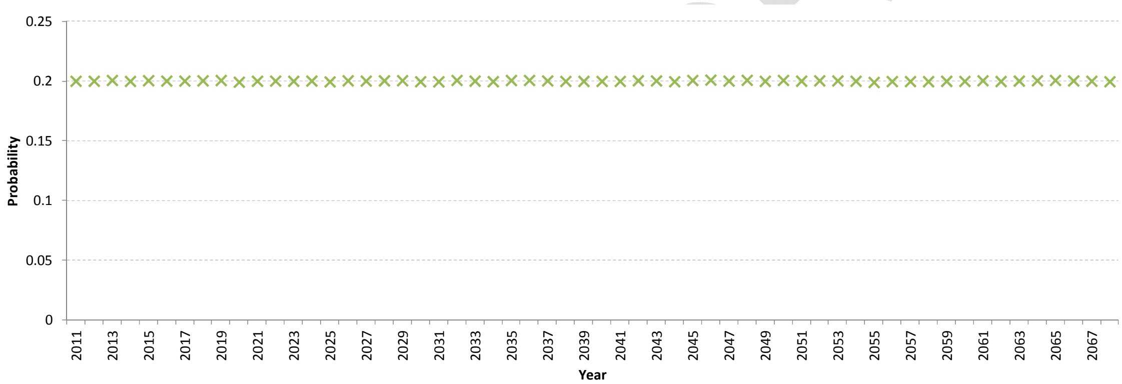


1E.4.5.2 Unscheduled Service Disruption Events and Costs

Checking unscheduled service disruption input can be problematic given complexity and morphing of a component's event-tree and the reliability re-sets through a life-cycle. In the case of the Calcasieu Lock hurricane event, it is relatively straight forward given that the service disruption event has a flat PUP, a single branch failure consequence, and no PUP adjustments post-repair.

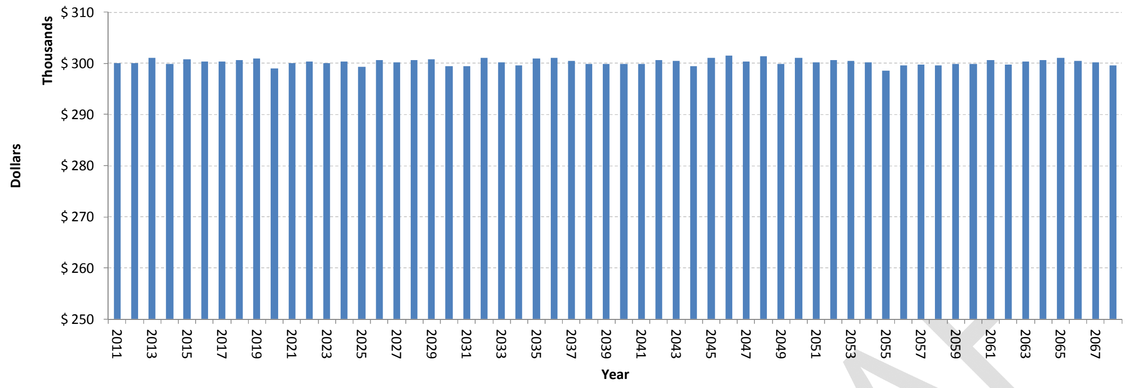
Out of the Lock Risk Module (LRM) of NIM, the expected yearly failure (a.k.a. service disruption) probabilities, repair costs, and survivability are summarized. As shown in **FIGURE 1E.2**, the expected service disruption (hurricane event occurrence) is approximately 20% for each year, which makes sense given the flat 20% PUP entered as input. Note, that given the nature of simulation[2], the results are not exactly 20% for each year. Similarly, the expected repair costs are approximately $300,000 for each year (**FIGURE 1E.3**), which makes sense given the repair cost is $1,500,000 and the probability of incurring this repair cost is 20% for each year.

FIGURE 1E.2 – LRM Expected Service Disruption Probability



[2] In this case 1M simulations were performed.

FIGURE 1E.3 – LRM Expected Unscheduled Repair Cost



For many components that are modeled in a typical analysis, the event-tree contains a failure-repair where the unreliable component is replaced. As such, a scheduled replacement of the component in the future might not actually be needed. To account for this the LRM tracks a survivability statistic. In the case of the Calcasieu Lock hurricane event, the hurricane damage repairs do not make the project less susceptible to future hurricane damage. As such the survivability of the component (a.k.a. hurricane service disruption event) does not decrease through time as shown in **FIGURE 1E.4**.

FIGURE 1E.4 – LRM Expected Survivability

Attachment 5
Calcasieu Lock Feasibility Study
Capacity Attachment

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Section 1
INTRODUCTION

This attachment documents the data sources, procedures, analytical methods and results of the Tonnage-Transit Time (Capacity) analysis for the Calcasieu Lock Study. The analysis was performed between August, 2010 and December, 2011. The base year used for this study is 2007.

1.1 GEOGRAPHIC SCOPE

Capacity curves were developed for 6 locks on the Gulf Intracoastal Waterway, 2 on the Port Allen route, and 1 lock on the Old River. All of these locks are located in the New Orleans district. **Figure A2- 1** shows the location of locks on the Gulf Intracoastal Waterway and Old River.

Figure A2- 1
Calcasieu Locks

1.2 PROJECT SETTING

The Intracoastal Waterway (IWW) traces the U.S. coast along the Gulf of Mexico from Apalachee Bay near St. Marks, Florida, to the Mexican border at Brownsville, Texas. Mile 0.0 of the IWW intersects the Mississippi River at mile 98.2 above Head of Passes (AHP), the location of Harvey lock, and extends eastwardly for approximately 376 miles and westwardly for approximately 690 miles. In addition to the mainstem, the IWW includes a major alternate channel, 64 miles long, which connects Morgan City, Louisiana to Port Allen, Louisiana at Mississippi River mile 227.6 AHP, and a parallel mainstem channel, 9.0 miles long, which joins the Mississippi River at mile 88.0 AHP, the location of Algiers lock, to the mainstem at IWW West mile 6.2. Project dimensions for the mainstem channel and the alternate route are 12 feet deep and 125 feet wide, except for the 150 foot width between the Mississippi River and Mobile Bay portion of the IWW East. Numerous side channels and tributaries intersect both the eastern and western mainstem channels providing access to inland areas and coastal harbors.

Within the study area, there are nine primary navigation locks. On the IWW mainstem west: Algiers, Harvey, Bayou Boeuf, Leland Bowman, and Calcasieu, with Port Allen and Bayou Sorrel on the IWW Morgan City - Port Allen Alternate Route. On the Inner Harbor Navigation Canal (IHNC), which intersects the Mississippi River at mile 93 AHP there is the IHNC lock, connecting the eastern and western sections of the IWW. On Old River, there is the Old River lock near mile 304 AHP on the Mississippi River, which links the Atchafalaya and Mississippi Rivers. West of Calcasieu lock, the western most lock identified above, there are four additional navigation structures. These include the East and West Brazos River Floodgates located at IWW West mile 404.1, and the East and West Colorado River locks located at IWW West mile 444.8. There are no navigation structures on the IWW east of the IHNC lock. **Table A2-1** describes the physical characteristics and locations of the nine primary locks.

The Intracoastal Waterway is a middle-aged system compared to other inland waterway segments within the United States. As **Table A2- 1** shows, with the exception of Port Allen, Old River and Leland Bowman, most of the primary locks are over 40 years old. However, the IWW continues to be a critical part of our nation’s infrastructure and confers wide-ranging benefits on national and state economies. The waterway is not only important to American commerce, it supports a variety of other public purposes, including flood control, waterside commercial development, and water-based recreational activities.

Table A2- 1
System Physical Description of Locks

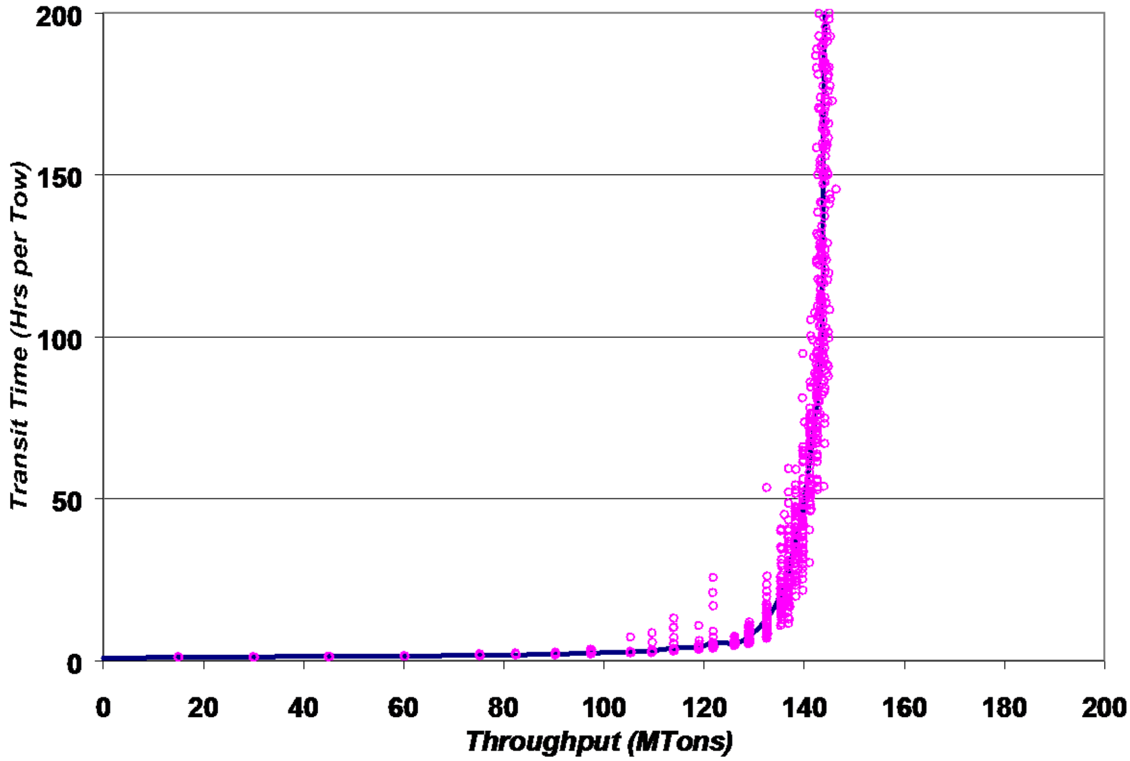
Waterway/Lock	GIWW Mile	Miss. River Mile	Length (Feet)	Width (Feet)	Sill Depth (Feet)	Lift (Feet)	Year Opened
GIWW East							
IHNC	0	92.6	640	75	31.5	17	1923
GIWW West							
Algiers	0	88.0	760	75	13	18	1956
Harvey	0	98.2	425	75	12	20	1935
Bayou Boeuf	93.3	n.a.	1156	75	13	11	1954
Leland Bowman	162.7	n.a.	1200	110	15	5	1985
Calcasieu	238.9	n.a.	1206	75	13	4	1950
GIWW Alt. Route M.C. - P.A.							
Port Allen	64.1	227.6	1202	84	14	45	1961
Bayou Sorrel	36.7	n.a.	797	56	14	21	1952
Atchafalaya-Mississippi River Link (Old River)							
Old River	n.a.	304	1200	75	11	35	1963

1.3 CAPACITY ANALYSIS

1.3.1 Model Runs

The Waterways Analysis Model (WAM) was used to make traffic-transit time estimates in this study. A full explanation of the model can be found in Section 2. WAM is a discrete event computer simulation model. Being a simulation model, every time WAM is run it produces an estimate of how the modeled system performs. Many output statistics are generated during each run. The most important of these are the total amount of traffic served and the time needed to serve it. If many runs are made at several different traffic levels, the performance of a system over its full range of capabilities can be presumed. **Figure A2- 2** shows the results of a complete set of runs for one condition and its associated capacity curve. Each point in the figure represents one run. A WAM curve is defined by the average of 50 runs at 27 different traffic levels.

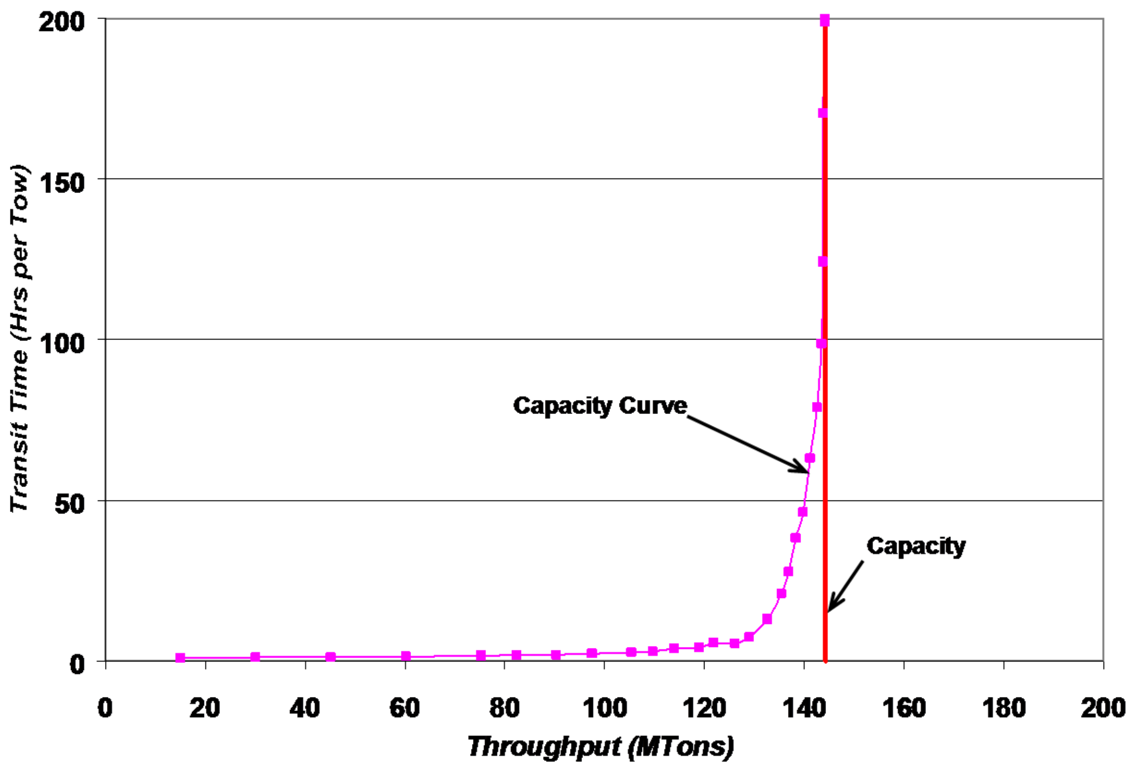
Figure A2- 2
One Set of WAM Runs



1.3.2 Capacity Curves

A capacity curve defines the relationship between project throughput and transit time. **Figure A2- 3** is typical of many capacity curves in this analysis. At most locks, transit times remain very low until demand reaches about 80% of capacity. As traffic levels increase from that level, transit times increase rapidly. Throughput is measured as annual tons served, and transit time includes both the time needed to "process" the vessel and the time the vessel is "delayed". A vessel's process time begins when either the lock operator signals a waiting tow that the lock is ready for processing, or the tow is at the arrival point and the lock is idle. Process time ends when the lock is free to serve another vessel. Delay occurs when a vessel arrives at a lock and cannot be served immediately. Capacity is defined as the level of tonnage where the capacity curve reaches its vertical asymptote. At this point, additional demand results in increased delay but no increase in throughput.

Figure A2- 3
Typical Capacity Curves



1.3.3 Major Maintenance Curves

Every capacity curve represents the relationship between tonnage and transit time for a given, very specific, set of circumstances. Many factors are considered when developing capacity curves. Fleet size and loadings, processing times, drainage event impacts, arrival and inter-arrival patterns, service policies, etc., all have an effect on the shape of the curve, and the ultimate capacity.

Downtime is a factor that receives significant attention in this study. For purposes of this analysis, downtime is defined as time when all traffic is unable to use a lock chamber. Downtime can occur because the chamber itself is unavailable, or for reasons that are beyond the control of the lock operator, like weather. When a chamber is "down", processing stops and vessels must either use another chamber, if available, or wait until the downtime ends.

Downtime is singled out for attention in this study. GULFNIM, the economic model used in this study, includes major maintenance events required to keep a lock in reasonably good operational condition. In order to fully consider the effects of major maintenance events, GULFNIM needs several capacity curves for each lock. Hence, at least 30 curves were created for Calcasieu Lock.

1.3.4 Relevant Range

While capacity is useful to demonstrate relative differences between alternatives, only the relevant range of a curve is used during an economic analysis. Relevant range is lock specific and depends on current and projected future traffic levels. The lower bound of a range is defined as the minimum expected demand, measured in tons, throughout the period of analysis. Conversely, the upper bound is set at the maximum expected tonnage. The capacity of a curve may lie above the relevant range, below the relevant range, or within the relevant range.

Section 2
MODEL DESCRIPTION

2.1 GENERAL DESCRIPTION

Tonnage-transit time (capacity) curves were developed using the Waterway Analysis Model (WAM). The WAM is a discrete event computer simulation model developed by the Corps of Engineers for use in simulating tow movements on the inland waterways system. It was developed as part of the U. S. Army Corps of Engineers Inland Navigation Systems Analysis Program (INSA) for the Office of the Chief of Engineers by CACI, Inc. WAM was written in the mid 1970's and has been continually modified and improved since the early 1980's. WAM has been used in navigation studies on the Ohio River and its tributaries for the last 20 years. The version of WAM used for all locks in this study, except Calcasieu, has been approved for use as part of the Corps Planning Model Improvement Program.

In order to simulate the multi-purpose aspects of operations at Calcasieu, significant modifications were made to the "approved for use" version of the WAM. Those modifications are described in detail in an addendum to this attachment.

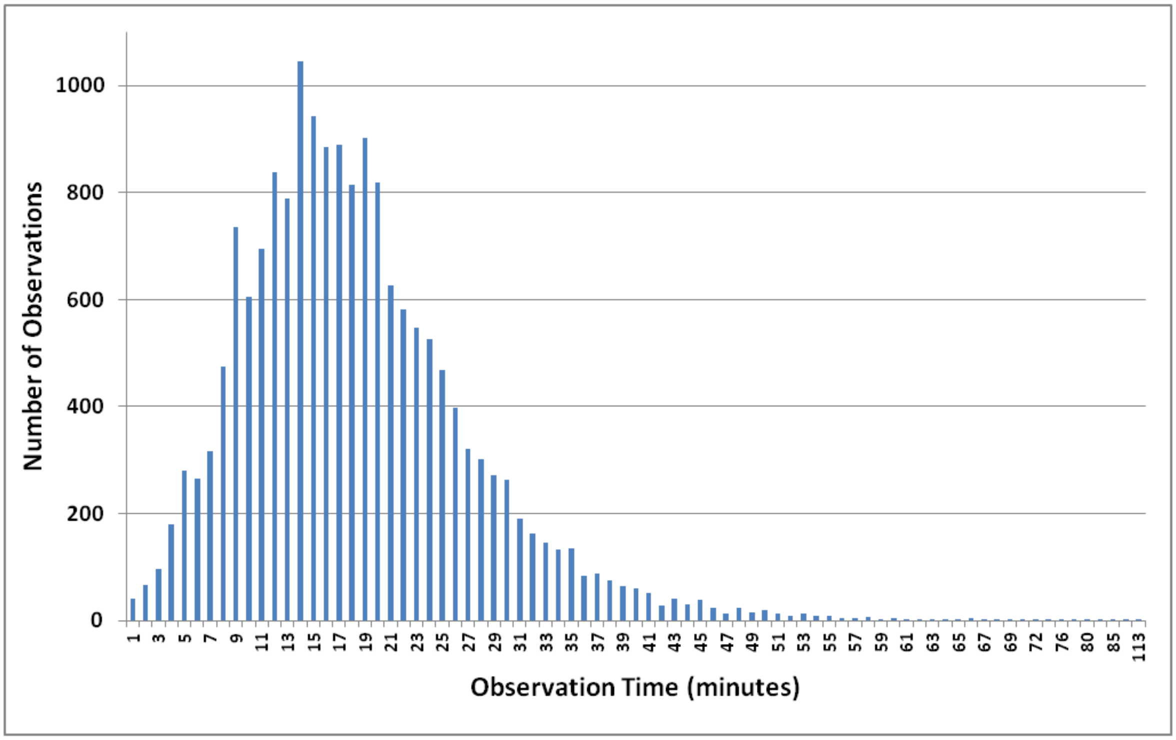
WAM is a simulation model. That means it incorporates the concept of variability into the modeling process. Instead of an action taking a fixed amount of time to accomplish, say 15 minutes every time, it may take any value between 5 and 30 minutes. Instead of every vessel arriving 60 minutes after the previous vessel, a vessel may arrive anywhere between a couple minutes and several hours after the previous vessel. This type of modeling is well suited for real world events, since real world events seldom take exactly the same amount of time every time they occur.

The interactions between the variability of the arrivals and the variability of the processing times causes times when the lock is idle and times when the lock is busy, with vessels waiting to process. The model monitors and accumulates many statistics as it executes. These statistics are written to files so the results of the model run can be reviewed and analyzed at will.

2.1.1 Processing Time Components

Figure A2- 4 shows a histogram of an actual component time data set used in this study. Notice the shape of the figure. Although it can be as low as 1 minute, there is less than a 4% chance that the value will be less than 6 minutes. On the other hand, 92% of the values are between 6 and 35, inclusive. The chance of the value being greater than 36 minutes is about the same as it being less than 6 minutes. Over 80 data sets like **Figure A2- 4** were used in this study.

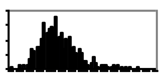
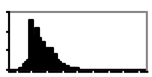
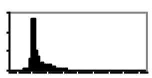
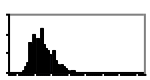
Figure A2- 4
Component Processing Time Histogram



2.1.2 WAM Lockage Process

WAM is a highly detailed lock simulation model. A detailed model explanation is beyond the scope of this Attachment. Fundamentally however, the model is easy to describe. Vessels arrive at the lock where they either begin processing, or are made to wait because the facility is busy or “down”. When the lock is ready to process the vessel, the vessel goes through 4 distinct processes if the lock is in standard locking mode and 1 process if the lock is in open pass mode. **Table A2- 2** shows a simple representation of a standard lockage.

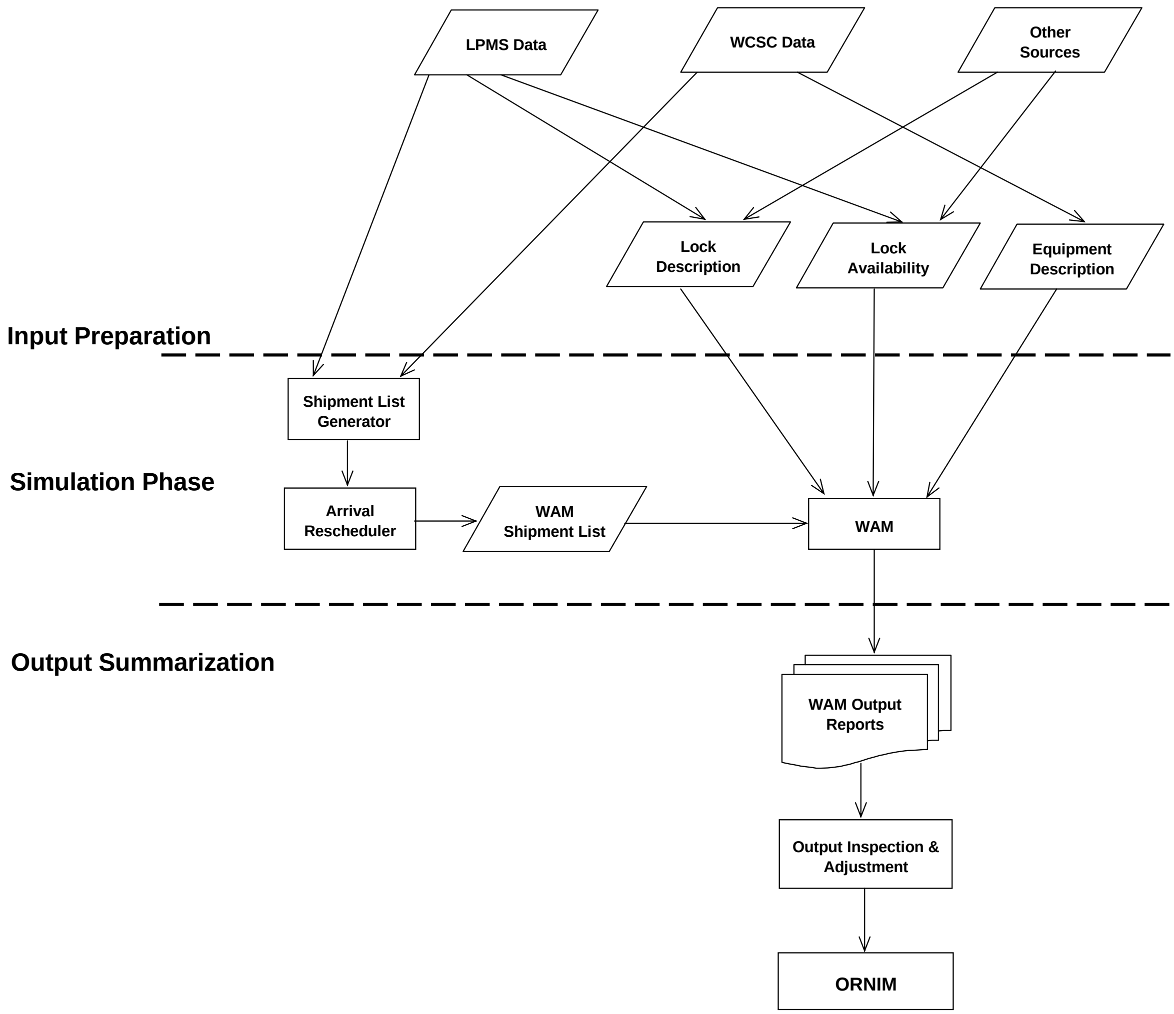
Table A2- 2
WAM Lockage

Description	Wam Component	LPMS Time
Arrival	Input to WAM from Shipment list	Arrival
Delay	Determined by WAM based on Conditions at Lock	Start of Lockage
Approach	 Approach Distribution Fit From Data	Bow Over Sill
Entry	 Entry Distribution Fit From Data	End of Entry
Chambering	 Chambering Distribution Fit From Data	Start of Exit
Exit	 Exit Distribution Fit From Data	End of Lockage

2.1.3 WAM Modeling Process

WAM modeling consists of 3 basic steps: 1) input preparation, 2) system simulation, and 3) output review and summarization. **Figure A2- 5** provides a general overview of the modeling process.

Figure A2- 5
Model Process Overview



2.2 INPUT PREPARATION

The WAM simulation module “simulates” tow movement through navigation locks based on the model configuration. Many factors are included when configuring a WAM simulation. The most important features are listed below.

- the lock
  - number of chambers
  - chamber sizes
  - processing times
  - interference characteristics (multi-chamber locks only)
  - drainage status and rules (Calcasieu Lock only)
  - downtime
  - service policy
- the fleet using the lock
  - towboat types and sizes

- barge types and sizes
- tow sizes/barges per tow
- empty movements
- recreation and other craft

- the fleet arrival pattern
  - monthly variations
  - daily variations
  - hourly variations
  - recreation craft arrival variations

2.2.1 Lock Data

2.2.1.1 Processing Times, Sample Set Development

As stated earlier, standard lockages are simulated in the WAM by four sequential periods of time. They are in order of occurrence, the approach, entry, chambering and exit. A vessel's total processing time equals the sum of the approach, entry, chambering and exit times. Processing time is added to the delay time, if any, to get total transit time for the vessel. Transit time is shown as the ordinate on capacity curve charts.

The Corps Lock Performance Monitoring System serves as the data source for processing times used by WAM. Processing time data is retrieved from the LPMS system and grouped into these components.

- Long Approach (Fly and Exchange)
- Short Approach (Turnback)
- Chamber Entry
- Chambering
- Long Exit (Fly and Exchange)
- Short Exit (Turnback)
- Chamber Turnback

Approaches and exits are grouped based on whether they are long or short. This is done because there is a large difference in these times, and the differentiation gives the model the ability to identify the most efficient lockage policy.

2.2.1.1.1 Sample Set Development, Overview

LPMS Data was imported into lock specific Microsoft Access database tables. A form was then used to select a specific lock's component times. Component times were grouped based on lock number, component type (i.e. long approach), chamber number (main or auxiliary), vessel direction (upstream or downstream), and number of cuts (1, 2 …or 5). LPMS summary data for the selected criteria was then displayed. Summary data included the locks' components' mean times, total observations, minimum and maximum value, and standard deviation for each year of the selected data sets.

2.2.1.1.2 Sample Set Development, Sample Set Size and Data Years

The first activity associated with developing valid component processing time sample sets was to combine years 2000-2009 and compare each year's data separately to determine whether the data sets for each year were similar

Each additional year's data was compared with the base year 2007. Visual and calculated comparisons were made to insure that something had not happened to make data from other years invalid. The visual comparison consisted of viewing various histograms of the selected data set in different single and multi-year scenarios. The skewness of each year's frequency distribution and general 'spread' of observations was considered and compared to the base year. The calculated comparison consisted of analyzing the LPMS summary data in various single and multi-year scenarios for each selected year or group of years. Each year(s) means, standard deviations, number of observations, and highest and lowest observations were compared with the base year. If insufficient sample sizes existed after combining all 2000-2009 data, which occurred in some of the double cuts and straight multi component data sets, data from another project was added to the insufficient sample size.

2.2.1.1.3 Sample Set Development, Rounding

Lock component data sets had various degrees of rounding from very little rounding to moderate rounding, and to extreme rounding, as shown in **Figure A2- 6**, **Figure A2- 7,** and **Figure A2- 8**, respectively. Rounding occurs when lock operators record the LPMS tow processing times in increments of 5 minutes (e.g., 5, 10, 15, …25) instead of the nearest minute. Moderate (subtle) rounding occurs when there are several times recorded in increments of 5 minutes in the data set while extreme (severe) rounding occurs when the times are recorded in only one or a few increments of 5 minutes or when nearly all occurrences are given the same time. Although some of the data sets contained some moderate and extreme rounding, all of the lock component data sets were used in this study due to each lock project having different lock dimensions. That is, there were no locks that could be a proxy for another lock. Processing times will tend to vary according to the lock's unique length and width. Refer to **Table A2- 1** for the various lock sizes.

Figure A2- 6
Data With Very Little Rounding

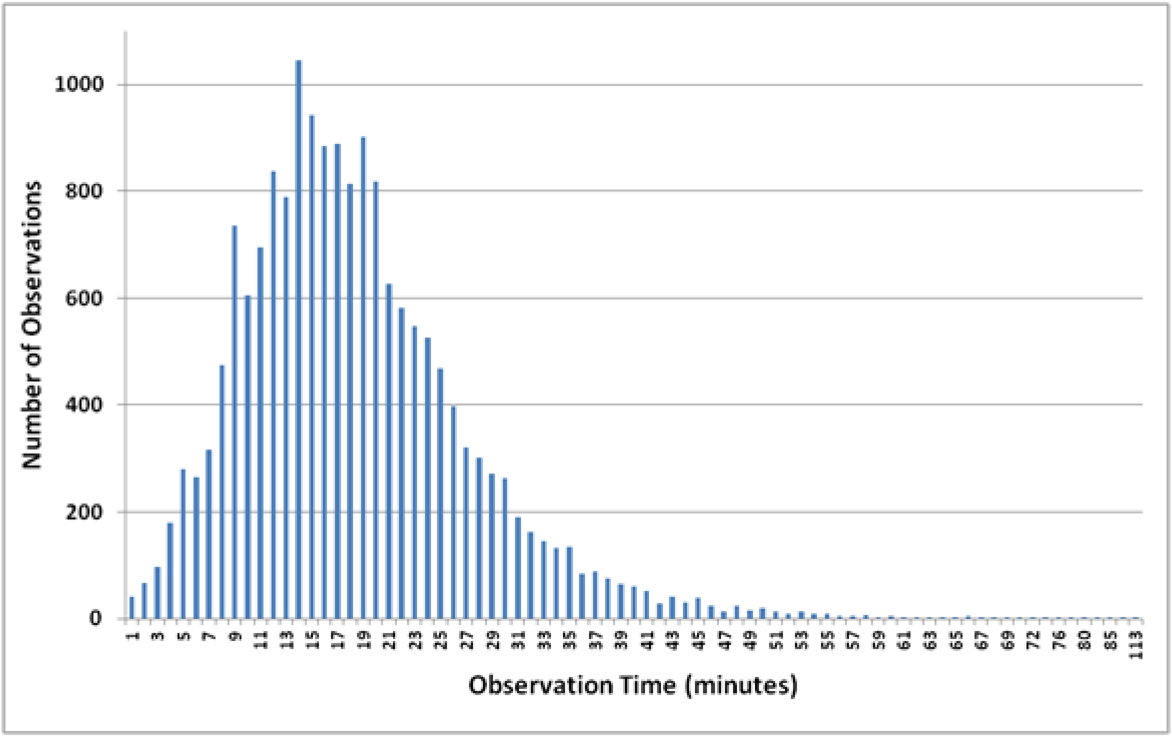


Figure A2- 7
Data with Moderate Rounding

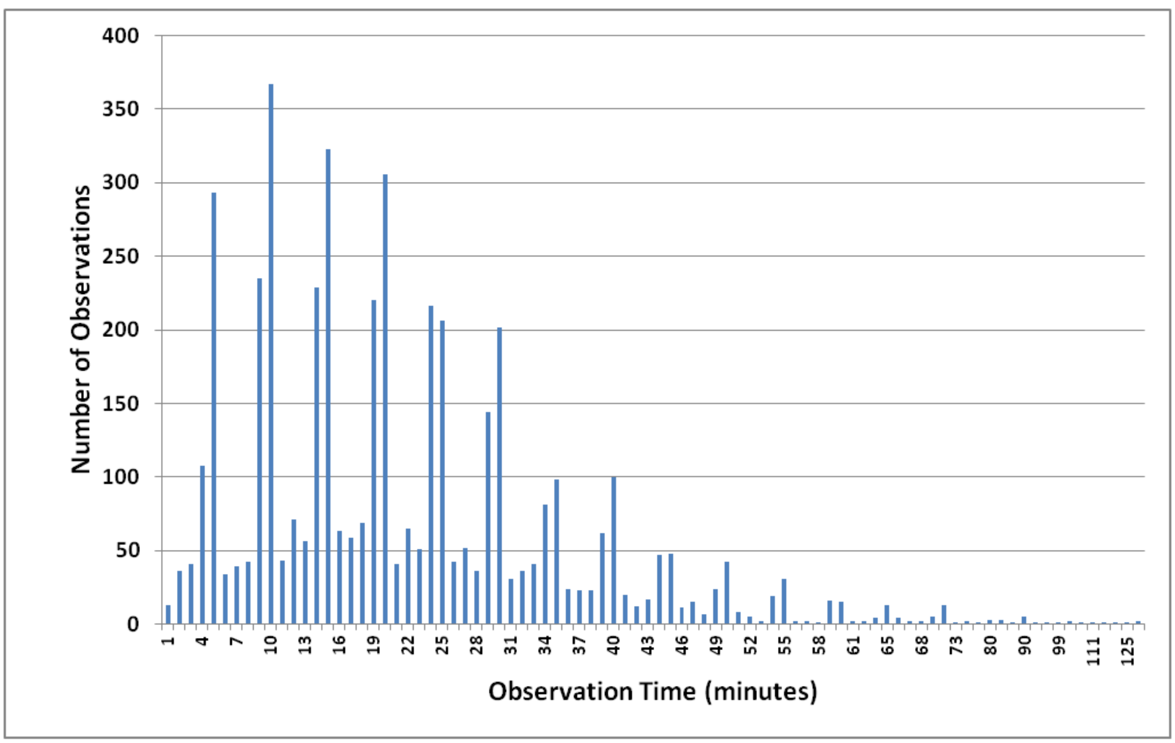
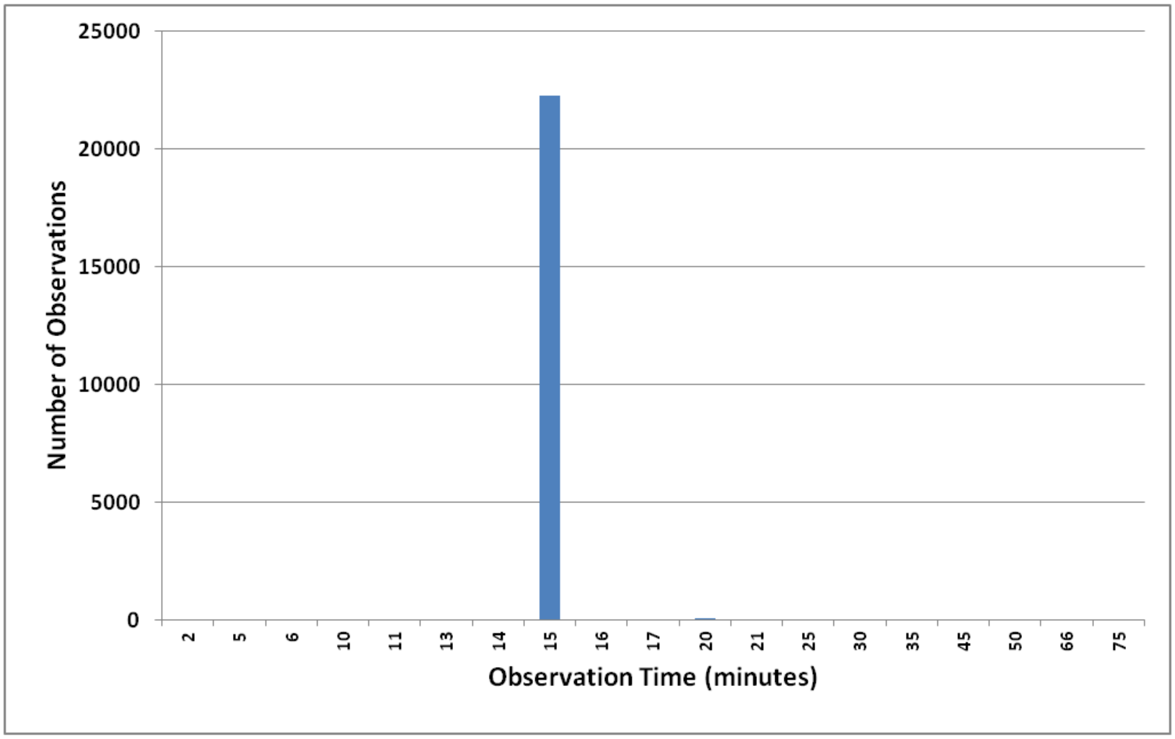


Figure A2- 8
Data with Severe Rounding



2.2.1.1.4 Sample Set Development, Outliers

For purposes of this study, outliers are data that do not belong in the data set. They are considered invalid, and are not included in the final data set. Outliers can take the form of very low values, or very high values.

Low outliers were determined by first setting a lower threshold for each component type based on the number of occurrences of the lowest observation. If the lowest observation occurred several times in the data set, the time remained in the data set. Conversely, if the observation occurred only a few times in the data set, the observation was removed as an outlier and became the threshold value. The threshold was determined by looking at the process, and determining the shortest process time possible. For example, a single cut chambering time begins when the vessel is tied off in the chamber and ends when the gates are fully open and the vessel can begin its exit. During this period, one set of gates is closed, the chamber was filled or emptied, and the other gates are opened. If the upper and lower pools were approximately equal, the filling or emptying process would be very short, essentially zero. This leaves the minimum process time as the time it takes to close one set of gates and open the other. **Table A2- 3** shows the threshold values used in this study.

Table A2- 3
Probability Distribution Types
(minutes)

Component Type	Project								
	Bayou Boef	Port Allen	Leland	Old River	Calcasieu	Harvey	Inner Harbor	Algiers	Bayou Sorrel
	1156 x 75	1202 x 84	1190 x 110	1190 x 75	1194 x 75	415 x 75	626 x 75	760 x 75	800 x 56
Long Approach	2	3	2	2	*1	*1	3	*1	*1
Short Approach	1	1	1	1	1	1	1	1	1
Entry	1	2	1	2	1	1	2	*1	*1
Chambering	1	3	1	2	2	1	3	1	1
Long Exit	*1	3	2	2	*1	2	3	2	2
Short Exit	1	1	1	1	1	1	1	1	1
Chamber Turnback	1	2	1	1	2	1	2	2	2
Straight Multi	1	3	2	1	1	1	1	1	1
Open Pass	1	na	2	na	1	na	na	2	2
Open Pass Multi	1	na	na	na	na	na	na	na	na

There were no specific rules for removing high outliers. Less emphasis was placed on higher component observation times than the lower observation times. "High Outliers" were removed only when they were considered extreme, and were unique to each selected data set. Examples of extreme outlier(s) would include an obvious typographical error such as the observation time of 999 minutes or high observation time(s) that contain large 'gaps' or differences in data values. An example of a large 'gap' in data would be a 100 minute time and the next highest values in the data set 30 minutes. In this case, the 100 minute time is over 3 times as large as the next largest value.

2.2.1.1.5 Processing Times, Distribution Fitting

Valid sample sets were analyzed using a commercial software product called Expert Fit ® by Averill Law and Associates. Expert Fit is an automated probability distribution fitting software package that analyzes the sample set, fits 20 distribution types to the set, determines which distribution type best represents the set, and displays the parameters that describe the distribution. **Table A2- 4** shows the distribution types considered by Expert Fit, and the parameters that define the distributions.

Table A2- 4
Probability Distribution Types
(minutes)

Distribution Type	Parameter 1	Parameter 2	Parameter 3	Parameter 4
Beta	Low EndPt	Hi EndPt	Shape #1	Shape #2
Chi-Square	Degrees Freedom	Location		
Constant	Value			
Erlang	Mean[1]	Shape	Location	
Exponential	Scale	Location		
Gamma	Mean[1]	Shape	Location	
Inverse Gaussian	Scale	Shape	Location	
Inverted Weibull	Scale	Shape	Location	
Johnson SB	Low EndPt	Hi EndPt	Shape #1	Shape #2
Lognormal	Mean[1]	Std Dev	Location	
Log-LaPlace	Scale	Shape	Location	
Log-Logistic	Scale	Shape	Location	
Normal	Mean	Std Dev		
Pareto	Scale	Location		
Pearson Type 5	(1/Scale)*Shape	Shape	Location	
Pearson Type 6	Scale	Shape #1	Shape #2	Location
Random Walk	Scale	Shape	Location	
Rayleigh	Scale	2	Location	
Uniform	Lower Limit	Upper Limit		
Weibull	Scale	Shape	Location	

1. An adjusted mean equal to sample mean minus location

2.2.1.3 Downtime

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime events. Downtimes happen for a variety of reasons and can last from a few minutes to over a month. Some downtimes are scheduled ahead of time while others occur without warning. This study addresses downtime by segregating these events into two groups, random minor downtimes and major maintenance downtimes.

The Corps LPMS data is the main data source for downtimes. LPMS data includes fields for vessel stalls. These stall events are used to determine how often and for what duration lock chambers are unable to serve traffic.

2.2.1.3.1 Random Minor Downtime

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Historical LPMS data from the years 2000 through 2009 were used to develop an estimate of how often and for how long, each lock chamber is "down" or unable to serve traffic. LPMS categorizes the causes of downtime into 5 major groups, and then further subdivides each major group into subgroups, for a total of 19 different causes of downtime. These categories and sub-categories are shown in **Table A2- 5**. Data was developed for each downtime subgroup by determining the number of events expected each year, and the total annual amount of downtime.

Table A2- 5
LPMS Downtime Types

Weather
Fog
Rain
Sleet or Hail
Snow
Wind
Surface Conditions
Ice
River Currents/Outdrafts
Flood
Tow Conditions
Interference by Other Vessel
Tow Malfunction
Tow Staff Ocuppied w Other Duties
Lock Conditions
Debris
Lock Hardware Malfunction
Lock Staff Occupied w Other Duties
Test and Maintain Lock
Others
Tow Detained by Coast Guard
Collision or Accident
Bridge Delay
Other

Downtime files were developed by creating the events for each subgroup, and combining the events into one file. Each event in the downtime file was created keeping in mind the time of year that the event subgroup usually occurred, and in accordance with the distribution of event durations for that subgroup.

2.2.1.3.2 Major Maintenance Downtimes Calcasieu Lock Only

Major maintenance events are long duration, usually scheduled, events that impact the ability of the chamber to operate. These events close the chamber, that is, traffic cannot pass through the "down" chamber.

Major maintenance events were modeled at Calcasieu Lock to determine the economic impact of these events. The events modeled are shown in Section 3.1 of this report. These events were developed by New Orleans District operations personnel. All events were modeled using the arrival rescheduling capabilities of WAM. Arrival rescheduling is fully described in Section 2.5.

2.2.2 Vessels

The WAM allows each vessel to be classified based on several attributes. For the purposes of this analysis, the most important attributes are the length, width and carrying capacity. These attributes are used by WAM to determine the number of cuts needed to process a vessel, and the tonnage carried by that vessel. The WAM determines the number of cuts by comparing the lock chamber size with the number and size of the vessels in a shipment.

Vessels are grouped into one of three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group.

2.2.2.1 Towboats

Towboats were categorized into 9 groups based on horsepower. **Table A2- 6** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 6
Towboat Classes, Horsepowers, & Dimensions

TB Class	Min HP in Class	Max HP in Class	Length	Width
1	0	800	55	22
2	801	1500	62	24
3	1501	1800	76	29
4	1801	2400	78	31
5	2401	3200	103	33
6	3201	5000	121	38
7	5001	5600	130	45
8	5601	8400	147	45

2.2.2.2 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed, and the towboat type. This study models 12 barge types which are typical on the Gulf Intracoastal Waterway system. **Table A2- 7** shows the barge types and their dimensions. The average loading per barge varies slightly by lock, so barge loadings are shown for each lock in the Detailed Lock Information section.

Table A2- 7
Barge Types and Dimensions

Econ Modeling Barge Class	WCSC Average Loading	Econ Modeling Barge Type	WCSC VTCC Code	LPMS Barge Type	Econ Modeling Length	Min WCSC Length	Max WCSC Length	LPMS Length	Econ Modeling Width	Min WCSC Width	Max WCSC Width	LPMS Width
1	1,576	Tanker 150x54	5	H or L	150	100	174	B	54	50	54	E
2	1,368	Tanker 200x35	5	H or L	200	195	200	D	35	28	36	B
3	1,555	Tanker 214x42	5	H or L	214	201	259	E	42	42	49	D
								C				D
4	2,152	Tanker 200x54	5	H or L	200	195	200	E	54	50	54	E
5	2,220	Tanker 264x54	5	H or L	264	260	289	F	54	50	54	E
6	3,249	Tanker 300x54	5	H or L	300	290	300	G	54	50	54	E
								G				F
7	3,351	Tanker 380x54	5	H or L	380	300	1200	H	54	50	54	E
								H				F
8	685	Non-Tanker 150x35	4	Not H or L	150	100	174	B	35	28	36	B
9	1,550	Non-tanker 200x35	4	Not H or L	200	195	200	D	35	28	36	B
								E				B
10	1,576	Non-Tanker 200x40	4	Not H or L	200	195	200	E	40	37	41	C
11	144	Tankers - All Others	5	H or L								
12	1,462	Non-Tankers - All Others	4	Not H or L								

2.2.3 Shipment List

The shipment list file contains a stream of vessel demands input to the WAM during program execution. It is generated based on historic LPMS and WCSC data, and may contain several thousand records. Every record represents a vessel that must be processed through the lock. The records contain information regarding the arrival time, direction, vessel type (tow, recreational craft, or lightboat), commodity type and tonnage (if applicable), towboat type (if applicable), and type and number of barges (if applicable). When taken in total, a shipment list closely matches the overall characteristics of the actual 2007 fleet at each respective lock.

2.2.3.1 LPMS Summary Program

The LPMS Summary Program was developed in conjunction with the shipment list generator program. The program summarizes the fleet through a lock project by predominate barge type and commodity in each tow. For example, if a tow has 4 jumbo hopper barges and 3 jumbo tankers, then the tow is counted as a 7-barge jumbo hopper barge tow. While most tows on the GIWW are configured homogeneously, some tows are a mix of barge types and commodities. The summary program assumes homogeneous tows.

The LPMS Summary Program reads an entire year of raw LPMS data and creates several tables that describe the fleet. Some of the most important ways that data is summarized include; the number of barges by barge type and direction, the total tonnage of each commodity carried in each barge type by direction, the number of empty barges by barge type and direction, the distribution of barges per tow by barge type and direction, the distribution of tows by month of year, day of week and hour of day. These summary tables are used by the shipment list generator to generate tows that reflect historical tow size distributions that arrive based on historical temporal distributions.

2.2.3.2 WCSC Summary File

The Waterborne Commerce Statistics Center (WCSC) input files were created manually using 2007 WCSC raw data for the 8 Calcasieu Study locks. WCSC barge data is recorded by the shipping companies and collected at the Navigation Data Center. There are two wcsc input files created for each lock project to include a ".lst" file and a summary file. These files are used by WAM's shipment generator to create shipment lists. The WCSC input files describe the origin destination (O-D) pairs by barge type and commodity for barges traveling both in the upstream and downstream direction. Each lock project has its own unique O-D matrix which describes the number of loaded barges, the 9 MVD commodity groupings the barge carries, the average loading, and the total tonnage for each of the 12 barge types used in this study.

2.2.3.3 Shipment List Generator

Shipment lists are generated by the WAM Shipment Generator (Ship62), which was developed in the 1995.[1] The ultimate objective of Ship62 is to produce shipment lists that closely reflect historic fleet characteristics. Fleet characteristics can be described in two ways. First, the fleet can be described by its physical characteristics, the most important of which are listed in **Table A2- 8**. Second, the fleet can be described temporally, that is, how arrivals are distributed on a monthly, daily and hourly basis.

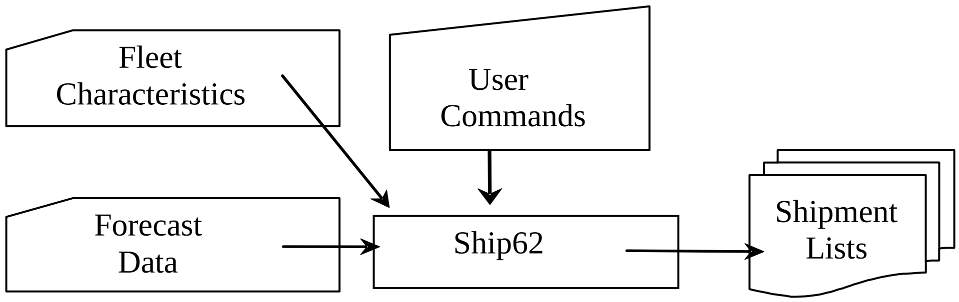
Table A2- 8
Shipment List Statistics of Interest

Number of Tows
Tons per Tow
Number of Barges
Number of Loaded Barges
Number of Empty Barges
Percent Empty Barges
Tons per Loaded Barge
Barges per Tow
Number of Recreation Craft
Number of Lightboats

Ship62 has three basic inputs: 1) the fleet characteristics summary files; 2) the forecast file and, 3) a control file containing user defined instructions. The fleet summary files are created by two standalone programs, LPMS Summary and WCSC Summary, described above. Although Ship62 has the ability to read forecasted demand flows to capture flow shifts, this feature was not used during this study. The user defined instructions file contains input and output file name information, a random number seed, and an escalation factor that determines the how many shipments are created in the shipment list. **Figure A2- 9** is a simplified shipment list generator flow chart.

[1] Multi-Lock Shipment Generator for the Waterway Analysis Model, December 20, 1995.

Figure A2- 9
Shipment List Generator Flow Chart



The Ship62 stochastically generates shipment lists, using target fleet distributions derived from LPMS and WCSC data. Performance statistics (e.g. transit time for a given annual tonnage) out of the WAM are sensitive to the arrival patterns in the shipment list, which are variable due to the generator's stochastic generation method. Therefore, 50 shipment lists are generated and run through the WAM to estimate average tow transit time for any given tonnage level.

2.2.3.4 Shipment List Calibration

The shipment list generator uses two data sources to develop shipment lists, the LPMS data and the WCSC data. These data sources each have their own strengths and weaknesses. For example, LPMS is a better data source for barge counts, tow and other vessel counts, and is the only source for empty barge and lock specific processing time information. On the other hand, WCSC is a better data source for tonnage moved per barge, and commodity type information. These two data sources, therefore, are used together to create shipment lists that reflect the actual fleet at a lock.

Before shipment lists can be used for WAM production runs, they must first be calibrated to insure that they truly reflect the fleet observed at the lock of interest. Shipment lists are calibrated by manually adjusting the LPMS summary data file until the generated fleet matches the observed fleet. The statistics most often adjusted are the number of empty barges, by barge type, and barges per tow percentages for each barge type.

2.2.4 Tow Arrival Rescheduling

The shipment list generator creates shipment lists that are valid for normal lock operation conditions. Shipment list arrival times reflect the actual 2007 arrival pattern.

During normal lock operations, tow arrivals vary by month of year, day of week and hour of day. At most locks in this study, there is very little variation in the rate of tow arrivals by month, day, or hour. When long, disruptive closures occur however, tow arrival patterns change dramatically. Since the locks analyzed in this report are single chamber locks, lock closures stop all traffic through the lock. When relatively long duration closures occur, historic data shows the number of arrivals decrease significantly during the closure. Tow arrival rescheduling mimics this decrease in arrivals by rescheduling arrivals around the closure(s) of interest.

2.3 MODEL EXECUTION

As stated in Section 2.1 WAM was developed in the 1970's. Although WAM has been continually modified and enhanced since that time, it retains the original input-output mechanisms of the era, ASCII files.

2.3.1 Making a WAM Run

In its most simple form, WAM requires four fundamental input files to fully define the system and conditions which are to be simulated. These four files are: the shipment list, the network file, the downtime file, and the run control file. The Calcasieu version of WAM requires 14 additional files to describe the drainage conditions and rules that define the effect drainage has on tow traffic.

The shipment list, which is created by the Shipment List Generator described in Section 2.2.3.3, contains the list of vessels seeking to use the lock. The network file describes the operational characteristics of the lock including chamber size, processing time distributions, service policy, open pass schedule, and towboat and barge dimensions. The downtime file contains a list of downtime events which control when a chamber is able to serve traffic and when is it unavailable. The run control file contains information that controls how much simulated time WAM will execute, the type of and extent of WAM output, and the random number seed passed to the model.

For the Calcasieu version of the WAM, 14 additional files are required.

- A drainage event file that describes the drainage impact level of the current velocity through the lock during open pass periods.
- A tow width definition file that defines the assumed tow width given the number and types of barges in the tow.
- Four minimum horsepower class files which describe the minimum towboat horsepower required to pass through the lock given drainage impact level and tow width.
- Four probability of reconfiguration files which describe the probability that a tow will need to reconfigure before it can pass through the lock.
- Four reconfiguration time files which describe the amount of time required to reconfigure a tow if reconfiguration is required.

The assumptions used to enumerate the values in these files are derived from an interview conducted at Calcasieu Lock on 27 July 2010. The MFR from that meeting is included as an Addendum to this attachment.

In addition to the input files, five supporting programs are used while running WAM. These five programs are: the WAM executable, the shipment list generator, a shipment list sorting program, an arrival rescheduling program, and a downtime file warm-up program. It is beyond the scope of this report to describe each of these programs in detail. Suffice it say, a great deal of file manipulation and program execution is required to make one WAM run.

2.3.2 Making a WAM Curve

It requires 1,350 executions of the WAM to create one capacity curve. Every one of these model executions, called runs, is made with a set of four fundamental input files that are slightly different from all other runs. (For the Calcasieu version, the 14 additional files remain the same from run to run.) Obviously, it would be difficult if not impossible to manually create these input files, run WAM, and gather the relevant information from the output files. Therefore, an automated graphical user interface known as the WAMBPP was developed to facilitate the process of creating input files, executing WAM, gathering pertinent data from the output files, and appending this data into various tables of a Microsoft Access database.

2.4 OUTPUT REVIEW AND ADJUSTMENT

WAM possesses the ability to produce vast quantities of output data. A user can trace every event of the modeling process if so desired. WAM gives the user full control over the amount and type of output produced.

Only two pieces of WAM output data are used when creating capacity curves, the tonnage processed during a run, and the average transit time for all tows that processed during the run. These two pieces of information, when averaged over the 50 runs made at a traffic level, define a point on a capacity curve. The curve is created by connecting these average points over the range defined by the 27 traffic levels made for each curve.

2.4.1 Outlier Removal

Periodically, WAM will produce a run where either the tonnage processed or transit time is unreasonable. These runs are known as outliers. Although outlier runs are rare, their impact on a curve can be very large.

At its most basic mathematical level, a capacity curve is defined by a set of x, y values in a 2 dimensional space. Therefore, outliers have two ways of appearing. Either a tonnage value is out of bounds or the transit time is out of bounds. Therefore, we search for outliers using two different set of bounds, one for tonnage, one for transit time.

Through years of experience and examination of data, we've found that tonnage is seldom the outlier. Tonnage varies very little from run-to-run. This makes sense. It all comes down to how many tows are in queue at the end of the year. A typical lock on the GIWW serves 10,000 or more tows per year. If there are 20 or 200 tows in queue at the end of the year, it makes little difference. Therefore, the tonnage bounds were set at plus or minus 2% of the average tonnage.

Transit time on the other hand is highly variable. Once traffic starts entering the "elbow" of a capacity curve, transit times can easily vary by 100% from run-to-run. Experience has shown that transit time outliers are always high outliers. Therefore, no low boundary was set. The upper bound was set at 300% of the average transit time.

Using these rules, the *Summary Data* tables in each lock's databases were searched for outliers. Outliers identified by the search were deleted from the table.

Section 3
DETAILED LOCK DATA

3.1 CALCASIEU LOCK

Calcasieu Lock is located approximately 238 waterway miles west of New Orleans LA on the Gulf Intracoastal Waterway. Calcasieu consists of one 1205’ x 75’ lock chamber which serves three purposes; as a navigation lock, to prevent saltwater intrusion, and as a flood way to drain the Mermanteau River Basin.

Figure A2- 10
Calcasieu Lock

The multi-purpose nature of Calcasieu Lock makes it a much more complicated lock to model than typical single purpose locks in the Corps. Whereas typical single purpose locks primarily pass traffic with “standard” lockages where a chamber is filled or emptied with the gates closed on both ends, Calcasieu passes traffic with a combination of “standard” and “open pass” lockages. Open pass lockages occur when the gates at both ends of the chamber are “open” and the vessel is allowed to “pass” through the lock without the chamber being filled or emptied.

For purposes of this modeling effort, Calcasieu is considered to be in “standard” locking mode whenever the east gage is less than 2.5 feet. The lock is considered to be in “open pass” mode whenever the east gage is greater than 2.5 feet and the west gage is lower than the east.

An additional complication is added during open pass lockages. That is, depending on the differential between the east and west gages during open pass operations, some tows may not be able to pass through the lock due to the towboat horsepower being insufficient to push through the current velocity in the chamber.

More detailed explanation regarding lock gage readings, current velocities, and tows impacted by high current velocities are provided in the next section.

3.1.1 Existing Condition Input Data

3.1.1.1 Current Velocity – Towboat Horsepower Interaction

As stated above, current velocities can become so great during open pass lockages that some tows are not able to push through the lock chamber. If this is the case the tow must either wait for the current velocity to decrease sufficiently, reconfigure the tow, or wait for a helper boat to arrive. The modeling rules that govern which tows are affected, what they do if they are affected, and the amount of time they are affected were developed during a meeting on 27 July 2010 between the lock personnel, representatives from the towing industry, and the capacity modeler. The Memo for Record from that meeting is included as an Addendum to this Attachment.

3.1.1.2 Gage Readings

As described above, the gage readings on the east and west ends of the lock determine whether the lock is in open pass or standard locking mode. Calcasieu is equipped with gages that automatically record their readings every hour. These hourly gage readings served as the basis for determining whether the lock is in open pass or standard locking mode.

Review of the gage readings revealed that these hourly readings are unreliable prior to mid-2006. This is primarily due to the damage caused by Hurricane Katrina in 2005. Therefore, only three years of gage readings are used in this draft study, 2007, 2008, and 2009. At the time this study began, 2010 data was not yet finalized.

3.1.1.3 Years Analyzed Consequences

As stated above, three years of valid gage readings were available when this study began. Since the gage readings have such a significant impact on operations at the lock, capacity curves were developed for each of those three years. This meant three open pass vs. standard locking schedules were developed, as were three velocity impact schedules and three fleets. In addition, the New Orleans District requested that capacity curves be developed assuming no velocity impacts. Therefore, a total of 6 curves were developed for each maintenance policy assumption at the lock.

3.1.1.4 Processing Times

Nine component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, multi-vessel, and open pass) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 9** shows sample set sizes, data years, and mean times for each component.

Table A2- 9
Calcasieu Processing Time Information
Single Cuts

Lock Component	Up bound Number Of Samples	Up bound Years Selected	Up bound Mean LPMS time (min)	Up bound Number of Outliers Removed	Down bound Number Of Samples	Down bound Years Selected	Down bound Mean LPMS time (min)	Down bound Number of Outliers Removed
Long Approach	17,518	00-09	18.37	0	18,390	00-09	19.71	0
Short Approach	11,399	00-09	8.32	0	12,405	00-09	8.92	0
Entry	29,825	00-09	5.60	0	31,779	00-09	5.51	0
Chambering	29,803	00-09	5.41	22	31,752	00-09	5.35	27
Long Exit	17,727	00-09	6.02	0	18,489	00-09	6.02	0
Short Exit	11,135	00-09	5.95	0	12,227	00-09	5.95	0
Turn back	9,673	00-09	5.17	1	10,605	01-09	5.19	1
Straight Multi	5,324	00-09	4.69	0	5,194	00-09	4.63	0
Open Pass	23,774	01-09	22.10	5	22,578	01-09	20.27	4

3.1.1.5 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as non-hurricane related weather events, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in Section 2.2.1.3.1.

Downtime events were grouped by type of event over the 10 year period. **Table A2-10** shows a summary of the data, and the downtimes used to make the WAM runs.

Table A2- 10
Calcasieu Historic LPMS Stalls and WAM Downtimes

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	1.0	214	0.6	208
Rain (B)	0.0	0	0.0	0
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.0	0	1.1	86
Lightning (F)	0.0	0	0	0
Surface Conditions				
Low Water (G)	0.0	0	0	0
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.1	60	0.2	60
Flood (J)	0.0	0	0.0	0
Tow Conditions				
Interference by other vessels (K)	0.4	92	0.5	97
Tow malfunction (L)	0.1	25	0.0	0
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	2.2	115	4	115
Debris (O)	0.0	0	0.0	0
Tow accident or collision (P)	1.8	76	1	83
Lock Condition				
Debris in chamber (Q)	1.1	88	0.8	69
Hardware malfunction (R)	0.3	102	0.4	93
Staff elsewhere occupied (S)	3.1	57	1.2	70
Testing / maintenance (T)	30.0	81	20.5	80
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.0	0	0.0	0
Collision / accident (W)	0.1	46	0.1	46
Vehicular / RR bridge (X)	33.8	125	33.6	128
Inspection or testing lock (Y)	5.6	55	4.3	63
Other (Z)	0.5	105	0.4	129
Average	80	99	69	106
Totals		7,964		7,338

3.1.1.6 Major Maintenance Downtimes

Major maintenance events are long duration, usually scheduled, chamber closures. These events were modeled in WAM to facilitate the analysis of the impact maintenance has on navigation traffic. **Table A2- 11** shows the Major Maintenance closure durations modeled for Calcasieu. Note the highlighted line is a long duration event caused by hurricane damage. Three days of the 10 day closure event are caused by personnel evacuation of the site and 7 days are attributable to repairs of the damage caused by the hurricane.

Table A2- 11
Calcasieu Maintenance Scenarios Analyzed

File Name Code	Work Item	Closure Time (Hours)	Closure Time (Days)	Closure Breakouts	Start in Month
69Day12-12	Rehabilitation of X Chamber Guidewall (W & E)	828	69	12-hour shifts	January
69Day12-12	Rehabilitation of XX Guidewall and Dolphin (SW & NE)	828	69	12-hour shifts	January
61Day12-12	Rehabilitation of XX Guidewall and Dolphin (SE & NW)	732	61	12-hour shifts	January
10Day24	Hurricane Closure	156	10	24-hour shifts	August
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 1st Gate	252	18	24/12-hour shifts	February
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 2nd Gate	252	18	24/12-hour shifts	April
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 3rd Gate	252	18	24/12-hour shifts	February
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 4th Gate	252	18	24/12-hour shifts	April
15Day12-12	Rewiring and machinery Rehabilitation	180	15	12-hour shifts	April
13Day12-12	Maintenance by Hired Labor Units	156	13	12-hour shifts	March
9Day12-12	Rehabilitation of Face Timber X Chamber Guidewall (W & E)	108	9	12-hour shifts	January
7Day12-12	Rehabilitation of Face Timber XX Guidewall (SE & NW)	84	7	12-hour shifts	January
5Day12-12	Rehabilitation of Face Timber XX Guidewall (SW & NE)	60	5	12-hour shifts	January

3.1.1.7 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, other commercial vessel types, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual 2007 fleet.

A typical shipment can be characterized in three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives the sequence of events during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual 2007 fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.1.1.7.1 Vessel Types

Vessels are grouped into three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, non-commercial vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 12** shows the number of vessels, by vessel type, for the 2007 Calcasieu fleet.

Table A2- 12
Calcasieu Number of Vessels by Type

Tows	13,502
Lightboats/Other	1,525
Recreation Craft	301

3.1.1.7.2 Towboat Types

Towboat classification was driven by the horsepower ranges discussed at a face-to-face meeting at Calcasieu held on July 27, 2010. **Table A2- 13** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 13
Calcasieu Towboat Types, Horsepowers, & Dimensions

TB Class	Min HP in Class	Max HP in Class	Length	Width
1	0	800	55	22
2	801	1500	62	24
3	1501	1800	76	29
4	1801	2400	78	31
5	2401	3200	103	33
6	3201	5000	121	38
7	5001	5600	130	45
8	5601	8400	147	45

3.1.1.7.3 Barge Types

3.1.1.7.3.1 Barge Classification

This section describes the methodology used to marry the 298 barge type-length-width groupings found in Calcasieu WCSC data with the 301 groupings found in LPMS. This effort results in a more manageable 12 classes which are used for capacity and economic modeling.

3.1.1.7.3.2 WCSC Data Analysis

The method began by finding the records in the 2007 WCSC Detail and Detail tables that travel through Calcasieu lock. These records were then analyzed using the Vessel field and the Master_Vessel table. This allowed us to break out Calcasieu vessels using their VTCC code, overall length, and overall breadth fields from Master_Vessel. These fields were then grouped to come up with the 298 unique barge type-length-width combinations found at Calcasieu. Within the 298 combinations there are 12 unique barge types, 152 unique lengths, and 61 unique widths.

3.1.1.7.3.3 LPMS Data

Compared to WCSC, LPMS uses vastly different coding techniques to represent barge types and dimensions. This leads to a need for reconciliation between the databases before classification can begin.

3.1.1.7.3.4 Need for Data Reconciliation

LPMS uses a different vessel typing classification than WCSC. Therefore, the vessel types shown in each data set must be reconciled.

LPMS also uses a different barge length and width classification system. WCSC data provides barge dimensions in feet, down to the tenth of a foot in some cases. LPMS uses a system of “codes” to represent “ranges” of feet. For example, barge width code “B” represents a width of 28 to 36 feet. Therefore a barge shown as 35 feet wide in WCSC is represented in LPMS as width “B”.

3.1.1.7.3.5 Reconciliation Table

Table A2- 14 shows an example from the table used to reconcile the differences between WCSC and LPMS. As you can see, each WCSC VTCC vessel code has an assigned LPMS barge type code(s). The same goes for lengths and widths.

This table began with a make-table query that selected the VTTC Code, Overall Length and Overall Width information for every movement in the Detail and Detail tables that move through Calcasieu in 2007. Then a Common Name field was added and the LPMS fields were added using a series of update queries.

Table A2- 14
WCSC–LPMS Barge type-length-width Reconciliation

WCSC Common	WCSC VTCC Code	WCSC Length	WCSC Width	LPMS Type	LPMS Length	LPMS Width
Tanker Double Hull	5A71	195	35	H Or L	D	B
Tanker Double Hull	5A71	200	35	H Or L	E	B
Tanker Double Hull	5A71	195	35	H Or L	D	B
Tanker Double Hull	5A71	195	35	H Or L	D	B
Tanker Double Hull	5A71	297.5	54	H Or L	G	E
Tanker Double Hull	5A71	297.5	54	H Or L	G	E
Tanker Other	5A74	297.5	54	H Or L	G	E
Tanker Double Hull	5A71	297	54	H Or L	G	E
Tanker Double Hull	5A71	195.1	35	H Or L	D	B
Tanker Double Hull	5A71	195.1	35	H Or L	D	B
Tanker Double Hull	5A71	195.1	35	H Or L	D	B
Tanker Other	5A74	297.5	54	H Or L	G	E
Tanker Double Hull	5A71	297.5	54	H Or L	G	E
Tanker Double Hull	5A71	200	54	H Or L	E	E
Tanker Single Hull	5A70	298	50	H Or L	G	E
Tanker Single Hull	5A70	298	50	H Or L	G	E
Tanker Single Hull	5A70	298	50	H Or L	G	E

3.1.1.7.3.6 Barge Classification

Final barge classification was accomplished using queries and visual inspection. A query was created using the 2007 Detail and Detail records that moved through Calcasieu. That table was linked to the Master_Vessel table to get the VTCC number of each vessel. The VTCC number was then linked to the VTCC code shown in the Reconciliation table. The result was a table which is partially shown in **Table A2- 15.**

Table A2- 15
WCSC Vessel Summary Using LPMS Codes

LPMS Type	LPMS Length	LengthRange	LPMS Width	WidthRange	Count	Percentage of All
H Or L	G	290-300 ft	E	50-54 ft	9140	31.9%
H Or L	D	195-199 ft	B	28-36 ft	4501	15.7%
C	E	200-259 ft	B	28-36 ft	3395	11.8%
H Or L	E	200-259 ft	B	28-36 ft	1679	5.9%
O	D	195-199 ft	B	28-36 ft	1326	4.6%
C	D	195-199 ft	B	28-36 ft	1222	4.3%
O	E	200-259 ft	B	28-36 ft	1209	4.2%
H Or L	E	200-259 ft	E	50-54 ft	942	3.3%
H Or L	E	200-259 ft	D	42-49 ft	667	2.3%
F	D	195-199 ft	B	28-36 ft	614	2.1%
F	E	200-259 ft	C	37-41 ft	565	2.0%
H Or L	C	175-194 ft	E	50-54 ft	493	1.7%
H Or L	F	260-289 ft	E	50-54 ft	456	1.6%
F	E	200-259 ft	B	28-36 ft	436	1.5%
H Or L	B	100-174 ft	E	50-54 ft	423	1.5%
H Or L	H	Over 300 ft	E	50-54 ft	310	1.1%
H Or L	G	290-300 ft	F	Over 54 ft	208	0.7%
H Or L	H	Over 300 ft	F	Over 54 ft	128	0.4%
F	B	100-174 ft	B	28-36 ft	110	0.4%
H Or L	D	195-199 ft	E	50-54 ft	106	0.4%
H Or L	C	175-194 ft	D	42-49 ft	98	0.3%
H Or L	B	100-174 ft	B	28-36 ft	94	0.3%
H Or L	D	195-199 ft	D	42-49 ft	86	0.3%
F	B	100-174 ft	D	42-49 ft	69	0.2%

Table A2- 15 above shows almost a third of vessels are 300x54 Tankers. Likewise 195x35 tankers are also a common barge through Calcasieu.

A table similar to **Table A2- 15** was visually examined to produce the final barge classification criteria.

Considerable visual inspection was performed before a preliminary classification system was finalized. The following should be considered "one possible" classification system. It is open to revision.

3.1.1.7.3.7 Barge Types

The first decision was to have only two general barge type descriptors, Tankers and Non-Tankers. All VTCC codes in WCSC beginning in "5" are classified as Tankers, as are barge types H or L in LPMS. All other VTCC or barge type codes are classified as Non-Tankers. So the first step was to start at the top of **Table A2- 15** and classify each record as Tanker or Non-Tanker.

3.1.1.7.3.8 Barge Sizes

The next step involved visually scanning the data in **Table A2- 15** to determine how many classes should be dedicated to tankers versus non-tankers. This was done by listing the various tanker dimensions shown in the top half of the table and then looking for opportunities to consolidate two or more dimensions into one representative group. This process resulted in 7 Tanker classes.

The same process was applied to Non-Tankers, which resulted in 3 Non-Tanker classes.

Two classes were created for anything that didn't fit into the previously defined class definitions, one for Tankers – All Others and one for Non-Tankers – All Others.

3.1.1.7.3.9 Barge Classes with Specifications

Table A2- 16 shows the 12 barge classes created using this process, the class names, and dimensions used during economic modeling.

In addition, it also shows the codes and dimension ranges used by the model coders to convert WCSC and LPMS data into the model classes.

Table A2- 16
Barge Classification Specifications

Econ Modeling Barge Class	WCSC Average Loading	Econ Modeling Barge Type	WCSC VTCC Code	LPMS Barge Type	Econ Modeling Length	Min WCSC Length	Max WCSC Length	LPMS Length	Econ Modeling Width	Min WCSC Width	Max WCSC Width	LPMS Width
1	1,576	Tanker 150x54	5	H or L	150	100	174	B	54	50	54	E
2	1,368	Tanker 200x35	5	H or L	200	195	200	D	35	28	36	B
3	1,555	Tanker 214x42	5	H or L	214	201	259	E	42	42	49	D
								C				D
4	2,152	Tanker 200x54	5	H or L	200	195	200	E	54	50	54	E
5	2,220	Tanker 264x54	5	H or L	264	260	289	F	54	50	54	E
6	3,249	Tanker 300x54	5	H or L	300	290	300	G	54	50	54	E
								G				F
7	3,351	Tanker 380x54	5	H or L	380	300	1200	H	54	50	54	E
								H				F
8	685	Non-Tanker 150x35	4	Not H or L	150	100	174	B	35	28	36	B
9	1,550	Non-tanker 200x35	4	Not H or L	200	195	200	D	35	28	36	B
								E				B
10	1,576	Non-Tanker 200x40	4	Not H or L	200	195	200	E	40	37	41	C
11	144	Tankers - All Others	5	H or L								
12	1,462	Non-Tankers - All Others	4	Not H or L								

3.1.1.7.4 Arrival Variation

Temporal variations in traffic demand were accounted for by allowing the arrivals to vary by month of year, day of week, and hour of day for tows, light boats, recreation craft, and other vessels.

3.1.2 Existing Condition Calibration and Validation

3.1.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3.4.

Table A2- 17 thru **Table A2- 19** shows the statistics used when calibrating the three shipment lists used in this study. The target values for tons/loaded barge were taken directly from WCSC data because WCSC data is more accurate than LPMS for this statistic. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data because LPMS is more accurate than WCSC for this statistic. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the averages of five different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 2% of the Target values for all overall statistics.

Table A2- 17
Calcasieu Shipment List Calibration 2007 Fleet

Calcasieu		100% yr 2007	
	Target	WAM Runs	% Difference
Tons (calc)	46,320	46,208	-0.24%
Up	22,673	22,488	-0.81%
Down	23,647	23,720	0.31%
Tows (LPMS)	13,502	13,271	-1.71%
Up	6,758	6,586	-2.55%
Down	6,744	6,685	-0.87%
Tons/Tow (calc)	3,431	3,482	1.50%
Up	3,355	3,415	1.78%
Down	3,506	3,548	1.19%
Barges (calc)	36,257	36,118	-0.38%
Up	18,154	17,899	-1.40%
Down	18,103	18,219	0.64%
Loaded Barges (LPMS)	21,763	21,708	-0.25%
Up	10,010	9,925	-0.85%
Down	11,753	11,783	0.25%
Empty Barges (LPMS)	14,494	14,410	-0.58%
Up	8,144	7,974	-2.09%
Down	6,350	6,436	1.35%
Percent Empty (calc)	40.0%	39.9%	-0.2%
Up	44.9%	44.5%	-0.7%
Down	35.1%	35.3%	0.7%
Tons/Loaded Barge (WC)	2,128	2,129	0.01%
Up	2,265	2,266	0.03%
Down	2,012	2,013	0.05%
Barges/Tow	2.69	2.72	1.35%
Up	2.69	2.72	1.18%
Down	2.68	2.73	1.53%
Rec/Other	301	301	0.00%
Up	147	159	7.89%
Dn	154	142	-7.53%
Light Boat	1,525	1,525	0.01%
Up	811	767	-5.40%
Dn	714	758	6.16%

Table A2- 18
Calcasieu Shipment List Calibration 2008 Fleet

Calcasieu		100% yr 2008	
	Target	**WAM Runs**	**% Difference**
Tons (calc)	41,976	41,992	0.04%
Up	20,131	20,121	-0.05%
Down	21,845	21,871	0.12%
Tows (LPMS)	12,292	12,266	-0.21%
Up	6,150	6,124	-0.43%
Down	6,142	6,143	0.01%
Tons/Tow (calc)	3,415	3,423	0.25%
Up	3,273	3,286	0.38%
Down	3,557	3,561	0.12%
Barges (calc)	32,412	32,355	-0.18%
Up	16,238	16,110	-0.79%
Down	16,174	16,244	0.44%
Loaded Barges (LPMS)	19,780	19,742	-0.19%
Up	8,955	8,909	-0.52%
Down	10,825	10,833	0.07%
Empty Barges (LPMS)	12,632	12,613	-0.15%
Up	7,283	7,202	-1.12%
Down	5,349	5,411	1.17%
Percent Empty (calc)	39.0%	39.0%	0.0%
Up	44.9%	44.7%	-0.3%
Down	33.1%	33.3%	0.7%
Tons/Loaded Barge (WC)	2,122	2,127	0.23%
Up	2,248	2,259	0.47%
Down	2,018	2,019	0.05%
Barges/Tow	2.64	2.64	0.03%
Up	2.64	2.63	-0.36%
Down	2.63	2.64	0.43%
Rec/Other	252	252	0.00%
Up	141	119	-15.74%
Dn	111	133	20.00%
Light Boat	1,630	1,630	0.02%
Up	828	815	-1.62%
Dn	802	816	1.72%

Table A2- 19
Calcasieu Shipment List Calibration 2009 Fleet

Calcasieu		100% yr 2009	
	Target	WAM Runs	% Difference
Tons (calc)	36,539	36,309	-0.63%
Up	18,283	18,127	-0.85%
Down	18,257	18,181	-0.41%
Tows (LPMS)	11,207	11,165	-0.37%
Up	5,622	5,541	-1.44%
Down	5,585	5,624	0.70%
Tons/Tow (calc)	3,260	3,252	-0.25%
Up	3,252	3,272	0.61%
Down	3,269	3,233	-1.10%
Barges (calc)	26,609	26,539	-0.26%
Up	13,342	13,209	-1.00%
Down	13,267	13,330	0.47%
Loaded Barges (LPMS)	15,708	15,607	-0.64%
Up	7,583	7,519	-0.85%
Down	8,125	8,088	-0.45%
Empty Barges (LPMS)	10,901	10,932	0.28%
Up	5,759	5,690	-1.19%
Down	5,142	5,241	1.93%
Percent Empty (calc)	41.0%	41.2%	0.5%
Up	43.2%	43.1%	-0.2%
Down	38.8%	39.3%	1.5%
Tons/Loaded Barge (WC)	2,326	2,326	0.01%
Up	2,411	2,411	0.00%
Down	2,247	2,248	0.04%
Barges/Tow	2.37	2.38	0.12%
Up	2.37	2.38	0.46%
Down	2.38	2.37	-0.22%
Rec/Other	249	249	0.00%
Up	108	129	19.26%
Dn	141	120	-14.75%
Light Boat	1,468	1,468	0.00%
Up	683	738	8.08%
Dn	785	730	-7.03%

3.1.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate the results produced by WAM. Validation ensures WAM results reasonably reproduce actual base year operational characteristics, processing times, and delay times. The validation process for Calcasieu Lock consists of three steps. First the lockage type operations must be validated. Second, lock processing times must be validated for open pass and standard locking processes. Third, delay times must be validated. In addition, the three validation steps must be performed for each of the three years of drainage events used to create an overall traffic – transit time curve.

3.1.2.2.1 Lockage Type Validation

This validation step is required for Calcasieu Lock for each of the years 2007-2009. Validation is required for each year because each year has its own drainage schedule caused by varying wet and dry periods during each year.

Validation for this step is performed by ensuring the proportion of historic lockages using “open pass” versus “standard” lockage processes reasonably matches that proportion estimated by WAM. For definitional purposes, open pass lockages occur when the gates on both ends of the lock are open and vessels are able to pass through the lock without waiting for the lock to fill or empty. Standard lockages occur when the gates on the exiting end of the chamber are closed when the vessel enters the chamber. When the vessel has fully entered the chamber, the gates behind it are closed and the gates ahead of it are opened to allow the chamber to fill or empty to the level at the exiting end of the chamber. At that time the gates on the exiting end of the chamber are opened fully and the vessel(s) are allowed to proceed.

The following table shows the modeled proportions for each year closely approximate the historic proportions measured at the lock.

Table A2- 20
Calcasieu Lockage Type Validation

	Proportion of Lockages Expressed as Percentage			
	Historic Lockages		WAM Lockages	
Year	Open Pass	Standard	Open Pass	Standard
2007	38.9%	61.1%	40.2%	59.8%
2008	39.6%	60.4%	38.8%	61.2%
2009	38.0%	62.0%	37.7%	62.3%

3.1.2.2.2 Processing Time Validation

The next step is to validate the tow processing times at the lock. This is performed for both standard and open pass lockages for the years 2007-2009. The following table shows the modeled processing times vary somewhat from the historic times on a yearly basis. However, when averaged over the three years, the modeled times closely approximate the times measured at the lock.

Table A2- 21
Calcasieu Processing Time Validation

	Historic Processing Times		WAM Processing Times	
Year	Open Pass	Standard	Open Pass	Standard
2007	23.8	34.0	24.3	35.3
2008	24.4	36.3	24.5	35.0
2009	25.3	37.2	24.9	34.6
Ave	24.5	35.8	24.6	35.0

4.1.2.2.3 Delay Time Validation

The final validation step is to validate the delay times predicted by the model against the delay times measured at the lock. The WAM results shown below are the result of 50 WAM runs at the traffic levels shown in the shipment list calibration section above using a 6 Up – 6 Down lockage policy. The results shown below also use the historic lock closures experienced each year. The following table compares the modeled delays with the measured delays for 2007, 2008, and 2009.

Table A2- 22
Calcasieu Delay Time Validation

		WAM Delay Times	
Year	Historic Delay Times	Average	Std Dev
2007	86.8	166.0	17.8
2008	67.3	99.2	7.4
2009	57.9	70.1	4.6
Ave	70.7	111.8	9.9
* WAM Delays using 6U-6D and 50 iterations			

One can see the historic delay times vary considerably from year to year, as do the WAM estimated delay times. In addition, the average historic delay for the three years is about 37% lower than the average delay estimated by WAM.

A number of factors influence delays at a lock. In the case of Calcasieu the most important factors include the level of traffic demand, lock closure durations, and the percent of open pass versus standard lockages in concert with processing time differences between open pass and standard lockages.

Table A2- 23
Summary of Factors Influencing Delay

Year	Tow Demand	Closures (Days)	Historic Proc Time (min)	WAM Proc Time (min)	Historic Delay (min)	WAM Delay (min)
2007	13,287	16.7	30.0	28.3	86.8	166.0
2008	12,258	10.1	31.6	28.6	67.2	99.2
2009	11,145	4.1	32.7	29.3	57.9	70.1
* Weighted Processing Time of Open Pass and Standard Lockages						

One can see from **Table A2- 23** above that the number of tows passing through Calcasieu decreased significantly, about 17%, from 2007 to 2009. This traffic decrease usually leads to decreased delays if taken in isolation.

One can also see from **Table A2- 23** that the number of days the lock was closed decreased dramatically from 2007 to 2009. Again this decrease in closure days normally leads to decreased delays if taken in isolation.

Table A2- 23 shows weighted historic processing times increased somewhat from 2007 to 2009 while weighted WAM processing times remained constant. Based on **Table A2- 23** these results are reasonable.

Putting these observations together one expects delays to decrease from 2007 to 2008 and from 2008 to 2009. That is exactly what we see with both the historic data and WAM results.

3.1.3 Existing Conditions Analyzed

This section presents the results of the WAM traffic-transit curves produced for Calcasieu Lock. **Table A2- 24** shows a summary of all the curves produced by WAM.

Table A2- 24
Summary of Calcasieu Conditions Analyzed

	With Drainage Impacts			Without Drainage Impacts		
Closure Scenario	2007	2008	2009	2007	2008	2009
Full Operation	X	X	X	X	X	X
69 Day 12-12	X	X	X	X	X	X
61 Day 12-12	X	X	X	X	X	X
10 Day Total Closure	X	X	X	X	X	X
18 Day 24/12-12	X	X	X	X	X	X
15 Day 12-12	X	X	X	X	X	X
13 Day 12-12	X	X	X	X	X	X
9 Day 12-12	X	X	X	X	X	X
7 Day 12-12	X	X	X	X	X	X
5 Day 12-12	X	X	X	X	X	X

A short description of each closure scenario follows:

1. The Full Operation scenario is a scenario where no major maintenance events occur. Random minor closure events such as minor weather related events, minor maintenance events, and other minor closures do occur in this scenario.
2. The 69 Day 12-12 scenario is a scenario where for 69 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
3. The 61 Day 12-12 scenario is a scenario where for 61 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
4. The 10 day total scenario is a scenario where the lock is closed 24 hours per day for 10 continuous days
5. The 18 day 24/12-12 closure scenario is a scenario where the lock is closed for 24 per day for 3 days and then operates 12 hours closed 12 hours open for 15 days.
6. The 15 Day 12-12 scenario is a scenario where for 15 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
7. The 13 Day 12-12 scenario is a scenario where for 13 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
8. The 9 Day 12-12 scenario is a scenario where for 9 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
9. The 7 Day 12-12 scenario is a scenario where for 7 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.
10. The 5 Day 12-12 scenario is a scenario where for 5 days the lock is in a 12 hours open 12 hours closed condition. The random minor events included in the full operation scenario also occur.

These closure scenarios were selected to fulfill the need to model all the major maintenance events shown in Section 3.1.1.6.

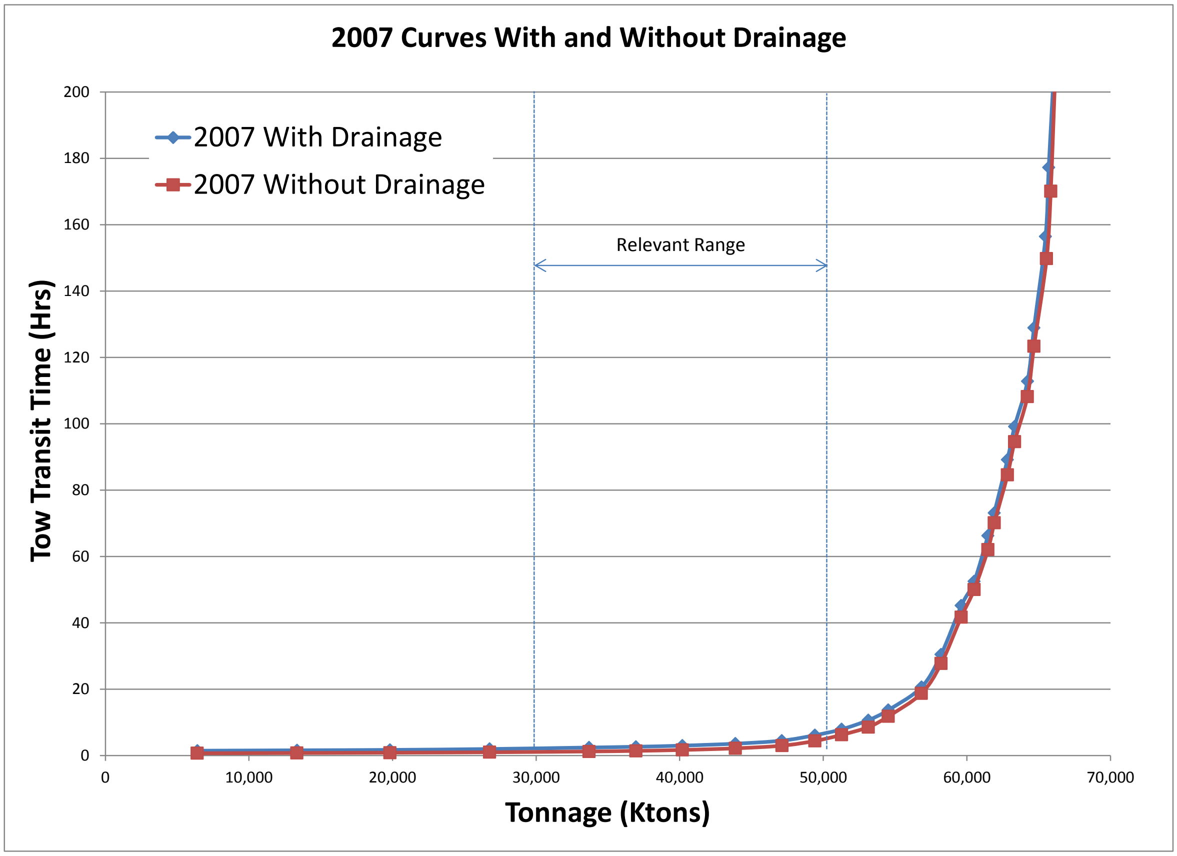
3.1.3.1 Existing Project Results

3.1.3.1.1 Full Operation Capacity Curves

Figure A2- 11 shows the tonnage transit-time curves (aka capacity curves) and other information for Calcasieu Lock, Existing Condition, Full Operation scenario, using the 2007 fleet and open pass schedule. One curve assumes there are no drainage impacts during the simulation; the other assumes the historic 2007 drainage impacts. These two curves are shown together to illustrate the effect drainage events have on lock operations.

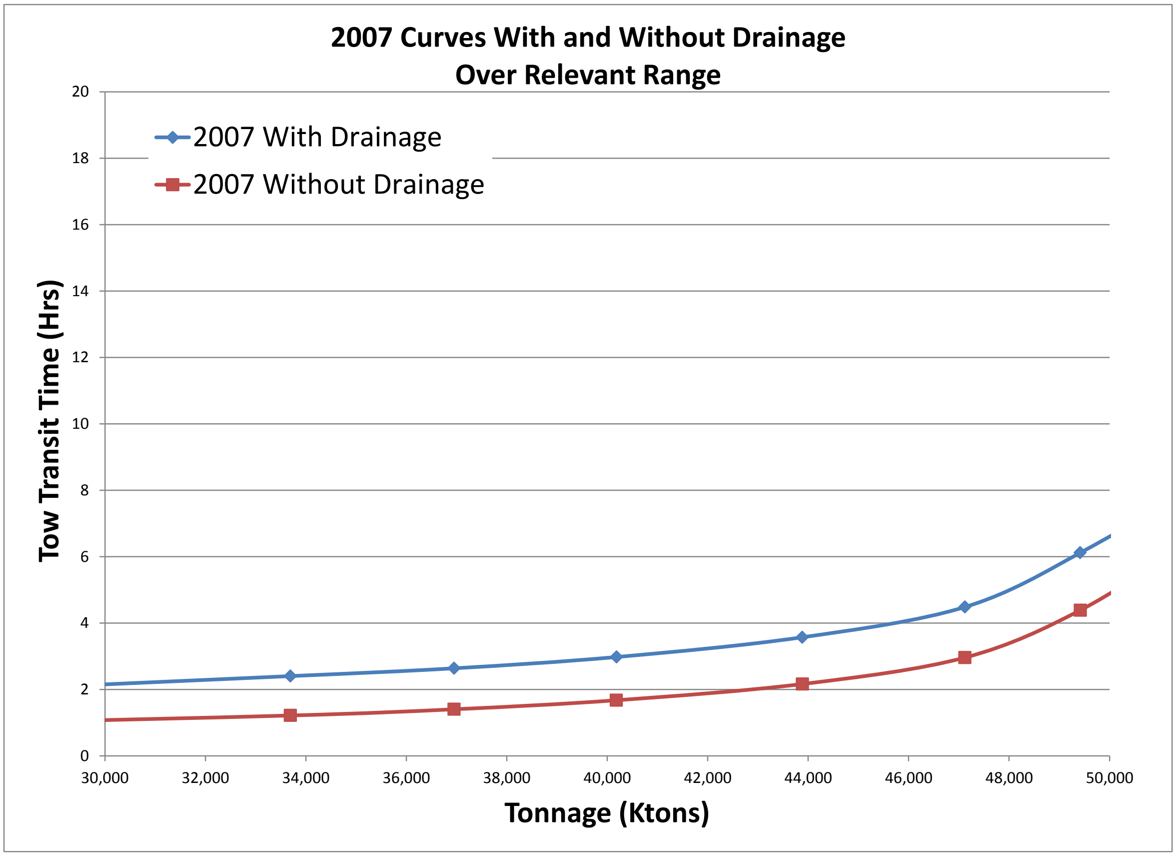
Figure A2- 11 also shows the relevant range of traffic demand. This is the range of tonnage projected to use Calcasieu over the study period. The economic model uses this range of the curve when processing traffic at Calcasieu.

Figure A2- 11
Calcasieu 2007 Full Operation Capacity Curves



In order to more clearly show the effect of drainage at Calcasieu, **Figure A2- 12** shows the same data as the previous figure but it focuses on only the relevant range of the curves. One can see from this more focused figure that drainage events, as they occurred in 2007, increase the expected transit-time by about 75%.

Figure A2- 12
Calcasieu 2007 Full Op Relevant Range Capacity Curves



The next two Figures show full operation capacity curves using the 2008 and 2009 fleets and open pass schedules with and without drainage impacts. A third chart is shown which averages the 2007, 2008, and 2009 curves. It is these curves that are used as input by the GULFNIM economic model. Only the relevant ranges are shown in these charts so the reader can be more focused on the range of traffic used by the GULFNIM economic model.

Figure A2- 13
Calcasieu 2008 Full Op Relevant Range Capacity Curves

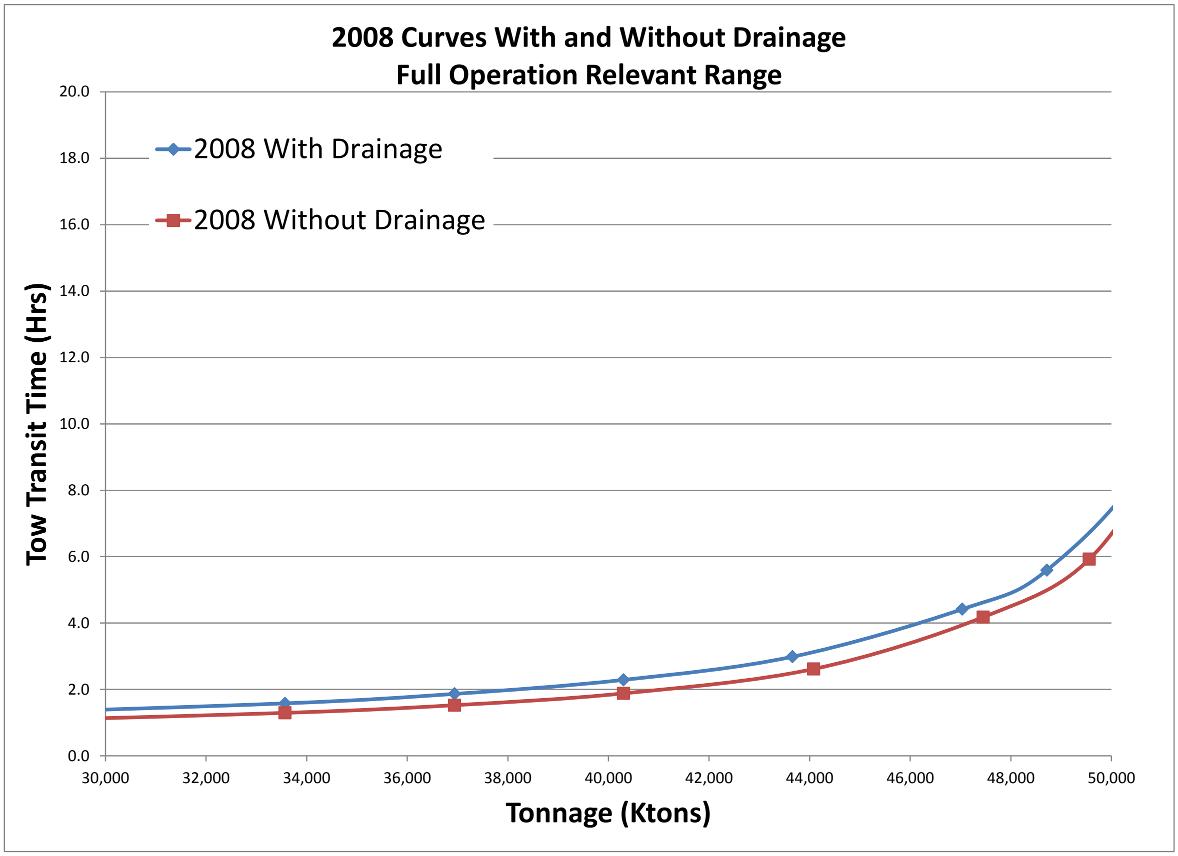


Figure A2- 14
Calcasieu 2009 Full Op Relevant Range Capacity Curves

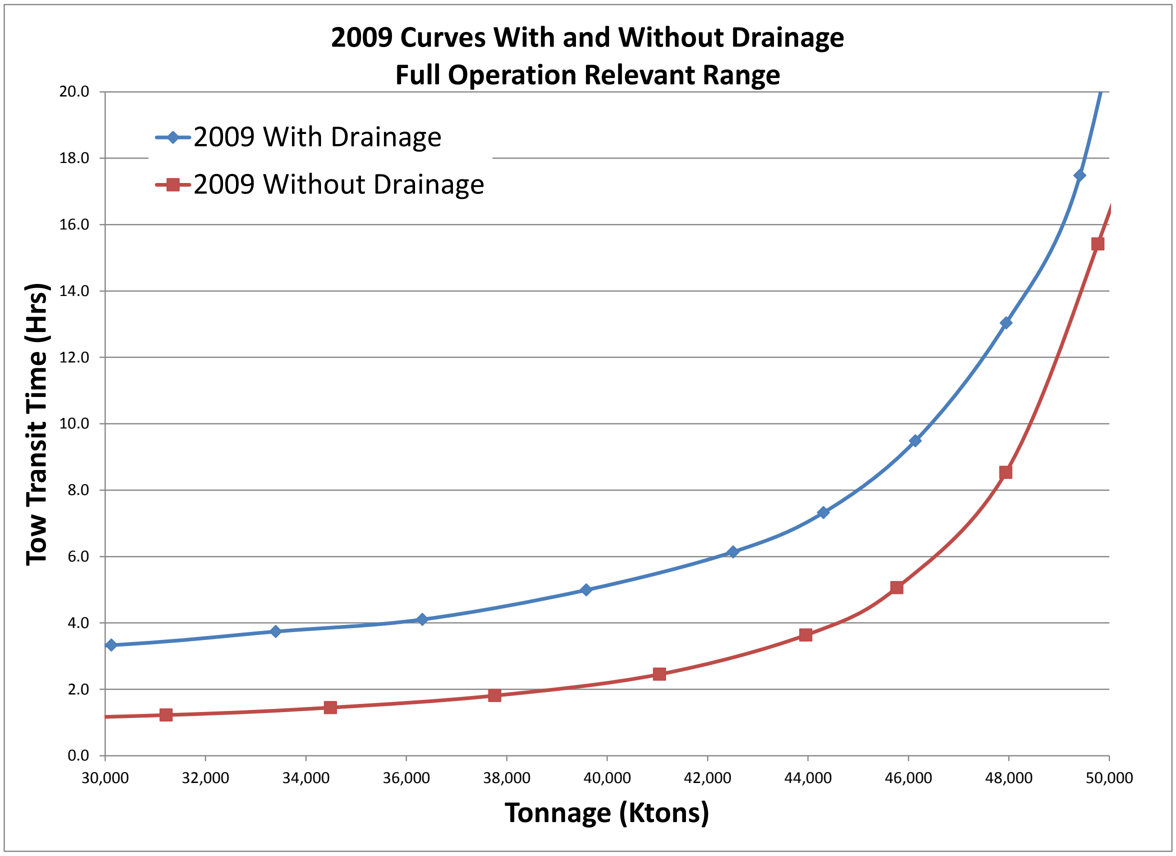
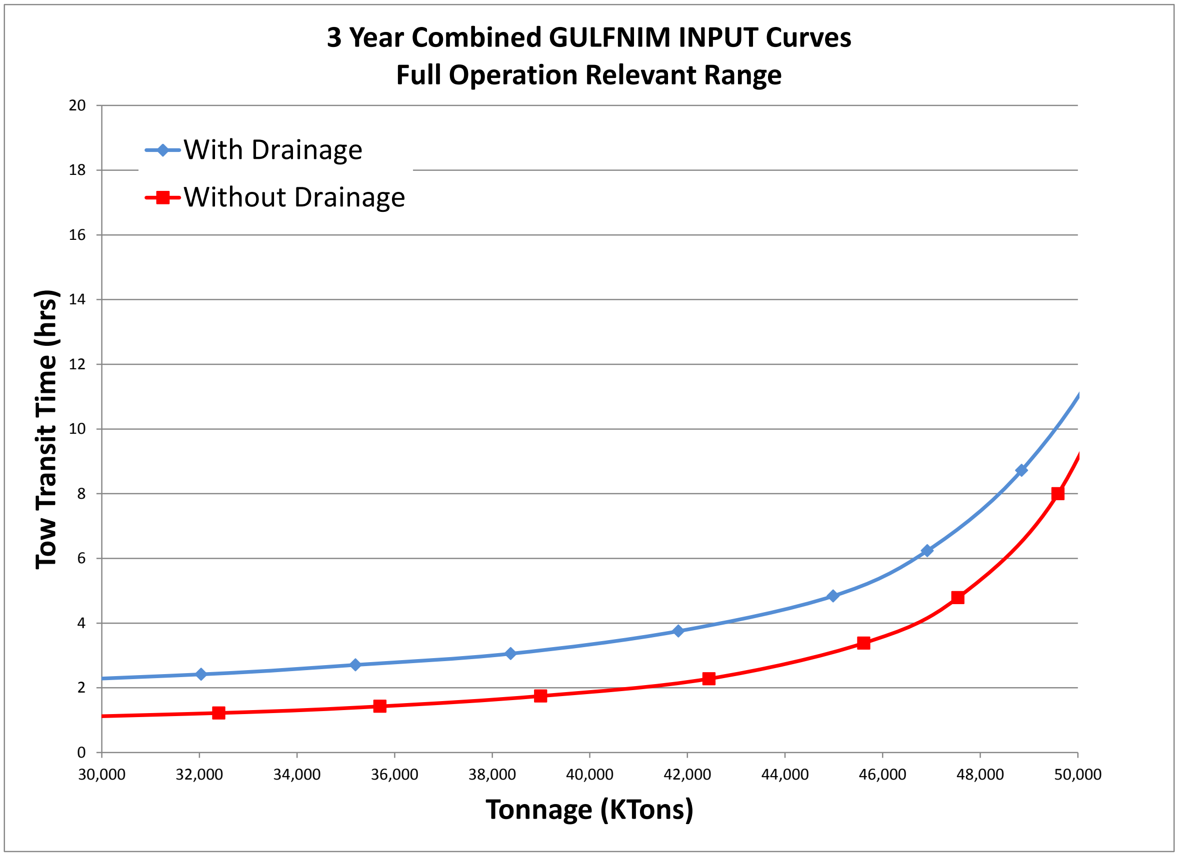


Figure A2- 15
Calcasieu GULFNIM Full Op Relevant Range Capacity Curves



3.1.3.1.2 Existing Condition Full Operations Observations

This section is provided to help interpret the results of the Existing Condition Full Operations curves shown in the previous section.

First, let's consider the without drainage curves for the individual years. Comparing **Figure A2- 12**, **Figure A2- 13**, and **Figure A2- 14** one can see the transit times at 50,000 KTons increase as one moves from 2007 to 2008 to 2009. Since drainage effects are not considered in these curves, the increase is not caused by drainage effects. One factor affecting these curves is the proportion of lockages made in open pass versus standard lockages. Open pass lockages require less time to accomplish than standard lockages (see **Table A2- 21**). This means that as the proportion of open pass lockages decrease, processing time increases resulting in increased delay and transit time. **Table A2- 20** shows that indeed, the proportion of open pass lockages decreases as one moves from 2007 to 2008 to 2009. In addition to processing time increases, **Table A2- 17**, **Table A2- 18**, and **Table A2- 19** shows tons per tow decreases as one moves from 2007 to 2008 and 2009. This means that it takes more tows to move the same amount of cargo. More tows mean higher delays to move the same amount of traffic. The conclusion of these observations is that the increased transit time is plausible and entirely explainable.

Second, let's consider the difference between the "with" and "without" drainage curves for the three years shown. At the low end of the relevant range there is about a 1.2

hour difference in 2007, a 0.3 hour difference in 2008, and a 2.1 hour difference in 2009. This substantial difference in drainage effects are explainable only by looking at the proportion of time spent at each drainage impact level. Consider Table A2- 25.

Table A2- 25
Drainage Impact Level Analysis

Drainage Impact Level	2007 Days Duration (%)	2008 Days Duration (%)	2009 Days Duration (%)
0	81.4%	89.8%	73.7%
1	4.0%	3.4%	4.5%
2	10.0%	4.2%	15.2%
3	4.3%	2.0%	6.5%
4	0.3%	0.6%	0.2%

Table A2- 25 shows the percent of time spent at each drainage impact level. Level 0 means no drainage impact and all tows are able to pass through Calcasieu during open pass without being impacted. As the drainage impact level increases, the number of tows impacted also increases until at Level 4 essentially all traffic is stopped.

Cursory review of **Table A2- 25** supports the difference in drainage effects reflected in **Figure A2- 12**, **Figure A2- 13**, and **Figure A2- 14**. That is, the very small drainage effect shown in 2007 is supported by the fact that almost 90% of the time the drainage level is at 0. Conversely the large drainage impact shown in 2010 is supported by the fact that the impact level is a 0 only about 74% of the time and is at level 2 or 3 almost 22% of the time. Again, the conclusion of these observations is that the substantial difference in drainage effects is plausible and entirely explainable.

3.1.3.1.2.1 Various Maintenance Closure Capacity Curves

This section presents the tonnage transit-time curves required by the GULFNIM model to evaluate the effect of various maintenance activities projected to occur during the period of analysis. The curves evaluated and presented here are based off a spreadsheet prepared by New Orleans District Operations personnel. That spreadsheet is shown as **Table A2- 11.** A summarized version of that spreadsheet is repeated here for the reader's convenience as **Table A2- 26**. A full explanation of the maintenance events shown here is available in the Engineering Appendix to this report. For simplicities sake only the 3 year average curves are presented in this section.

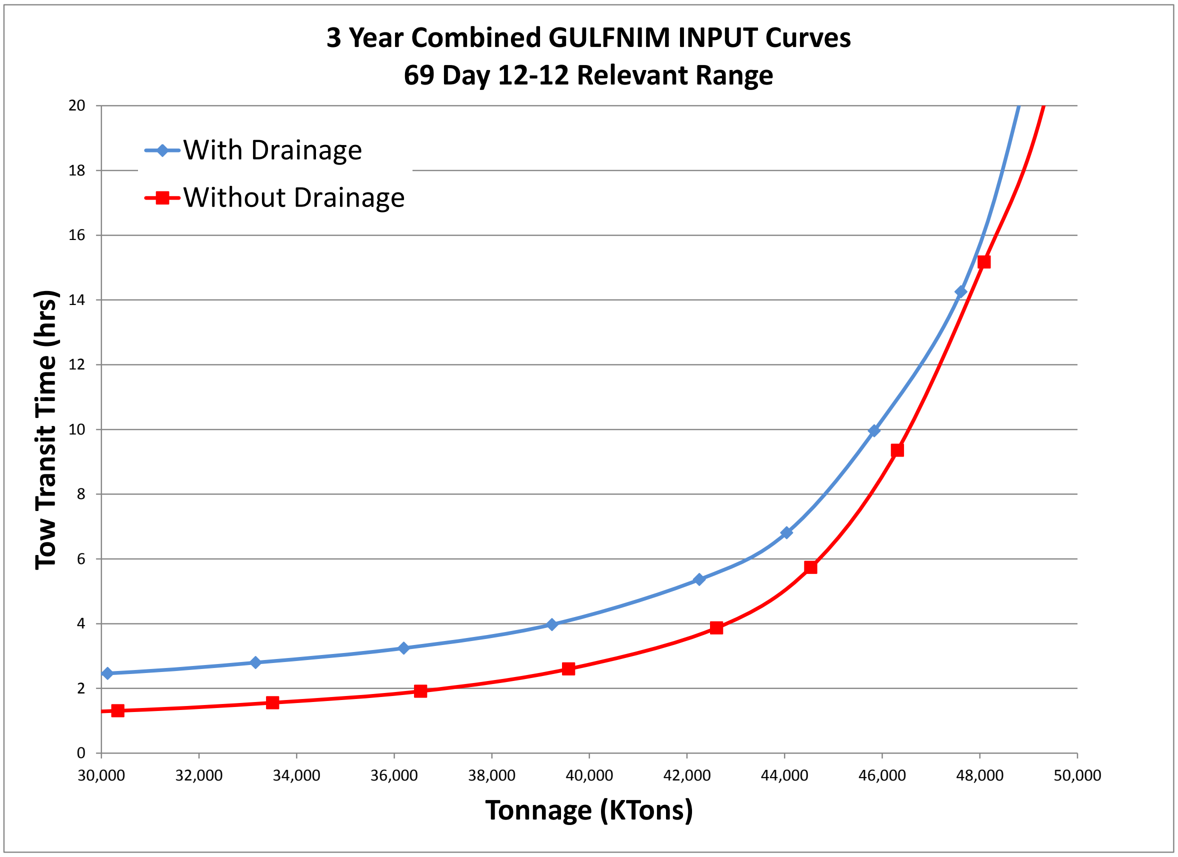
Table A2- 26
Calcasieu Maintenance Scenarios Analyzed

File Name Code	Work Item	Closure Time (Hours)	Closure Time (Days)	Closure Breakouts	Start in Month
69Day12-12	Rehabilitation of X Chamber Guidewall (W & E)	828	69	12-hour shifts	January
69Day12-12	Rehabilitation of XX Guidewall and Dolphin (SW & NE)	828	69	12-hour shifts	January
61Day12-12	Rehabilitation of XX Guidewall and Dolphin (SE & NW)	732	61	12-hour shifts	January
10Day24	Hurricane Closure	156	10	24-hour shifts	August
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 1st Gate	252	18	24/12-hour shifts	February
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 2nd Gate	252	18	24/12-hour shifts	April
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 3rd Gate	252	18	24/12-hour shifts	February
18Day24/12-12	Dewatering & Monitoring / Major Repairs / 4th Gate	252	18	24/12-hour shifts	April
15Day12-12	Rewiring and machinery Rehabilitation	180	15	12-hour shifts	April
13Day12-12	Maintenance by Hired Labor Units	156	13	12-hour shifts	March
9Day12-12	Rehabilitation of Face Timber X Chamber Guidewall (W & E)	108	9	12-hour shifts	January
7Day12-12	Rehabilitation of Face Timber XX Guidewall (SE & NW)	84	7	12-hour shifts	January
5Day12-12	Rehabilitation of Face Timber XX Guidewall (SW & NE)	60	5	12-hour shifts	January

3.1.3.1.2.2 69 Day 12-Hour Shift Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day from 7 AM to 7 PM. The closures begin on January 1 and run for 69 continuous days. This schedule was developed to match the SW and NE guidewall and dolphin repair schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 12 hour closure so they arrive while the chamber is open.

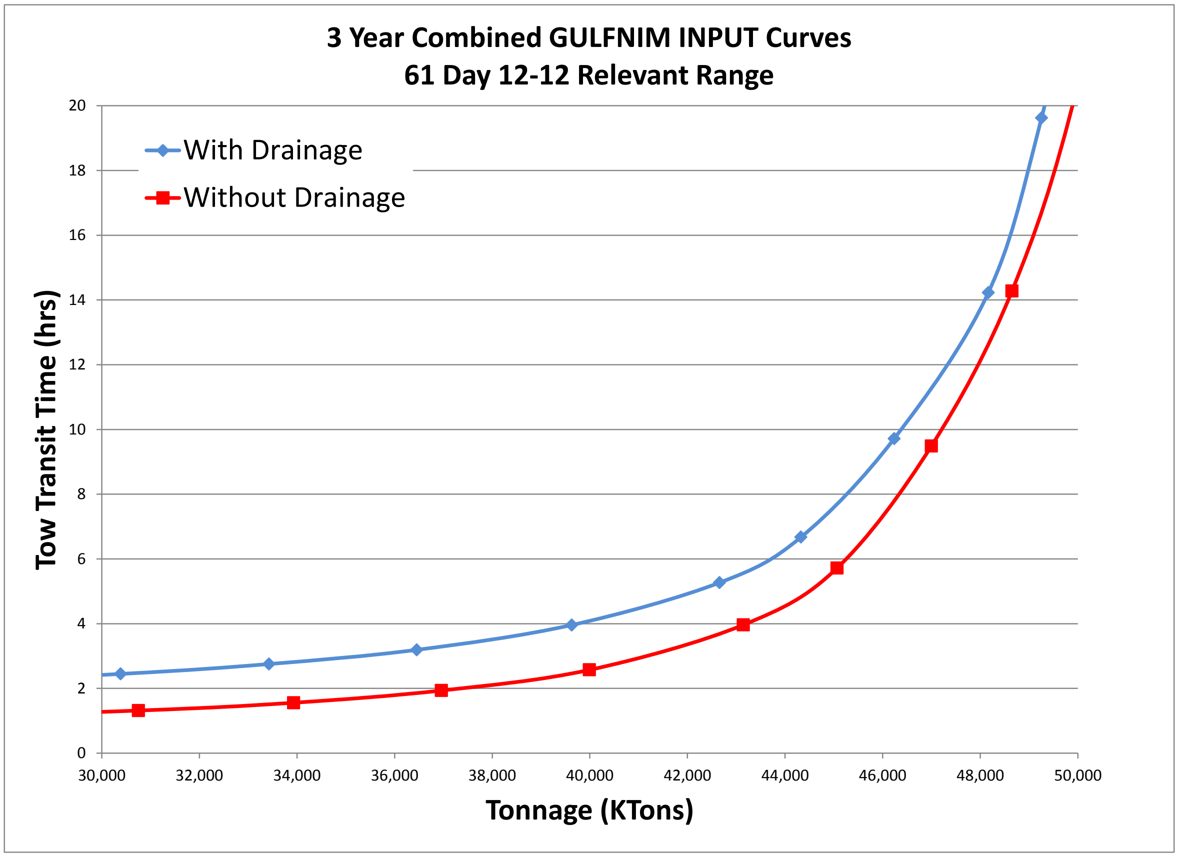
Figure A2- 16
3 Year Combined 69 Day 12 Hour Closures



3.1.3.1.2.3 61 Day 12-Hour Shift Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day from 7 AM to 7 PM. The closures begin on January 1 and run for 61 continuous days. This schedule was developed to match the SE and NW guidewall and dolphin repair schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 12 hour closure so they arrive while the chamber is open.

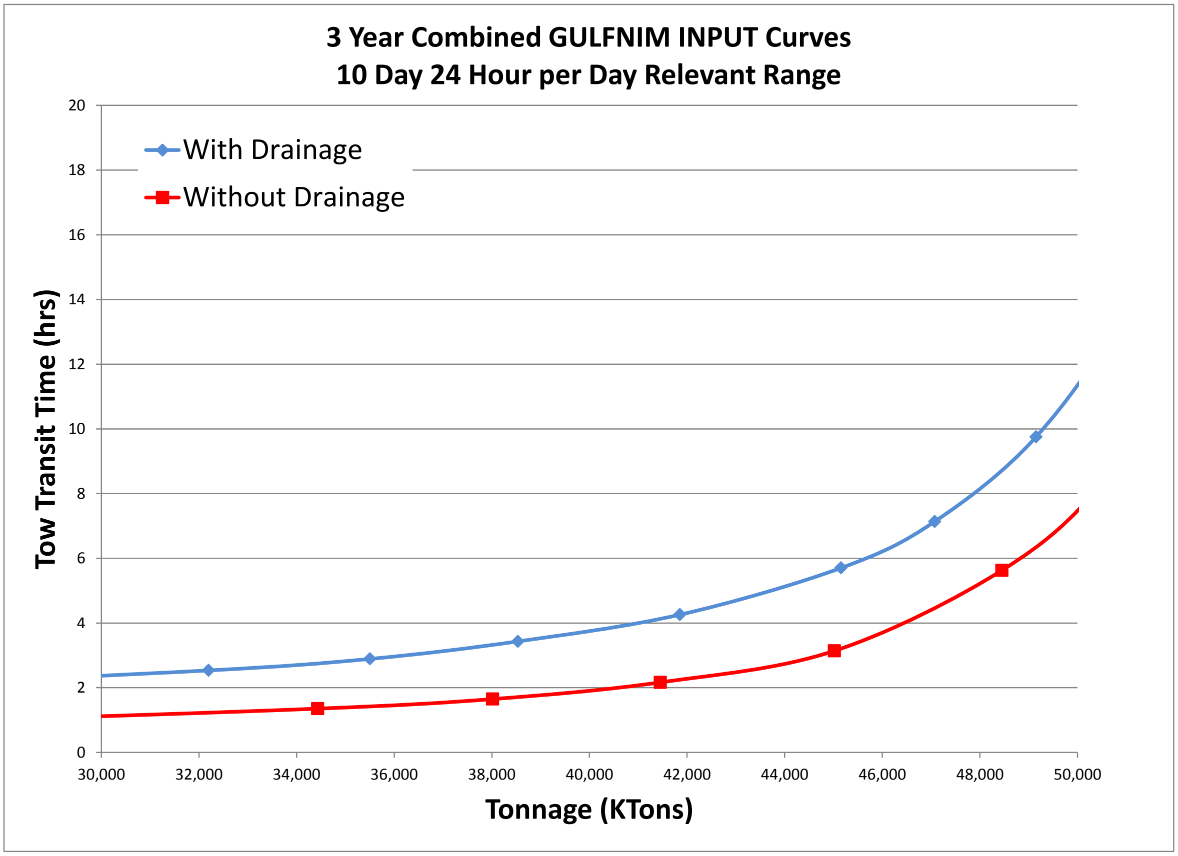
Figure A2- 17
3 Year Combined 61 Day 12 Hour Closures



3.1.3.1.2.4 7 Day 24 hour per day Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 24 hours per day 10 continuous days. This schedule was developed to match the expected hurricane closure and repair schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 10day closure so they arrive while the chamber is open.

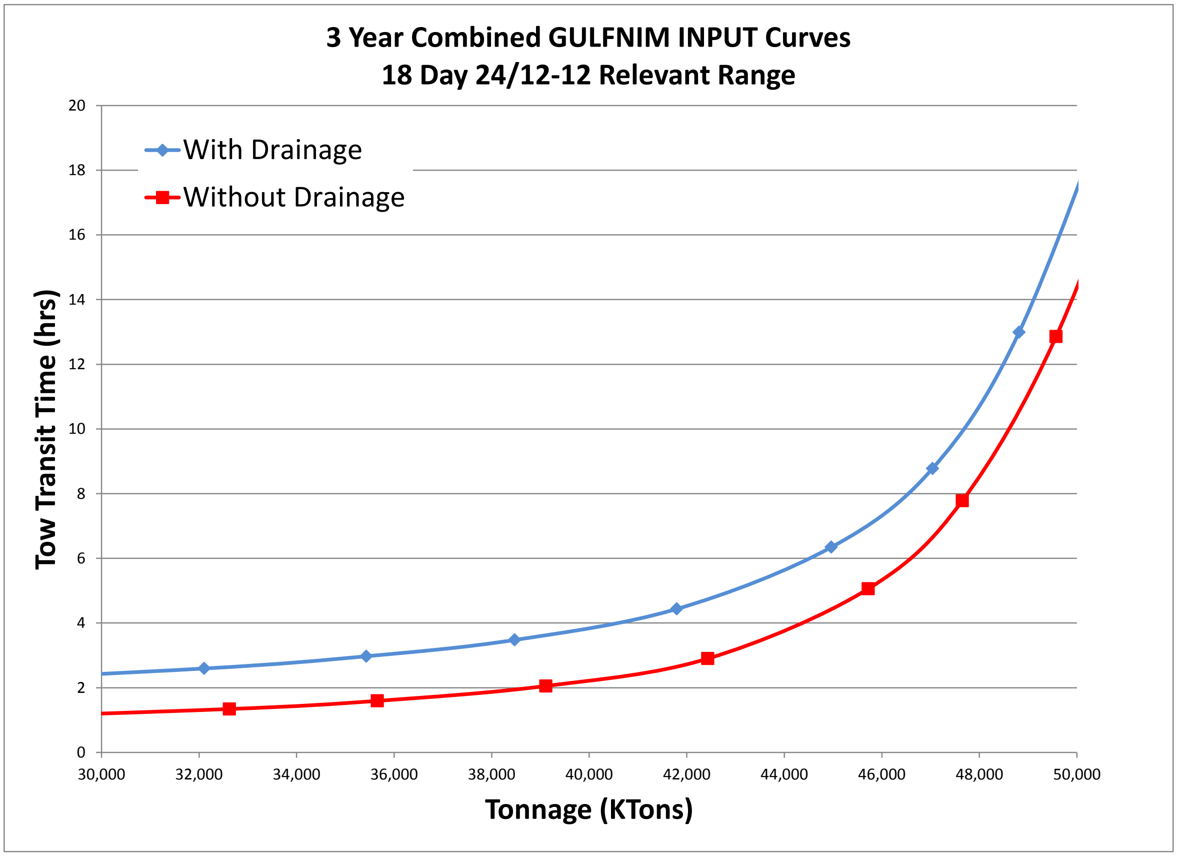
Figure A2- 18
3 Year Combined 10 Day 24 Hour per Day Closures



3.1.3.1.2.5 18 Day 24/12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 24 hours per day for 3 continuous days then is closed 12 hours per day for 10 more days. Thirty days later this cycle repeats itself. This schedule was developed to match the miter gate repair schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 3 day 24 hour per day closure and during the 10 day 12 hours per day closures so they arrive while the chamber is open.

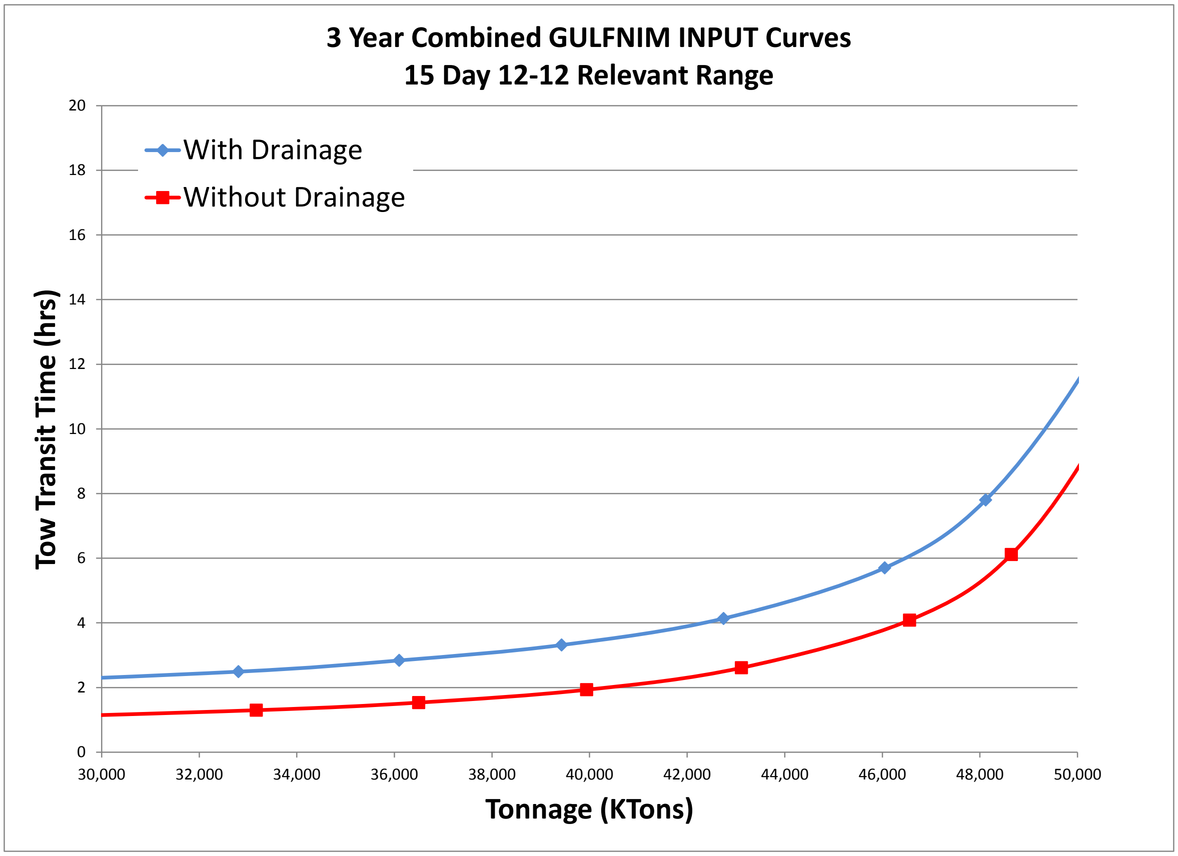
Figure A2- 19
3 Year Combined 18 Day 24/12 - Closures



3.1.3.1.2.6 15 Day 12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day for 15 days. This schedule was developed to match the rewiring and machinery rehabilitation provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 15day 12 hours per day closures so they arrive while the chamber is open.

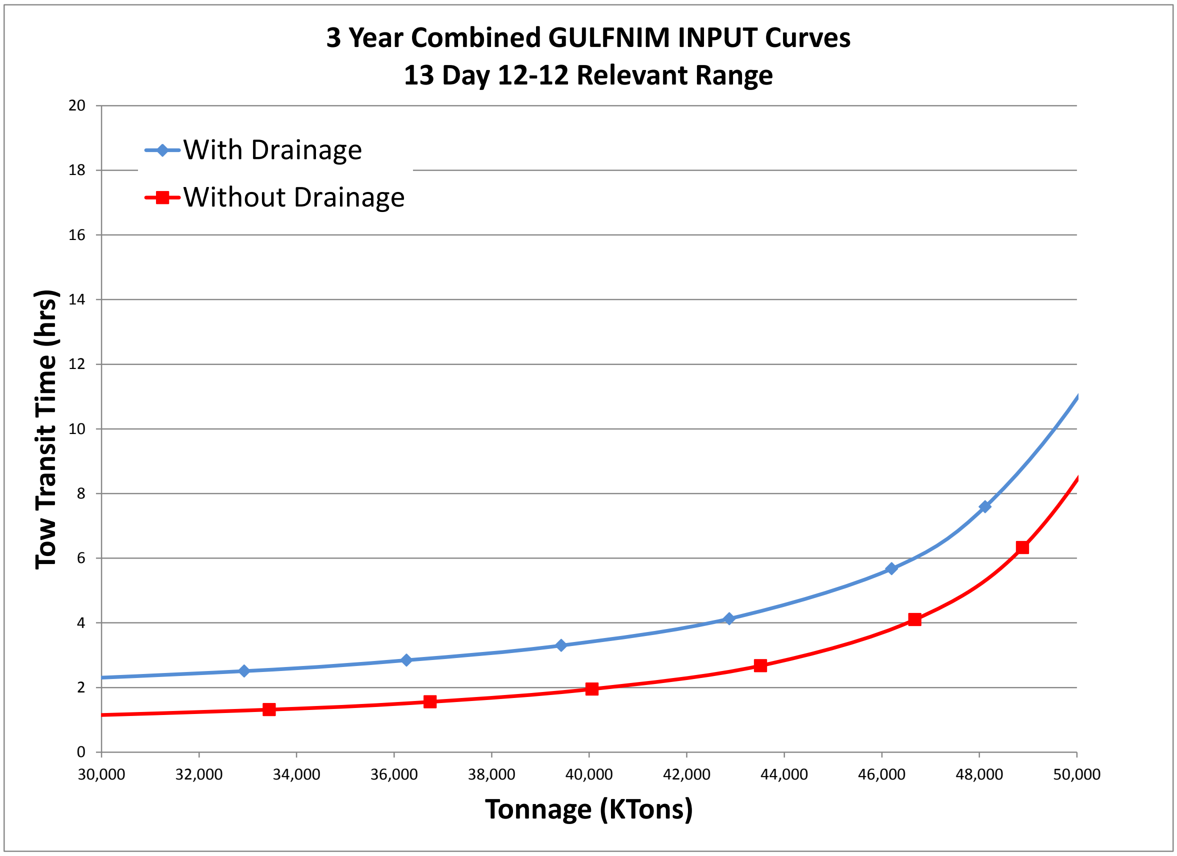
Figure A2- 20
3 Year Combined 15 Day 12 Hour Closures



3.1.3.1.2.7 13 Day 12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day for 13 days. This schedule was developed to match the maintenance by hired labor units schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 13 day 12 hours per day closures so they arrive while the chamber is open.

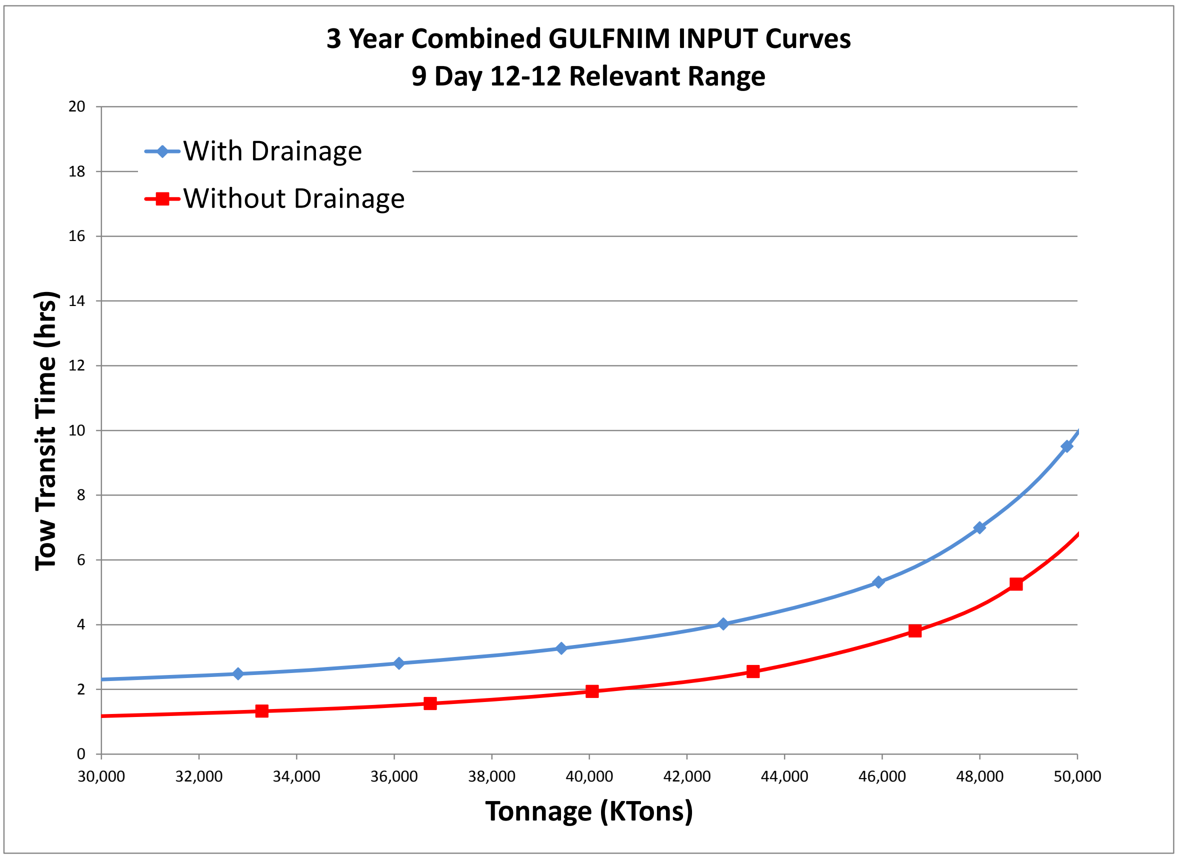
Figure A2- 21
3 Year Combined 13 Day 12 Hour Closures



3.1.3.1.2.8 9 Day 12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day for 9 days. This schedule was developed to match the rehabilitation of face timber X chamber guidewall (W & E) schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 9 day 12 hour per day closures so they arrive while the chamber is open.

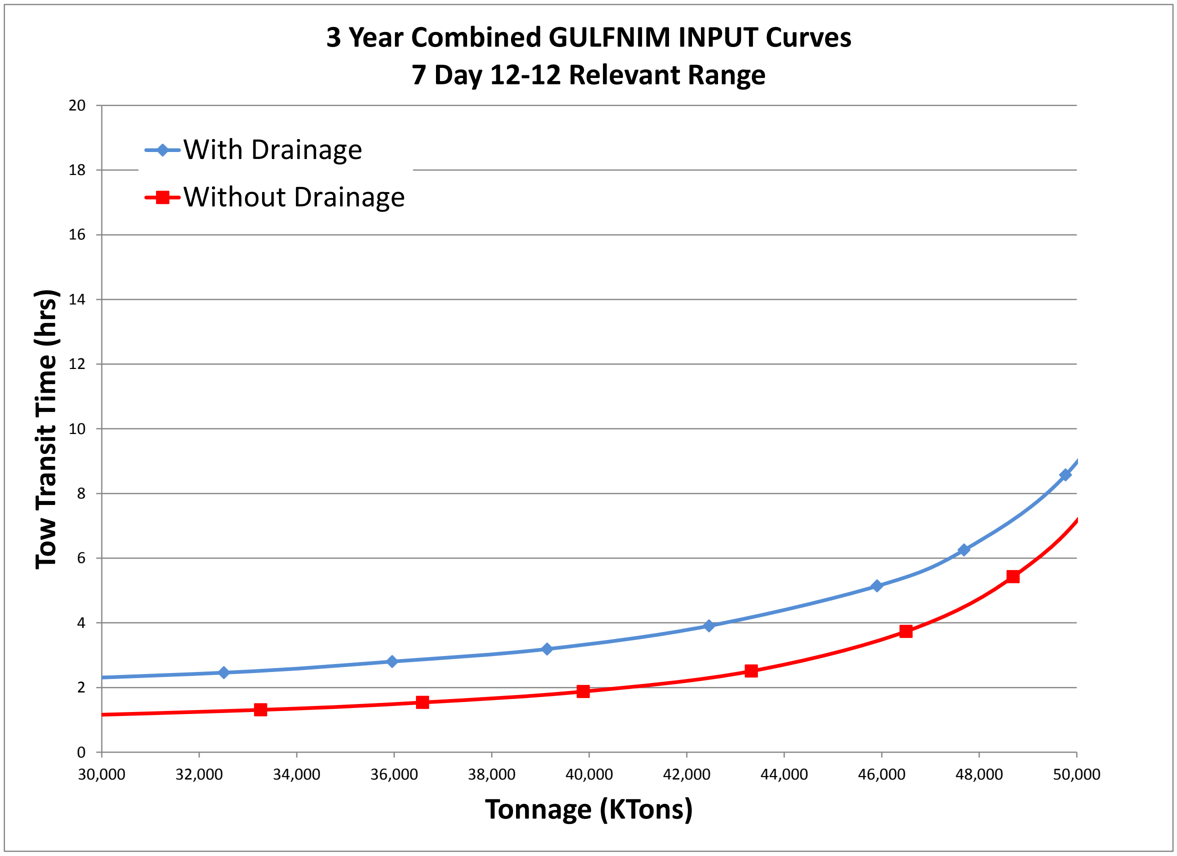
Figure A2- 22
3 Year Combined 9 Day 12 Hour Closures



3.1.3.1.2.9 7 Day 12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day for 7 days. This schedule was developed to match the rehabilitation of face timber XX guidewall (SE & NW) schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 7 day 12 hour per day closures so they arrive while the chamber is open.

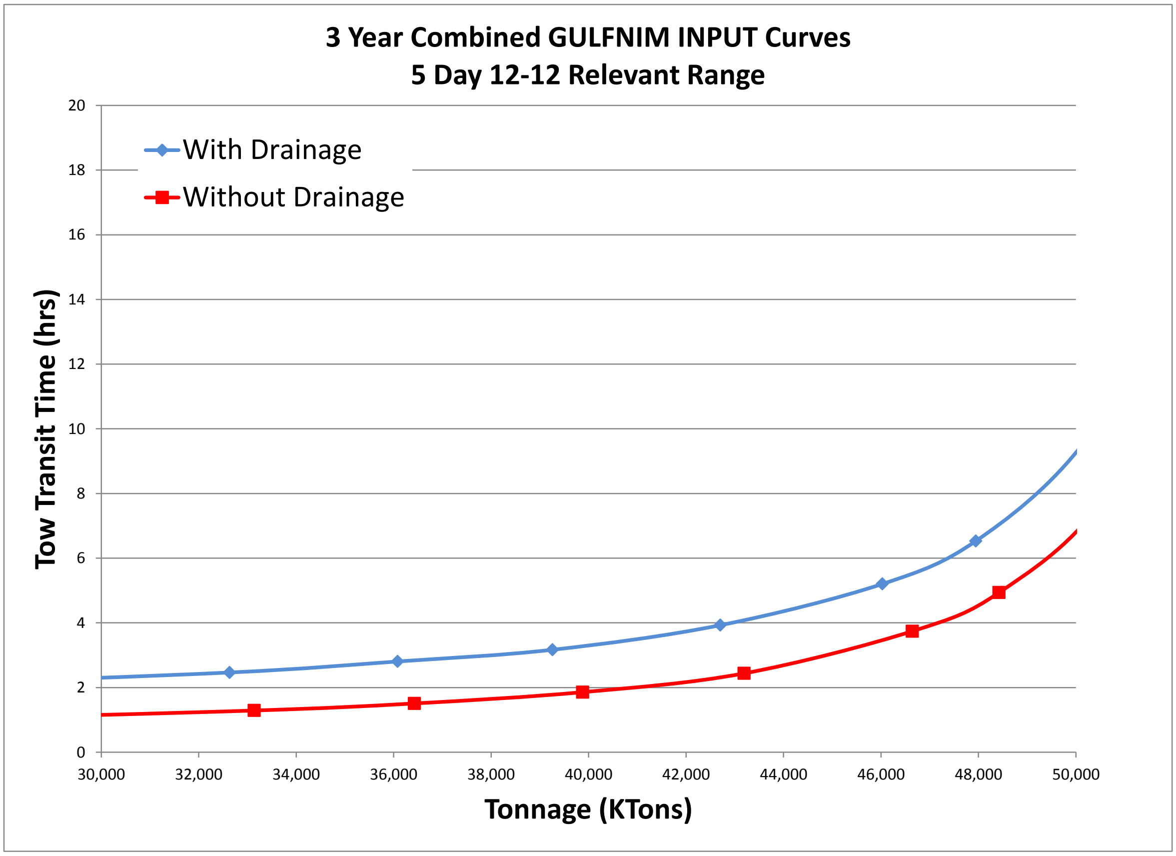
Figure A2- 23
3 Year Combined 7 Day 12 Hour Closures



3.1.3.1.2.10 5 Day 12-12 Closure

This closure scenario assumes the existing chamber at Calcasieu closes for 12 hours per day for 5 days. This schedule was developed to match the rehabilitation of face timber XX guidewall (SW & NE) schedule provided by MVN Operations Division personnel. It should be noted these runs are made with arrival rescheduling which reschedules arrivals that normally arrive during the 5 day 12 hour per day closures so they arrive while the chamber is open.

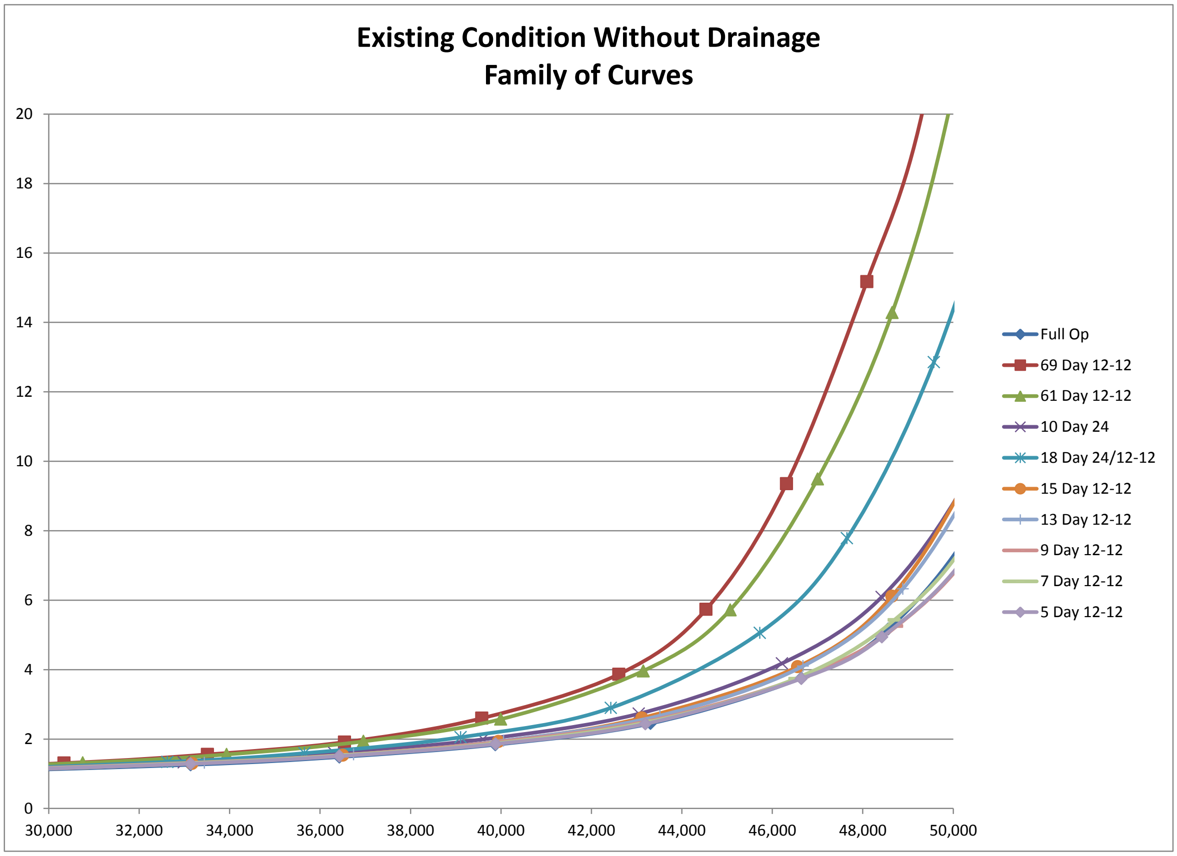
Figure A2- 24
3 Year Combined 5 Day 12 Hour Closures



3.1.3.1.2.11 Without Drainage family of Curves

The Figures above compare the “Without Drainage” curves to the “With Drainage” curves for each maintenance closure scenario provided by MVN Operations personnel. This section compares all the “Without Drainage” curves for all maintenance closure scenarios. Such a comparison helps the reader understand the impact of each maintenance closure scenario compared to all others. **Figure A2- 25** shown here is known as the Without Drainage family of Curves.

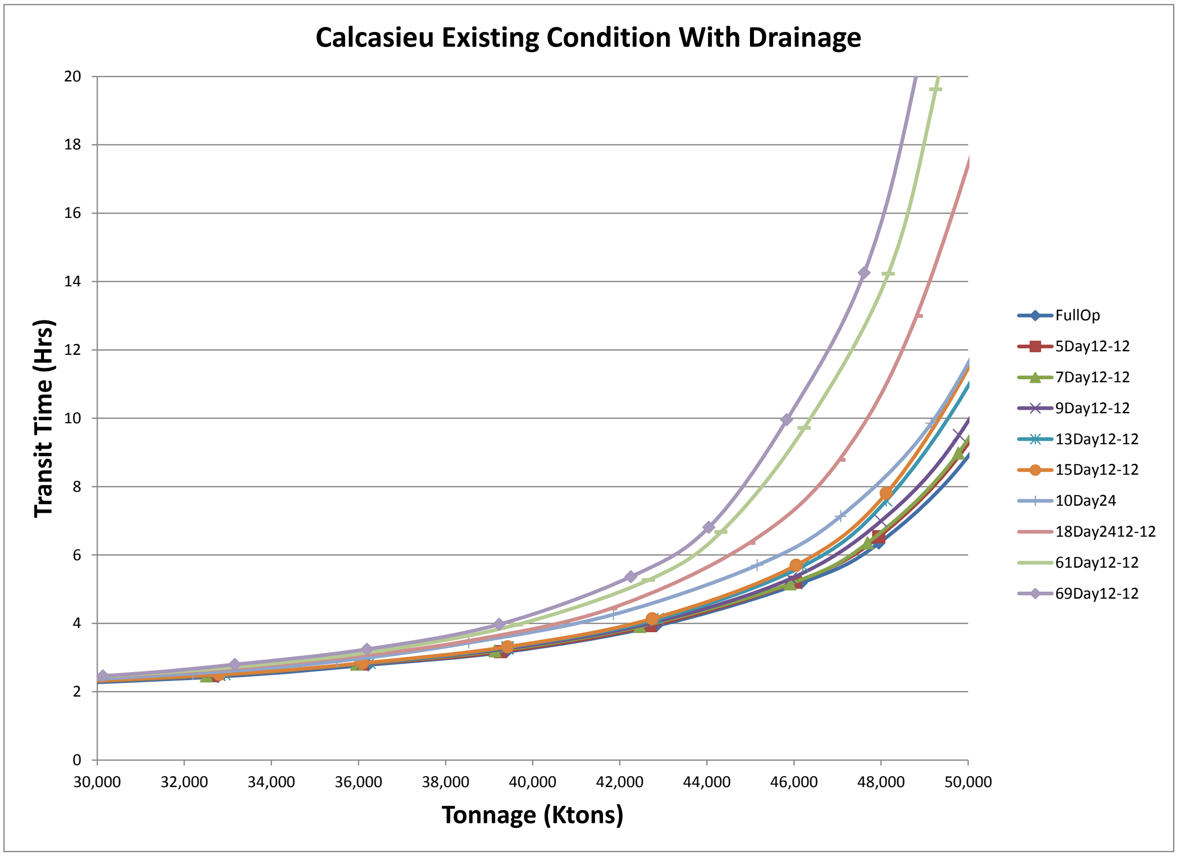
Figure A2- 25
Without Drainage Family of Curves



3.1.3.1.2.12 With Drainage family of Curves

The Figures above compare the “Without Drainage” curves to the “With Drainage” curves for each maintenance closure scenario provided by MVN Operations personnel. This section compares all the “With Drainage” curves for all maintenance closure scenarios. Such a comparison helps the reader understand the impact of each maintenance closure scenario compared to all others. **Figure A2- 26** shown here is known as the With Drainage family of Curves.

Figure A2- 26
With Drainage Family of Curves



3.2 LELAND BOWMAN LOCKS AND DAM

Leland Bowman Lock and Dam is located on river mile 162.7 on the Gulf Intracoastal waterway and consists of 1200' x 110' single main chamber with a lift of 5 feet at normal pool, see **Figure A2- 27.** In 2007, Leland Bowman processed 47.3 million tons of commodities, 43% of which was petroleum. Over 14,200 tows with 37,700 barges, and 200 recreation craft and 2,000 lightboats passed through Leland Bowman in 2007. The average tow size was 2.6 barges per tow carrying 3,300 tons.

Figure A2- 27
Leland Bowman Locks

3.2.1 Existing Condition Input Data

3.2.1.1 Processing Times

The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions[2]. Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Mostly all of the lock component time distributions were created using years 2000-2009. .Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figures A2- 28 and **Figure A2- 29** show an example histogram for down bound long approach and up bound chambering times at Leland Bowman. When compared to other locks on the Gulf Intracoastal Waterway, Leland Bowman exhibits very little to moderate data rounding. We used Leland Bowman's data to develop processing time distributions for the without project condition. See Section 2.2.1.1.5 for a description of how probability distributions were developed.

[2]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 28
Leland Bowman Down bound Long Approach

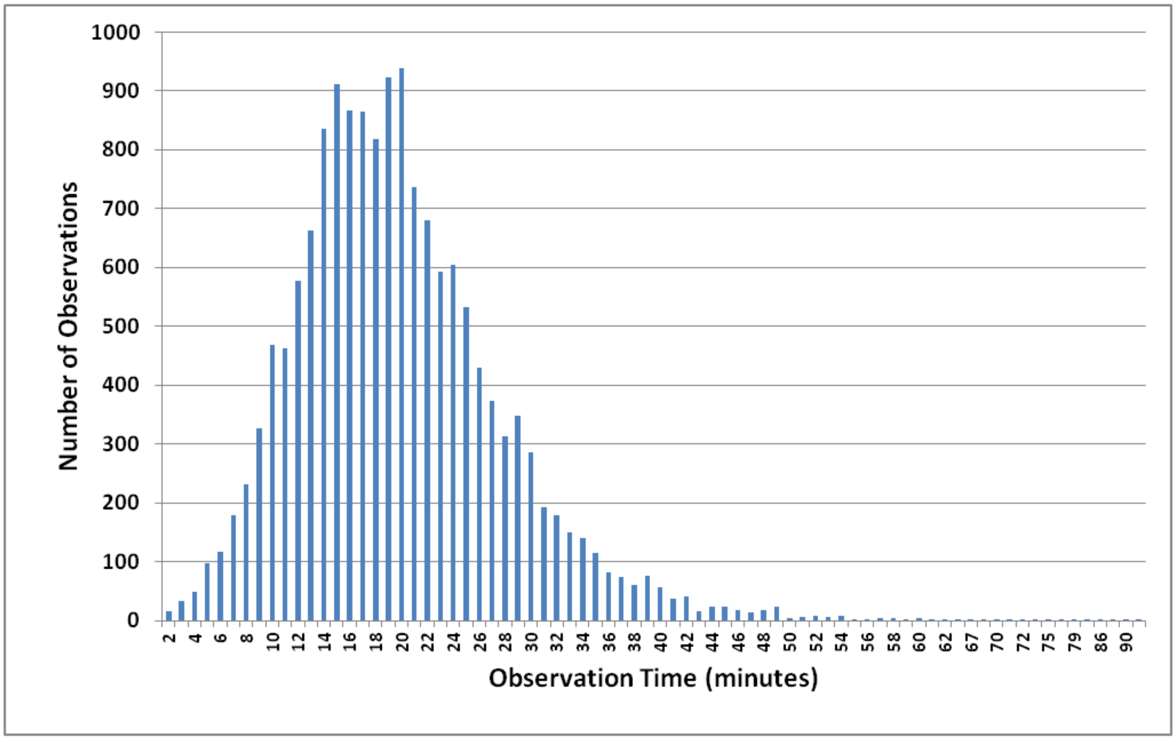
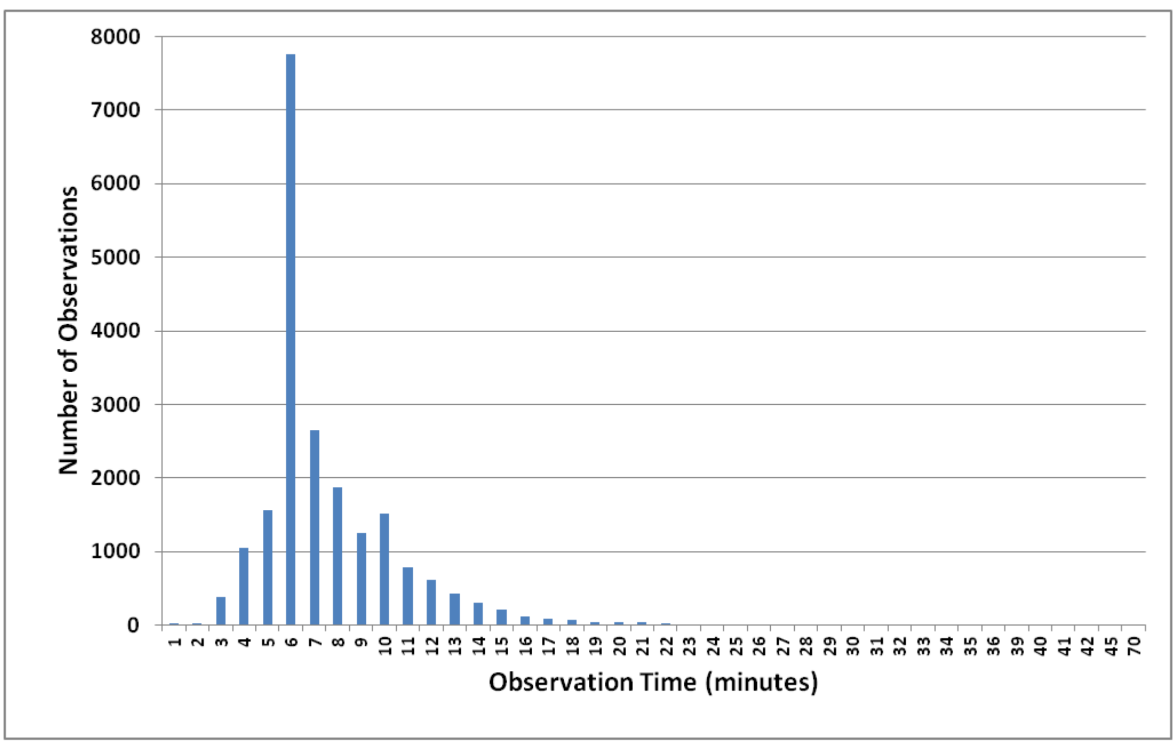


Figure A2- 29
Leland Bowman Up bound Long Approach

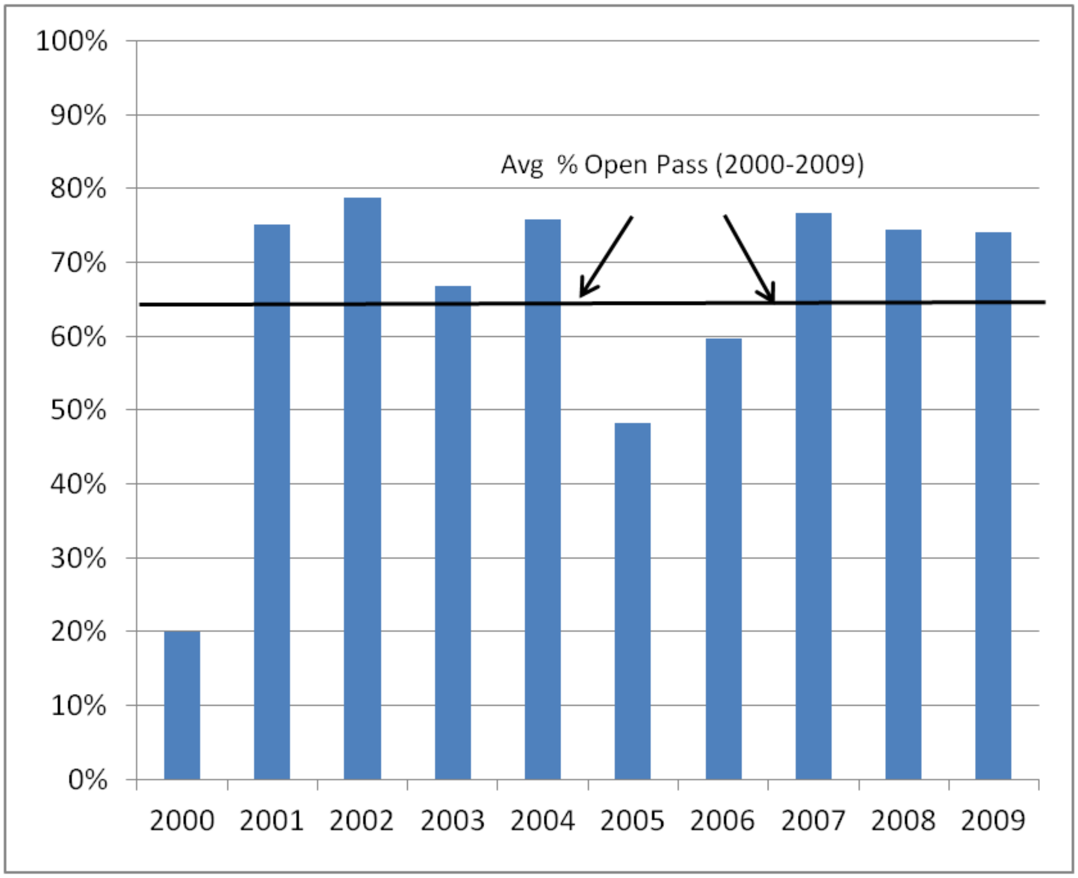


Nine component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, straight multi, and open pass) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 27** show sample set sizes, data years, and mean times for each component. **Figure A2- 30 s**hows the percent of the year from 2000-2009 that Leland Bowman was in open pass. The average for all these years was 65.0% open pass, and slightly higher at 75.1% open pass for the later years 2007 – 2009.

Table A2- 27
Leland Bowman Component Processing Time Information
Single Cuts

	Up bound				Down bound			
Lock Component	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	15,098	00-09	19.72	5	15,715	00-09	19.88	2
Short Approach	5,384	00-09	9.65	0	5,656	00-09	9.24	1
Entry	20,895	00-09	5.70	0	21,753	00-09	5.61	0
Chambering	20,895	00-09	7.55	0	21,753	00-09	7.47	0
Long Exit	15,175	00-09	5.36	24	15,799	00-09	5.25	46
Short Exit	5,402	00-09	5.74	0	5,588	00-09	5.61	0
Turn back	4,562	01-09	6.08	0	4,829	01-09	6.01	1
Straight Multi	5,192	01-09	4.40	11	5,388	01-09	4.47	14
Open Pass	31476	01-09	18.39	0	30429	01-09	20.40	1

Figure A2- 30
Leland Bowman – Percent of Open Pass



3.2.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in Section 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 28** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 28
Leland Bowman Historic LPMS Stalls and WAM Downtime

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	0.0	0	0.0	0
Rain (B)	0.0	0	0.0	0
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.0	0	0.0	0
Lightning (F)	0.0	0	0.0	0
Surface Conditions				
Low Water (G)	0.0	0	0.0	0
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.0	0	0.0	0
Flood (J)	0.0	0	0.0	0
Tow Conditions				
Interference by other vessels (K)	0.0	0	0.0	0
Tow malfunction (L)	0.1	93	0.1	93
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	0.0	0	0.0	0
Debris (O)	0.0	0	0.0	0
Tow accident or collision (P)	0.2	189	0.1	313
Lock Condition				
Debris in chamber (Q)	0.2	40	0.2	40
Hardware malfunction (R)	0.1	161	0.1	161
Staff elsewhere occupied (S)	0.0	0	0.0	0
Testing / maintenance (T)	1.5	193	1.7	191
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.3	31	0.0	0
Collision / accident (W)	0.0	0	0.0	0
Vehicular / RR bridge (X)	0.0	0	0.0	0
Inspection or testing lock (Y)	0.0	0	0.0	0
Other (Z)	0.3	459	0.3	459
Average	3	188	3	211
Totals		507		527

3.2.1.3 Vessel Types

Vessels are grouped into one of three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 29** shows the number of vessels, by vessel type, for the 2007 Leland Bowman fleet.

Table A2- 29
Leland Bowman Number of Vessels by Type

Tows	14,287
Lightboats	2,025
Recreation Craft	199

3.2.1.4 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 30** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 30
Leland Bowman Towboat Types, Horsepowers, & Dimension

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	388
2	801-1500	62 x 24	821
3	1501-1800	76 x 29	405
4	1801-2400	78 x 31	212
5	2401-3200	103 x 33	120
6	3201-5000	121 x 38	58
7	5001-5600	130 x 45	21
8	5601-8400	147 x 45	0

3.2.1.5 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 31** shows the barge types, barge dimensions, number of barges, percent loaded, and average number of barges per tow in the 2007 Leland Bowman fleet.

Table A2- 31
Leland Bowman Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	350	57.7%	3.7
200' Tanker	200 x 35	5,737	57.0%	3.7
214' Tanker	214 x 42	635	55.9%	1.8
200' Tanker	200 x 54	1,311	51.2%	2.0
264' Tanker	264 x 5f4	439	53.3%	1.5
300' Tanker	300 x 54	10,027	61.6%	2.1
380' Tanker	380 x 54	435	63.0%	1.3
150' Non-Tanker	150 x 35	1,803	49.8%	1.5
200' Non-Tanker	200 x 35	11,023	62.5%	4.8
200' Non-Tanker	200 x 40	942	50.7%	5.1
Tankers All Others		3,433	62.3%	2.4
Non-Tankers Others		1,890	51.5%	1.8

3.2.2 Existing Condition Calibration and Validation

3.2.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3.4. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Leland Bowman in 2007. In 2007, 2,025 lightboats and 199 recreation craft traveled through Leland Bowman.

Table A2- 32 shows the statistics used when calibrating the shipment list. The target values for tons per loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 32
Leland Bowman Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	47,265	46,380	-1.87%
Up	23,778	23,246	-2.24%
Down	23,524	23,134	-1.66%
Tows (LPMS)	14,287	14,295	0.06%
Up	7,126	7,184	0.81%
Down	7,161	7,112	-0.69%
Tons/Tow (calc)	3,308	3,244	-1.93%
Up	3,337	3,236	-3.02%
Down	3,285	3,253	-0.98%
Barges (calc)	37,688	37,068	-1.65%
Up	18,875	18,592	-1.50%
Down	18,813	18,476	-1.79%
Loaded Barges (LPMS)	22,558	22,110	-1.98%
Up	10,598	10,354	-2.30%
Down	11,960	11,756	-1.70%
Empty Barges (LPMS)	15,130	14,958	-1.14%
Up	8,277	8,238	-0.47%
Down	6,853	6,719	-1.95%
Percent Empty (calc)	40.1%	40.4%	0.51%
Up	43.9%	44.3%	1.05%
Down	36.4%	36.4%	-0.16%
Tons/Loaded Barge (WC)	2,095	2,098	0.11%
Up	2,244	2,245	0.07%
Down	1,967	1,968	0.04%
Barges/Tow	2.64	2.59	-1.70%
Up	2.65	2.59	-2.29%
Down	2.63	2.60	-1.11%
Rec/Other	199	204	2.3%
Up	101	100	-1.3%
Dn	98	104	6.1%
Light Boat	2,025	2,025	0.00%
Up	984	981	-0.27%
Dn	1,041	1,044	0.26%

3.2.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO lockage policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 33** shows how well WAM reproduces the target processing and delay times. WAM output was within plus or minus 16% of actual base year target values for the delay and processing times, respectively, at Leland Bowman.

Table A2- 33
Leland Bowman Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	27.1	21.5	0.06	-20.5%
Tow Average Delay	66.9	65.2	10.98	-2.6%
Tow Average Transit Time	94.0	86.7	10.99	-7.8%
Validation Down Time				
Number of Events, Main	6	6	-	0.0%
Total Minutes, Main	848	848	-	0.0%
Percent of Year Closed, Main	0.16%	0.16%	-	0.0%
**2000-09 LPMS Data (NaSS)*				

3.2.3 Without Project Analysis

3.2.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part “Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time.” Two lockage policies were evaluated at Leland Bowman; FIFO (First-In, First-Out) and 6-up/6-down service policies

To determine the best or “optimal” lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The ‘optimal’ lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization.

According to the results shown in **Table A2- 34**, the lockage policy with the highest tonnage level and lowest transit time is the policy where tows are served with a 6-up 6-down policy.

Table A2- 34
Leland Bowman WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
Leland Bowman 6U6D	84,126	0.32	587.0	587.3
Leland Bowman FIFO	84,001	0.33	588.2	588.5
**Optimal WOPC Lockage Policy: 6U6D*				

3.2.3.2 WOPC Results

3.2.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Leland Bowman. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2-35**. Of the 9 locks modeled in this study, Leland Bowman had the highest lock capacity at 86.3 million tons.

Table A2- 35
Leland Bowman WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
Full Operation	86.3	18.83

3.2.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 31 shows the capacity curve and other information for Leland Bowman L&D, Without Project Condition full operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 31 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 35**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the difference in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 31
Leland Bowman Without Project Condition Capacity Curve

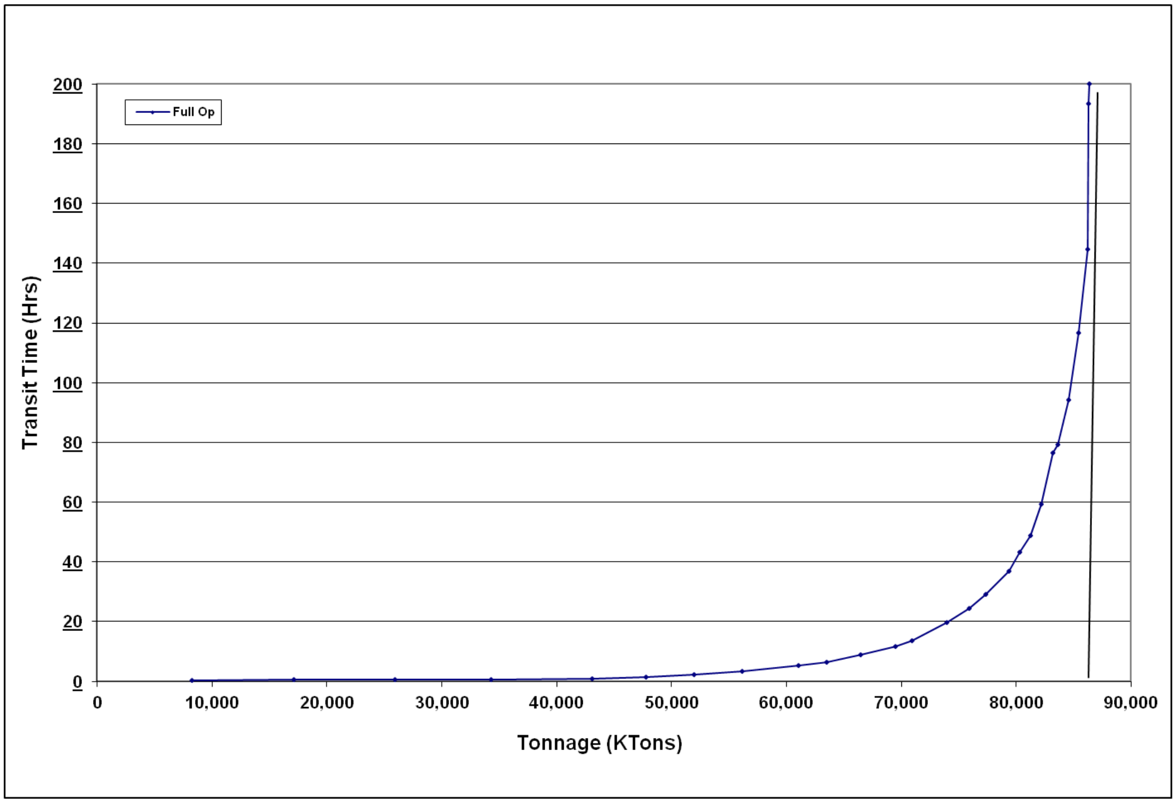
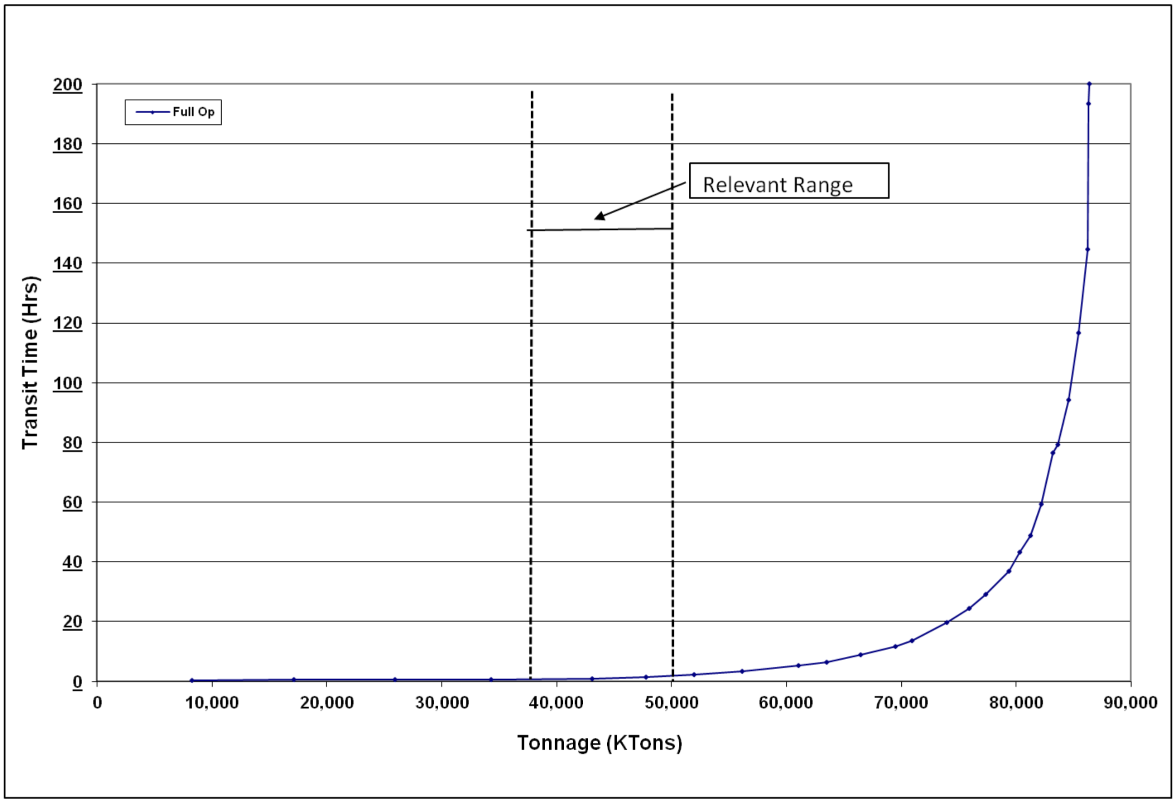


Figure A2- 32 shows the relevant range of traffic demand for Leland's Bowman Without Project Condition Capacity Curve. This is the range of tonnage projected to use Leland Bowman over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Leland Bowman.

Figure A2- 32
Leland Bowman Without Project Condition Capacity Curve

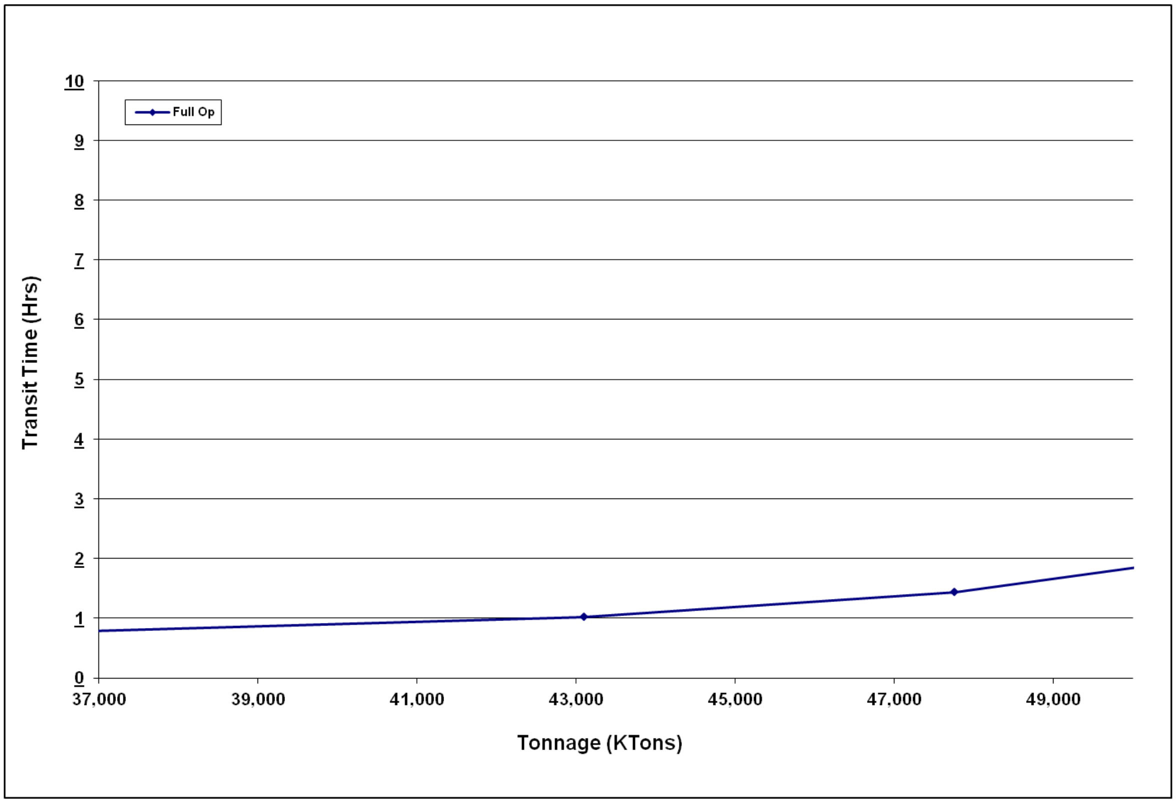


3.2.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Leland Bowman L&D does have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 33** shows delays remain low even at the highest projected demands.

Figure A2- 33
Leland Bowman Without Project Condition Capacity Curve
Relevant Range



3.3 BAYOU BOEUF LOCKS AND DAM

Bayou Boeuf Lock and Dam is located on river mile 93.3 on the Gulf Intracoastal Waterway and consists of a single main chamber 1156’ x 75’ with a lift of 11 feet at normal pool, see **Figure A2- 34**. In 2007, Bayou Boeuf processed 30.2 million tons of commodities, of which 44% was petroleum. Over 15,000 tows with 29,200 barges, and 550 recreation craft and 6,800 lightboats passed through Bayou Boeuf in 2007. The average tow size was 1.9 barges per tow carrying 2,000 tons.[3]

Figure A2- 34
Bayou Boeuf Locks

3.3.1 Existing Condition Input Data

3.3.1.1 Processing Times

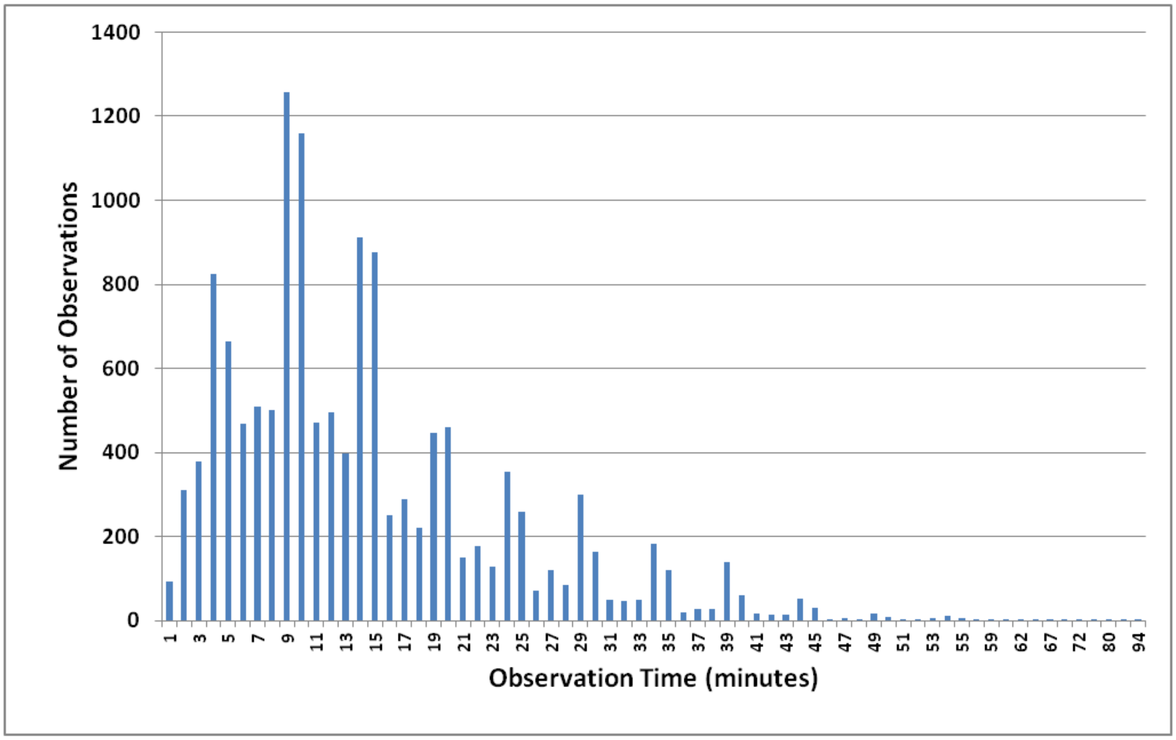
The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[4] Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 35 shows a histogram for up bound long approaches to Bayou Boeuf’s 1156’ main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Bayou Boeuf exhibits a moderate amount of data rounding. Therefore, we used Bayou Boeuf’s data to develop processing time distributions for the without project condition. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

[3]Lock Performance Monitoring System, 2002

[4]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 35
Bayou Boeuf Up bound Long Approach to Main Chamber

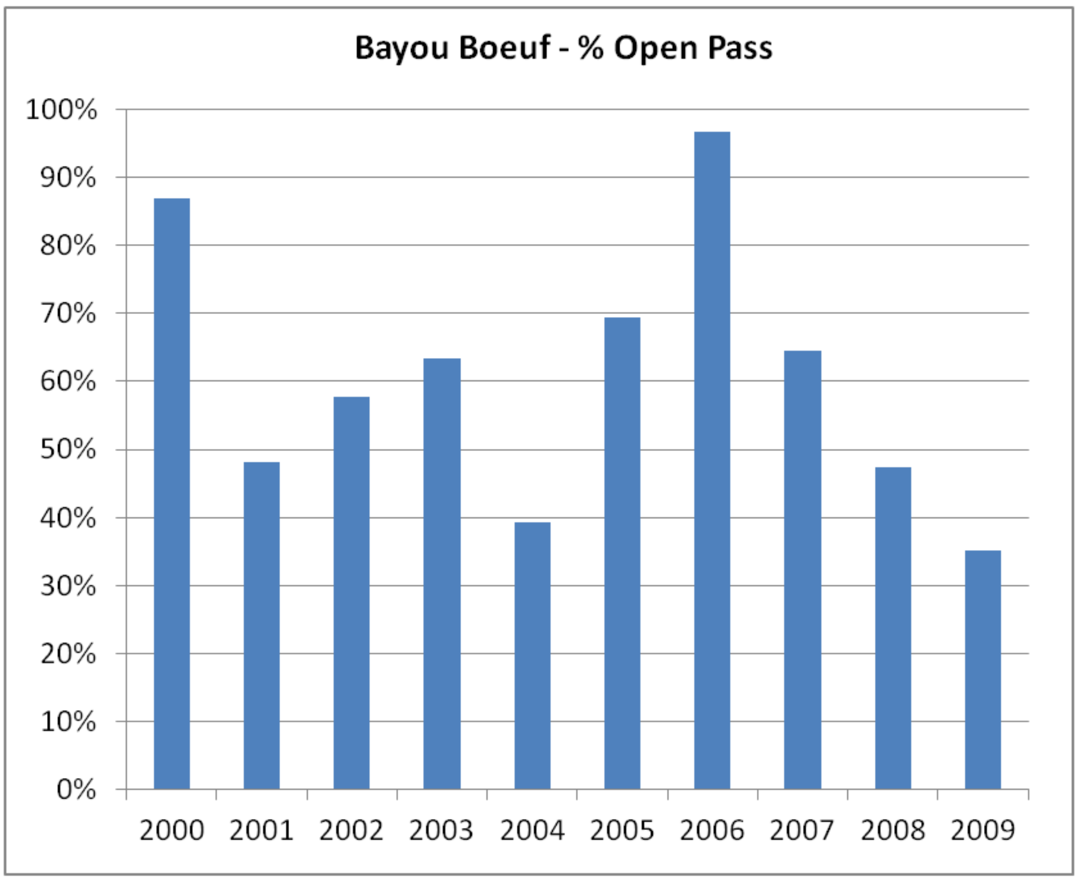


Ten component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, straight multi, open pass, and open pass multi) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 36** shows sample set sizes, data years, and mean times for each component. **Figure A2- 36** Shows the percent of the year from 2000-2009 that Bayou Boeuf was in open pass. The average for all these years was 61.0% open pass, and a little lower at 49%% open pass for the later years 2007 – 2009.

Table A2- 36
Bayou Boeuf Processing Time Information
Single Cuts

Lock Component	Up bound Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Down bound Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	13,734	00-09	14.30	0	15,059	00-09	15.20	0
Short Approach	6,860	00-09	7.82	0	8,932	00-09	7.82	0
Entry	24,325	00-09	5.84	0	27,954	00-09	6.06	0
Chambering	24,325	00-09	7.03	0	27,954	00-09	7.04	0
Long Exit	12,391	00-09	5.56	0	13,386	00-09	5.67	0
Short Exit	7,711	00-09	6.48	0	9,929	00-09	6.56	0
Turn back	6,858	00-09	6.27	2	8,930	00-09	6.32	2
Straight Multi	4,121	00-09	3.28	0	4,773	00-09	3.37	0
Open Pass	30,618	00-09	14.29	1	32,196	00-09	15.56	2
Open Pass Multi	1,897	00-09	16.31	0	1,973	00-09	17.24	0

Figure A2- 36
Bayou Boeuf – Percent of Open Pass



3.3.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 37** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 37
Bayou Boeuf Historical LPMS Stalls and WAM Downtime

Closure Category (LPMS Code)	Main Chamber 2000-2009 LPMS Average Freq./Yr	Dur (min)	2000-2009 WAM Downtime Freq./Yr	Dur (min)
Weather				
Fog (A)	4.5	124	1.2	163
Rain (B)	0.0	0	0.0	0
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.4	403	0.4	729
Lightning (F)	0.1	248	0.0	0
Surface Conditions				
Low Water (G)	0.4	50	0.2	72
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.1	68	0.1	68
Flood (J)	0.0	0	0.0	0
Tow Conditions				
Interference by other vessels (K)	0.2	41	0.1	60
Tow malfunction (L)	0.1	76	0.0	0
Tow staff elsewhere occupied (M)	0.6	58	0.3	75
Operations (run-spill-divert water) (N)	687.1	52	436.1	53
Debris (O)	0.6	51	0.2	43
Tow accident or collision (P)	1.2	79	1.2	78
Lock Condition				
Debris in chamber (Q)	0.1	90	0.1	90
Hardware malfunction (R)	0.9	123	0.9	123
Staff elsewhere occupied (S)	2.0	37	0.9	27
Testing / maintenance (T)	1.2	247	1.1	262
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.5	105	0.5	105
Collision / accident (W)	0.0	0	0.0	0
Vehicular / RR bridge (X)	0.0	0	0.0	0
Inspection or testing lock (Y)	0.3	101	0.3	91
Other (Z)	0.6	204	0.5	237
Average	701	53	444	55
Totals		37,401		24,383

3.3.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.3.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 38** shows the number of vessels, by vessel type, for the 2007 Bayou Boeuf fleet.

Table A2- 38
Bayou Boeuf Towboat Types, Horsepowers, & Dimensions

Tows	15,039
Lightboats	6,831
Recreation Craft	554

3.3.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 39** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 39
Bayou Boeuf Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	2,396
2	801-1500	62 x 24	2,938
3	1501-1800	76 x 29	764
4	1801-2400	78 x 31	430
5	2401-3200	103 x 33	213
6	3201-5000	121 x 38	115
7	5001-5600	130 x 45	0
8	5601-8400	147 x 45	2

3.3.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 40** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Bayou Boeuf fleet.

Table A2- 40
Bayou Boeuf Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	57	36.8%	2.5
200' Tanker	200 x 35	1,866	46.7%	2.1
214' Tanker	214 x 42	665	43.2%	1.7
200' Tanker	200 x 54	522	53.6%	1.6
264' Tanker	264 x 5f4	300	63.7%	1.4
300' Tanker	300 x 54	4,319	80.1%	1.9
380' Tanker	380 x 54	452	50.2%	1.4
150' Non-Tanker	150 x 35	3,741	34.3%	1.6
200' Non-Tanker	200 x 35	11,884	49.8%	5.0
200' Non-Tanker	200 x 40	50	26.0%	1.9
Tankers All Others		3,680	51.3%	1.3
Non-Tankers Others		6,259	31.9%	2.1

3.3.2 Existing Condition Calibration and Validation

3.3.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and light boats as measured by LPMS at Bayou Boeuf in 2007. In 2007, 6,831 light boats and 554 recreation craft traveled through Bayou Boeuf.

Table A2- 41 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 41
Bayou Boeuf Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	30,193	29,835	-1.19%
Up	14,901	14,812	-0.60%
Down	15,291	15,022	-1.76%
Tows (LPMS)	15,039	15,262	1.49%
Up	7,328	7,407	1.07%
Down	7,711	7,856	1.88%
Tons/Tow (calc)	2,008	1,955	-2.63%
Up	2,033	2,000	-1.65%
Down	1,983	1,912	-3.57%
Barges (calc)	29,208	28,771	-1.50%
Up	13,870	13,749	-0.87%
Down	15,338	15,023	-2.06%
Loaded Barges (LPMS)	16,532	16,457	-0.45%
Up	8,895	8,856	-0.44%
Down	7,637	7,601	-0.47%
Empty Barges (LPMS)	12,676	12,314	-2.85%
Up	4,975	4,893	-1.65%
Down	7,701	7,422	-3.63%
Percent Empty (calc)	43.4%	42.8%	-1.38%
Up	35.9%	35.6%	-0.79%
Down	50.2%	49.4%	-1.60%
Tons/Loaded Barge (WC)	1,826	1,813	-0.74%
Up	1,675	1,673	-0.16%
Down	2,002	1,976	-1.29%
Barges/Tow	1.94	1.89	-2.93%
Up	1.89	1.86	-1.92%
Down	1.99	1.91	-3.86%
Rec/Other	554	545	-1.6%
Up	267	271	1.6%
Dn	287	274	-4.5%
Light Boat	6,831	6,858	0.40%
Up	3,368	3,467	2.94%
Dn	3,463	3,391	-2.08%

3.3.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO lockage policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 42** shows how well WAM reproduces the target processing and delay times. WAM closely reproduces processing times at Bayou Boeuf. We had difficulty getting the delay to validate.

Table A2- 42
Bayou Boeuf Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	22.4	23.8	0.1108	6.1%
Tow Average Delay	25.5	30.0	0.0000	17.5%
Tow Average Transit Time	48.0	53.8	0.1108	12.2%
Validation Down Time				
Number of Events, Main	1	1	-	0.0%
Total Minutes, Main	68	68	-	0.0%
Percent of Year Closed, Main	0.0%	0.0%	-	0.0%
**2007 LPMS Data (NaSS)*				

3.3.3 Without Project Analysis

3.3.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Bayou Boeuf; FIFO (First-In, First-Out) and 6-up/6-down service policy

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 43**, the lockage policy with the highest tonnage level and lowest transit time is the 6-up, 6-down lockage policy. Therefore, the 6-up/6-down policy was used to create Bayou Boeuf's WOPC capacity curves.

Table A2- 43
Bayou Boeuf WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Bayou Boeuf FIFO	57,152	0.39	86.70	87.09
Bayou Boeuf 6U6D	57,187	0.38	90.02	90.40
*Optimal WOPC Lockage Policy: FIFO				

3.3.3.2 WOPC Results

3.3.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Bayou Boeuf. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2-44**.

Table A2- 44
Bayou Boeuf Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
No closures (normal operation)	58.5	21.74

3.3.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, the navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 37 shows the capacity curve and other information for Bayou Boeuf L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 37 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 44**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 37
Bayou Boeuf Without Project Condition Capacity Curve

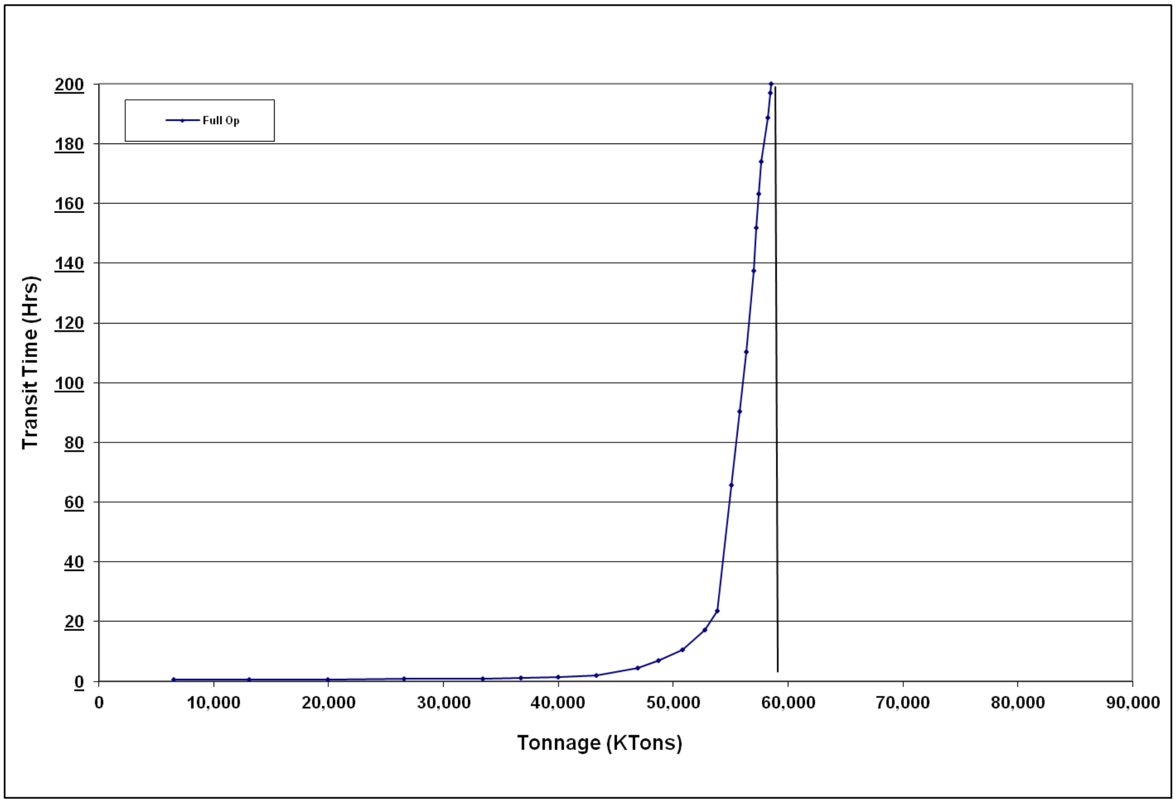
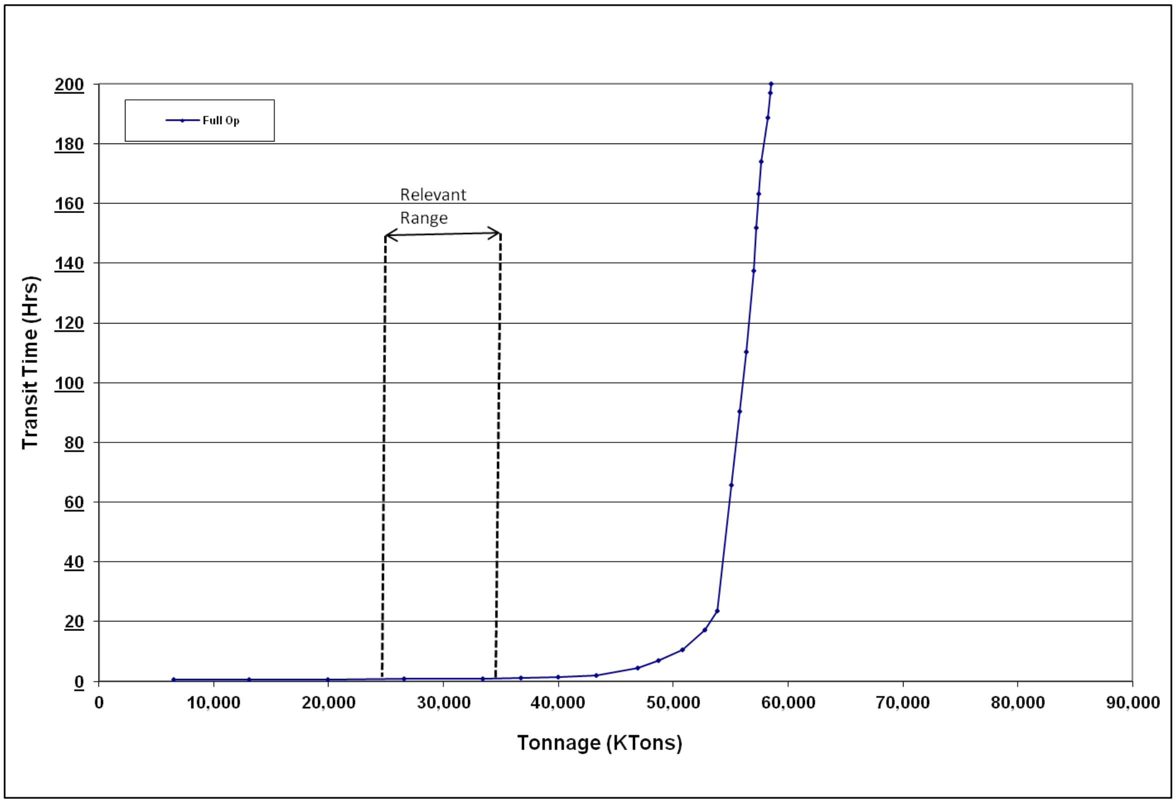


Figure A2- 38 shows the relevant range of traffic demand. This is the range of tonnage projected to use Bayou Boeuf over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Bayou Boeuf.

Figure A2- 38
Bayou Boeuf Without Project Condition Capacity Curve

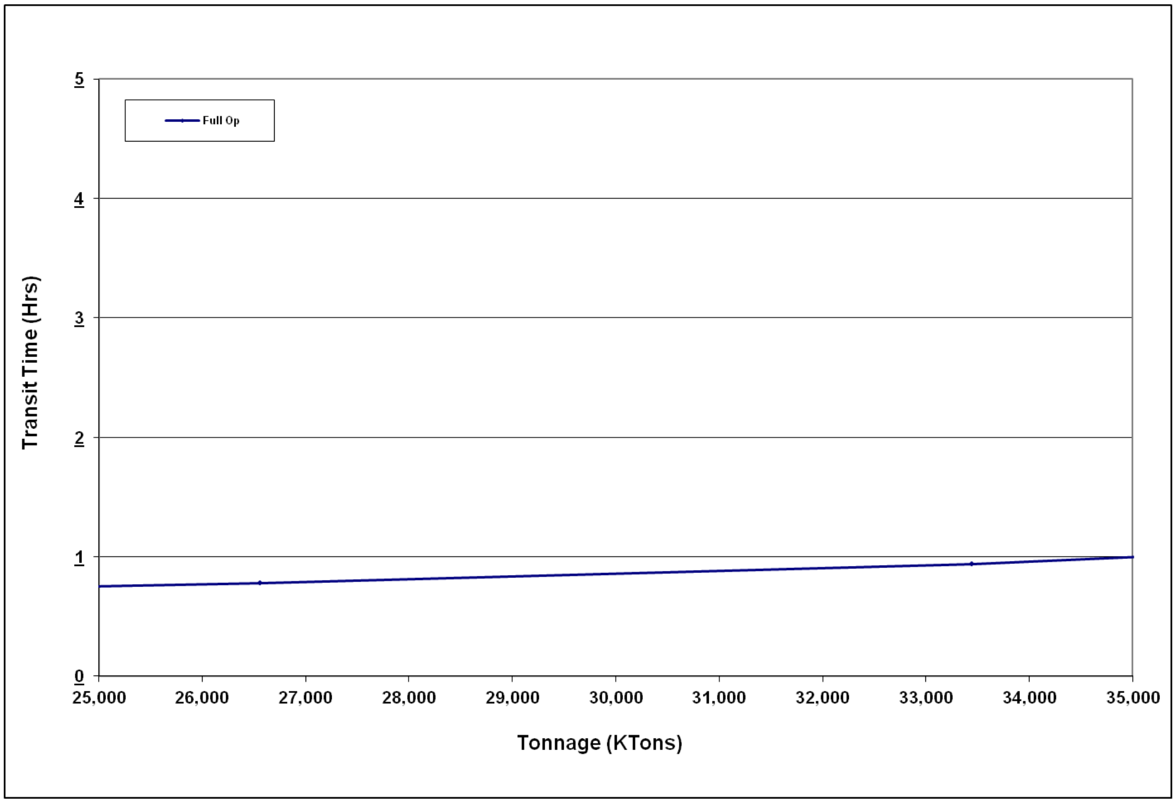


3.3.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Bayou Boeuf L&D does have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 39** shows delays remain low even at the highest projected demands

Figure A2- 39
Bayou Boeuf Without Project Condition Capacity Curve
Relevant Range



3.4 HARVEY LOCKS AND DAM

Harvey Lock and Dam is located on river mile 0 on the Gulf Intracoastal Waterway West and consists of 425' x 75' single main chamber with a lift of 20 feet at normal pool, see **Figure A2- 40**. In 2007, Harvey processed 3.6 million tons of commodities, of which 48.7% was petroleum. 2,900 tows with 3,400 barges, and 380 recreation craft and 3,500 lightboats passed through Harvey in 2007. The average tow size was 1.2 barges per tow carrying 1,200 tons.[5]

Figure A2- 40
Harvey Locks

3.4.1 Existing Condition Input Data

3.4.1.1 Processing Times

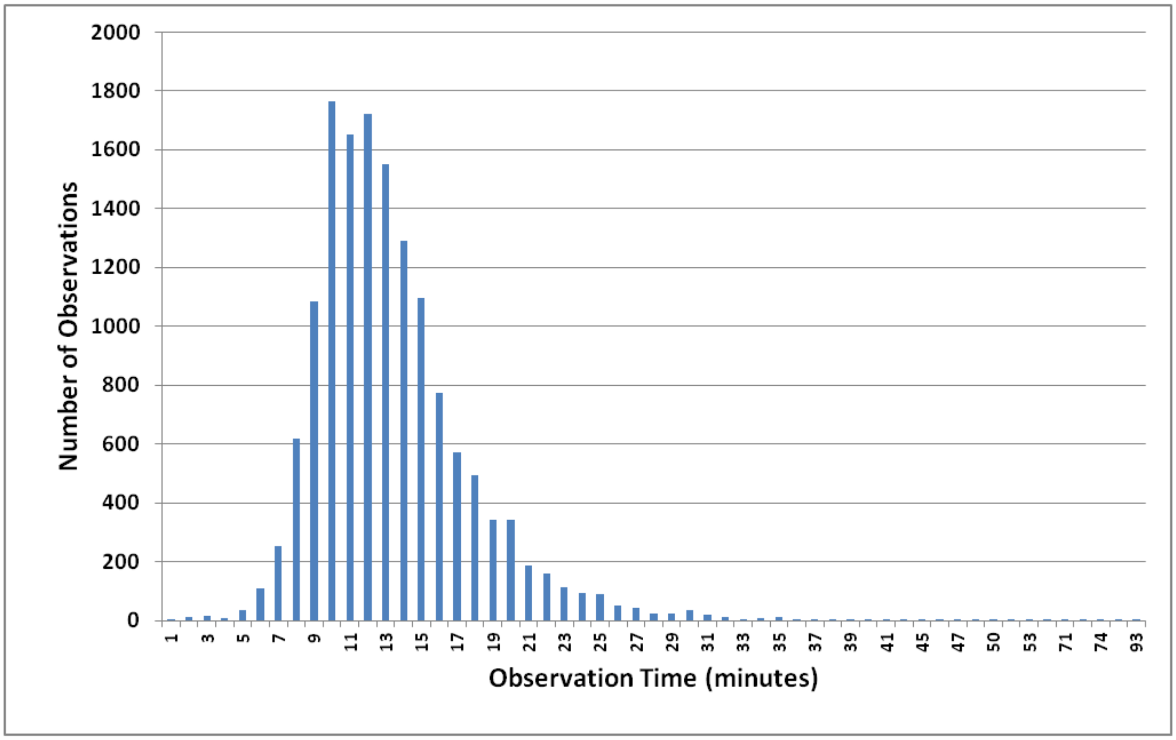
The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[6] Although 2007was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 41 shows a histogram for up bound chambering times to Harvey's 425' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Harvey exhibits very little amount of data rounding. Therefore, we used Harvey's data to develop processing time distributions for the Without Project Condition. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

[5]Lock Performance Monitoring System, 2002

[6]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 41
Harvey Upbound Chambering



Eight component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, and straight multi) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 45** shows sample set sizes, data years, and mean times for each component.

Table A2- 45
Harvey Processing Time Information
Single Cuts

Lock Component	Up bound Number Of Samples	Up bound Years Selected	Up bound Mean LPMS time (min)	Up bound Number of Outliers Removed	Down bound Number Of Samples	Down bound Years Selected	Down bound Mean LPMS time (min)	Down bound Number of Outliers Removed
Long Approach	11,925	00-09	8.39	0	11,438	00-09	8.40	0
Short Approach	2,470	00-09	6.19	0	2,039	00-09	8.92	0
Entry	14,656	00-09	6.91	0	13,655	00-09	7.66	0
Chambering	14,656	00-09	13.37	0	13,655	00-09	13.80	0
Long Exit	12,181	00-09	4.73	9	11,472	00-09	5.58	5
Short Exit	2,286	00-09	4.98	0	1,946	00-09	5.93	0
Turnback	2,470	00-09	20.35	0	1,975	00-09	17.96	0
Straight Multi	407	00-09	4.26	0	385	00-09	4.96	0

3.4.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 46** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 46
Harvey Historical LPMS Stalls and WAM Downtime

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	0.5	186	0.6	199
Rain (B)	0.5	24	0.5	24
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.2	32	0.2	32
Lightning (F)	3.8	53	4.3	51
Surface Conditions				
Low Water (G)	0.7	316	1.1	347
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.4	257	0.3	162
Flood (J)	0.1	1160	0.1	1160
Tow Conditions				
Interference by other vessels (K)	40.9	26	45.2	26
Tow malfunction (L)	0.8	33	0.9	31
Tow staff elsewhere occupied (M)	0.4	35	0.5	31
Operations (run-spill-divert water) (N)	0.0	0	0.0	0
Debris (O)	0.4	142	0.4	142
Tow accident or collision (P)		92	2.5	87
Lock Condition				
Debris in chamber (Q)	0.8	279	0.9	358
Hardware malfunction (R)	3.3	174	3.9	177
Staff elsewhere occupied (S)	0.5	40	0.6	41
Testing / maintenance (T)	2.2	120	2.5	103
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.8	90	0.8	90
Collision / accident (W)	0.1	50	0.1	50
Vehicular / RR bridge (X)	22.8	63	24.3	60
Inspection or testing lock (Y)	0.6	49	0.9	48
Other (Z)	1.6	173	1.7	165
Average	81	59	92	60
Totals		4,816		5,550

3.4.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.4.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 47** shows the number of vessels, by vessel type, for the 2007 Harvey fleet.

Table A2- 47
Harvey Number of Vessels by Type

Tows	2,929
Lightboats	3,474
Recreation Craft	384

3.4.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 48** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 48
Harvey Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	1,564
2	801-1500	62 x 24	1,896
3	1501-1800	76 x 29	193
4	1801-2400	78 x 31	78
5	2401-3200	103 x 33	138
6	3201-5000	121 x 38	50
7	5001-5600	130 x 45	0
8	5601-8400	147 x 45	11

3.4.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 49** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Harvey fleet.

Table A2- 49
Harvey Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	19	26.3%	1.1
200' Tanker	200 x 35	398	49.2%	1.1
214' Tanker	214 x 42	79	46.8%	1.0
200' Tanker	200 x 54	229	45.0%	1.0
264' Tanker	264 x 5f4	53	26.4%	1.0
300' Tanker	300 x 54	244	43.0%	1.1
380' Tanker	380 x 54	110	60.9%	1.0
150' Non-Tanker	150 x 35	368	64.1%	1.4
200' Non-Tanker	200 x 35	723	38.2%	1.3
200' Non-Tanker	200 x 40	19	57.9%	1.1
Tankers All Others		472	52.8%	1.0
Non-Tankers Others		690	64.3%	1.2

3.4.2 Existing Condition Calibration and Validation

3.4.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Harvey in 2007. In 2007, 3,474 lightboats and 384 recreation craft traveled through Harvey.

Table A2- 50 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 50
Harvey Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	3,592	3,542	-1.37%
Up	1,466	1,446	-1.40%
Down	2,126	2,097	-1.36%
Tows (LPMS)	2,929	2,927	-0.08%
Up	1,535	1,540	0.35%
Down	1,394	1,386	-0.55%
Tons/Tow (calc)	1,226	1,210	-1.29%
Up	955	939	-1.73%
Down	1,525	1,512	-0.81%
Barges (calc)	3,411	3,346	-1.92%
Up	1,795	1,745	-2.80%
Down	1,616	1,601	-0.93%
Loaded Barges (LPMS)	1,776	1,746	-1.67%
Up	718	707	-1.58%
Down	1,058	1,040	-1.73%
Empty Barges (LPMS)	1,635	1,599	-2.18%
Up	1,077	1,038	-3.62%
Down	558	561	0.60%
Percent Empty (calc)	47.9%	47.8%	-0.27%
Up	60.0%	59.5%	-0.84%
Down	34.5%	35.1%	1.54%
Tons/Loaded Barge (WC)	2,022	2,028	0.30%
Up	2,042	2,046	0.18%
Down	2,009	2,017	0.38%
Barges/Tow	1.16	1.14	-1.83%
Up	1.17	1.13	-3.14%
Down	1.16	1.15	-0.38%
Rec/Other	384	365	-5.0%
Up	232	173	-25.4%
Dn	152	192	26.1%
Light Boat	3,474	3,473	-0.04%
Up	1,853	1,745	-5.83%
Dn	1,621	1,728	6.58%

3.4.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO lockage policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 51** shows how well WAM reproduces the target processing and delay times. WAM output was within 7% of actual base year target values for the processing times, and WAM underestimated delay times by about 19% at Harvey.

Table A2- 51
Harvey Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	34.4	36.7	0.1588	6.8%
Tow Average Delay	38.5	32.6	3.0397	-15.2%
Tow Average Transit Time	72.9	69.3	3.1160	-4.9%
Validation Down Time				
Number of Events, Main	152	152	-	0.0%
Total Minutes, Main	7,724	7,724	-	0.0%
Percent of Year Closed, Main	1.5%	1.5%	-	0.0%
**2007 LPMS Data (NaSS)*				

3.4.3 Without Project Analysis

3.4.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Harvey; FIFO (First-In, First-Out) and 6-up/6-down service policy.

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 52**, the lockage policy with the highest tonnage level and lowest transit time is FIFO lockage policy. Therefore, the FIFO policy was used to create Harvey's WOPC capacity curves.

Table A2- 52
Harvey WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Harvey FIFO	14,182	0.65	507	507
Harvey 6U6D	12,843	0.64	886	887
*Optimal WOPC Lockage Policy: FIFO				

3.4.3.2 WOPC Results

3.4.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Harvey. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2- 53**.

Table A2- 53
Harvey Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
Full Operation	13.6	38.65

3.4.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 42 shows the capacity curve and other information for Harvey L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 42 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 53**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 42
Harvey Without Project Condition Capacity Curve

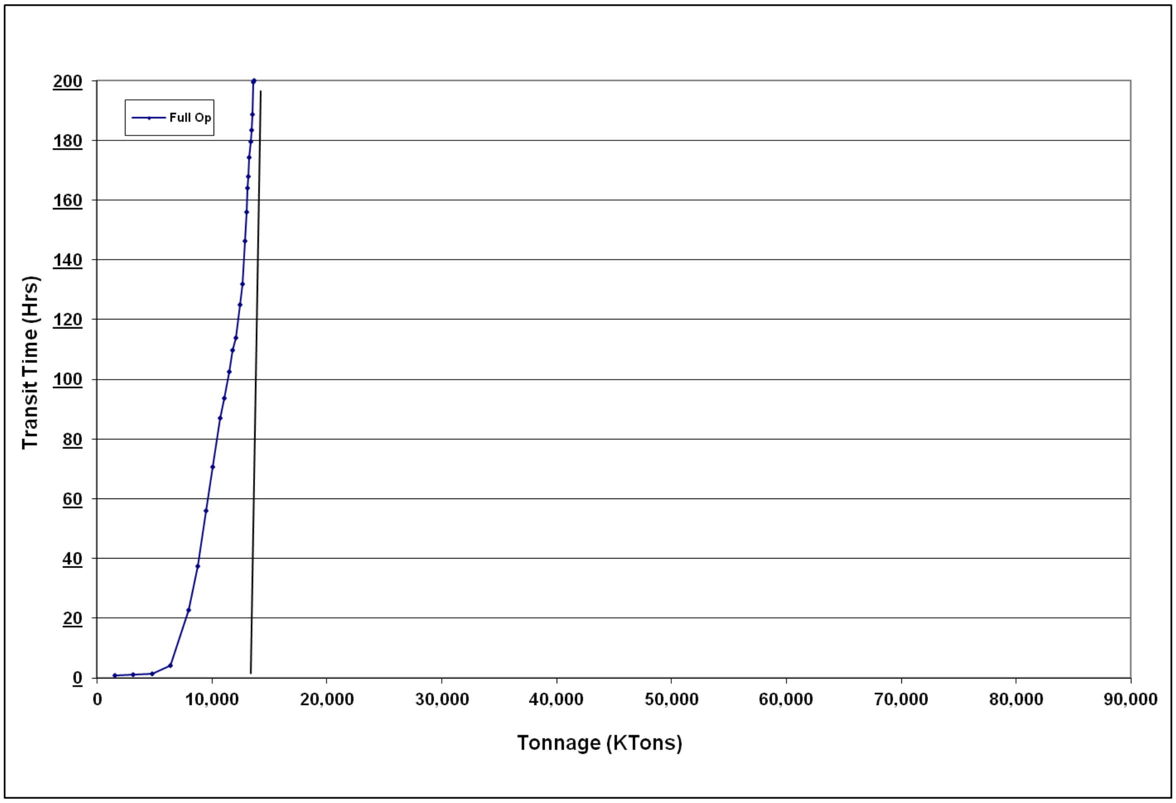
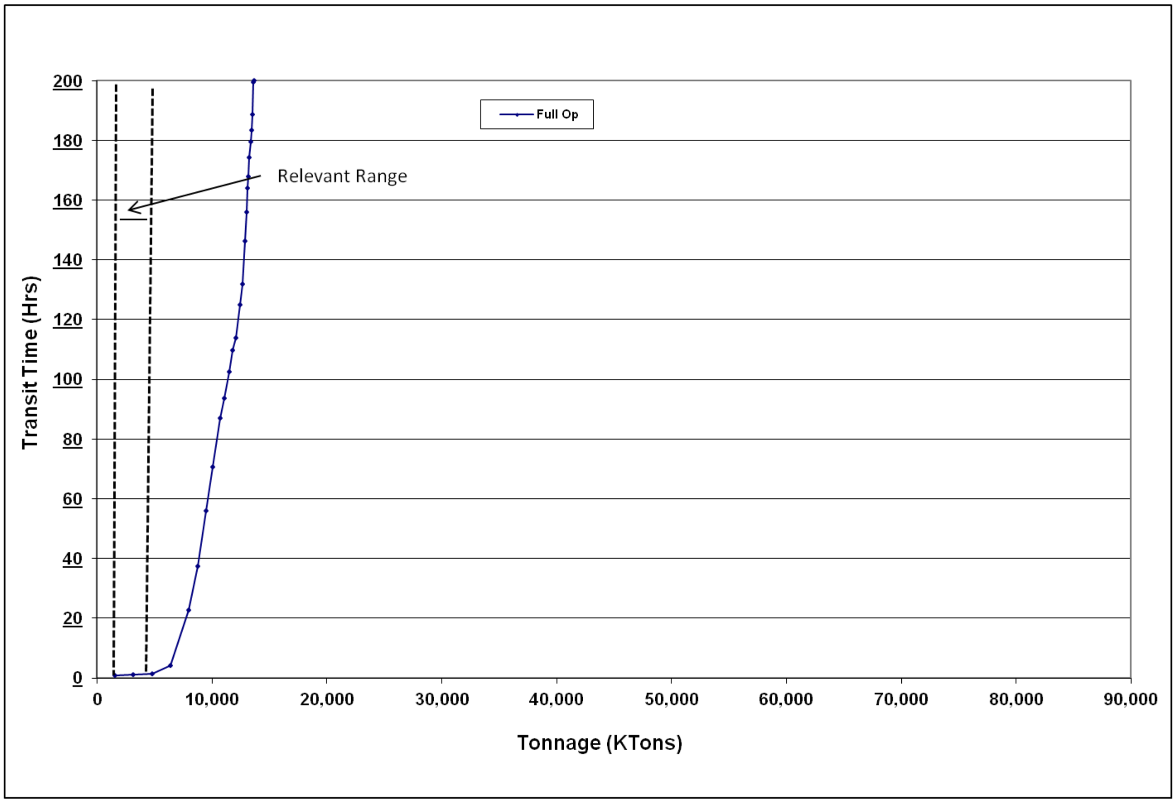


Figure A2- 43 shows the relevant range of traffic demand. This is the range of tonnage projected to use Harvey over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Harvey.

Figure A2- 43
Harvey Without Project Condition Capacity Curve

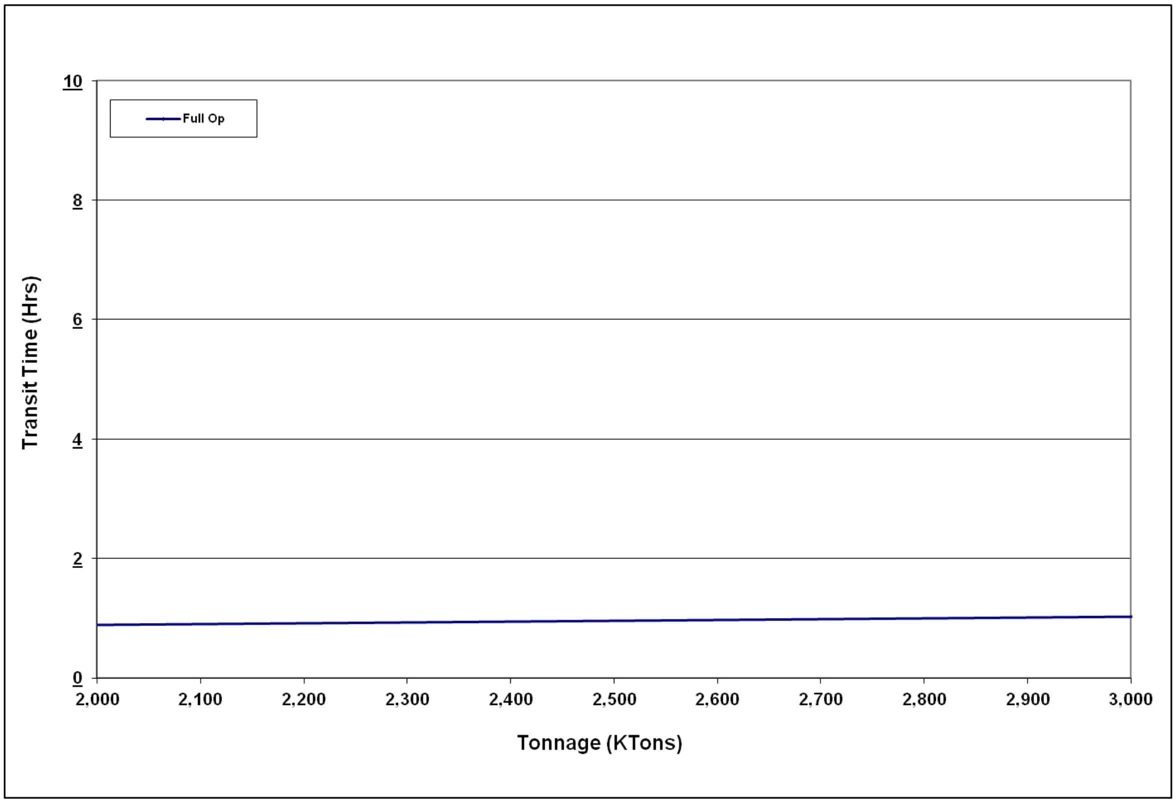


3.4.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Harvey L&D does have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 44** shows delays remain low even at the highest projected demands

Figure A2- 44
Harvey Without Project Condition Capacity Curve – Relevant Range



3.5 INNER HARBOR LOCKS AND DAM

Inner Harbor Lock and Dam is located on river mile 7 on the Gulf Intracoastal Waterway East and consists of 640' x 75' single main chamber with a lift of 17 feet at normal pool, see **Figure A2- 45**. In 2007, Inner Harbor processed 22.4 million tons of commodities, of which 33.7% was petroleum. 7,700 tows with 16,800 barges, and 500 recreation craft and 4,400 lightboats passed through Inner Harbor in 2007. The average tow size was 2.2 barges per tow carrying 2,900 tons.[7]

Figure A2- 45
Inner Harbor Locks

3.5.1 Existing Condition Input Data

3.5.1.1 Processing Times

The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[8] Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 46 shows a histogram for up bound chambering times for Inner Harbor's 640' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Inner Harbor exhibits a moderate amount of data rounding. Therefore, we used Inner Harbor's data to develop processing time distributions for the Without Project Condition. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

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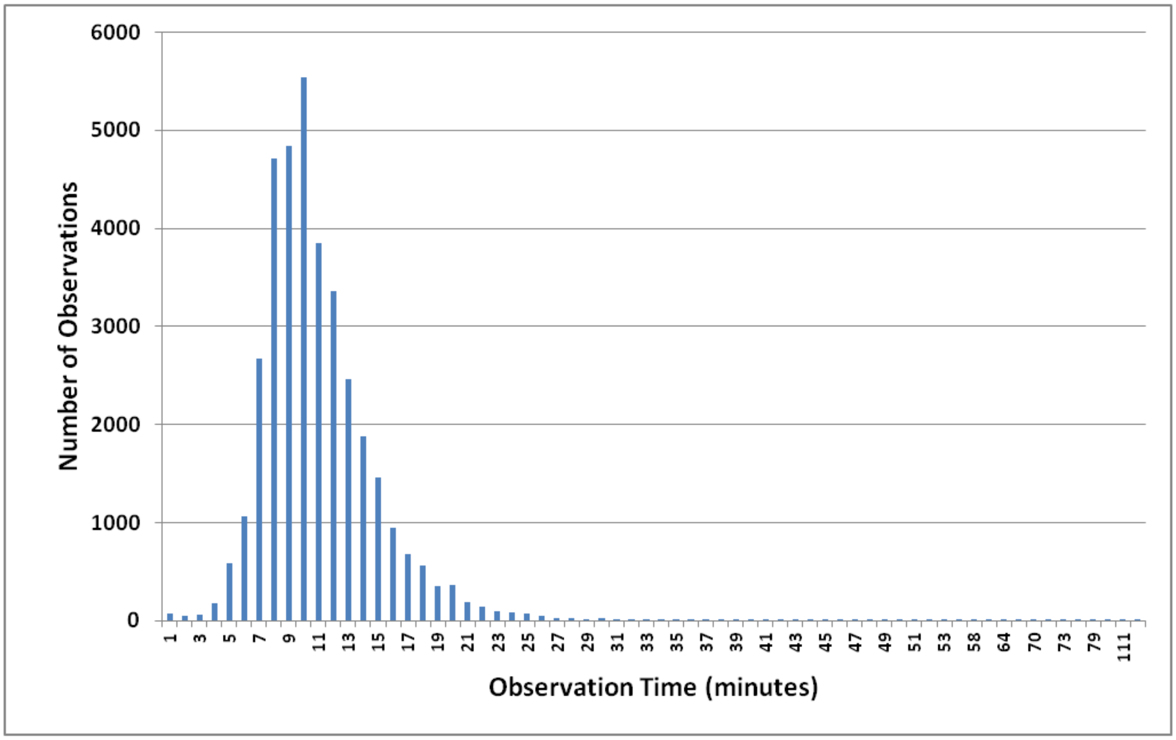
[7]Lock Performance Monitoring System, 2002

[8]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 46
Inner Harbor Up bound Chambering



Seven component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, and chamber turn backs) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 54** shows sample set sizes, data years, and mean times for each component.

Table A2- 54
Inner Harbor Processing Time Information
Single Cuts

	Up bound				Down bound			
Lock Component	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	17,435	00-09	9.34	0	15,414	00-09	9.43	0
Short Approach	14,734	00-05,07-09	4.61	0	12,903	00-05,07-09	3.39	0
Entry	36,540	00-09	7.20	0	36,540	00-09	7.20	0
Chambering	36,540	00-09	10.99	0	32,825	00-09	11.92	0
Long Exit	17,749	00-09	4.93	0	16,843	00-09	6.35	0
Short Exit	17,005	00-09	5.05	0	14,659	00-09	6.43	0
Turn back	14,735	00-09	13.04	2	12,901	00-05,07-09	15.38	2

3.5.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 55** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 55
Inner Harbor Historical LPMS Stalls and WAM Downtime

Closure Category (LPMS Code)	Main Chamber 2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	11.5	284	14.7	276
Rain (B)	0.0	0	0.0	0
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	1.4	206	2.2	246
Lightning (F)	1.5	39	1.9	37
Surface Conditions				
Low Water (G)	0.0	0	0.0	0
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.0	0	0.0	0
Flood (J)	0.1	936	0.2	936
Tow Conditions				
Interference by other vessels (K)	2.6	46	2.0	41
Tow malfunction (L)	0.6	69	0.4	77
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	0.1	28	0.1	28
Debris (O)	0.1	54	0.1	54
Tow accident or collision (P)	1.3	92	1.4	103
Lock Condition				
Debris in chamber (Q)	0.3	46	0.2	49
Hardware malfunction (R)	2.3	96	2.2	99
Staff elsewhere occupied (S)	0.2	51	0.2	51
Testing / maintenance (T)	4.6	126	4.9	129
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.3	65	0.2	33
Collision / accident (W)	0.7	81	1.0	77
Vehicular / RR bridge (X)	23.7	91	26.6	96
Inspection or testing lock (Y)	0.2	55	0.2	55
Other (Z)	1.0	169	1.0	261
Average	53	138	60	150
Totals		7,220		8,900

3.5.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.5.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 56** shows the number of vessels, by vessel type, for the 2007 Inner Harbor fleet.

Table A2- 56
Inner Harbor Number of Vessels by Type

Tows	7,675
Lightboats	4,379
Recreation Craft	474

3.5.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 57** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 57
Inner Harbor Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	1,021
2	801-1500	62 x 24	2,237
3	1501-1800	76 x 29	483
4	1801-2400	78 x 31	108
5	2401-3200	103 x 33	458
6	3201-5000	121 x 38	104
7	5001-5600	130 x 45	0
8	5601-8400	147 x 45	7

3.5.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 58** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Inner Harbor fleet.

Table A2- 58
Inner Harbor Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	47	44.7%	1.7
200' Tanker	200 x 35	827	57.7%	1.7
214' Tanker	214 x 42	247	52.6%	1.7
200' Tanker	200 x 54	222	45.9%	1.2
264' Tanker	264 x 5f4	457	49.0%	1.4
300' Tanker	300 x 54	4,568	58.1%	1.8
380' Tanker	380 x 54	224	52.7%	1.1
150' Non-Tanker	150 x 35	507	60.0%	1.5
200' Non-Tanker	200 x 35	7,758	63.3%	3.5
200' Non-Tanker	200 x 40	45	62.2%	1.9
Tankers All Others		611	57.0%	1.3
Non-Tankers Others		1,218	49.3%	1.6

3.5.2 Existing Condition Calibration and Validation

3.5.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Inner Harbor in 2007. In 2007, 4,379 lightboats and other vessels types, and 474 recreation craft traveled through Inner Harbor.

Table A2- 59 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 59
Inner Harbor Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	22,416	22,250	-0.74%
Up	13,619	13,475	-1.06%
Down	8,797	8,776	-0.24%
Tows (LPMS)	7,675	7,728	0.69%
Up	3,934	3,969	0.88%
Down	3,741	3,760	0.50%
Tons/Tow (calc)	2,921	2,879	-1.42%
Up	3,462	3,395	-1.93%
Down	2,351	2,334	-0.73%
Barges (calc)	16,783	16,712	-0.43%
Up	9,230	9,169	-0.66%
Down	7,553	7,543	-0.14%
Loaded Barges (LPMS)	10,011	9,939	-0.72%
Up	6,045	5,987	-0.96%
Down	3,966	3,952	-0.36%
Empty Barges (LPMS)	6,772	6,773	0.01%
Up	3,185	3,182	-0.09%
Down	3,587	3,591	0.11%
Percent Empty (calc)	40.4%	40.5%	0.44%
Up	34.5%	34.7%	0.57%
Down	47.5%	47.6%	0.25%
Tons/Loaded Barge (WC)	2,239	2,239	-0.02%
Up	2,253	2,251	-0.10%
Down	2,218	2,221	0.12%
Barges/Tow	2.19	2.16	-1.11%
Up	2.35	2.31	-1.53%
Down	2.02	2.01	-0.63%
Rec/Other	474	412	-13.2%
Up	255	202	-20.8%
Dn	219	210	-4.3%
Light Boat	4,379	4,379	0.01%
Up	2,008	2,193	9.21%
Dn	2,371	2,186	-7.79%

3.5.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO lockage policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 60** shows how well WAM reproduces the target processing and delay times. WAM closely reproduces processing times at Inner Harbor by 4%, but underestimates delay times by 47%.

Table A2- 60
Inner Harbor Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**St dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	46.4	45.2	0.199	-2.52%
Tow Average Delay	488.6	524.2	130.260	7.27%
Tow Average Transit Time	535.0	569.4	130.364	6.42%
Validation Down Time				
Number of Events, Main	460	460	-	0.0%
Total Minutes, Main	52,279	52,279	-	0.0%
Percent of Year Closed, Main	9.9%	9.9%	-	0.0%
**2007 LPMS Data (NaSS)*				

3.5.3 Without Project Analysis

3.5.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Inner Harbor; FIFO (First-In, First-Out) and 6-up/6-down service policy

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 61**, the lockage policy with the highest tonnage level and lowest transit time is FIFO lockage policy. Therefore, the FIFO policy was used to create Inner Harbor's WOPC capacity curves.

Table A2- 61
Inner Harbor WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Inner Harbor FIFO	25,660	0.77	369	369
Inner Harbor 6U6D	24,645	0.73	475	475
*Optimal WOPC Lockage Policy: FIFO				

3.5.3.2 WOPC Results

3.5.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Inner Harbor. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2-62**.

Table A2- 62
Inner Harbor Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
No closures (normal operation)	25.5	46.1

3.5.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 47shows the capacity curve and other information for Inner Harbor L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at each tonnage level.

Figure A2- 47 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 62**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 47
Inner Harbor Without Project Condition Capacity Curve

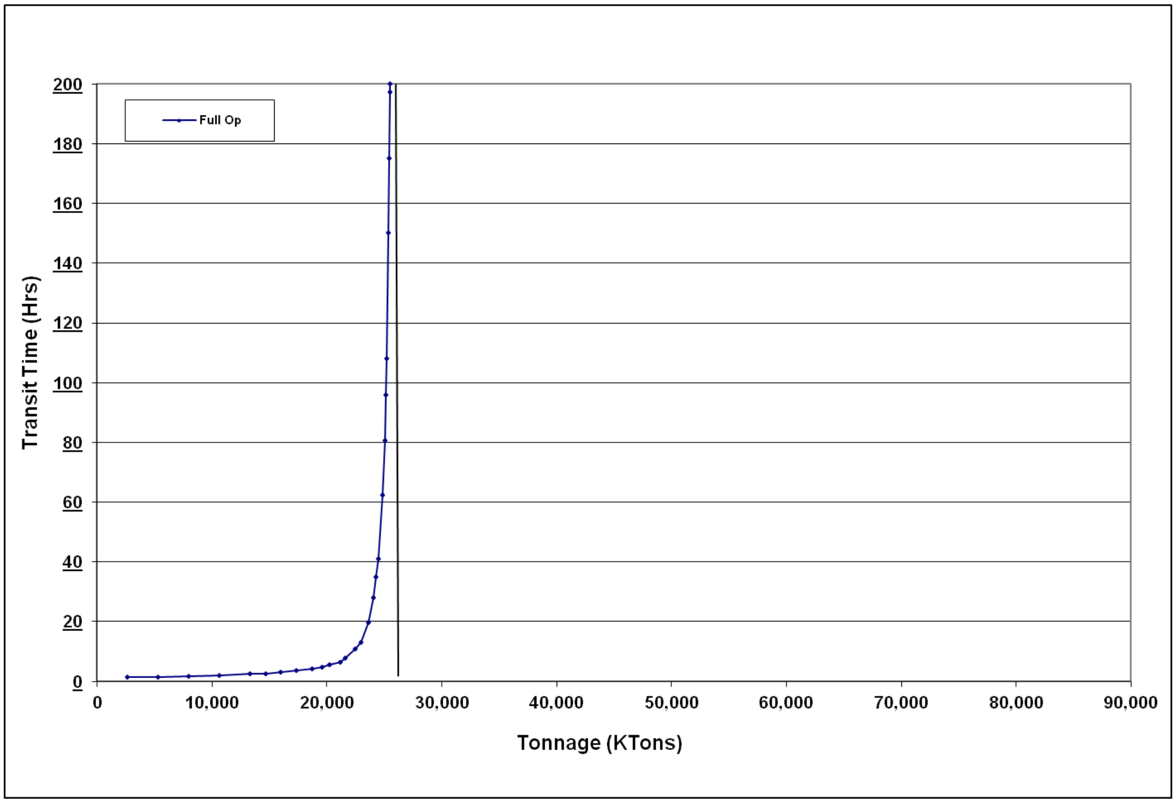
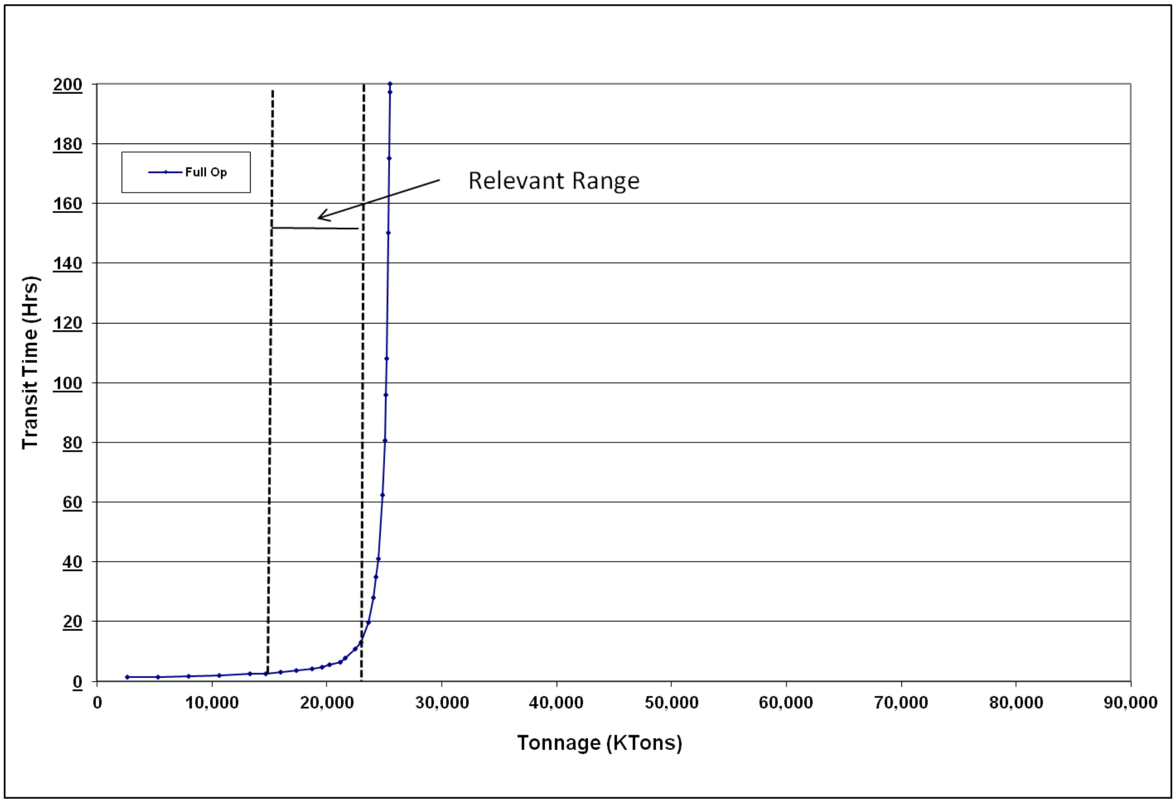


Figure A2- 48 shows the relevant range of traffic demand. This is the range of tonnage projected to use Inner Harbor over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Inner Harbor.

Figure A2- 48
Inner Harbor Without Project Condition Capacity Curve

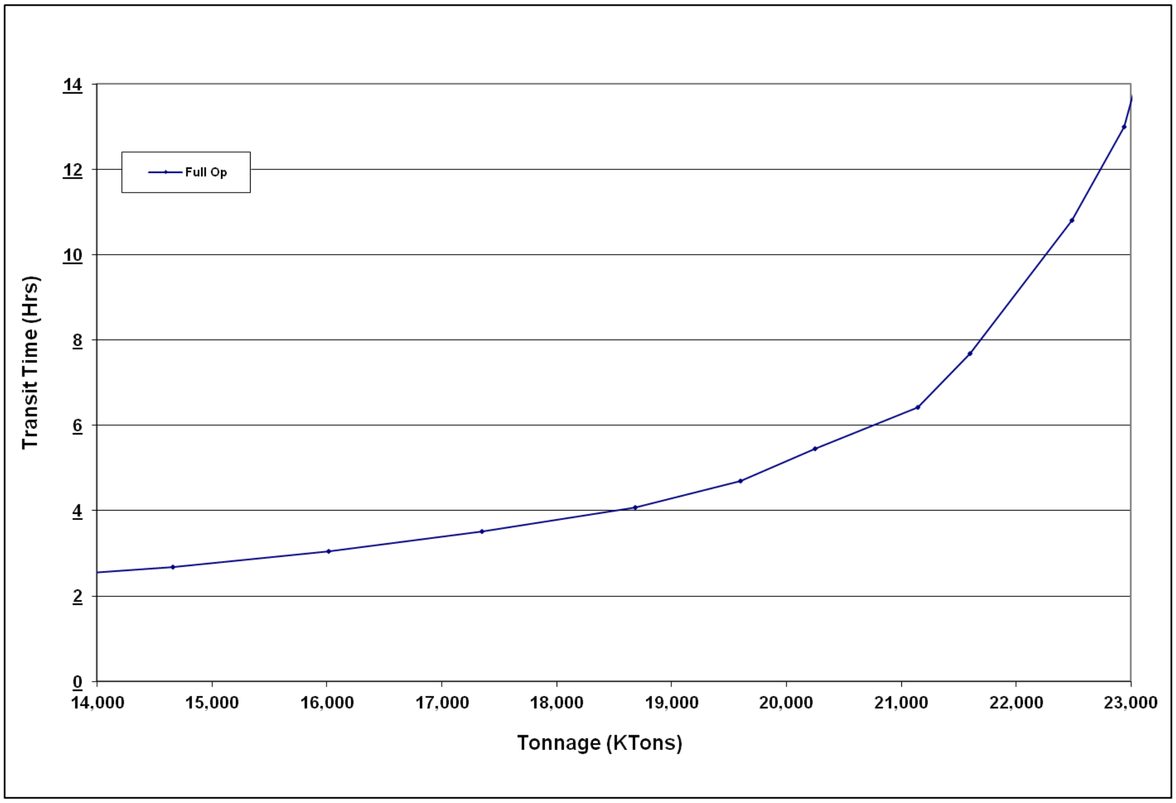


3.5.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Inner Harbor L&D does have sufficient capacity at the lowest expected demand but does not have sufficient capacity to serve navigation demand as capacity reaches the highest expected demand throughout the period of analysis. **Figure A2- 49** shows delays are small at the lowest projected demands but increase as traffic approaches the highest expected demands.

Figure A2- 49
Inner Harbor Without Project Condition Capacity Curve
Relevant Range



3.6 ALGIERS LOCKS AND DAM

Algiers Lock and Dam is located on river mile 0 on the Gulf Intracoastal Waterway and consists of 760' x 75' single main chamber with a lift of 18 feet at normal pool, see **Figure A2- 50**. In 2007, Algiers processed 30.0 million tons of commodities, of which 43% was petroleum. 9,800 tows with 24,600 barges, and 170 recreation craft and 2,700 lightboats passed through Algiers in 2007. The average tow size was 2.5 barges per tow carrying 3,000 tons.[9]

Figure A2- 50
Algiers Locks

3.6.1 Existing Condition Input Data

3.6.1.1 Processing Times

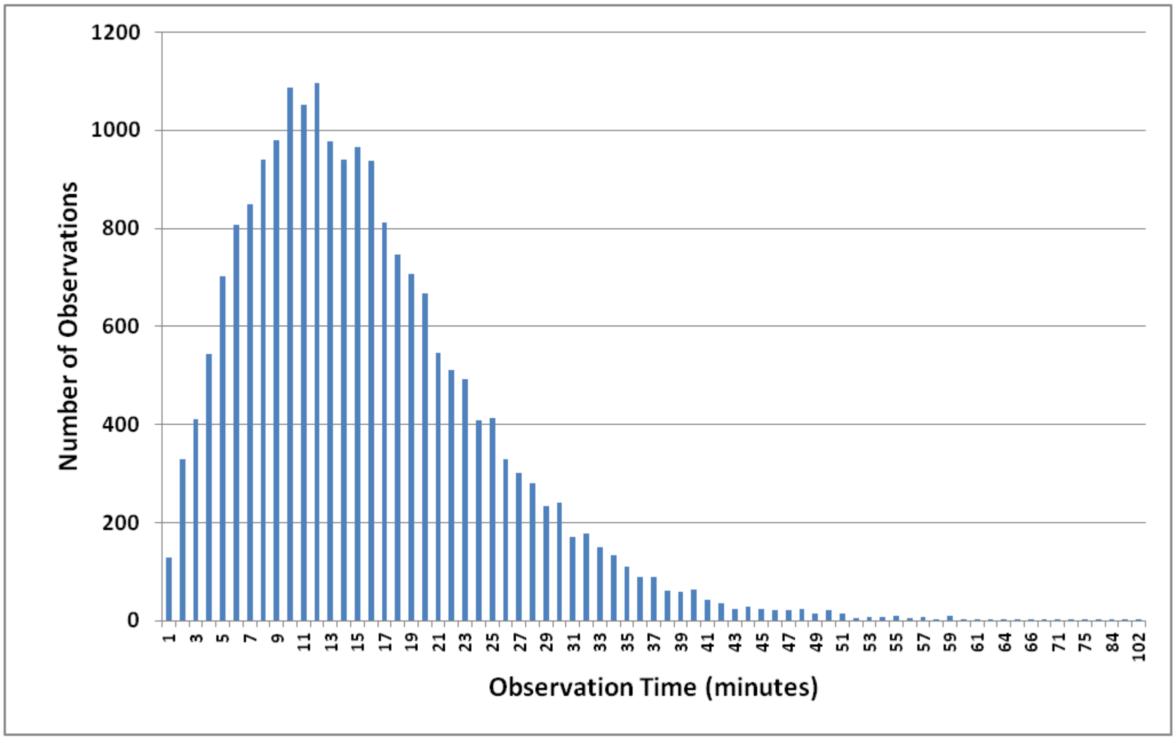
The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[10] Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 51 shows a histogram for the up bound long approaches to Algiers's 760' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Algiers exhibits very little amount of data rounding. Therefore, we used Algiers's data to develop processing time distributions for the main chamber single and double cuts for the Without Project Condition. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

[9]Lock Performance Monitoring System, 2002

[10]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 51
Algiers Up bound Long Approach to Main Chamber



Nine component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, straight multi, and open pass) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 63** and **Table A2- 64** shows sample set sizes, data years, and mean times for each component. **Figure A2- 52 s**hows the percent of the year from 2000-2009 that Algiers was in open pass. The average for all these years was 5.5% open pass, and a little lower at 1.5% open pass for the later years 2007 – 2009

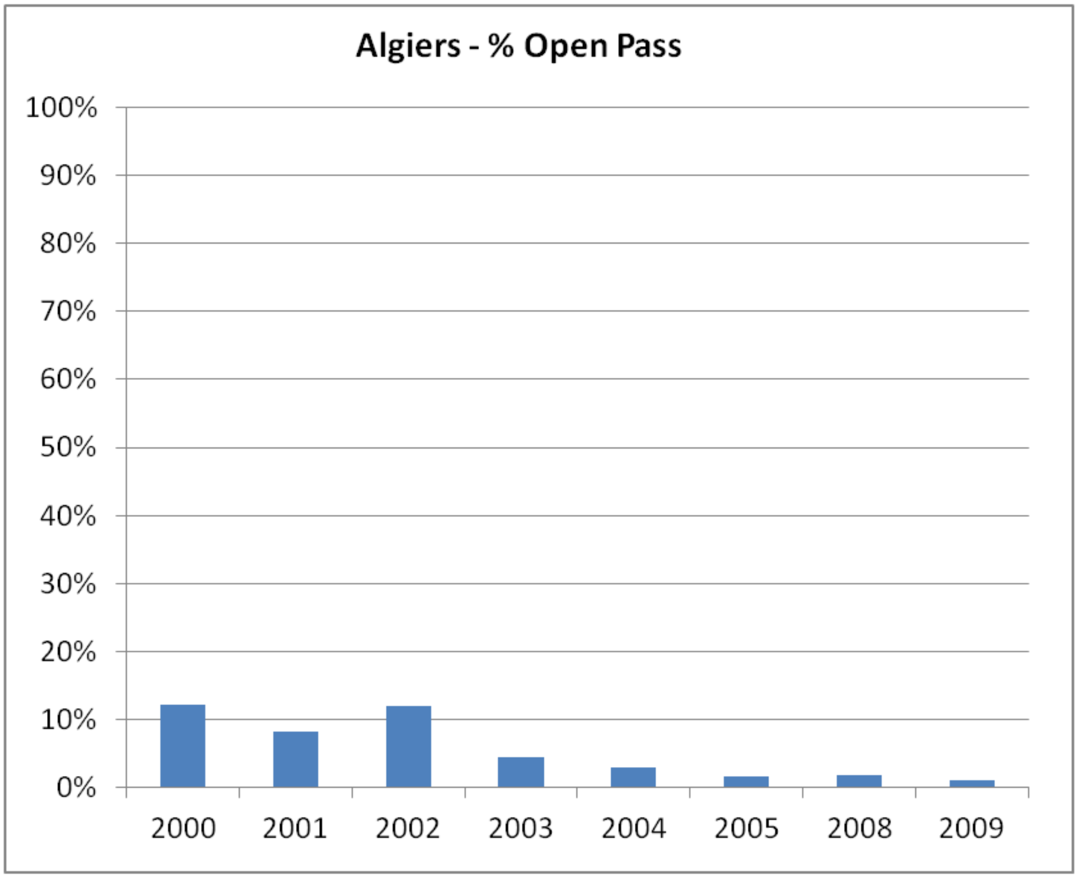
Table A2- 63
Algiers Processing Time Information
Single Cuts

Lock Component	Up bound Number Of Samples	Up bound Years Selected	Up bound Mean LPMS time (min)	Up bound Number of Outliers Removed	Down bound Number Of Samples	Down bound Years Selected	Down bound Mean LPMS time (min)	Down bound Number of Outliers Removed
Long Approach	20,880	00-09	15.68	0	21,093	00-09	19.52	0
Short Approach	11,939	00-09	8.25	0	15,822	00-09	7.98	0
Entry	34,536	00-09	9.54	1	39,145	00-09	8.65	0
Chambering	34,537	00-09	14.39	0	39,145	00-09	13.66	0
Long Exit	21,108	00-09	6.51	0	21,803	00-09	6.10	0
Short Exit	12,665	00-09	6.39	0	16,555	00-09	6.15	0
Turn back	12,880	00-09	10.93	0	17,225	00-09	11.16	1
Straight Multi	3,762	00-09	4.56	0	4,243	00-09	4.42	0
Open Pass	504	00-05,08-09	18.77	0	546	00-05,08-09	19.84	0

Table A2- 64
Algiers Processing Time Information
Double Cuts

Lock Component	Up bound Number Of Samples	Up bound Years Selected	Up bound Mean LPMS time (min)	Up bound Number of Outliers Removed	Down bound Number Of Samples	Down bound Years Selected	Down bound Mean LPMS time (min)	Down bound Number of Outliers Removed
Long Approach	121	00-10	9.10	0	123	02-09	7.69	0
Short Approach	633	01-09	6.55	0	883	00-09	5.79	0
Entry	754	00-09	10.10	0	1,015	00-09	8.93	0
Chambering	752	00-09	16.74	2	1,014	00-09	15.27	1
Long Exit	404	00-09	6.99	0	491	00-09	6.43	1
Short Exit	289	01-09	6.37	0	425	00-09	6.31	0
Turn back	625	02-09	10.80	1	865	02-09	10.84	1

Figure A2- 52
Algiers – Percent of Open Pass



3.6.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

WAM random minor downtime files were developed using historical LPMS data based on years from 2000 through 2009. Downtime events were grouped by type of event over the 10 year period. **Table A2- 65** shows a summary of the data and the downtimes used in WAM.

Table A2- 65
Algiers Historical LPMS Stalls and WAM Downtime

Closure Category (LPMS Code)	Main Chamber 2000-2009 LPMS Average Freq./Yr	Dur (min)	2000-2009 WAM Downtime Freq./Yr	Dur (min)
Weather				
Fog (A)	8.7	336	10.2	323
Rain (B)	0.1	44	0.1	44
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.2	65	0.1	63
Lightning (F)	0.5	115	0.5	115
Surface Conditions				
Low Water (G)	0.4	84	0.4	84
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.3	58	0.6	56
Flood (J)	0.0	0	0.0	0
Tow Conditions				
Interference by other vessels (K)	3.6	54	4.8	54
Tow malfunction (L)	0.5	66	0.4	93
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	0.0	0	0.0	0
Debris (O)	0.3	46	0.3	46
Tow accident or collision (P)	1.0	97	1.1	91
Lock Condition				
Debris in chamber (Q)	0.5	487	0.6	412
Hardware malfunction (R)	1.2	256	1.5	212
Staff elsewhere occupied (S)	0.0	0	0.0	0
Testing / maintenance (T)	0.5	112	0.7	117
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.4	149	0.5	166
Collision / accident (W)	0.1	190	0.1	190
Vehicular / RR bridge (X)	0.0	0	0.0	0
Inspection or testing lock (Y)	0.0	0	0.0	0
Other (Z)	1.3	259	1.2	296
Average	20	225	23	214
Totals		4,405		4,945

3.6.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.6.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 66** shows the number of vessels, by vessel type, for the 2007 Algiers fleet.

Table A2- 66
Algiers Number of Vessels by Type

Tows	9,834
Lightboats	2,703
Recreation Craft	174

3.6.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 67** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 67
Algiers Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	706
2	801-1500	62 x 24	1,174
3	1501-1800	76 x 29	440
4	1801-2400	78 x 31	252
5	2401-3200	103 x 33	124
6	3201-5000	121 x 38	101
7	5001-5600	130 x 45	2
8	5601-8400	147 x 45	6

3.6.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 68** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Algiers fleet.

Table A2- 68
Algiers Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	51	68.6%	2.6
200' Tanker	200 x 35	1,197	56.0%	2.1
214' Tanker	214 x 42	550	41.8%	1.6
200' Tanker	200 x 54	406	47.0%	1.5
264' Tanker	264 x 5f4	222	58.6%	1.6
300' Tanker	300 x 54	6,480	60.9%	1.9
380' Tanker	380 x 54	387	52.7%	1.2
150' Non-Tanker	150 x 35	916	51.5%	1.7
200' Non-Tanker	200 x 35	11,392	56.8%	4.7
200' Non-Tanker	200 x 40	75	64.0%	3.3
Tankers All Others		1,311	60.3%	1.3
Non-Tankers Others		1,570	62.0%	1.9

3.6.2 Existing Condition Calibration and Validation

3.6.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Algiers in 2007. In 2007, 2,703 lightboats and other vessels types, and 174 recreation craft traveled through Algiers.

Table A2- 69 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 69
Algiers Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	30,020	29,997	-0.08%
Up	15,189	15,178	-0.07%
Down	14,832	14,819	-0.09%
Tows (LPMS)	9,834	10,041	2.10%
Up	4,707	4,809	2.16%
Down	5,127	5,233	2.06%
Tons/Tow (calc)	3,053	2,987	-2.14%
Up	3,227	3,156	-2.18%
Down	2,893	2,832	-2.10%
Barges (calc)	24,606	24,516	-0.37%
Up	11,515	11,492	-0.20%
Down	13,091	13,024	-0.52%
Loaded Barges (LPMS)	14,198	14,179	-0.14%
Up	6,808	6,797	-0.16%
Down	7,390	7,382	-0.12%
Empty Barges (LPMS)	10,408	10,337	-0.68%
Up	4,707	4,695	-0.25%
Down	5,701	5,642	-1.03%
Percent Empty (calc)	42.3%	42.2%	-0.32%
Up	40.9%	40.9%	-0.06%
Down	43.5%	43.3%	-0.52%
Tons/Loaded Barge (WC)	2,114	2,116	0.06%
Up	2,231	2,233	0.09%
Down	2,007	2,008	0.03%
Barges/Tow	2.50	2.44	-2.42%
Up	2.45	2.39	-2.31%
Down	2.55	2.49	-2.52%
Rec/Other	174	169	-2.9%
Up	68	79	16.2%
Dn	106	90	-15.1%
Light Boat	2,703	2,698	-0.20%
Up	1,314	1,366	3.92%
Dn	1,389	1,332	-4.10%

3.6.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO lockage policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 70** shows how well WAM reproduces the target processing and delay times. WAM slightly underestimates the processing times and overestimates the delay times at Algiers. We had difficulty getting the delay to validate. When the LPMS open pass schedule was only 4.5% of the year, WAM overestimated the delay times. Upon further investigation, we discovered that the open pass schedule appeared to be much higher than shown in the LPMS data for the initial year selected, The LPMS data shows that the highest percentage of open pass in any given year from 2000-2009 at Algiers was 12.2%, thus, a different year was selected to determine a longer open pass period. When the open pass schedule was increased to 12.2% of the year, the WAM delays were reduced significantly to better match the target delay.

Table A2- 70
Algiers Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	46.6	44.6	0.10	-4.2%
Tow Average Delay	257.4	252.0	21.21	-2.1%
Tow Average Transit Time	304.0	296.6	21.29	-2.4%
Validation Down Time				
Number of Events, Main	24	24	-	0.0%
Total Minutes, Main	4,858	4,858	-	0.0%
Percent of Year Closed, Main	0.9%	0.9%	-	0.0%
**2000-09 LPMS Data (NaSS)*				

3.6.3 Without Project Analysis

3.6.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Algiers; FIFO (First-In, First-Out) and 6-up/6-down service policy.

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 71**, the lockage policy with the highest tonnage level and lowest transit time is FIFO lockage policy. Therefore, the FIFO policy was used to create Algiers's WOPC capacity curves.

Table A2- 71
Algiers WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Algiers FIFO	35,541	0.74	1,966	1,967
Algiers 6U6D	35,137	0.69	1,992	1,993

*Optimal WOPC Lockage Policy: FIFO

3.6.3.2 WOPC Results

3.6.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Algiers. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2- 72**.

Table A2- 72
Algiers Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
No closures (normal operation)	35.2	45.21

3.6.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 53 shows the capacity curve and other information for Algiers L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 53 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 72**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 53
Algiers Without Project Condition Capacity Curve

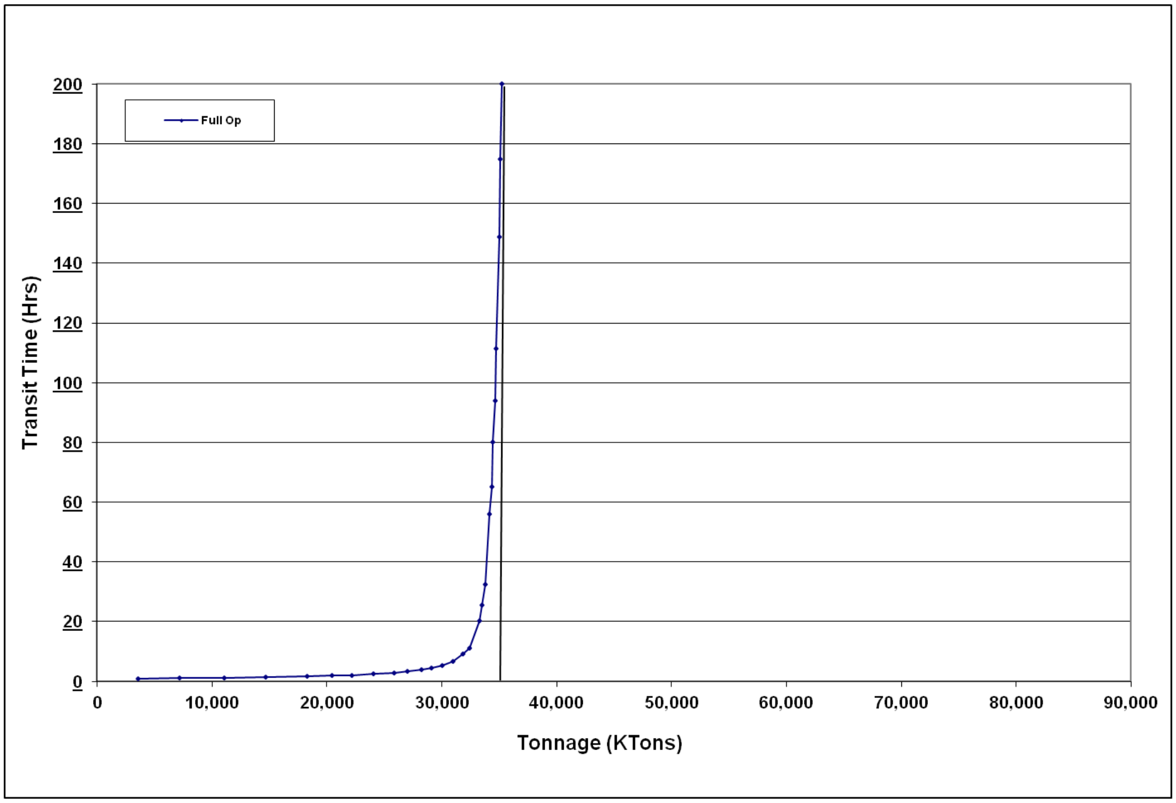
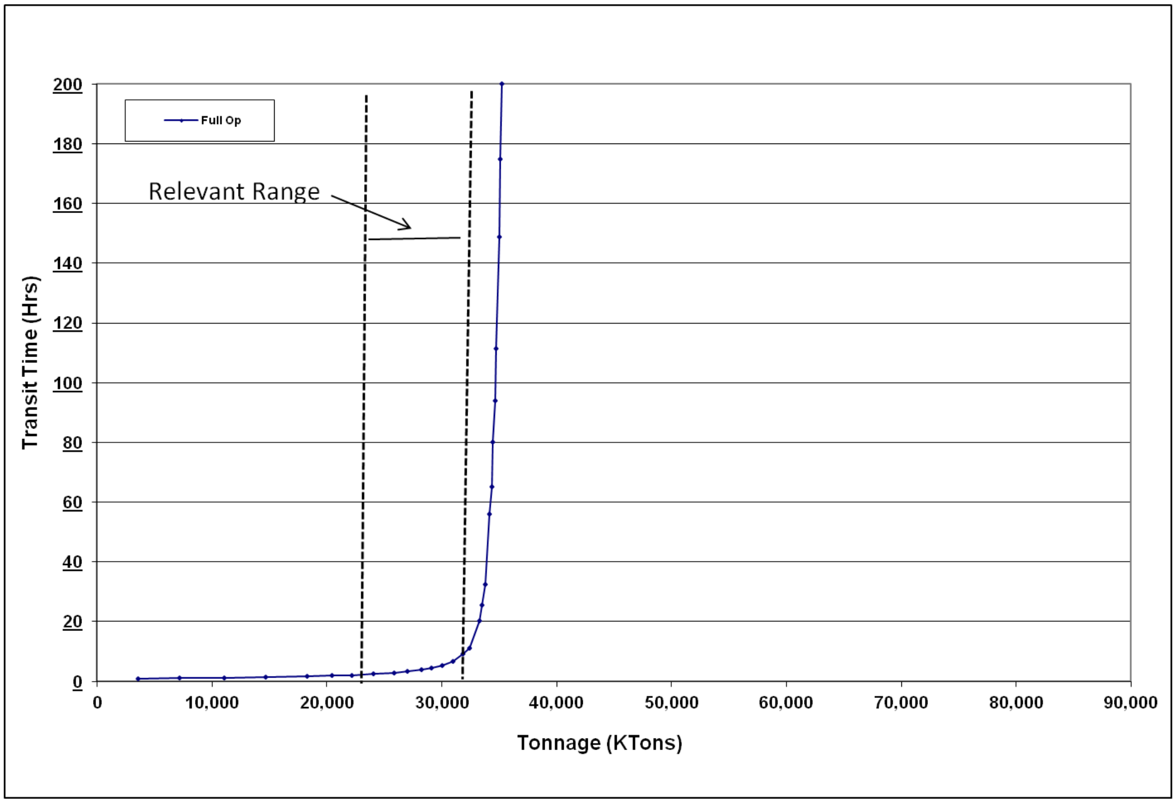


Figure A2- 54 shows the relevant range of traffic demand. This is the range of tonnage projected to use Algiers over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Algiers.

Figure A2- 54
Algiers Without Project Condition Capacity Curve

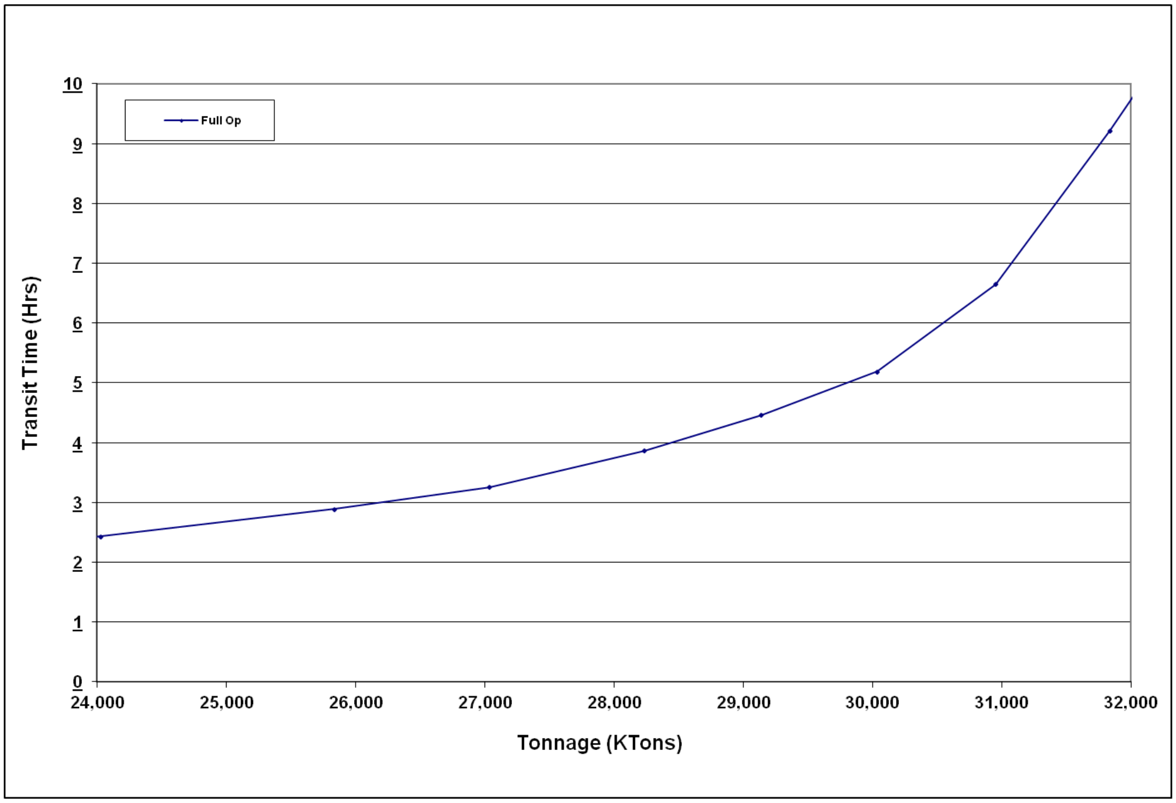


3.6.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Algiers L&D does have sufficient capacity at the lowest expected demand but does not have sufficient capacity to serve navigation demand as capacity reaches the highest expected demand throughout the period of analysis. **Figure A2- 55** shows delays are small at the lowest projected demands but increase as traffic approaches the highest expected demands.

Figure A2- 55
Algiers Without Project Condition Capacity Curve - Relevant Range



3.7 OLD RIVER LOCKS AND DAM

Old River Lock and Dam is located on river mile 1 on the Old River and consists of 1200' x 75' single main chamber with a lift of 35 feet at normal pool, see **Figure A2- 56**. In 2007, Old River processed 8.4 million tons of commodities, of which 46.7% was aggregates. 2,600 tows with 8,700 barges, and 800 recreation craft and lightboats passed through Old River in 2007. The average tow size was 3.4 barges per tow carrying 3,300 tons.[11]

Figure A2- 56
Old River Locks

3.7.1 Existing Condition Input Data

3.7.1.1 Processing Times

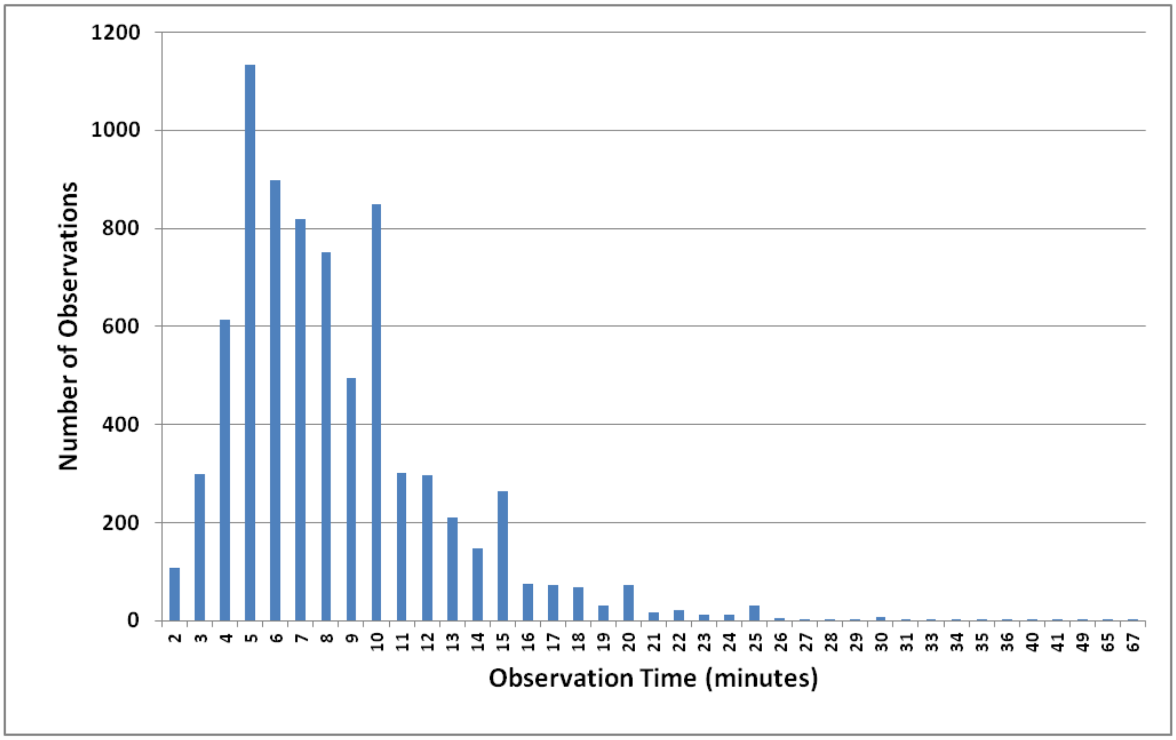
The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[12] Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 57 shows a histogram for the up bound entry times to Old River's 1200' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Old River exhibits a moderate amount of data rounding. Therefore, we used Old River's data to develop processing time distributions for the Without Project Condition. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

[11]Lock Performance Monitoring System, 2002

[12]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 57
Old River Upbound Entry to Main Chamber



Eight component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, and straight multi) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 73** show sample set sizes, data years, and mean times for each component.

Table A2- 73
Old River Processing Time Information
Single Cuts

Lock Component	Up bound				Down bound			
	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	6,268	04-09	9.46	5	5,395	04-09	9.69	8
Short Approach	884	04-09	9.49	0	831	04-09	10.27	0
Entry	7,626	04-09	8.38	4	6,665	04-09	9.00	9
Chambering	7,627	04-09	13.76	3	6,673	04-09	13.85	1
Long Exit	6,256	04-09	7.34	4	5,374	04-09	7.86	4
Short Exit	894	04-09	7.65	0	831	04-09	8.13	0
Turn back	884	04-09	12.76	0	831	04-09	13.49	0
Straight Multi	160	04-09	6.84	0	103	04-09	6.93	0

3.7.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

WAM random minor downtime files were developed using historical LPMS data based on years from 2000 through 2009. Downtime events were grouped by type of event over the 10 year period. **Table A2- 74** shows a summary of the data and the downtimes used in WAM.

Table A2- 74
Old River Historical LPMS Stalls and WAM Downtime

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	0.2	58	0.1	40
Rain (B)	0.0	0	0.0	0
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)	0.0	0	0.0	0
Wind (E)	0.1	45	0.8	208
Lightning (F)	0.0	0	0.0	0
Surface Conditions	0.0	0	0.0	0
Low Water (G)	0.0	0	0.0	0
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.0	0	0.0	0
Flood (J)	0.0	0	0.0	0
Tow Conditions	0.0	0	0.0	0
Interference by other vessels (K)	0.0	0	0.0	0
Tow malfunction (L)	0.0	0	0.0	0
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	0.0	0	0.0	0
Debris (O)	0.0	0	0.0	0
Tow accident or collision (P)	0.6	110	0.7	109
Lock Condition	0.0	0	0.0	0
Debris in chamber (Q)	0.0	0	0.0	0
Hardware malfunction (R)	1.0	221	1.2	198
Staff elsewhere occupied (S)	0.1	40	0.1	40
Testing / maintenance (T)	2.0	270	1.3	292
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others	0.0	0	0.0	0
Tow detained (V)	0.0	0	0.0	0
Collision / accident (W)	0.1	240	0.1	240
Vehicular / RR bridge (X)	0.1	146	0.2	146
Inspection or testing lock (Y)	0.0	0	0.0	0
Other (Z)	0.1	45	0.20	45
Average	4	207	5	198
Totals		891		930

3.7.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the “what and when” of the WAM fleet closely match the “what and when” of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.7.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 75** shows the number of vessels, by vessel type, for the 2007 Old River fleet.

Table A2- 75
Old River Number of Vessels by Type

Tows	2,571
Lightboats	805
Recreation Craft	17

3.7.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 76** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 76
Old River Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	20
2	801-1500	62 x 24	328
3	1501-1800	76 x 29	183
4	1801-2400	78 x 31	69
5	2401-3200	103 x 33	207
6	3201-5000	121 x 38	14
7	5001-5600	130 x 45	0
8	5601-8400	147 x 45	12

3.7.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 77** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Old River fleet.

Table A2- 77
Old River Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	117	44.4%	2.1
200' Tanker	200 x 35	54	31.5%	1.8
214' Tanker	214 x 42	0	0.0%	0.0
200' Tanker	200 x 54	18	38.9%	1.5
264' Tanker	264 x 5f4	79	34.2%	2.3
300' Tanker	300 x 54	1,338	54.0%	2.2
380' Tanker	380 x 54	47	63.8%	2.1
150' Non-Tanker	150 x 35	52	86.5%	1.5
200' Non-Tanker	200 x 35	6,861	45.2%	4.6
200' Non-Tanker	200 x 40	773	41.4%	3.3
Tankers All Others		46	60.9%	2.0
Non-Tankers Others		64	59.4%	1.5

3.7.2 Existing Condition Calibration and Validation

3.7.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Old River in 2007. In 2007, 805 lightboats and other vessels types, and only 17 recreation craft traveled through Old River.

Table A2- 78 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 78
Old River Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	8,438	8,431	-0.09%
Up	2,461	2,466	0.21%
Down	5,978	5,965	-0.21%
Tows (LPMS)	2,571	2,589	0.70%
Up	1,357	1,348	-0.66%
Down	1,214	1,241	2.22%
Tons/Tow (calc)	3,282	3,256	-0.78%
Up	1,813	1,829	0.88%
Down	4,924	4,807	-2.38%
Barges (calc)	8,670	8,517	-1.76%
Up	4,524	4,370	-3.40%
Down	4,146	4,147	0.02%
Loaded Barges (LPMS)	4,386	4,378	-0.18%
Up	980	976	-0.41%
Down	3,406	3,402	-0.12%
Empty Barges (LPMS)	4,284	4,139	-3.38%
Up	3,544	3,394	-4.23%
Down	740	745	0.68%
Percent Empty (calc)	49.4%	48.6%	-1.65%
Up	78.3%	77.7%	-0.86%
Down	17.8%	18.0%	0.65%
Tons/Loaded Barge (WC)	1,924	1,926	0.10%
Up	2,511	2,527	0.62%
Down	1,755	1,753	-0.09%
Barges/Tow	3.37	3.29	-2.45%
Up	3.33	3.24	-2.76%
Down	3.42	3.34	-2.15%
Rec/Other	17	20	17.6%
Up	3	9	200.0%
Dn	14	11	-21.4%
Light Boat	805	833	3.48%
Up	381	422	10.76%
Dn	424	411	-3.07%

3.7.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO service policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 79** shows how well WAM reproduces the target processing and delay times. WAM output closely matches the target processing times but underestimates the delay times.

Table A2- 79
Old River Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	41.7	39.4	0.2300	-5.5%
Tow Average Delay	27.6	11.3	1.9550	-59.0%
Tow Average Transit Time	69.3	50.7	2.0000	-26.8%
Validation Down Time				
Number of Events, Main	12	12	-	0.0%
Total Minutes, Main	1,697	1,697	-	0.0%
Percent of Year Closed, Main	0.3%	0.3%	-	0.0%
**2007 LPMS Data (NaSS)*				

3.7.3 Without Project Analysis

3.7.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Old River for both single and double cuts, FIFO (First-In, First-Out) and 6-up/6-down lockage policy.

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 80**, the lockage policy with the highest tonnage level and lowest transit time is the FIFO lockage policy. Therefore, the FIFO policy was used to create Old River's WOPC capacity curves.

Table A2- 80
Old River WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Old River FIFO	46,679	0.72	217.08	217.80
Old River 6U6D	44,059	0.73	482.72	483.45
*Optimal WOPC Lockage Policy: FIFO				

3.7.3.2 WOPC Results

3.7.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Old River. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2- 81.**

Table A2- 81
Old River Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
Full Operation	46.8	43.26

3.7.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, the navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 58 shows the capacity curve and other information for Old River L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 58 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 81**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 58
Old River Without Project Condition Capacity Curve

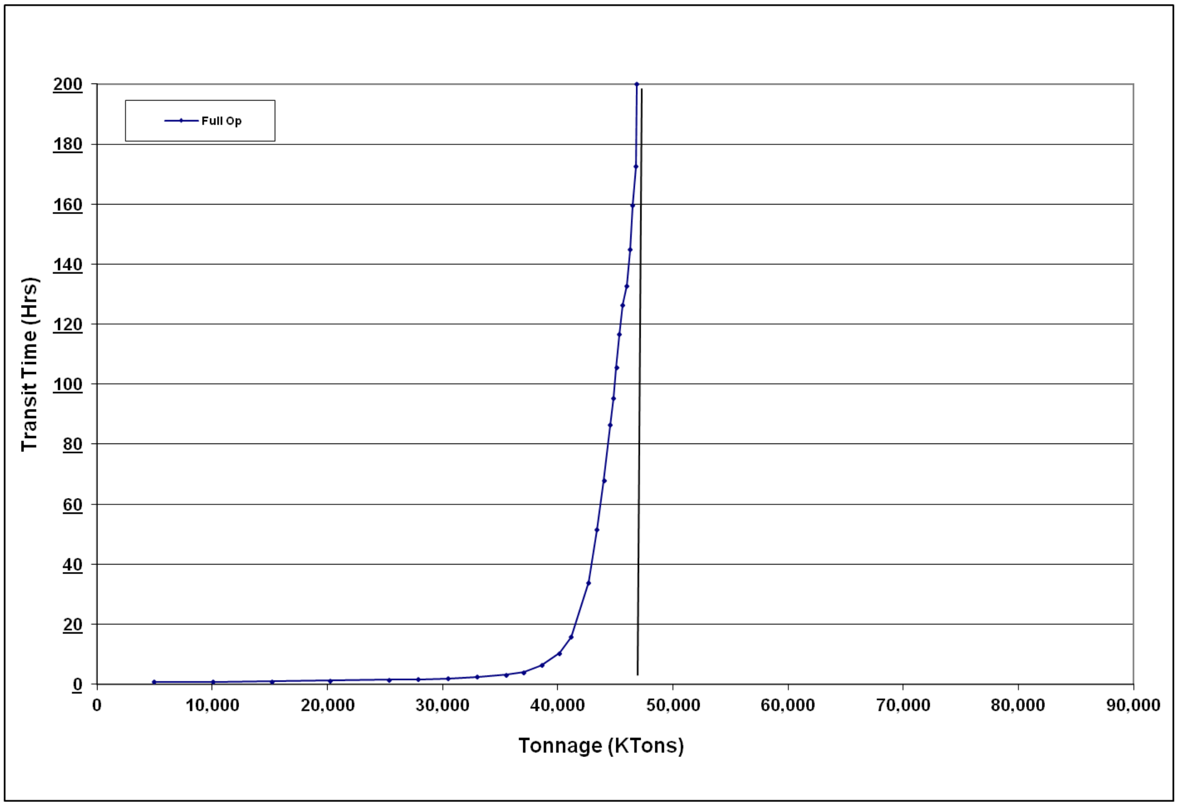
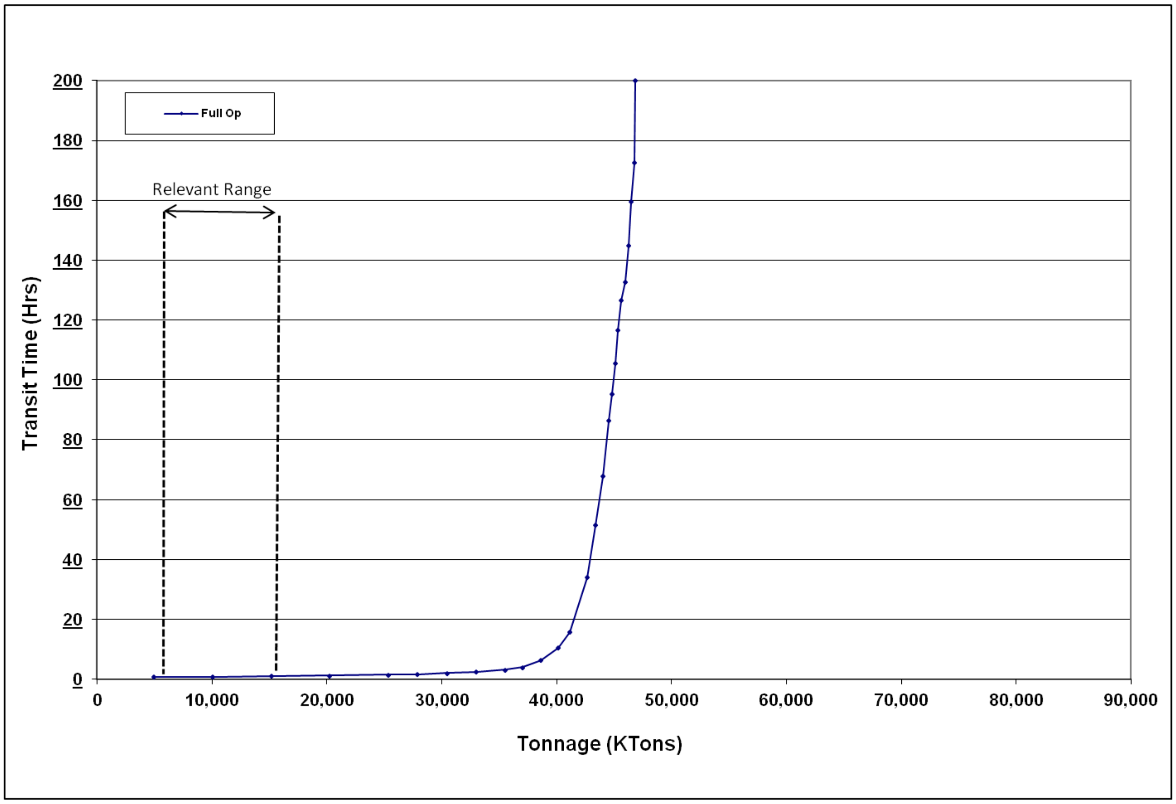


Figure A2- 59 shows the relevant range of traffic demand. This is the range of tonnage projected to use Old River over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Old River.

Figure A2- 59
Old River Without Project Condition Capacity Curve

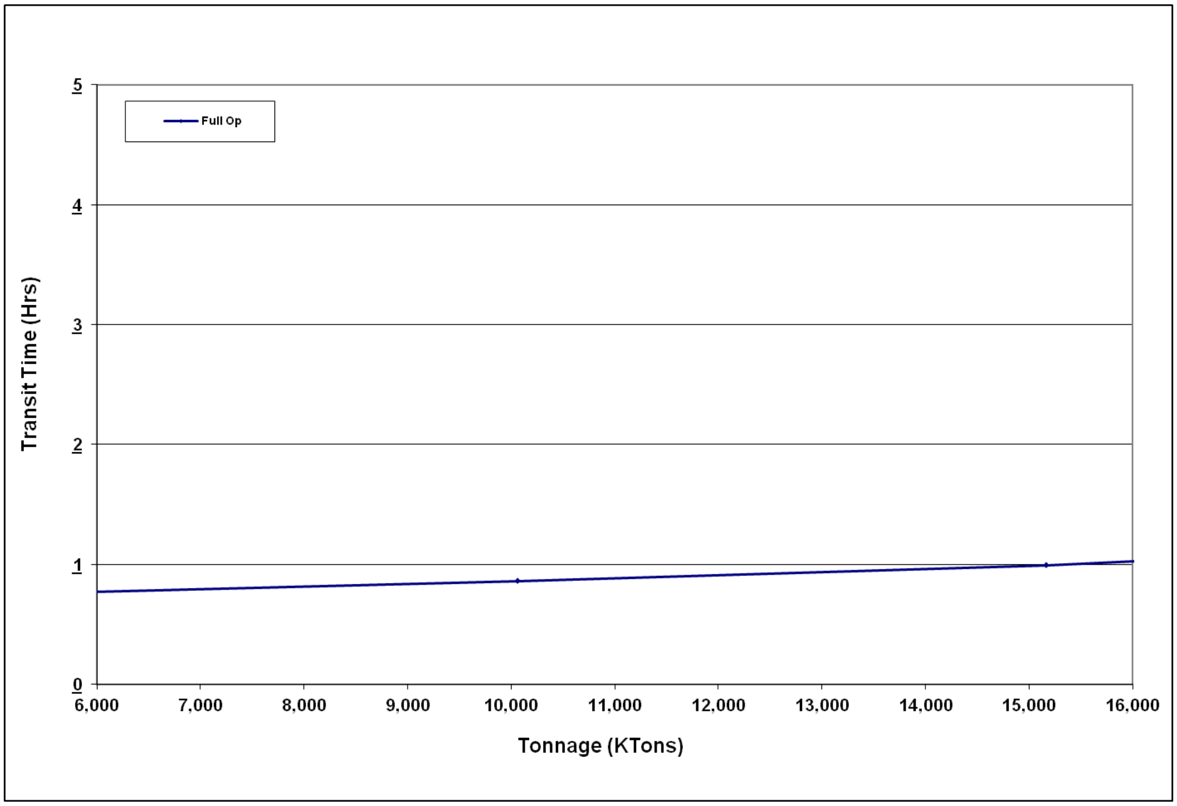


3.7.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Old River L&D does have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 60** shows delays remain low even at the highest projected demands

Figure A2- 60
Old River Without Project Condition Capacity Curve – Relevant Range



3.8 PORT ALLEN LOCKS AND DAM

Port Allen Lock and Dam is located on river mile 64.1 and consists of 1202' x 84' single main chamber with a lift of 45 feet at normal pool, see **Figure A2- 61**. In 2007, Port Allen processed 26.4 million tons of commodities, of which 30% was chemicals and 30% was petroleum. 6,700 tows with 23,900 barges, and 1,300 recreation craft and lightboats passed through Port Allen in 2007. The average tow size was 3.6 barges per tow carrying 3,900 tons.[13]

Figure A2- 61
Port Allen Locks

3.8.1 Existing Condition Input Data

3.8.1.1 Processing Times

The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[14] Although 2007 was chosen as the base year, data from 2000 through 2009 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 62 and **Figure A2- 63** show histograms for upbound entry and chambering times to Port Allen's 1200' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Port Allen exhibits moderate, **Figure A2- 62**, and extreme, **Figure A2- 63**, data rounding. Lock masters rounded in increments of 5 minutes for entry, exits, and approach times and to one single value for chambering times. Although rounding occurred at Port Allen, the data was still used o develop processing time distributions for the Without Project Condition because of the unique lock sizes used in this study. That is, there was no alternative lock to use as a proxy for Port Allen. See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

[13]Lock Performance Monitoring System, 2002

[14]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 62
Port Allen Upbound Entry

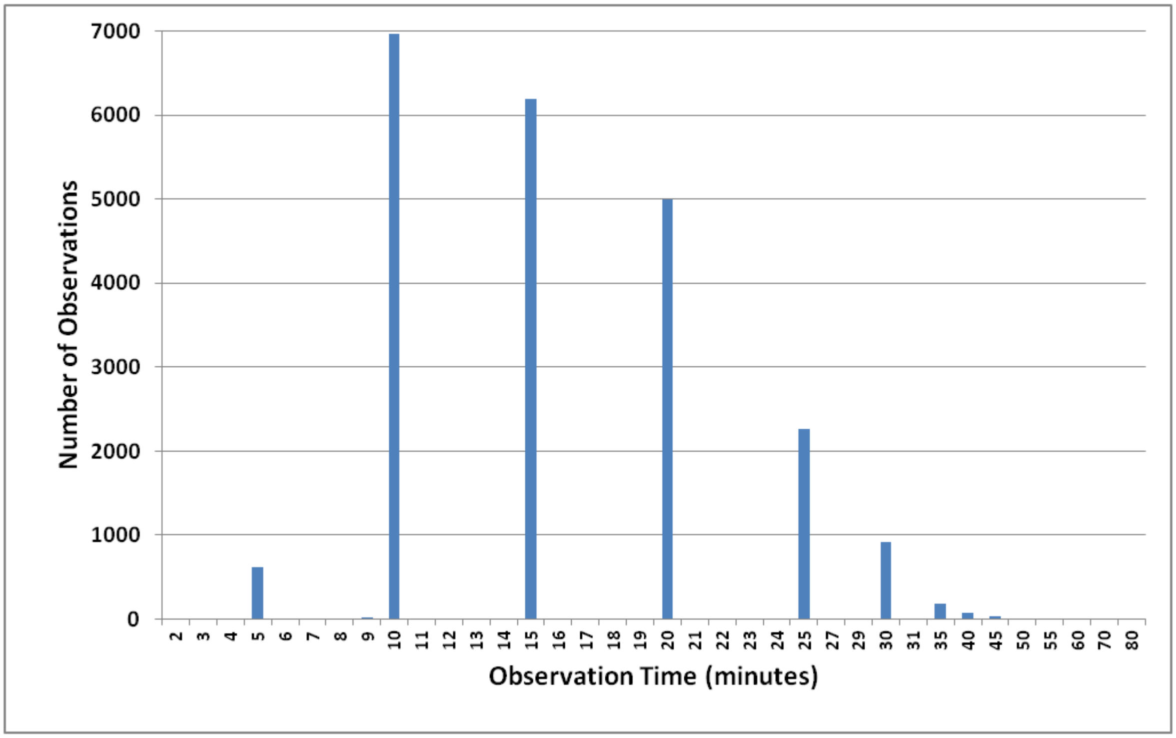
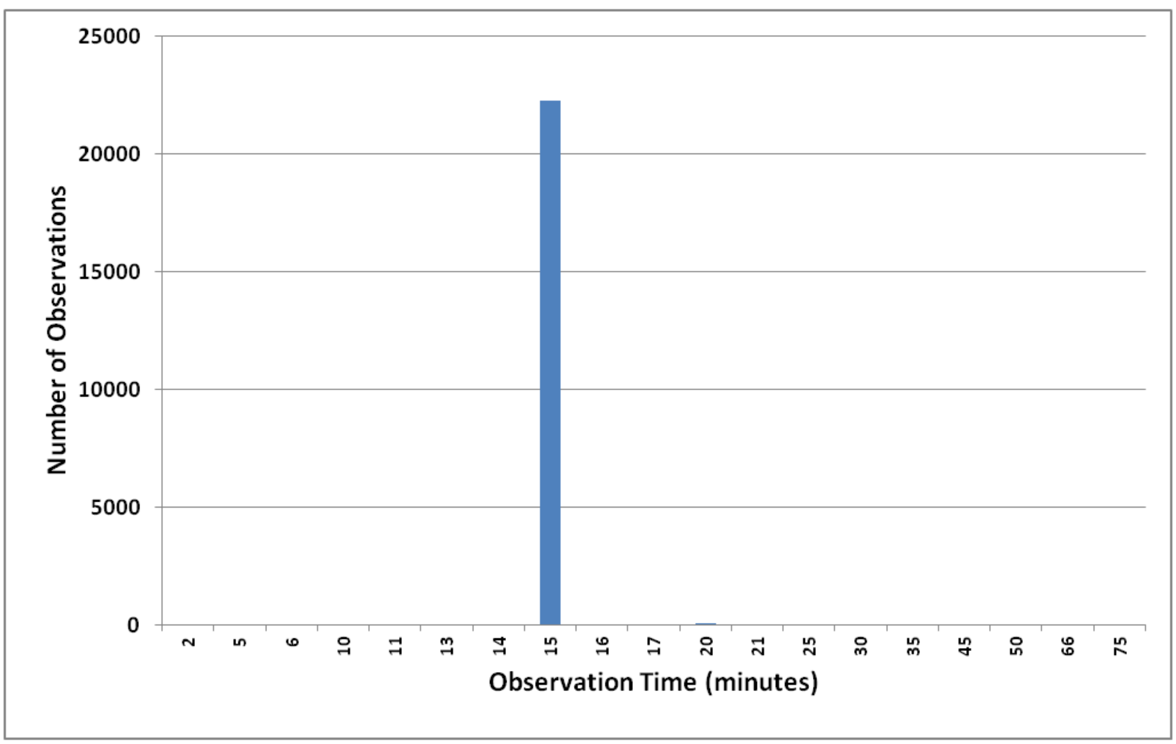


Figure A2- 63
Port Allen Upbound Chambering



Eight component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, and straight multi) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 82** shows sample set sizes, data years, and mean times for each component.

Table A2- 82
Port Allen Processing Time Information
Single Cuts

	Up bound				Down bound			
Lock Component	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	16,843	00-09	25.62	9	16,652	00-09	26.42	6
Short Approach	5,445	00-09	25.17	0	3,679	00-09	26.43	0
Entry	22,367	00-09	16.22	1	20,439	00-09	16.48	4
Chambering	22,471	00-09	15.02	12	20,520	00-09	15.03	20
Long Exit	17,037	00-09	11.40	4	16,714	00-09	11.30	4
Short Exit	5,274	00-09	11.80	0	3,619	00-09	11.71	0
Turn back	5,444	00-09	15.22	4	3,678	00-09	15.24	2
Straight Multi	5,833	00-09	9.60	0	4,836	00-09	9.44	0

3.8.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 83** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 83
Port Allen Historical LPMS Stalls and WAM Downtime

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	25.2	219	29.5	221
Rain (B)	0.6	62	0.7	57
Sleet or Hail (C)	0.0	0	2.1	51
Snow (D)	0.0	0	0.0	0
Wind (E)	3.8	57	3.4	63
Lightning (F)	0.5	71	0.4	84
Surface Conditions				
Low Water (G)	13.0	61	12.3	63
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.3	54	0.4	89
Flood (J)	4.5	263	4.5	263
Tow Conditions				
Interference by other vessels (K)	16.7	54	18.1	57
Tow malfunction (L)	3.4	56	3.2	58
Tow staff elsewhere occupied (M)	1.1	84	1.2	87
Operations (run-spill-divert water) (N)	383.7	104	349	103
Debris (O)	0.6	37	0.6	37
Tow accident or collision (P)	11.1	74	11	76
Lock Condition				
Debris in chamber (Q)	1.0	95	1.0	78
Hardware malfunction (R)	3.0	117	3.1	115
Staff elsewhere occupied (S)	8.3	61	8.4	58
Testing / maintenance (T)	23.9	109	24.5	115
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.8	107	0.5	123
Collision / accident (W)	0.2	77	0.3	91
Vehicular / RR bridge (X)	18.8	66	19.5	69
Inspection or testing lock (Y)	4.0	65	4.3	64
Other (Z)	3.2	165	3.8	152
Average	528	105	502	106
Totals		55,469		53,036

3.8.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.8.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 84** shows the number of vessels, by vessel type, for the 2007 Port Allen fleet.

Table A2- 84
Port Allen Number of Vessels by Type

Tows	6,720
Lightboats	1,244
Recreation Craft	44

3.8.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 85** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 85
Port Allen Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	169
2	801-1500	62 x 24	458
3	1501-1800	76 x 29	233
4	1801-2400	78 x 31	200
5	2401-3200	103 x 33	102
6	3201-5000	121 x 38	56
7	5001-5600	130 x 45	22
8	5601-8400	147 x 45	4

3.8.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 86** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 2007 Port Allen fleet.

Table A2- 86
Port Allen Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	289	54.7%	4.0
200' Tanker	200 x 35	4,564	57.7%	3.8
214' Tanker	214 x 42	195	0.0%	0.0
200' Tanker	200 x 54	719	54.9%	2.7
264' Tanker	264 x 5f4	120	46.7%	2.4
300' Tanker	300 x 54	3,689	59.6%	2.2
380' Tanker	380 x 54	37	86.5%	1.7
150' Non-Tanker	150 x 35	50	78.0%	1.4
200' Non-Tanker	200 x 35	11,699	60.2%	4.4
200' Non-Tanker	200 x 40	35	65.7%	3.5
Tankers All Others		2,242	62.9%	3.5
Non-Tankers Others		182	45.6%	1.9

3.8.2 Existing Condition Calibration and Validation

3.8.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Port Allen in 2007. In 2007, 1288 lightboats and recreation craft traveled through Port Allen.

Table A2- 87 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 87
Port Allen Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	26,422	26,359	-0.24%
Up	14,039	14,217	1.27%
Down	12,383	12,142	-1.95%
Tows (LPMS)	6,720	6,647	-1.08%
Up	3,482	3,483	0.04%
Down	3,238	3,164	-2.29%
Tons/Tow (calc)	3,932	3,965	0.85%
Up	4,032	4,082	1.23%
Down	3,824	3,837	0.34%
Barges (calc)	23,866	23,845	-0.09%
Up	12,598	12,683	0.68%
Down	11,268	11,161	-0.95%
Loaded Barges (LPMS)	14,189	14,158	-0.22%
Up	7,385	7,480	1.29%
Down	6,804	6,678	-1.85%
Empty Barges (LPMS)	9,677	9,686	0.10%
Up	5,213	5,203	-0.19%
Down	4,464	4,483	0.43%
Percent Empty (calc)	40.5%	40.6%	0.19%
Up	41.4%	41.0%	-0.86%
Down	39.6%	40.2%	1.39%
Tons/Loaded Barge (WC)	1,862	1,862	-0.02%
Up	1,901	1,901	-0.02%
Down	1,820	1,818	-0.11%
Barges/Tow	3.55	3.59	1.00%
Up	3.62	3.64	0.64%
Down	3.48	3.53	1.37%
Rec/Other	44	65	47.0%
Up	23	36	56.5%
Dn	21	29	36.5%
Light Boat	1,244	1,243	-0.11%
Up	590	624	5.71%
Dn	654	619	-5.35%

3.8.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO service policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 88** shows how well WAM reproduces the target processing and delay times. WAM closely reproduces processing times at Port Allen, but overestimates the delay times.

Table A2- 88
Port Allen Processing Time Validation

		WAM Simulations		Pct.
Statistic	***Target**	**Mean Value**	**Std dev**	**Diff**
Commercial Transit Performance (min)				
Tow Average Processing	67.7	72.0	0.2580	6.3%
Tow Average Delay	179.7	156.0	7.2690	-13.2%
Tow Average Transit Time	247.4	228.0	7.2700	-7.8%
Validation Down Time				
Number of Events, Main	502	502	-	0.0%
Total Minutes, Main	53,315	53,315	-	0.0%
Percent of Year Closed, Main	10.1%	10.1%	-	0.0%
**2000-09 LPMS Data (NaSS)*				

3.8.3 Without Project Analysis

3.8.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part "Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time." Two lockage policies were evaluated at Port Allen; FIFO (First-In, First-Out) and 6-up/6-down service policy.

To determine the best or "optimal" lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The 'optimal' lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 89**, the lockage policy with the highest tonnage level and lowest transit time is the FIFO lockage policy. Therefore, the FIFO policy was used to create Port Allen's WOPC capacity curves.

Table A2- 89
Port Allen WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
Port Allen FIFO	37,864	1.28	160.24	161.52
Port Allen 6U6D	36,101	1.27	337.10	338.37
**Optimal WOPC Lockage Policy: FIFO*				

3.8.3.2 WOPC Results

3.8.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Port Allen. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2-90.**

Table A2- 90
Port Allen Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
No closures (normal operation)	38.1	76.70

3.8.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, the navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 64 shows the capacity curve and other information for Port Allen L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 64 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 90**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 64
Port Allen Without Project Condition Capacity Curve

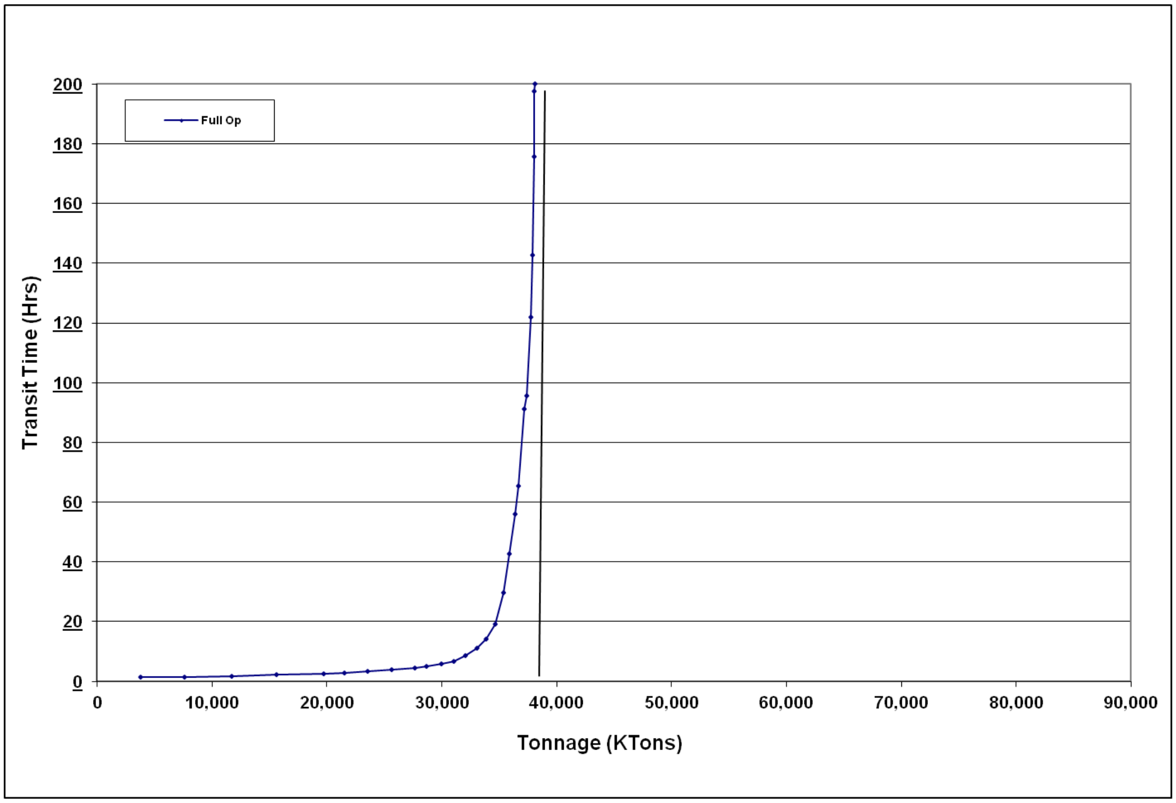
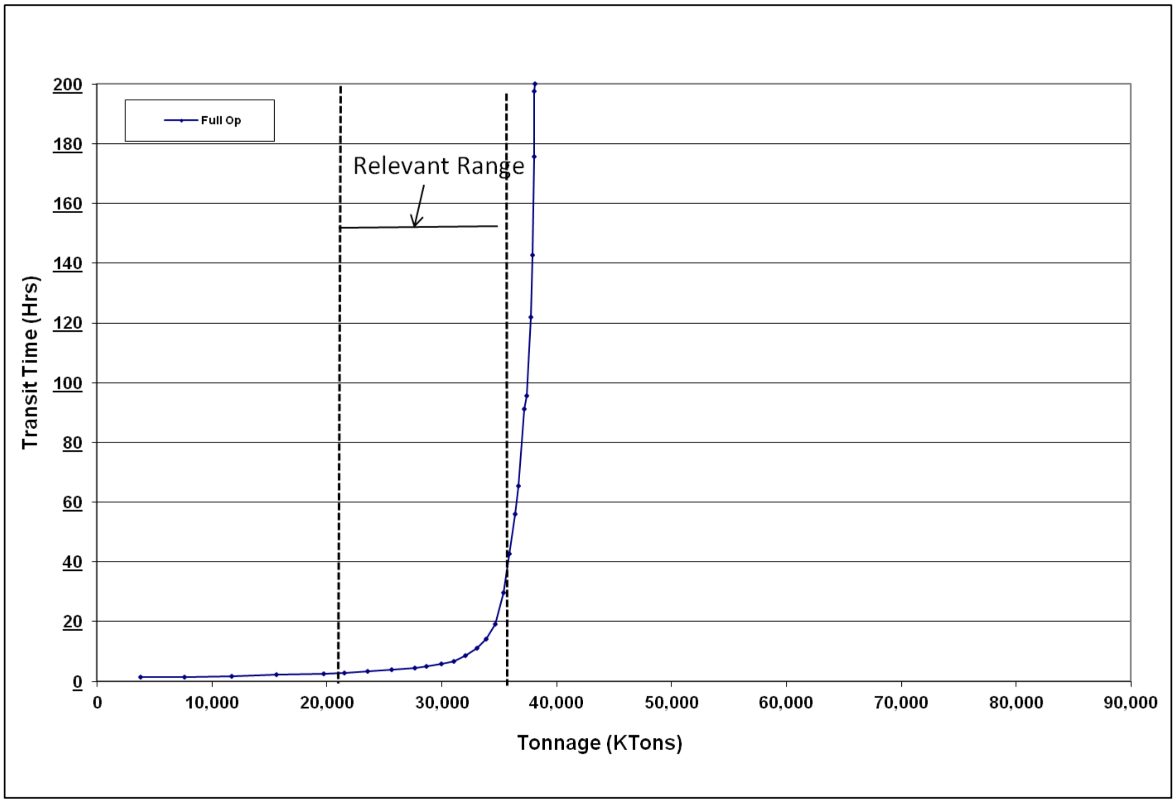


Figure A2- 65 shows the relevant range of traffic demand. This is the range of tonnage projected to use Port Allen over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Port Allen.

Figure A2- 65
Port Allen Without Project Condition Capacity Curve

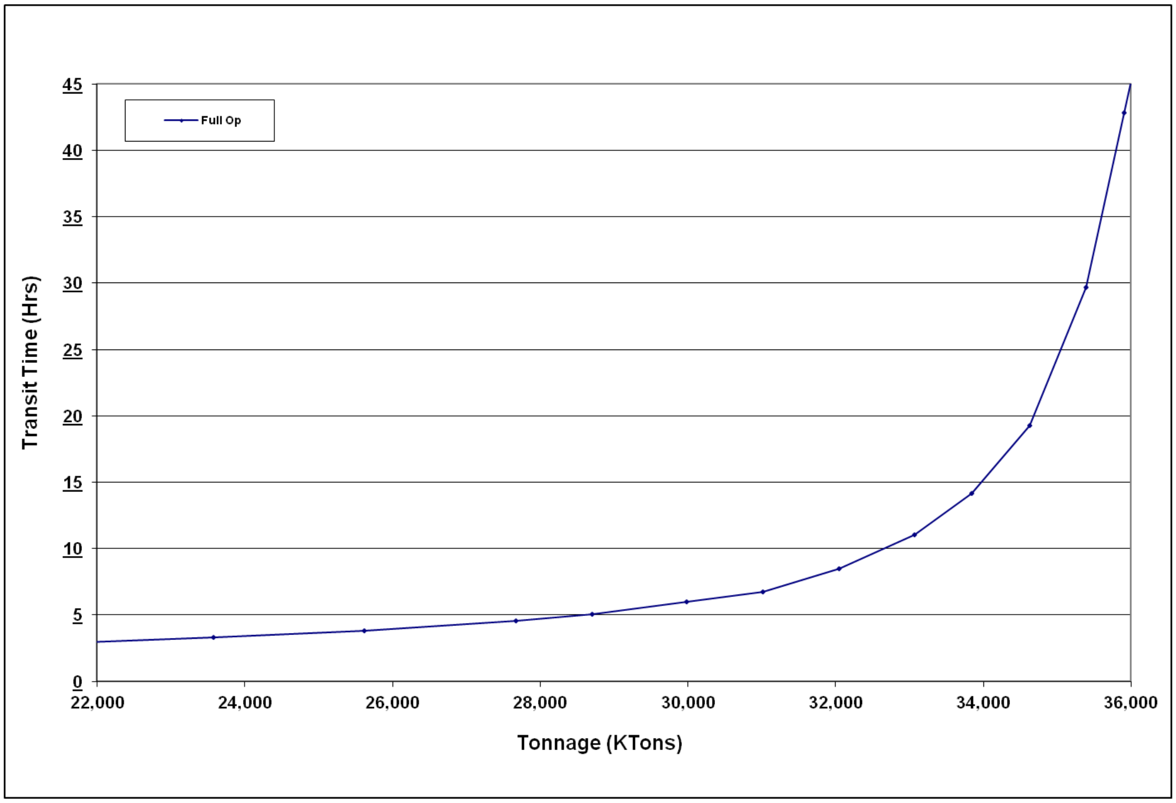


3.8.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Port Allen L&D does not have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 66** shows at projected demands, routine main chamber maintenance events cause significant transit times, and therefore, significant costs.

Figure A2- 66
Port Allen Without Project Condition Capacity Curve



3.9 BAYOU SORREL LOCKS AND DAM

Bayou Sorrel Lock and Dam is located on river mile 37.5 on the Gulf Intracoastal Waterway and consists of 800' x 56' single main chamber with a lift of 21 feet at normal pool, see **Figure A2- 67**. In 2007, Bayou Sorrel processed 24.5 million tons of commodities, of which 65.6% was coal. 5,700 tows with 22,300 barges, and 2,300 recreation craft and lightboats passed through Bayou Sorrel in 2007. The average tow size was 3.9 barges per tow carrying 4,200 tons.[15]

Figure A2- 67
Bayou Sorrel Locks

3.9.1 Existing Condition Input Data

3.9.1.1 Processing Times

The Corps of Engineers, Lock Performance Monitoring System (LPMS) served as the data source for defining detailed processing time distributions.[16] Although 1999 was chosen as the base year, data from 1980 through 2001 were reviewed. Section 2.2.1.1 provides a description of how detailed processing times were developed from LPMS data.

Figure A2- 68 shows a histogram for up bound long approaches times to Bayou Sorrel's 800' main chamber. When compared to other locks on the Gulf Intracoastal Waterway, Bayou Sorrel exhibits moderate data rounding. Therefore, we used Bayou Sorrel's data to develop single cut processing time distributions for the Without Project Condition. . See Section 2.2.1.1.3 for a full discussion of data rounding and Section 2.2.1.1.5 for a description of how probability distributions were developed.

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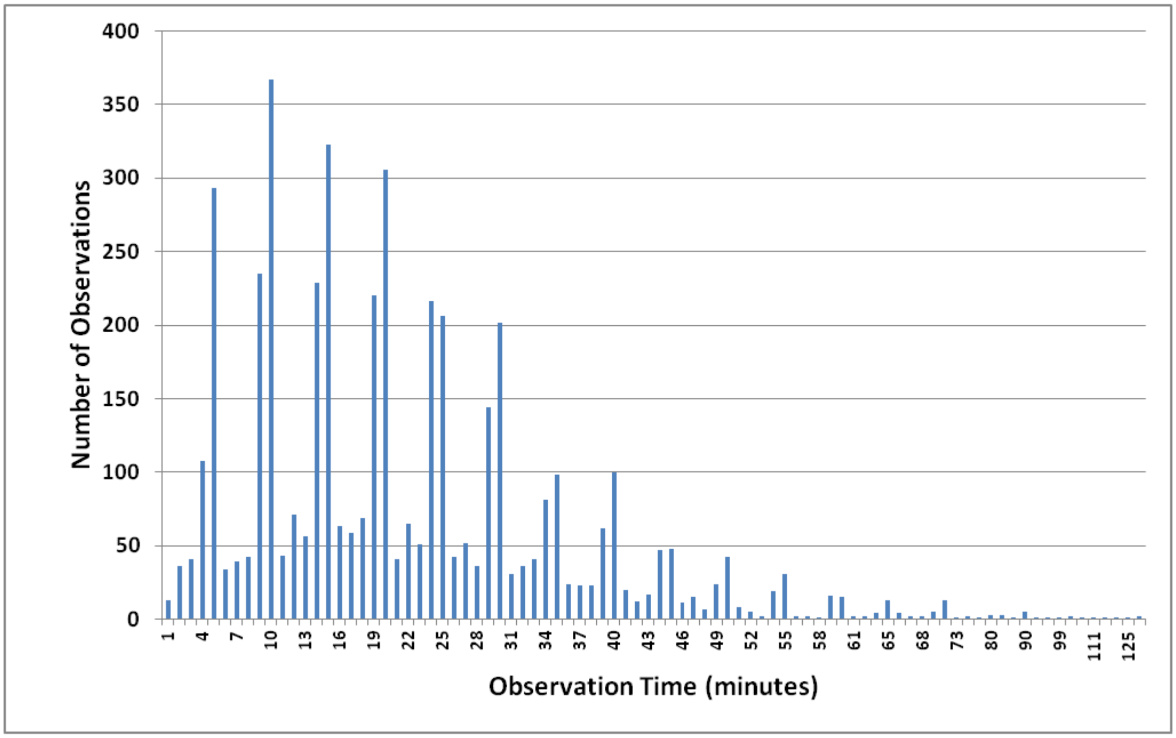
[15]Lock Performance Monitoring System, 2002

[16]For a complete discussion on LPMS data, see Lock Performance Monitoring System Users Manual for Data Collection and Editing, December 1990, NDC Report 90-L-3.

Figure A2- 68
Bayou Sorrel Upbound Long Approach



Nine component processing time sample sets (long approach, short approach, entry, chambering, long exit, short exit, chamber turn backs, straight multi, and open pass) were developed for each chamber, direction, and lockage type. These sample sets were then analyzed with a proprietary software package called Expert Fit®. Expert Fit analyzes each sample set, fits many different probability distributions to the set, determines which distribution fits the best, and displays the parameters needed to define the distribution in WAM. **Table A2- 91** shows sample set sizes, data years, and mean times for each component.

Table A2- 91
Bayou Sorrel Processing Time Information
Single Cuts

	Up bound				Down bound			
Lock Component	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed	Number Of Samples	Years Selected	Mean LPMS time (min)	Number of Outliers Removed
Long Approach	4,640	04-09	21.79	0	4,605	04-09	18.15	0
Short Approach	3,056	04-09	15.31	1	2,459	04-09	12.26	0
Entry	14,232	00-09	7.13	0	12,747	00-09	6.78	0
Chambering	14,232	00-09	7.81	0	12,746	00-09	7.67	0
Long Exit	9,668	00-09	6.44	0	9,078	00-09	6.21	0
Short Exit	4,101	00-09	6.21	0	3,245	00-09	6.09	0
Turn back	5,323	00-09	7.20	0	4,014	00-09	7.49	0
Straight Multi	146	00-09	5.87	0	111	00-09	5.75	0
Open Pass	741	00	28.36	0	689	00	26.75	0

3.9.1.2 Random Minor Downtimes

Locks experience periods of time when traffic is unable to transit through the facility. These periods are referred to as downtime. This study addresses downtime by segregating these events into two groups, random minor and major maintenance. This section discusses random minor downtimes.

Random minor downtimes are short duration, less than 1 day, unscheduled chamber closures. They are caused by various things such as the weather, mechanical breakdowns, river conditions, lock conditions, and other circumstances. Random minor downtime files were created through a multi-step process. A full explanation of this process is contained in 2.2.1.3.1.

Random minor downtime files were developed based on 2000-2009 LPMS data. Downtime events were grouped by type of event over the 10 year period. **Table A2- 92** shows a summary of the data and the downtimes used to make the WAM runs.

Table A2- 92
Bayou Sorrel Historical LPMS Stalls and WAM Downtime

	Main Chamber			
Closure Category (LPMS Code)	2000-2009 LPMS Average		2000-2009 WAM Downtime	
	Freq./Yr	Dur (min)	Freq./Yr	Dur (min)
Weather				
Fog (A)	34.9	308	39.7	309
Rain (B)	0.4	108	0.4	108
Sleet or Hail (C)	0.0	0	0.0	0
Snow (D)		328	0.1	328
Wind (E)	0.1	272	1.5	272
Lightning (F)	1.0	120	1.0	120
Surface Conditions				
Low Water (G)	0.1	80	0.1	80
Ice (H)	0.0	0	0.0	0
River current / outdraft (I)	0.0	0	0.0	0
Flood (J)	0.0	0	0.0	0
Tow Conditions				
Interference by other vessels (K)	0.7	158	0.8	155
Tow malfunction (L)	0.7	122	0.8	135
Tow staff elsewhere occupied (M)	0.0	0	0.0	0
Operations (run-spill-divert water) (N)	0.0	0	0.0	0
Debris (O)	0.0	0	0.0	0
Tow accident or collision (P)	4.6	81	4.0	76
Lock Condition				
Debris in chamber (Q)	0.3	48	0.3	48
Hardware malfunction (R)	1.9	171	1.4	200
Staff elsewhere occupied (S)	0.2	62	0.2	62
Testing / maintenance (T)	6.7	199	5.4	206
Ice on lock or lock equipment (U)	0.0	0	0.0	0
Others				
Tow detained (V)	0.3	109	0.3	109
Collision / accident (W)	0.4	61	0.4	61
Vehicular / RR bridge (X)	6.8	273	7.2	272
Inspection or testing lock (Y)	0.5	125	0.5	125
Other (Z)	2.6	296	4.6	312
Average	62	256	69	267
Totals		15,945		18,348

3.9.1.3 Fleet

The fleet is the sum total of all vessels that use the lock. This includes commercial tows, lightboats, and recreation craft. The fleet is fed to WAM as an external event file known as the shipment list. The shipment list is generated based on historic LPMS and WCSC data, and may contain several thousand records. Each record, which represents a shipment, has a unique arrival time and vessel description. When taken in total, a shipment list closely matches the overall characteristics of the actual fleet.

A typical shipment can be characterized three ways; by type of vessel, by size of vessel, and by time of arrival. WAM simulates three types of vessels, tows, recreation craft, and lightboats/other vessels. The size of the vessel is dependent on vessel type, and for tows, the number and type barges. Arrival times are based on historic arrival patterns, with each vessel type having its own arrival pattern.

The shipment list drives what happens at the lock during the simulation. Therefore, a great deal of effort is expended to ensure that the "what and when" of the WAM fleet closely match the "what and when" of the actual fleet. Section 2.2.3 provides a detailed description of how shipment lists are generated.

3.9.1.3.1 Vessel Types

Vessels are grouped into one three types in this study. Tows are commercial towboats pushing one or more barges. Lightboats are commercial towboats without barges. Recreation craft are non-commercial, usually small, vessels. Commercial-passenger vessels, government vessels, and other vessel types are counted and included in the lightboats group. **Table A2- 93** shows the number of vessels, by vessel type, for the 2007 Bayou Sorrel fleet.

Table A2- 93
Bayou Sorrel Number of Vessels by Type

Tows	5,773
Lightboats	2,260
Recreation Craft	52

3.9.1.3.2 Towboat Types

Towboats were categorized into 9 groups based on horsepower. **Table A2- 94** lists the towboat types, horsepowers and dimensions used in this study.

Table A2- 94
Bayou Sorrel Towboat Types, Horsepowers, & Dimensions

Towboat ID	Horsepower Range	Dimensions	Number of Arrivals
1	0-800	55 x 22	595
2	801-1500	62 x 24	921
3	1501-1800	76 x 29	222
4	1801-2400	78 x 31	164
5	2401-3200	103 x 33	108
6	3201-5000	121 x 38	37
7	5001-5600	130 x 45	19
8	5601-8400	147 x 45	0

3.9.1.3.3 Barge Types

Tow size is a key input determinant when estimating lock capacity. Tow size is determined by the type and number of barges being pushed. This study models 12 barge types which are typical on the inland navigation system. **Table A2- 95** shows the barge types, barge dimensions, number of barges, percent loaded, and barges per tow in the 1999 Bayou Sorrel fleet.

Table A2- 95
Bayou Sorrel Barge Data

Type	Dimensions	Number of Barges	Percent Loaded	Barges per Tow
150' Tanker	150 x 54	326	55.8%	3.8
200' Tanker	200 x 35	4,442	58.4%	4.4
214' Tanker	214 x 42	155	0.0%	0.0
200' Tanker	200 x 54	789	54.1%	3.0
264' Tanker	264 x 5f4	105	56.2%	2.5
300' Tanker	300 x 54	3,658	59.4%	2.3
380' Tanker	380 x 54	57	80.7%	1.9
150' Non-Tanker	150 x 35	92	73.9%	1.5
200' Non-Tanker	200 x 35	10,129	62.0%	5.6
200' Non-Tanker	200 x 40	19	68.4%	4.8
Tankers All Others		2,350	64.6%	3.4
Non-Tankers Others		209	51.2%	1.9

3.9.2 Existing Condition Calibration and Validation

3.9.2.1 Shipment List Calibration

After the input data is prepared, the next step in running WAM is shipment list calibration. Calibration is a process that fine tunes the input files so that generated shipment lists closely match the real world fleet. Calibration is necessary for two reasons. First, WAM uses two data sources to create the shipment lists, and the data sources are not perfectly compatible. Second, the shipment list generator generates tows that have only one barge type instead of two or more barge types in a single tow. For a full explanation of how the shipment list generator works, see Section 2.2.3.3. A detailed description of the calibration process can be found in Section 2.2.3. It should be noted that every shipment list contains the same number of recreational craft and lightboats as measured by LPMS at Bayou Sorrel in 2007. In 2007, 2,312 lightboats and recreation craft traveled through Bayou Sorrel.

Table A2- 96 shows the statistics used when calibrating the shipment list. The target values for tons/loaded barge were taken directly from WCSC data. The target values for number of tows, number of loaded barges, and number of empty barges were taken directly from LPMS data. The other remaining values were calculated based on the values taken directly from WCSC and LPMS. The values shown in the WAM Runs column are the

averages of ten different WAM shipment lists. Calibration is considered complete when the WAM Runs are within 3% of the Target values for all statistics.

Table A2- 96
Bayou Sorrel Shipment List Calibration

	Target	WAM Runs	% Difference
Tons (calc)	24,516	24,471	-0.19%
Up	13,044	13,027	-0.13%
Down	11,472	11,444	-0.24%
Tows (LPMS)	5,773	5,806	0.58%
Up	2,963	2,967	0.15%
Down	2,810	2,839	1.03%
Tons/Tow (calc)	4,247	4,215	-0.76%
Up	4,402	4,390	-0.27%
Down	4,082	4,031	-1.26%
Barges (calc)	22,330	22,379	0.22%
Up	11,688	11,700	0.10%
Down	10,642	10,679	0.35%
Loaded Barges (LPMS)	13,565	13,544	-0.15%
Up	7,255	7,247	-0.11%
Down	6,310	6,297	-0.20%
Empty Barges (LPMS)	8,765	8,834	0.79%
Up	4,433	4,453	0.44%
Down	4,332	4,382	1.15%
Percent Empty (calc)	39.3%	39.5%	0.57%
Up	37.9%	38.1%	0.34%
Down	40.7%	41.0%	0.80%
Tons/Loaded Barge (WC)	1,807	1,807	-0.03%
Up	1,798	1,798	-0.02%
Down	1,818	1,817	-0.04%
Barges/Tow	3.87	3.85	-0.35%
Up	3.94	3.94	-0.04%
Down	3.79	3.76	-0.68%
Rec/Other	52	51	-2.6%
Up	16	24	50.0%
Dn	36	27	-25.9%
Light Boat	2,260	2,259	-0.03%
Up	1,068	1,117	4.56%
Dn	1,192	1,143	-4.14%

3.9.2.2 Processing Time & Delay Validation

After the shipment list is calibrated, the next step is to validate WAM. Validation ensures that WAM results reasonably reproduce actual base year processing and delay times. Target processing and delay times, taken directly from LPMS, were used to validate WAM. Fifty WAM runs were made at base year traffic levels with the FIFO service policy. The average processing and delay times for those runs is then compared to actual data. **Table A2- 97** shows how well WAM reproduces the target processing and delay times. WAM reproduces processing and delay times at Bayou Sorrel reasonably well.

Table A2- 97
Bayou Sorrel Processing Time Validation

Statistic	*Target	WAM Simulations Mean Value	WAM Simulations Std dev	Pct. Diff
Commercial Transit Performance (min)				
Tow Average Processing	57.32	59.4	0.35	3.7%
Tow Average Delay	228.6	199.4	21.64	-12.7%
Tow Average Transit Time	285.9	258.9	21.64	-9.4%
Validation Down Time				
Number of Events, Main	142	142	-	0.0%
Total Minutes, Main	41,015	41,015	-	0.0%
Percent of Year Closed, Main	7.8%	7.8%	-	0.0%
*2007 LPMS Data (NaSS)				

3.9.3 Without Project Analysis

3.9.3.1 Identification of Optimal Lockage Policy

After input preparation, shipment list calibration, and processing and delay time validation, the next step is to determine the most efficient lockage policy. This is done to satisfy Corps regulation ER-1105-2-100 section II, E-9.c.a which states in part “Assume that all reasonably expected non-structural practices …. including … lockage policies are implemented at the appropriate time.” Two lockage policies were evaluated at Bayou Sorrel; (First-In, First-Out) and 6-up/6-down service policy

To determine the best or “optimal” lockage policy, 10 WAM runs were made at very high traffic levels for each lockage policy. The ‘optimal’ lockage policy is the policy that results in the highest tonnage level with the lowest processing time at maximum lock utilization. According to the results shown in **Table A2- 98**, the lockage policy with the highest tonnage level and lowest transit time is the 6-up, 6-down lockage policy. Therefore, the 6-up/6-down policy was used to create Bayou Sorrel’s WOPC capacity curves.

Table A2- 98
Bayou Sorrel WOPC Optimal Lockage Policy

RunID	KTons	Proctime (Hr)	Delay (Hr)	Transit Time (Hr)
*Bayou Sorrel FIFO	32,762	0.99	1,416.7	1,417.7
Bayou Sorrel 6U6D	32,144	0.97	1,456.8	1,457.8
**Optimal WOPC Lockage Policy: FIFO*				

3.9.3.2 WOPC Results

3.9.3.2.1 Project Capacities

Full capacity curves were developed for the Full Operation (no closure) at Bayou Sorrel. The processing time and capacity for the curves with a single main chamber operating for the entire year with only random minor downtimes is shown in **Table A2-99.**

Table A2- 99
Bayou Sorrel Existing WOPC Capacities and Transit Times

Project/Scenario	Capacity (Millions of Tons)	Avg. Processing Time (min/tow)
No closures (normal operation)	32.5	59.98

3.9.3.2.2 Capacity Curves

Capacity is a useful number when making simple comparisons between locks. However, the navigation economic studies do not use the capacity number. Instead, the economic analysis uses capacity curves. Capacity curves are used because they define the relationship between tonnage processed and expected transit time over a range of tonnage levels. This way, the economic model can determine expected transit time for any given tonnage between zero and capacity.

Figure A2- 69 shows the capacity curve and other information for Bayou Sorrel L&D, Without Project Condition, Full Operation scenario. This capacity curve is used to represent a year where only random downtime occurs. The curve is developed by running WAM at 27 different traffic levels, 50 different runs per level. Therefore, 1350 WAM runs were made to create one curve. The curve connects the averages at tonnage level.

Figure A2- 69 also shows a vertical line where the curve goes asymptotic. This value is the capacity shown in **Table A2- 99**. The capacity is the tonnage that corresponds with a transit time of 200 hours. The 200 hour transit time is an arbitrary value. In this reach of the curve, the different in tonnage between say, 100 hours and 300 hours is very small.

Figure A2- 69
Bayou Sorrel Without Project Condition Capacity Curve

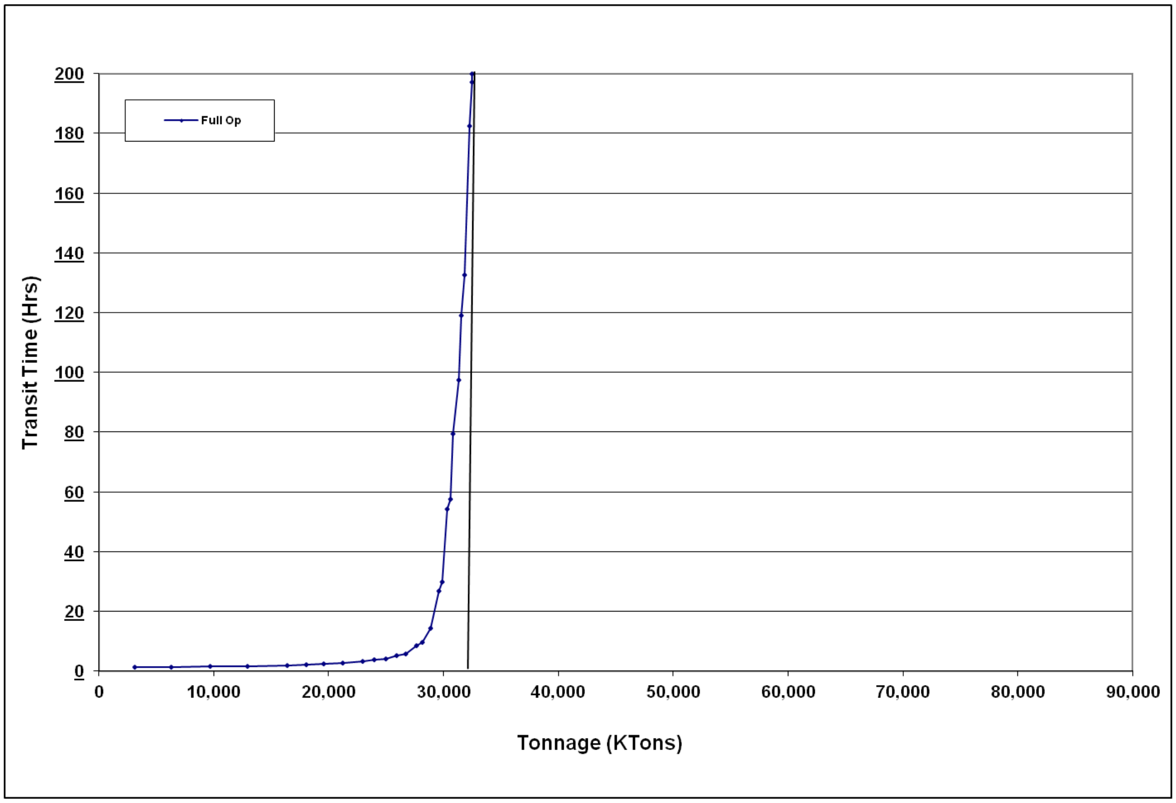
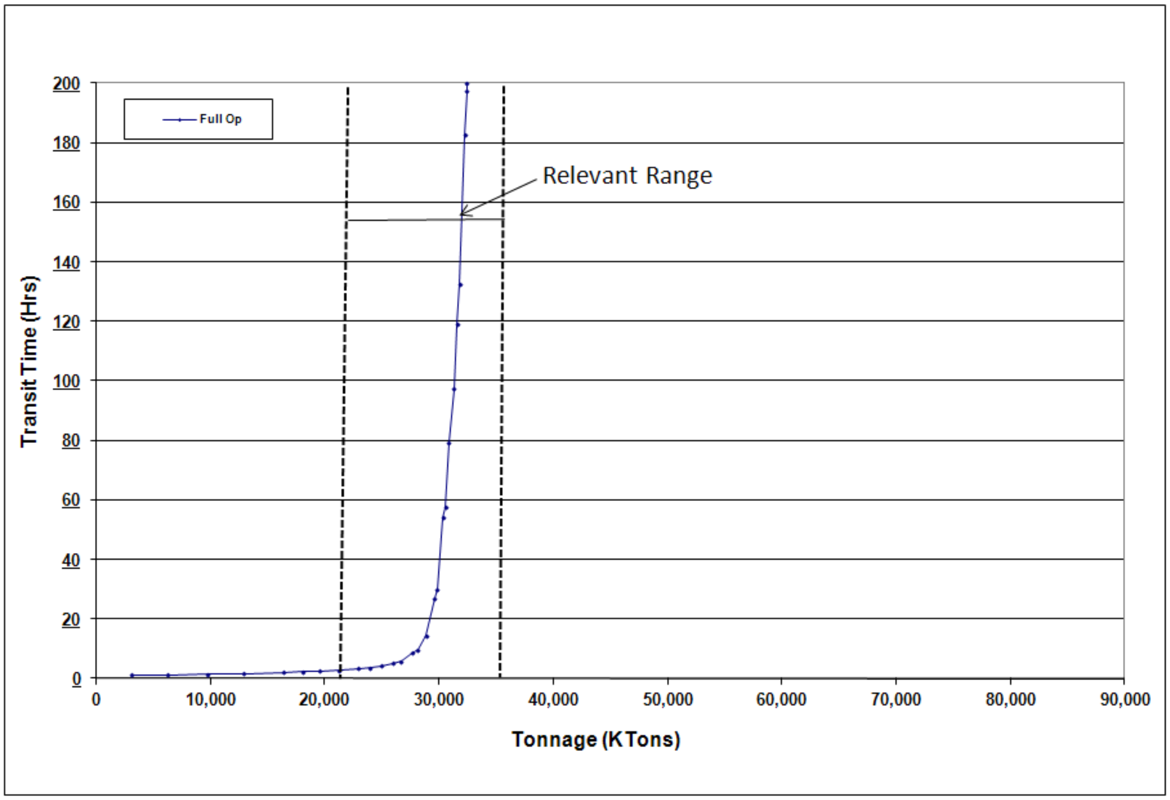


Figure A2- 70 shows the relevant range of traffic demand. This is the range of tonnage projected to use Bayou Sorrel over the study period, 2009-2060. The economic model uses this range of the curve when processing traffic at Bayou Sorrel.

Figure A2- 70
Bayou Sorrel Without Project Condition Capacity Curve

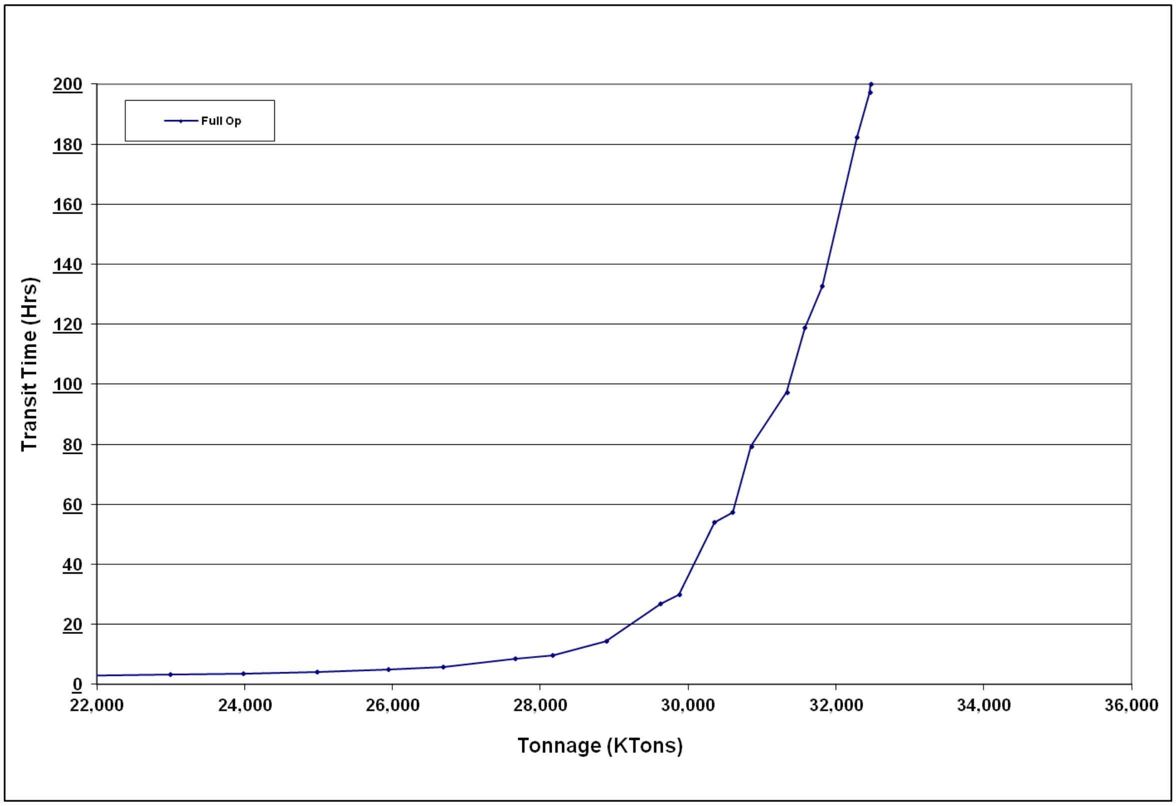


3.9.3.3 WOPC Interpretations, Observations, Insights

This section is provided to help interpret the results of the Without Project Condition capacity analysis.

The main point is that Bayou Sorrel L&D does not have sufficient capacity to serve navigation demand throughout the period of analysis. **Figure A2- 71** shows at projected demands, routine main chamber maintenance events cause significant transit times, and therefore, significant costs.

Figure A2- 71
Bayou Sorrel Without Project Condition Capacity Curve



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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX L

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GENERAL

Calcasieu Lock is located on the Gulf Intracoastal Waterway (GIWW), just east of the Calcasieu River, in Cameron Parish, LA, approximately 10 miles south of Lake Charles, LA. Calcasieu Lock is a critical component of the LA portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins. Therefore the primary Study area is the Lock and immediate vicinity; however a broader approach was taken in assessing environmental, economic and hydraulic conditions and potential impacts. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast was evaluated. Hydraulically, potential impacts are local and regional in nature as the operation of the Lock is done in conjunction with other structures in the Mermentau Basin. Therefore, the Mermentau Basin and certain adjacent drainage areas were evaluated.

Drainage alteration measures considered were in three general categories. The categories considered were construction of a new gate structure, pumping stations, and rehabilitation of an existing drainage structure on Black Bayou. Combinations of these categories were configured into the final array of alternatives.

CULVERT STRUCTURE

This measure involves construction of a sluice gate culvert structure south of the existing lock to divert drainage flows away from the existing lock chamber. The gate will only be used during drainage events. The type of gate structure will be determined by the ability to prevent saltwater intrusion in the Mermentau Basin. Typically where passage of vessels is not required, a sluice gate will be used. Machinery is normally hydraulic cylinders, one per gate (max 16 feet wide). Multiple gates can be run from the same hydraulic power unit if openings are staggered.

PUMPING STATION

Reduction of flows through the existing lock chamber could be diminished by the aid of pumping stations. Potential locations for the station and outfall would be either the former GIWW channel at the LA 384 road crossing or the Black Bayou inlet immediately west of LA 384. Hydraulic and Hydrologic (H&H) analysis was done to determine the minimum size necessary to reduce lockage times as well as the maximum pump size necessary to eliminate delays.

REHABILITATE BLACK BAYOU DRAINAGE STRUCTURE

The Black Bayou Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project was completed in 2006 by the Natural Resources Conservation Service (NRCS). During the intervening period a prolonged drought has limited the structures effectiveness. In 2011 the forebays of the structures were filled in the prevent undermining of the structure due to seepage underneath it. This measure would involve complete replacement of the structure with adequate foundations and scour protection. The ten culvert design, with 10 foot x 10 foot openings, will be re-evaluated and adjusted as necessary to maximize reduction in navigation delays.

FINAL ARRAY OF ALTERNATIVES

Alternative 1: An 82-foot wide and 100-foot long culvert that consists of five 9 foot x 14 foot openings that will allow for the passage of the additional flow. The structure will be generally within the alignment of the previously proposed south lock. The outfall and intakes will need to be excavated with material being beneficially used for marsh creation.

Alternative 2: A 3,700 cubic feet per second (cfs) pumping station would be constructed generally within the alignment of the previously proposed south lock. The outfall will need to be excavated with material being beneficially used for marsh creation.

Alternative 3: Supplemental Culverts would be added to the Black Bayou NRCS structure to increase its capacity and operate in conjunctions with it. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 3.0 North American Vertical Datum of 1988 (NAVD88). Black Bayou Dredging to the east and west of the NRCS structure will also occur.

Alternative 4: A 2,000 CFS Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure and operate in conjunction with it. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require the Corps to take over Operation and Maintenance, Repair, Replacement and Rehabilitation (O&MRRR) of the structure once its 20-year project life under CWPRA ends.

NOTE: Following IPR#1 in February 2013, it was determined that a 1,000 cfs pump would be insufficient to overcome the natural tendency to drain through the lock when the sector gates were open. Additional HH analysis indicated that a 2,000 cfs pump operating in conjunction with the Black Bayou structure would be sufficient to provide the drainage capacity the lock currently provides.

Alternative 5: A 3,700 CFS Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure.

HYDROLOGY AND HYDRAULICS

I. INTRODUCTION

In 2009, an in-house feasibility study was authorized for approximately 4,000 square miles in the southwestern Louisiana. The entire area is bounded on the north by US 190, on the west by the Calcasieu River, in the south by the Gulf of Mexico, and on the east by the Vermillion River and I-49. Inefficient drainage through the existing Calcasieu Lock is causing navigational traffic to be delayed, and this study is needed to find ways of improving this problem. Although drainage is not part of the study, it was found that reduced locking times cannot be achieved without improving drainage.

II. CLIMATOLOGY

A. Climate. The study area has a subtropical marine climate. Located in a subtropical latitude, its climate is influenced by the many water surfaces of the lakes, streams, and Gulf of Mexico. Throughout the year, these water bodies modify the relative humidity and temperature conditions, decreasing the range between the extremes. When southern winds prevail, these effects are increased, imparting the characteristics of a marine climate.

The area has mild winters and hot, humid summers. During the summer, prevailing southerly winds produce conditions favorable for afternoon thundershowers. In the colder seasons, the area is subjected to frontal movements that produce squalls and sudden temperature drops. River fogs are prevalent in the winter and spring when the temperature of the Calcasieu River and the Gulf Intracoastal Waterway (GIWW) are somewhat colder than the air temperature.

B. Temperature. Records of temperature are available from “Climatological Data” for Louisiana, published by the National Climatic Center. The study area can be described by using the normal temperature data observed at Hackberry 8 SSW, Lake Charles Airport, and Jennings stations. These stations are shown in table L-1 with the monthly and annual mean normals which are based on the period 1971 to 2010.The average annual mean normal temperature is 68.6^{o}F, with monthly mean temperature normal varying from 82.9^{o}F in July to 49.8^{o}F in January. Extreme temperatures since 1971 were 10^{o}F on Dec 24, 1989 and 107^{o}F on Aug 31, 2000 at the Jennings and Lake Charles Airport stations.

C. Precipitation. Records of precipitation are also available in publications by the National Climatic Center. Four stations in the study area have been used to show the rainfall data for the study area. All stations have normal precipitation records which are based on the period 1971-2010. These gages include Hackberry 8 SSW, Bell City 13 SW, Jennings, and Lake Charles Airport. Table L-2 lists the monthly and annual normals of the four stations. The average annual normal rainfall of the four stations is 54.06 inches. The wettest normal month is July with a monthly average of 6.18 inches. April is the driest normal month averaging 2.99 inches. Of the three stations, Bell City 13 SW has the maximum normal month with 7.32 inches occurring in July, and Lake Charles AP had the greatest day with 15.67 inches of rain falling on May16, 1980.

D. Wind. Onshore wind velocities based on records at the Lake Charles Municipal Airport average 8.7 mph and blow from the south during most of the year. Based on the Summary of Synoptic

Meteorological Observations taken by the U.S. Naval Weather Service Command over the period 1953-1971, offshore winds average 13.6 mph, with the predominately wind directions being southeast and east over the year.

E. Stream Gaging Data. Stream gaging data are available from five stations in the study area. The stations with their maximum and minimum extreme stages are shown in table L-3. Discharge records are not taken in the study area.

Table L-1. Mean Monthly and Annual Temperature (°F)
30-year Normals (1971-2010)

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Hackberry 8 SSW	51.1	54.7	61.6	68.1	75.5	81.2	82.9	M	79.3	70.8	61.5	53.9	M
Lake Charles AP	50.9	54.4	61.0	67.3	74.9	80.5	8206	82.4	78.4	69.5	60.1	53.3	69.9
Jennings	49.8	53.4	60.4	66.8	74.7	80.0	81.8	81.6	77.9	68.8	59.5	52.3	67.3
Average	50.7	54.2	61.0	67.4	75.0	80.6	82.4	82.0	78.5	69.7	60.4	53.2	68.6

Source: National Climatic Center

Table L-2. Monthly and Annual Normal Precipitation (Inches)
(1971-2010)

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Hackberry 8 SSW	5.70	3.46	3.78	4.01	4.92	6.63	6.62	5.47	5.53	4.37	4.72	4.37	59.58
Bell City 13 SW	3.02	5.26	1.63	0.33	2.53	3.47	7.32	4.43	2.55	2.24	3.87	2.19	38.84
Jennings	6.15	3.80	4.48	3.97	5.51	5.63	5.66	4.74	5.83	4.29	5.26	5.22	60.64
Lake Charles AP	5.52	3.28	3.54	3.64	6.06	6.07	5.13	4.85	5.95	3.94	4.03	1.96	57.19
Average	5.10	3.95	3.36	2.99	4.76	5.45	6.18	4.87	4.97	3.71	4.47	3.44	54.06

Source: National Climatic Center

Table L-3. Stream Gaging Data

			Record Stages (ft NGVD)			
Station	**Latitude/Longitude**	**Period of Record**	**Max[1]**	**Date**	**Min**	**Date**
Calcasieu Lock East	30-05-14 / 93-17-2	1951-2011	5.79a	28Jun1957	-1.21	08Jul1951
Calcasieu Lock West	30-05-14 / 93-17-28	1951-2011	7.99a	27Jun1957	-2.13	28Feb1984
Catfish Point CS North	29-51-48 / 92-51-00	1951-2011	8.30a	27Jun1957	-0.80	26Dec1975
Lacassine Wildlife Refuge	30-00-09 / 92-46-52	1947-2011	6.50	04Nov1985	-0.47	10Jun1951
Cameron	29-46-30 / 93-20-46	1939-2011	12.90a	27Jun1957	-3.12	25Feb1965

Source: U.S. Army Corps of Engineers, New Orleans District
[1] a=caused by hurricane

F. Floods and Storms of Record. There have been several floods in the study area caused by runoff from heavy rainfall. Following is a brief discussion of some of the major events that occurred over the last 30 years, including Hurricanes Juan, Lili, and Katrina and Tropical Storms Frances, Allison, and Isidore.

May 1978. Extremely heavy rain that began early on 3 May and continued throughout the day caused widespread flooding over the New Orleans metropolitan area. Storm totals for Audubon Park and Moisant Airport during 2-3 May were 10.6 and 6.8 inches, respectively. The Algiers station received a total of 11.72 inches during 3-4 May.

April 1980. There were two separate storms during April 1980.The first event occurred 2-3 April and averaged over 5 inches of rain throughout the New Orleans metropolitan area. The Audubon Park station measured nearly 7 inches on 2 April. This storm set the stage for the intense 12-13 April event, which averaged 9.5 inches over the same area. Most of the rain fell during the morning of the 13^{th}. The Algiers gage had a 2-day storm total of 11.86 inches with 9.71 inches falling on the 13 April. Moisant Airport had a maximum 24-hour rainfall of 7.95 inches on the 13^{th}. Flash flooding occurred rapidly, since the ground was already heavily saturated from the first April storm. Orleans and Jefferson Parishes experienced the greatest flooding.

October 1985. Hurricane Juan (25-31 October) was responsible for this flood. Juan was in the vicinity of Louisiana for six days. Most flooding was associated with the storm surge and backwater flooding produced by prolonged, strong easterly to southerly winds. Backwater flooding was aggravated by excessive rainfall that fell mostly during the first days of the storm. In the New Orleans metropolitan area, 3-day storm totals (27-29 October) ranged from 5 to 10 inches, with 10.33 inches at Gretna, 7.59 inches at Algiers, and 7.55 inches at Moisant Airport. This storm also caused the peak stages of 4.74 feet NGVD at IWW at Harvey Lock and 4.25 feet NGVD on Bayou Barataria at Barataria.

April 1988. This flood was associated with squall lines ahead of a slow-moving cold front during 1-3 April over the New Orleans area. Storm totals were over 10 inches at several stations. Most of the rain fell in a 12-hour period on 2 April, with nearly 9 inches recorded throughout the area. Some 3-day storm totals reported were 11.08 inches at Gretna, 10.72 inches at Algiers, and 10.63 inches at Audubon Park.

November 1989. A narrow, almost stationary east-west band of strong thunderstorms developed across the New Orleans metropolitan area on the morning of 7 November. As a result, heavy rains persisted over the study area before decreasing in the afternoon. The prolonged storm triggered flash floods throughout the area. Rainfall amounts of 8-12 inches were common from 9:00 AM to 6:00 PM during this day. In Jefferson Parish, rainfall reports from several of the parish's pumping stations indicated 10-12 inches of rain occurred between 8:00 AM and 2:00 PM. The Gretna gage totaled 17.13 inches over 7-9 November, with 13.70 inches recorded on the 8^{th}. The Algiers station recorded 10.85 inches for the same period. Many homes throughout the metropolitan area received some type of water damage.

May 1995. This flood resulted from torrential rain that accompanied 50 miles per hour winds and tornadoes. Intense rainfall began around 6:00 PM on 8 May and continued until midnight. Two to three inches of rain per hour fell for several hours during the peak storm period. At Moisant Airport

9.69 inches of rain fell in three hours, and 12.24 inches fell in less than 5 hours. The highest 1-hour rainfall total of 6.5 inches was reported at a National Weather Service (NWS) hourly recording station at Audubon Park. Three- and six-hour totals from this storm exceeded the same hourly totals for the 1978 and 1989 rainfall events and when compared to rainfall totals in NWS Technical Paper (TP) No. 40, 3 and 6 hour rainfall totals reported for this storm exceeded amounts projected for 500-year frequency events. Jefferson Parish experienced extensive flooding from this storm and recorded a maximum 19.53 inches of rainfall at a local gage. Other measurements include 13.70 inches at Gretna and 10.92 inches at Algiers, both occurring on 9 May.

September 1998. Tropical Storm Frances (8-13 September) brought torrential rains and strong winds to southeastern Louisiana. Storm totals topped 15 to 20 inches over much of the greater New Orleans area. Algiers and Gretna received 19.91 and 17.37 inches, respectively, over a 4 day period (10-13 September), while Audubon totaled 16.9 inches over 8-13 September. Frances set a new peak stage at the Intracoastal Waterway at Algiers Lock with a 4.63 feet NGVD reading.

June 2001. Tropical Storm Allison (6-11 June) brought extensive urban flooding in metropolitan areas around New Orleans. Rainfall totals over this period were 21.3 inches at Gretna and 14.28 inches at Audubon.

September 2002. Tropical Storm Isidore (18-26 September) first made landfall at Grand Isle, before moving across Lake Pontchartrain to the north. Tide levels were 4 to 6 feet above normal, but many areas flooded due to heavy rainfall. The rainfall totals near the study area ranged from 18.50 inches at the New Orleans Algiers station to 12.78 inches at Terrytown. Algiers recorded 15.34 inches on the 26^{th}.

October 2002. Hurricane Lili (23 September **-** 3 October) was originally a Category 4 hurricane and first made landfall as a downgraded Category 2 hurricane near Intracoastal City, LA to the west. Wind gusts up to 61 mph were reported near the study area. Rainfall estimates were rather low at 5 inches, due to the rapid forward movement of the storm. Tide levels were 4 to 7 feet above normal, with many areas outside of the study area being flooded. The stage at Harvey Canal at Lapalco reached 9.84 feet NGVD on the 5^{th}.

August 2005. Hurricane Katrina (29 August) first made landfall near Empire, LA as a slow moving Category 4 hurricane, and continued on a northerly track. The Slidell rain gage recorded at least 7 inches of rainfall, whereas rainfall totals from other gages are not available. Storm surge ranged from 14 feet near the eye wall to 32 feet at the center. Many of the hurricane protection structures in the New Orleans and Chalmette areas were overtopped, and many failed as a consequence, causing catastrophic loss of property and life. However, the west bank area of New Orleans is completely surrounded by levees which were not overtopped, mainly due to its distance from Lake Pontchartrain and being bordered by the Mississippi River and its two levees. Gage data from all nearby gages was insufficient.

September 2005. Hurricane Rita (September 24-26) Hurricane Rita first made landfall just west of Johnson's Bayou, LA as a Category 3 hurricane after downgrading from a 180 mph Category 5 hurricane. The coastal communities of southwest Louisiana were all heavily damaged or totally destroyed by the 20-foot surge. The storm surge also completely overtopped the Calcasieu Lock structure. Many low lying areas in Lake Charles also flooded.

September 2008. Hurricane Gustav (August 25-September 2) first made landfall on the morning of September 1, 2008 near Cocodrie, LA as a Category 2 hurricane with 105 mph winds. Twelve hours later, Gustav was downgraded to a Tropical Storm with 60 mph winds near Alexandria, LA. Due to improved hurricane protection measures made in the metropolitan New Orleans area since 2005, the entire city was spared from damages due to storm surge. Rainfall amounts were:

September 2008. Hurricane Ike (September 1-14) first made landfall near Galveston, Texas as a Category 2 hurricane with 110 mph winds on September 13, 2008. Although landfall was to the west in Texas, this storm caused extensive flooding due to storm surge created by the large wind field along the south central and southwest coastal parishes of Louisiana. The storm surge also completely overtopped the Calcasieu Lock structure.

G. Tides. Tides in the vicinity of Calcasieu Lock are predominantly semi-diurnal. The tidal range is about 0.8 foot NGVD with a mean high tide of 2.1 feet NGVD and a mean low tide of 1.3 foot NGVD.

III. HYDROLOGY

A. General. Rainfall runoff from the higher elevated farm lands north of I-10 drains into the flat wetlands that are trapped by the shell ridge at the Gulf of Mexico. The normal drainage path would have been for this runoff to drain into the Mermentau River, which would have enlarged itself on its way to the gulf during high rainfall events, but this is now routed into an easterly or westerly flow into the GIWW. The area is generally flat in topography, especially south of the GIWW where water surface elevations can lie between -3.0 feet and +4.0 feet North American Vertical Datum of 1988 (NAVD88), with an average overall elevation for the entire project area of +27.0 feet NAVD88. The minimum elevation is -22.0 feet NAVD88 and the maximum elevation is 122.0 feet NAVD88, but the maximum water surface elevation is only +44.0 feet NAVD88, which is located at the far northeastern edge of the project.

B. Study Area Description. The area gradually drains through numerous bayous that flow in a south or south westerly direction, converging into Lake Arthur. From this point, the Mermentau River retains its original name, even though Lake Arthur and Grand Lake are large fresh water lakes that connect the two main segments of the Mermentau River. At the approximate junction of Bayou Lacassine and the Mermentau River, the GIWW diverts flow into a westerly direction towards the Calcasieu Lock, or in an easterly direction towards the Leeland Bowman Lock. The remainder of the flow that cannot be handled by the GIWW drains through the southern part of the Mermentau River and the Catfish Point Control Structure just north of the town of Grand Chenier. The lock structures of Leeland Bowman and Schooner Bayou are included in this model, but were shown to have no effect from the 33-mile backwater profile created by the Calcasieu Lock. Since there are no protective dikes on the north side of this backwater profile, a certain amount of the flow has been known to flood these agricultural lands, especially if the east gage at the Calcasieu Lock rises above three feet. Only in the extreme rainfall events is this flow diverted towards the Catfish Point Control Structure to the south. The only way to find this out was to include the excessively large area that is now in the model.

C. Methodology. In flat terrain such as this area, the use of hydrologic and hydraulic storage areas is the best course of action. In this case, 81 storage areas wound up being the final choice, which includes 5 inland lakes. The size and location of each storage area is critical to the success of the project, so this must be taken as the first step and finalized as soon as possible. New technology using LIDAR and GIS software allows one to view the topography of an area in much greater detail and contrast, as shown in the color-shaded relief map below. Since the area is so large, more detail was needed on a series of enlarged areas showing topography, especially where the higher lands in the north meet the flat lands in the south. The project area and storage areas are outlined in black. The "hotter" colors of orange and red depict the higher elevations and the "colder" colors of dark blue depict the lower elevations. For this purpose, a legend with the elevations is not needed, because the choice of storage area boundaries is usually based upon sudden change in colors, caused by canals, main roads, and ridges.

It was originally assumed that the area just to the south of Alexandria would also be needed for the study, but this northern boundary was later lowered to US 190 between Kinder and Opelousas, Louisiana due to the large amounts of sandy soil that absorb the runoff. The lower Mermentau River was represented by five additional storage areas.

Once the storage areas were determined, hydrologic parameters and hydraulic storage curves were derived with software. One runoff hydrograph will be produced for each storage area and for each event. This will then be used as input for the hydraulic software, and allowed to enter the system of storage area connections and any available waterway through one artificial lateral weir located at the lowest point on the boundary of each storage area. The size of this lateral weir is adjusted in the calibration phase until the desired gage readings have been achieved. Lag times should fall between 30 minutes and 3 hours, so the choice of storage area size could affect this to the point that the boundaries may need to be redrawn for some. The advantage of this method is that both hydrologic and hydraulic parameters are adjusted during calibration such that the target elevations of the gages are reached to within 0.20 feet. Target elevations were derived from adjusted gage data available for all four locks or control structures.

Samples of detailed topography are shown in figures L-1 through L-3.

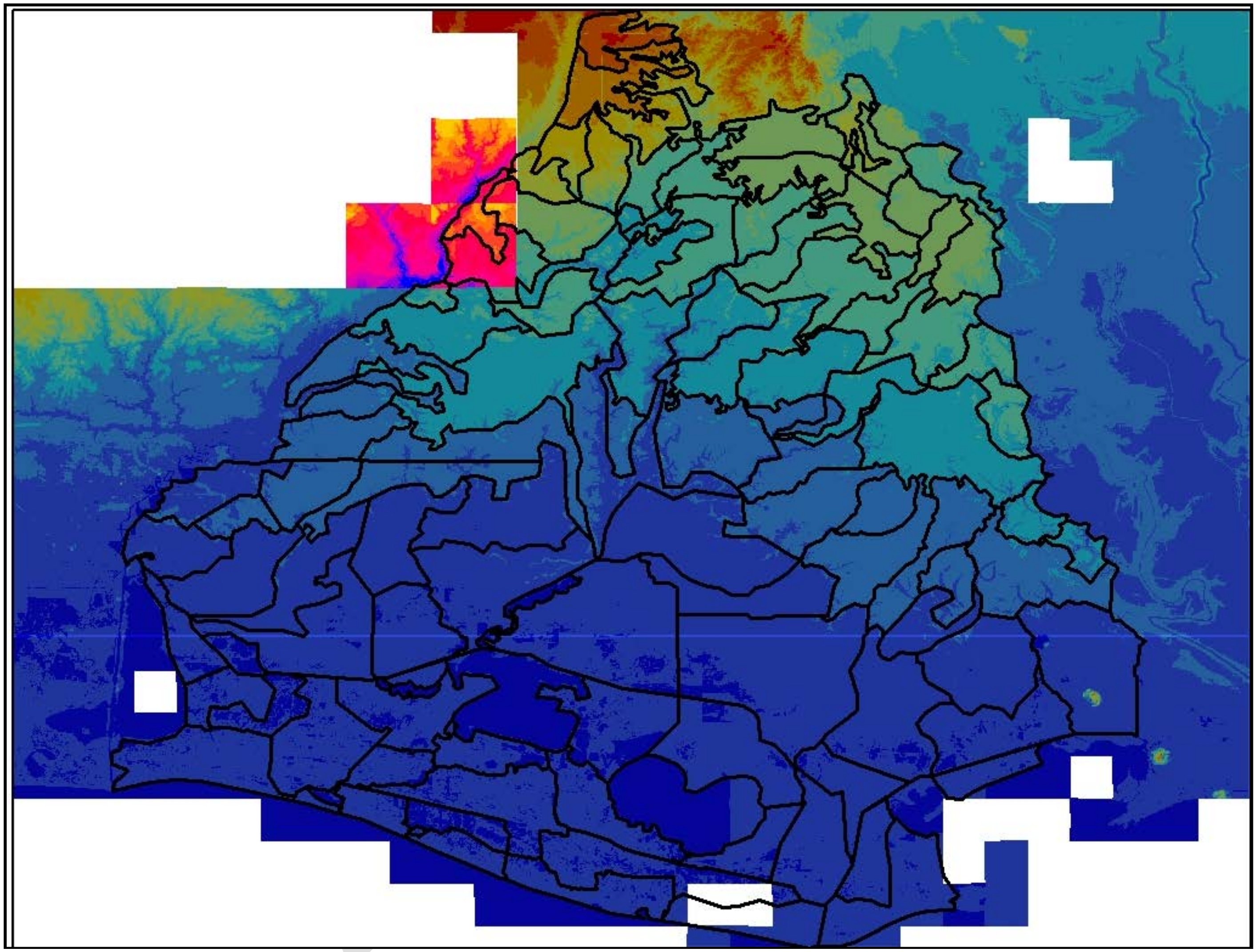

Figure L-1. Color-Shaded Relief Map From LIDAR as an Overview of Area Initially Considered To Cover the Entire Project

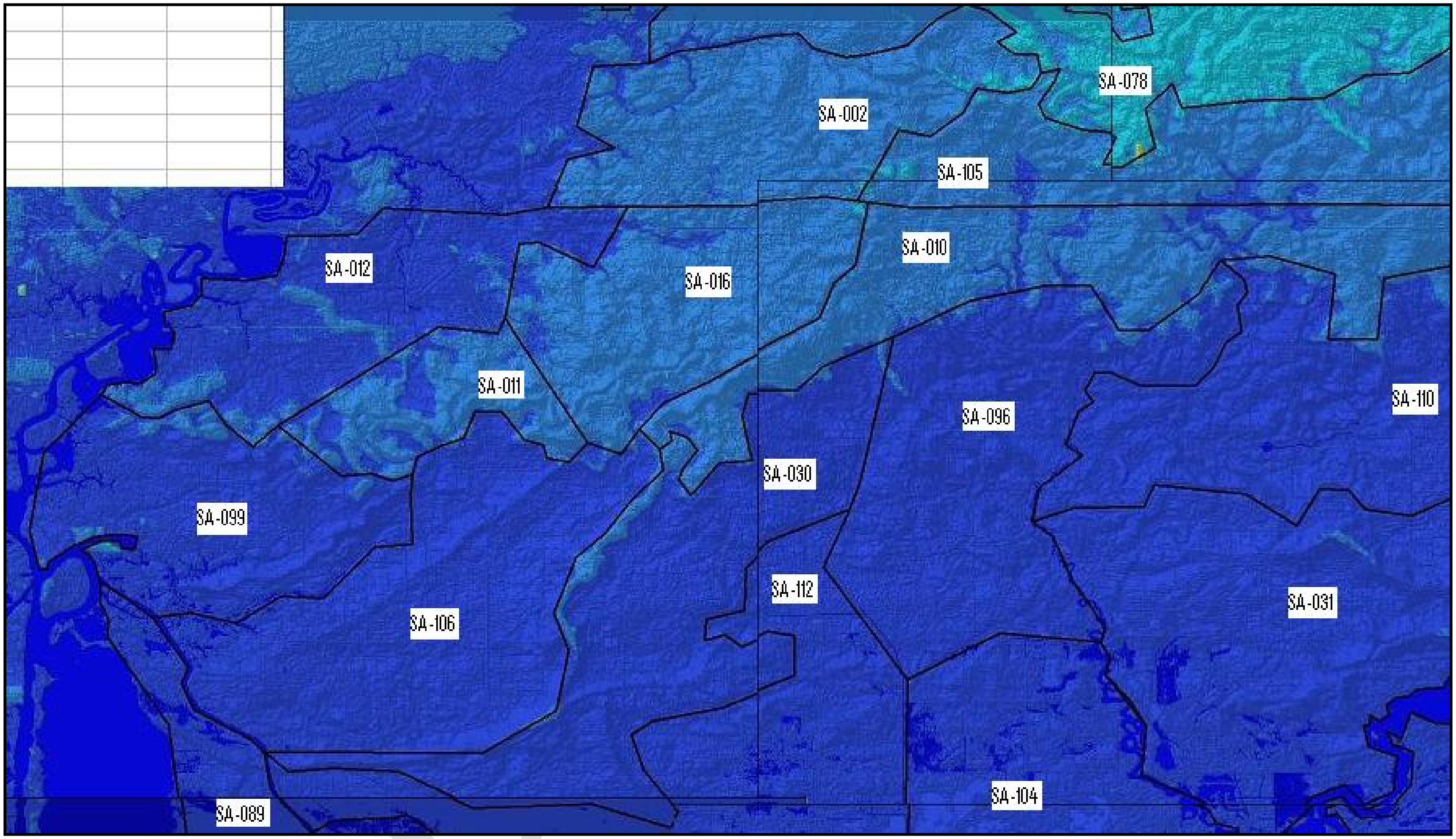

Figure L-2. Sample Color Shaded Relief Map From LIDAR Near Lake Charles, LA

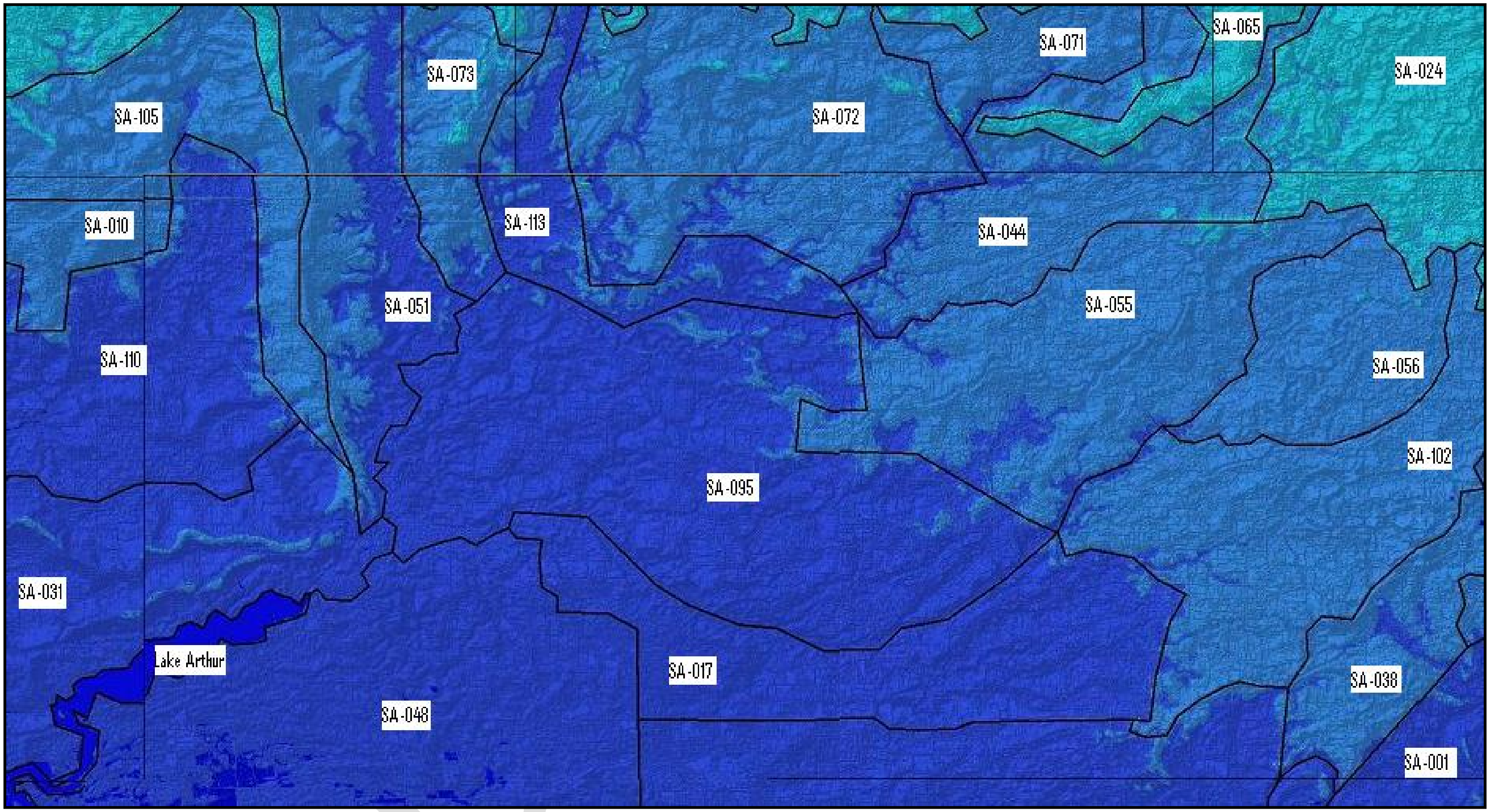

Figure L-3. Sample Color Shaded Relief Map From LIDAR Near Jennings, LA

D. Land Use. The Soil Conservation Service (SCS) Curve Number (CN) Method was used for mostly Class D soils to depict current land usage. The numbers range from a low value of 77 for forested areas to a high value of 98 for open water or concrete areas. GIS was used to generate a CN per storage area. There are nine parishes in this basin. Land type and the Hydrologic Soil Type were used in GIS to generate one CN per storage area. The CNs are based upon Table 2-2a, *Runoff curve number for urban areas*, from TR55 "Urban Hydrology for Small Watersheds". This table was used to translate the land type Class Id required by GIS. When a sub-storage area fell between parishes a weighted curve number was recalculated as shown in "Weighted CN From GIS" worksheet.

The soil cover complex and associated runoff curve number procedure outlined in the SCS National Engineering Handbook (SCS, 1972) were used to represent runoff potential from the watershed. Existing land uses were determined by using Class D soils for most of the entire basin, recent aerial photos, and GIS software. The results are tabulated in table L-4 as percentages for each runoff curve number for the entire project watershed.

Table L-4. Percentages for Runoff Curve Numbers

Land Use	Percent	CN
Forested	2.02%	77
Open land with Trees	4.83%	79
Open land	36.88%	80
Wetlands	13.80%	82
New Development	0.00%	84
Open Residential	4.28%	86
Open-dense Residential	3.41%	88
Dense-open Residential	27.42%	90
Dense Residential	0.97%	92
Schools and Research	0.67%	94
Industrial Areas	1.01%	96
Open Water or Concrete	4.72%	98

Once the weighted SCS Curve Number was calculated for each of the storage areas, all other parameters were able to be derived. Table L-5 shows all input parameters to HEC-HMS Hydrologic Modeling System software. The distance used to compute lag time and Time of Concentration was also found by using GIS software and the longest distance to each connection for each storage area. The rainfall event of November 5, 2002 showed a maximum of 4.84 inches in 6 hours. The isohyetal method was used to compute actual rainfall for each basin, and is also shown below. This method will be explained in greater detail in the next section. No further adjustment of these input parameters is necessary once calibration is achieved.

Drainage Paths were first drawn in red upon color shaded relief maps created from LIDAR. Once the lowest perimeter elevation and location were found, storage area connections were created in HEC-RAS to represent the end of each drainage path. This was then updated to the images shown as modified pink lines. Since most of the modified drainage paths were shorter than the original assumed drainage paths, this would only reduce most of the lag times and then create steeper runoff hydrographs of less duration. As for the very few storage areas that experienced longer drainage paths as a result, these were all found to be in locations such as to have almost no effect upon the Calcasieu Lock in question. Therefore, the modified drainage paths were not recalculated and updated to HEC-HMS. A few sample images are shown in figures L-4 and L-5.

Table L-5. Entire Hydrology Input to HEC-HMS

Storage	Area (sq. mi.)	Lag Time (min)	Time of Concentration (min)	SCS CN	Initial Abstraction (in.)	Impervious %
SA-001	25.960	382	229	87.34	0.29	87
SA-002	42.246	430	258	87.75	0.28	87
SA-006	31.210	202	121	98.78	0.02	98
SA-007	51.076	422	253	89.46	0.24	89
SA-008	29.057	455	273	88.60	0.26	88
SA-009	10.210	303	182	98.41	0.03	98
SA-010	50.990	553	332	89.66	0.23	89
SA-011	18.480	255	153	87.78	0.28	87
SA-012	39.070	465	279	85.70	0.33	85
SA-013	32.180	418	251	94.42	0.12	94
SA-014	72.690	392	235	97.55	0.05	97
SA-015	65.830	362	217	98.86	0.02	98
SA-016	39.460	417	250	88.35	0.26	88
SA-017	55.340	337	202	91.37	0.19	91
SA-019	51.270	400	240	98.83	0.02	98
SA-021	72.810	192	115	98.61	0.03	98
SA-023	81.790	383	230	96.99	0.06	96
SA-024	118.419	540	324	84.60	0.36	84
SA-029	27.445	217	130	80.87	0.47	80
SA-030	58.040	682	409	88.83	0.25	88
SA-031	98.470	638	383	91.57	0.18	91
SA-032	27.276	305	183	76.54	0.61	76
SA-033	164.210	647	388	91.26	0.19	91
SA-034	71.050	462	277	97.75	0.05	97
SA-036	21.600	195	117	98.79	0.02	98
SA-038	53.031	760	456	87.09	0.30	87
SA-039	53.761	652	391	86.85	0.30	86
SA-040	70.310	382	229	98.63	0.03	98
SA-041	42.029	385	231	83.95	0.38	83
SA-042	59.967	695	417	86.48	0.31	86
SA-044	48.059	728	437	85.07	0.35	85
SA-046	58.730	475	285	98.89	0.02	98
SA-048	142.570	602	361	92.30	0.17	92
SA-049	80.210	445	267	98.87	0.02	98
SA-051	54.210	978	587	86.66	0.31	86
SA-054	8.410	117	70	98.40	0.03	98
SA-055	63.390	602	361	90.63	0.21	90
SA-056	28.530	393	236	90.06	0.22	90
SA-065	33.458	398	239	87.37	0.29	87
SA-066	88.150	492	295	98.99	0.02	98
SA-067	53.080	420	252	97.54	0.05	97
SA-069	53.493	468	281	88.94	0.25	88
SA-070	98.130	610	366	90.27	0.22	90

Table L-5. Entire Hydrology Input to HEC-HMS

Storage	Area (sq. mi.)	Lag Time (min)	Time of Concentration (min)	SCS CN	Initial Abstraction (in.)	Impervious %
SA-071	15.872	285	171	86.29	0.32	86
SA-072	76.810	578	347	81.14	0.46	81
SA-073	21.590	392	235	86.01	0.33	86
SA-074	34.090	240	144	95.75	0.09	95
SA-075	9.130	183	110	83.01	0.41	83
SA-076	21.217	337	202	87.15	0.29	87
SA-077	42.668	570	342	81.07	0.47	81
SA-078	133.646	443	266	89.79	0.23	89
SA-079	24.720	135	81	98.71	0.03	98
SA-080	8.873	162	97	90.74	0.20	90
SA-083	30.670	187	112	87.66	0.28	87
SA-086	12.610	182	109	98.86	0.02	98
SA-087	31.860	390	234	98.99	0.02	98
SA-089	28.050	330	198	96.27	0.08	96
SA-090	30.310	195	117	99.00	0.02	99
SA-091	76.230	288	173	95.67	0.09	95
SA-092	26.110	270	162	98.89	0.02	98
SA-093	2.000	142	85	98.88	0.02	98
SA-094	61.160	463	278	86.45	0.31	86
SA-095	110.930	430	258	90.31	0.21	90
SA-096	60.290	610	366	88.80	0.25	88
SA-097	19.670	90	54	98.97	0.02	98
SA-098	5.440	188	113	98.99	0.02	98
SA-099	40.900	350	210	88.10	0.27	88
SA-100	28.170	333	200	87.56	0.28	87
SA-101	23.190	140	84	98.42	0.03	98
SA-102	61.860	757	454	90.20	0.22	90
SA-103	63.637	305	183	89.18	0.24	89
SA-104	54.800	373	224	95.71	0.09	95
SA-105	70.330	687	412	90.03	0.22	90
SA-106	63.830	585	351	89.72	0.23	89
SA-107	44.890	152	91	98.97	0.02	98
SA-110	81.310	863	518	90.94	0.20	90
SA-111	46.040	198	119	98.96	0.02	98
SA-112	85.010	573	344	94.71	0.11	94
SA-113	27.590	475	285	83.10	0.41	83
SA-114	9.040	235	141	98.98	0.02	98
SA-115	11.860	265	159	90.03	0.22	90
Lower	1.000	273	164	98.00	0.04	98
Lower	1.000	170	102	98.00	0.04	98
Lower	1.000	272	163	98.00	0.04	98
Lower	1.000	155	93	98.00	0.04	98
Old Lower	1.000	158	95	98.00	0.04	98

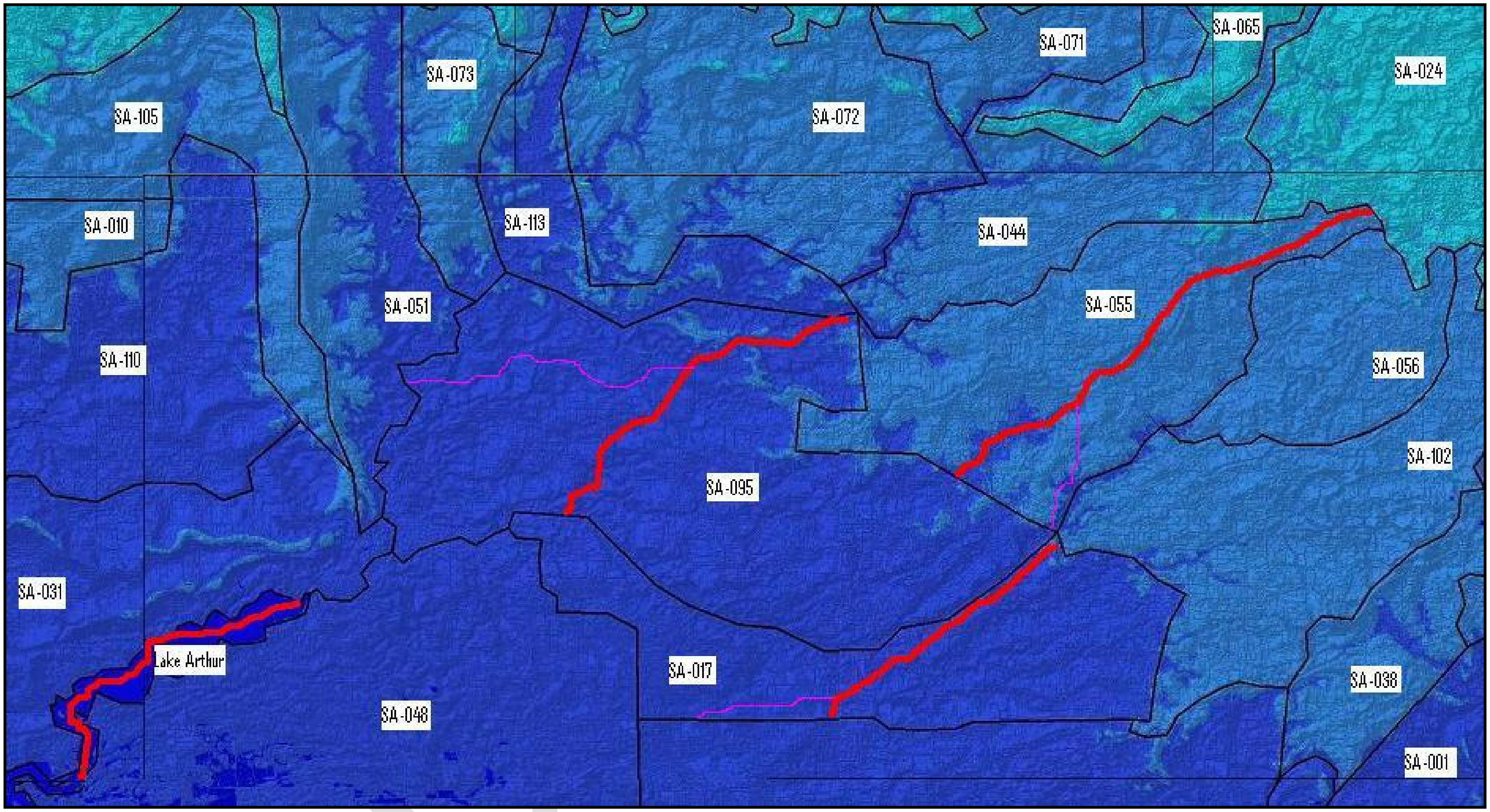

Figure L-4. Sample Drainage Paths Southeast of Jennings, LA

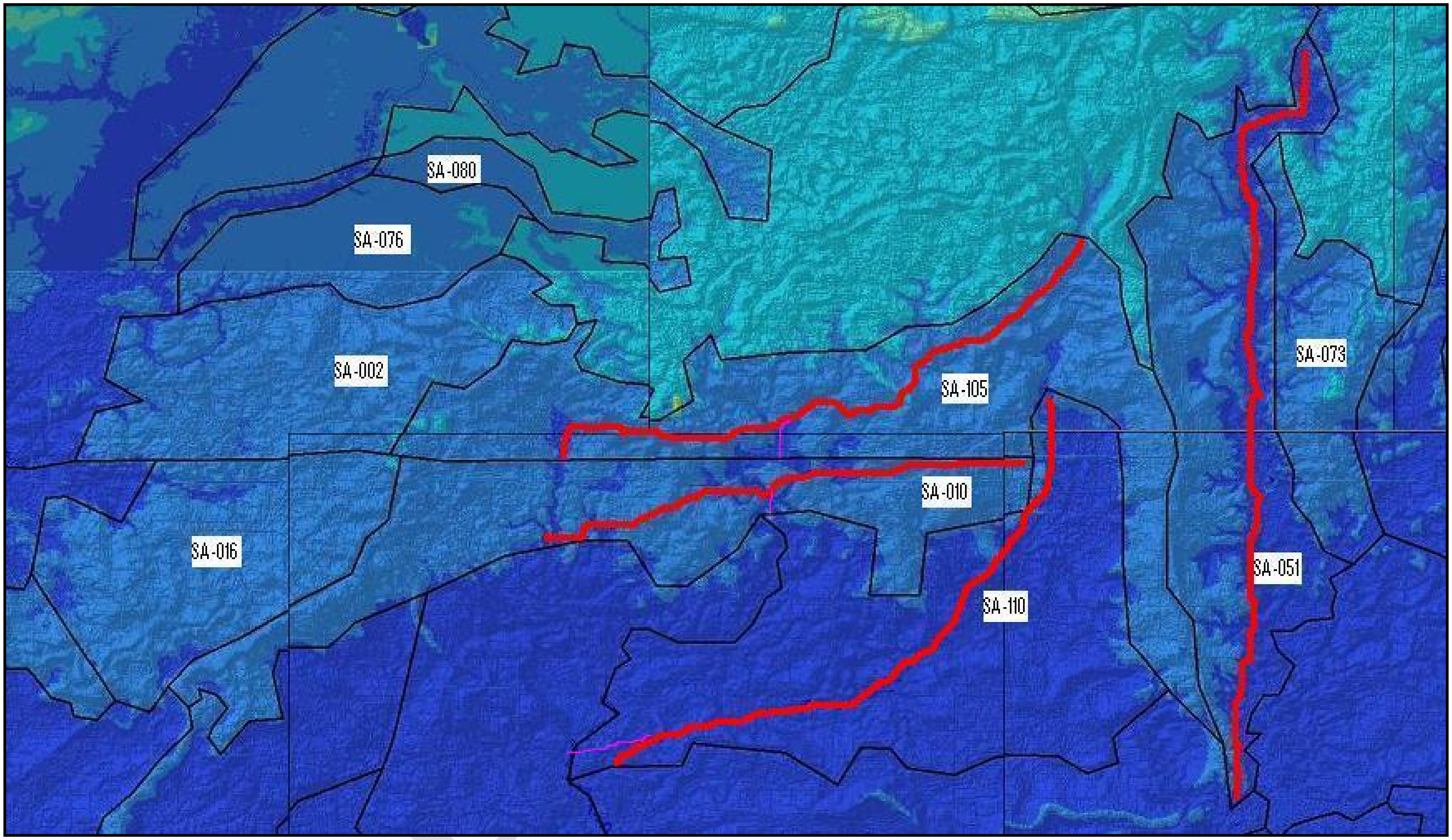

Figure L-5. Sample Drainage Paths West of Jennings, LA

IV. HYDROLOGIC MODELING

A. General. The hydrology and hydraulics was first calibrated to the rainfall event from November 5, 2002. This event was chosen based upon the simplest one-day runoff hydrograph that ended a wet period and was followed by a dry period, which guaranteed a successful calibration. The data from which this event was chosen was compiled from Corps website data from all four lock structures. The final candidates were also used to choose the verification event in 2001. More detail was required for the actual rainfall isohyetals, which was obtained from numerous rainfall stations available in NCDC publications. Once this was accomplished, water surface elevations were obtained for base conditions for nine synthetic rain fall events based upon the NWS TP-40 publication.

B. Rainfall. A summary report was compiled long after the rainfall event of November 5, 2002 by the Corps' Hydraulic Engineer. Rainfall data from the website www.ncdc.com was used to create more detailed rainfall isohyetals, which eventually led to the calculation of exact rainfall totals for each storage area's centroid.

C. Methodology. Lines were drawn between all known rainfall station totals and rainfall amounts in half-inch increments were marked on each line. All of the same numbered amounts were then connected, which yielded the first group of isohyetals of equal rainfall. It was actually easier to accomplish this with a spreadsheet and its plotting capabilities than by using GIS. Table L-6 lists the rainfall stations used.

Table L-6. Rainfall Stations Used

	*******November 2002******					
Location	**3**	**4**	**5**	**6**	**X-Longitude**	**Y-Latitude**
Hackberry 8 SSW	0.12	0.17	**4.84**	0.16	-93.40000	29.88333
Calcasieu Lock	0.23	0.37	4.40	0.00	-93.28333	30.08333
Bell City 13 SW	0.00	0.23	4.22	0.07	-93.08333	29.96667
Catfish Point Lock	0.03	0.10	3.39	0.00	-92.85000	29.86667
Jennings	0.14	0.47	3.86	0.00	-92.66667	30.20000
Eunice	0.19	1.34	3.36	0.03	-92.43333	30.50000
Ville Platte	0.45	2.00	3.57	0.02	-92.28333	30.70000
Grand Coteau	0.48	0.16	2.20	0.00	-92.03333	30.41667
Bunkie	0.48	3.68	2.37	0.00	-92.18333	30.96667
Oakdale	0.43	4.13	2.63	0.00	-92.66667	30.81667
Dry Creek 7 NW	0.42	4.90	2.53	0.00	-93.11667	30.73333
Vinton	0.37	1.17	2.50	0.01	-93.58333	30.20000
Freshwater Bayou Lock	0.07	0.00	0.90	0.94	-92.30000	29.55000
Schooner Bayou Lock	0.10	0.13	1.55	1.04	-92.26667	29.76667
Abbeville	0.01	0.95	1.34	0.61	-92.11667	29.96667
New Iberia	0.05	0.57	0.17	1.97	-91.78333	29.98333

The centroid of each area was calculated with GIS software, and the exact rainfall amount was linear interpolated between isohyetals for each of these points. The daily data from NCDC for the 4.84 inch maximum total was used to create the base rainfall curve, since this station also had the most reliable data. All exact rainfall amounts for each storage area centroid were then rounded to the nearest tenth of an inch of rainfall, and a multiplier was used to create that rainfall curve from the base 4.84 inches rainfall curve to match each storage area. These 8 rainfall curves ranged from 1.0 inches to 4.5 inches, and were all entered into the HEC-HMS software to produce exact runoff hydrographs for each storage area for November 5, 2002. This proved to be highly effective and made the hydraulic calibrations much easier. A map of the exact rainfall calculations, the rainfall isohyetals, and the extrapolated rainfall isohyetals is shown in figure L-6. Centroids are denoted by all of the unconnected dots.

The stations used for the verification event of 2001 are shown in table L-7. Plots for the verification event are shown in figures L-7 and L-8.

Table L-7. Stations Used to Verify Event of 2001

Station	Easting - X	Northing - Y	Rainfall (10 days)
Calcasieu Lock	2664142.648	581043.845	16.69
Hackberry 8 SSW	2625937.703	508970.215	11.97
Jennings	2859645.568	620676.385	10.04
Bell City 13 SW	2726739.997	537602.721	9.62
Eunice	2934400.198	728995.112	9.25
Catfish Point Lock	2800132.234	500187.129	9.08
Abbeville	3032801.364	534219.371	8.29
Ville Platte	2982243.123	801312.994	8.23
Oakdale	2862255.272	844947.550	7.92
Dry Creek 7 NW	2720523.741	816558.486	7.85
Oberlin Fire Tower	2829877.815	766523.603	7.76
Schooner Bayou Lock	2984714.653	461846.511	7.73
Grand Coteau	3060189.113	697699.248	7.41
Vinton	2570111.442	625203.805	6.95
Bunkie	3014392.695	898063.739	6.63
Freshwater Bayou Lock	2973475.650	383145.104	4.85
New Iberia	3138371.594	539709.890	4.54

Synthetic rainfall from the NWS-TP40 publication was used for nine events for the calibrated base conditions, as tabulated in table L-8.

The 10-year and 100-year rainfall events for base conditions were plotted for the entire study area by using GIS software, which is shown in figure L-9. The 10-year event clearly has the most effect, with the 100-year event adding only slightly more peak runoff. These peak stages are actually the results from HEC-RAS, the hydraulics portion of the study.

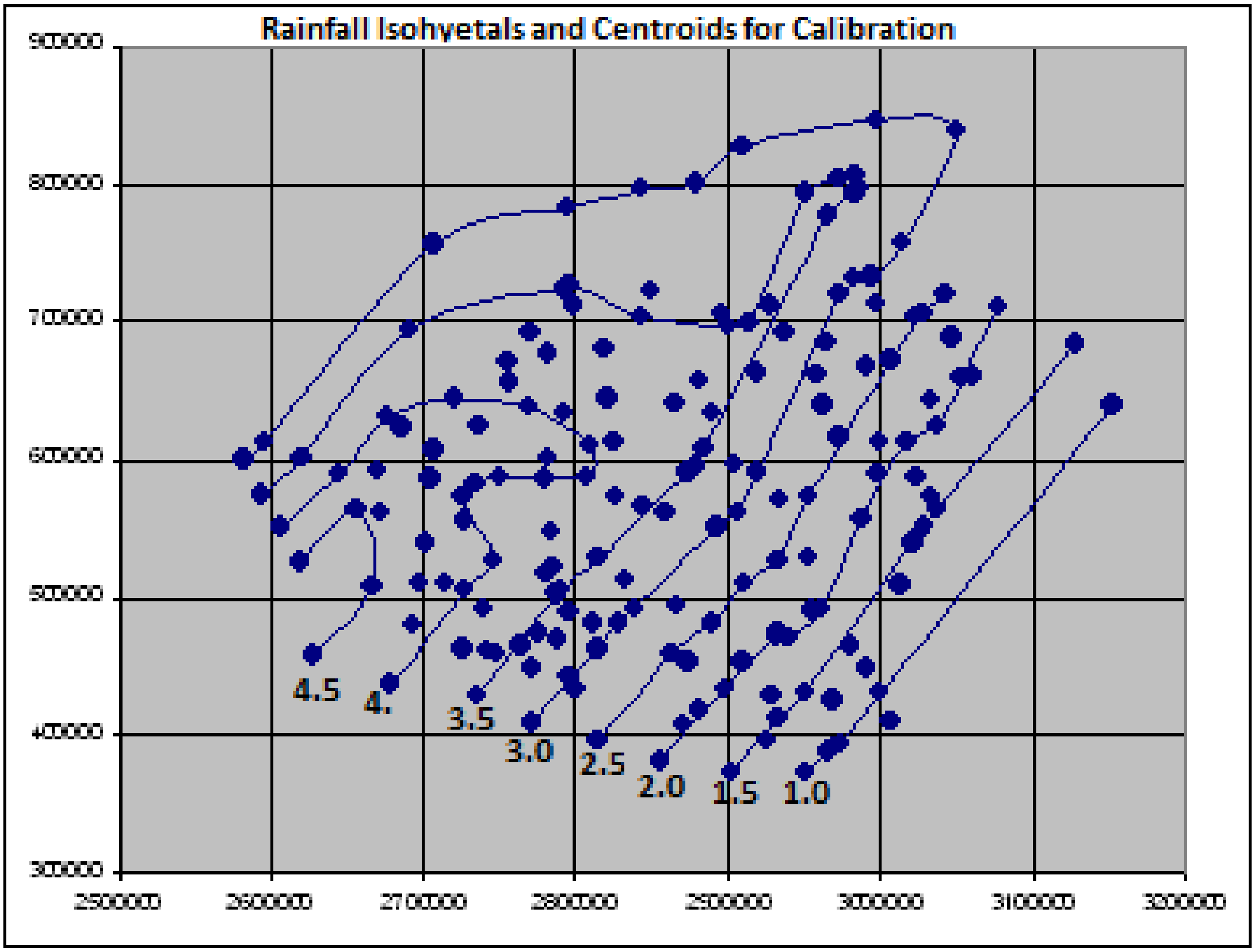

Figure L-6. Rainfall Isohyetals and Storage Area Centroids for Calibration

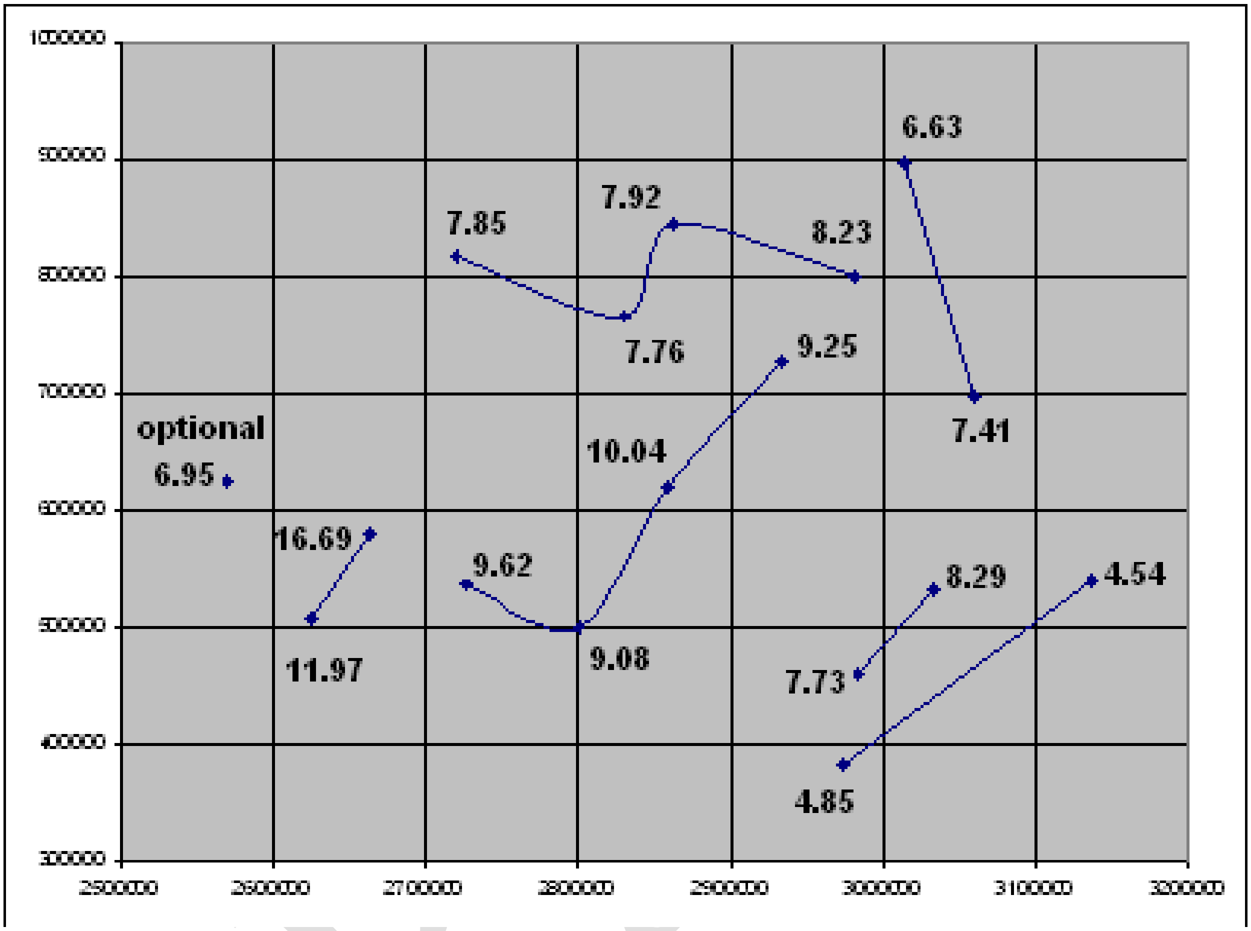

Figure L-7. Actual Rainfall Totals for Aug 28-Sept 6, 2001 in SW Louisiana

Table L-8. Probabilities for Calcasieu Parish Rainfall in Inches

Elapsed Time	100.00%	50.00%	20.00%	10.00%	4.00%	2.00%	1.00%	0.40%	0.20%
15 min	1.07	1.25	1.41	1.57	1.73	1.89	2.05	2.18	2.32
1 hour	2.10	2.45	2.90	3.35	3.80	4.25	4.75	5.13	5.52
2 hours	2.70	3.15	3.80	4.45	5.05	5.60	6.20	6.71	7.22
3 hours	2.90	3.50	4.30	5.00	5.70	6.40	7.25	7.88	8.50
6 hours	3.50	4.25	5.30	6.25	7.20	8.10	9.00	9.79	10.58
12 hours	4.10	5.10	6.50	7.60	9.00	10.00	11.00	11.98	12.97
24 hours	4.80	6.00	7.60	9.20	10.80	12.10	13.50	14.75	16.00

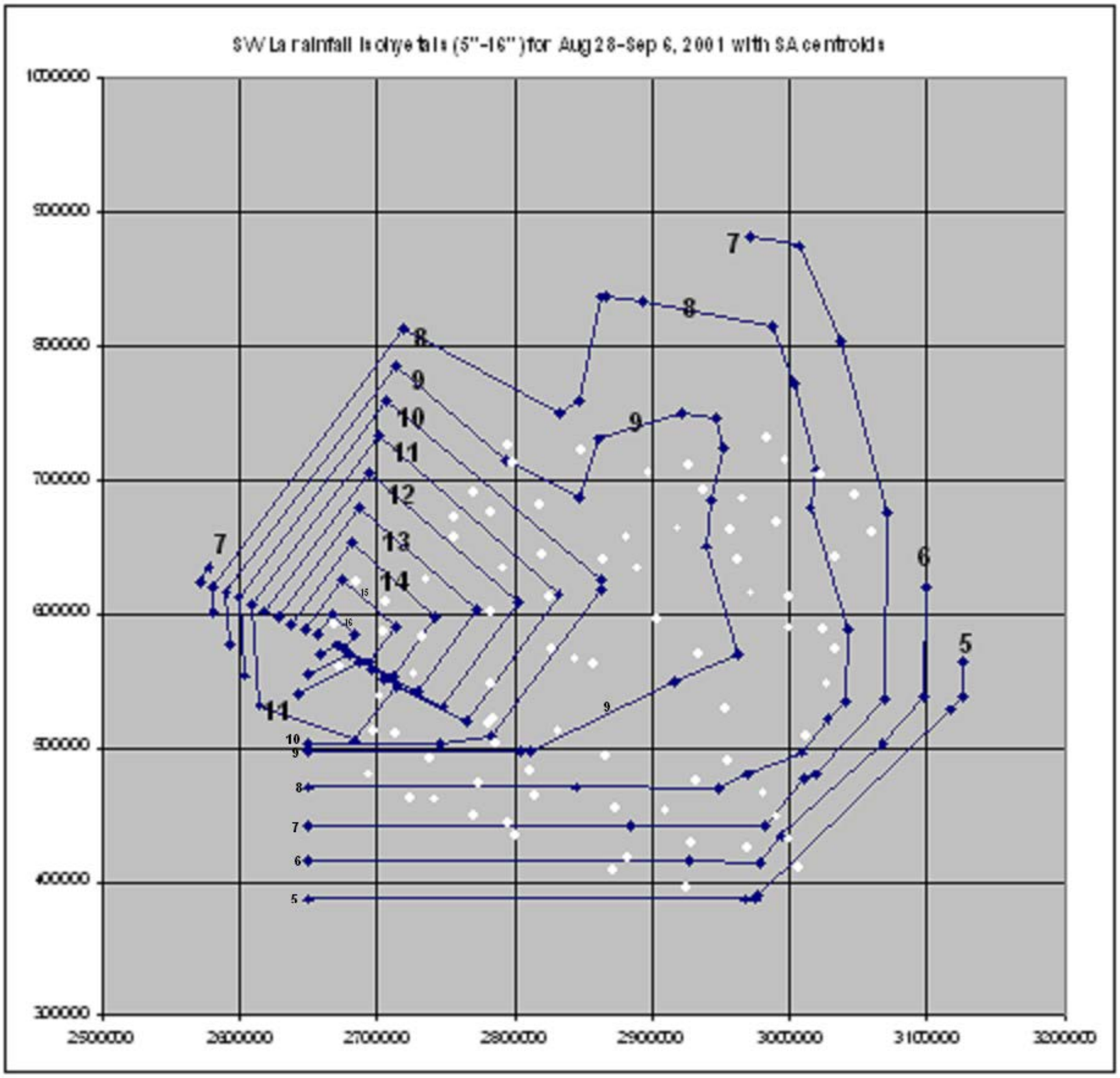

Figure L-8. Southwest Louisiana Rainfall Isohyetals for Aug 28 – Sept 6, 2001 with Storage Area Centroids Shown in White

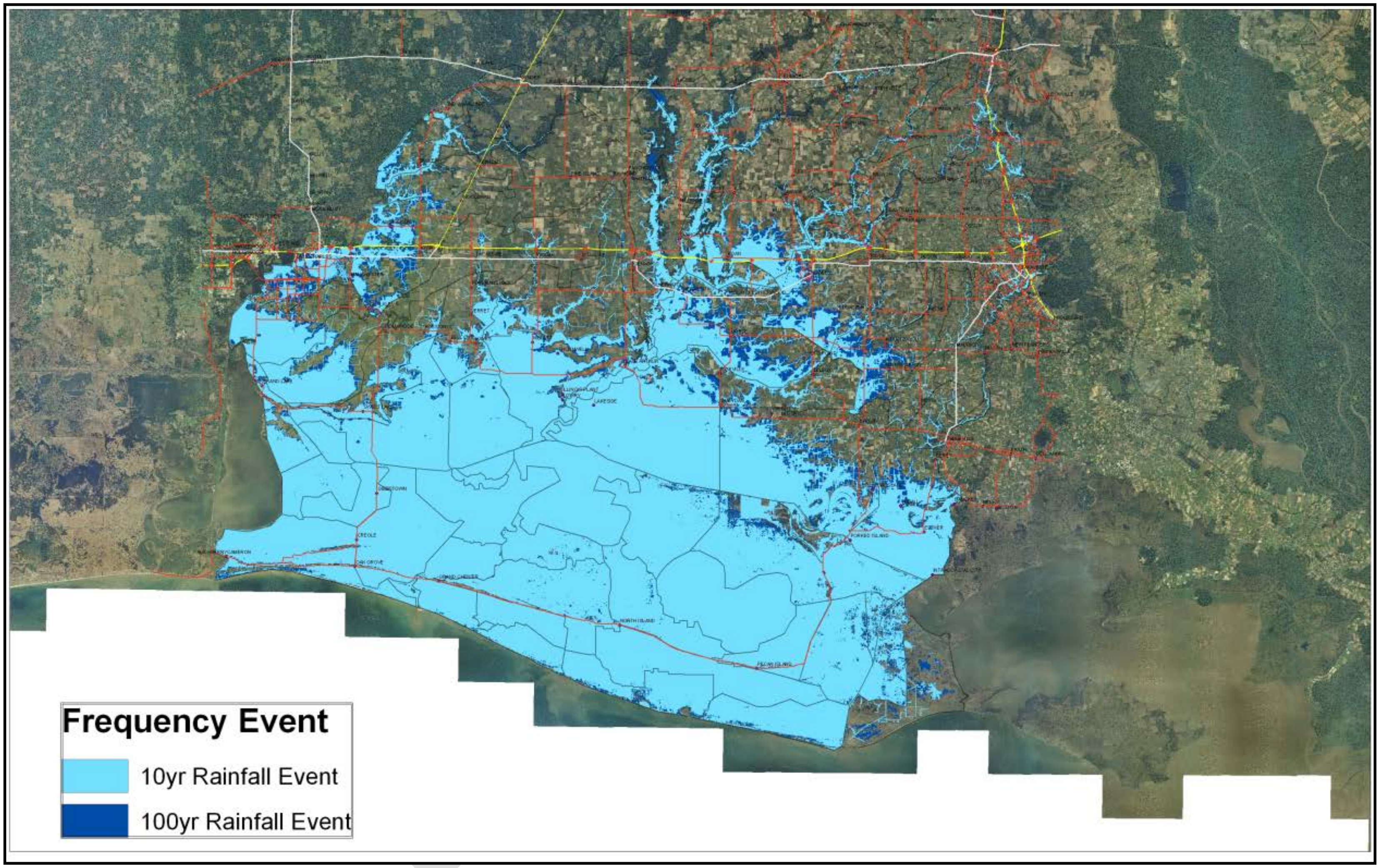

Figure L-9. Maximum Rainfall Inundation for 10-year and 100-year Events in Southwest Louisiana

V. HYDRAULIC MODELING

A. General. The watershed was modeled by focusing on three main components: geometry, hydrology, and boundary conditions. The geometry of the model describes the physical characteristics of the watershed including canals, storage areas, bridge crossings and locks. Subsurface drainage is best approximated by one artificial lateral weir per storage area, which drains into a canal or adjacent storage area at the lowest elevation on that storage area perimeter. Watershed hydrology describes the frequency, duration, and volume of storm water runoff as it travels from each storage area into the entry point at the storage area connection or lateral weir. Boundary conditions describe how the hydrographs are transported into and out of the watershed and between storage areas and canals.

Cross Section survey data from in-house sources was manually entered as flowing from upstream to downstream into HEC-RAS 4.0 River Analysis System software. Storage area boundaries and volume vs. elevation curves were also transported via spreadsheets from GIS software. To prevent the model from going unstable, very small pilot channels of negligible volume are usually added to each channel to prevent the model from running dry, but were never needed in this case.

B. Methodology. Having chosen November 5, 2002 as the most likely event to produce a successful calibration, it was simply a matter of looking up gage data for all four locks or structures and adjusting the readings for datum and subsidence. Once the rainfall runoff hydrographs for all areas was entered as inflow for each hydraulic storage area by the same name, it was a matter of adjusting the width of the few lateral weirs along the GIWW, which are located at the lowest elevation of each storage area. The model remained calibrated for 5 days after the actual event date, as shown in figure L-10. The model was actually test for a 21-day time period, but 5 days were sufficient for the initial calibration event.

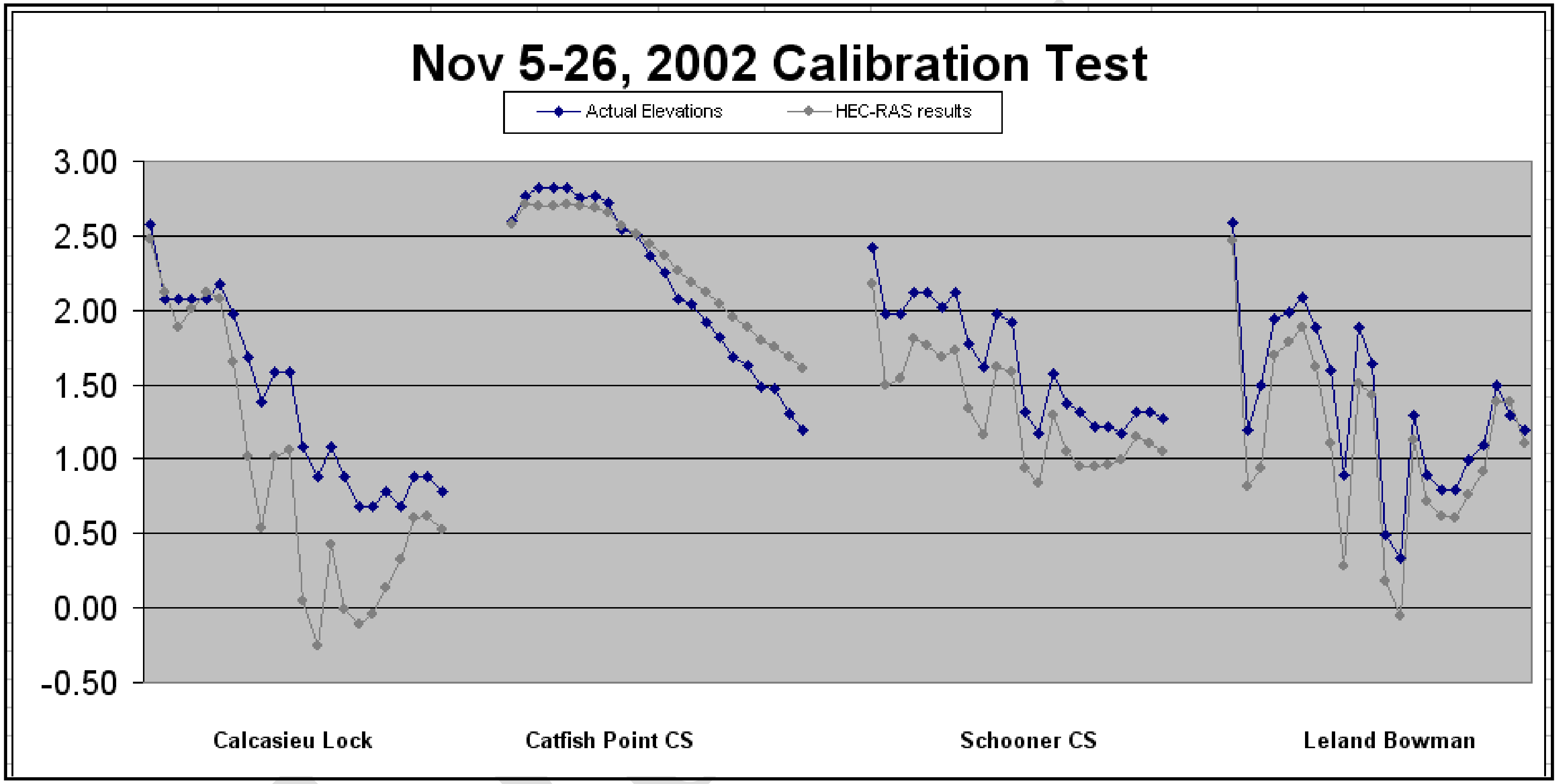

Figure L-10. November 5-26, 2002 Calibration Test

C. Geometry. Once the calibration was achieved, the geometry file and all hydrologic parameters were saved as a permanent record of base conditions. Runoff hydrographs from the nine synthetic rainfall events were then entered into HEC-RAS as input to this one calibrated geometry file. The results of maximum water surface elevations were then analyzed, but showed no lowering of peaks when test alternatives were run. This means that rainfall events govern due to the flat terrain in the southern part of the study, but drainage times are indeed affected either by sea level or lock openings. The initial elevations for each storage area are those that the HEC-RAS model requires to begin stable runs. They were derived from multiple HEC-RAS runs of the 1-year event, whereby the final elevation after many days should equal the starting elevation. From a hydraulic standpoint, this makes perfect sense, since a final elevation being higher than a starting elevation would mean that a particular storage area is experiencing long term ponding. The final elevation can never be lower than the starting elevation because the elevation of the lateral weir limits the drainage.

A backwater surface profile runs along the GIWW towards the east from the Calcasieu Lock, which is all the way to Bayou Lacassine and the Mermentau River at Lake Arthur. Since there is no protective dike on the north side of the GIWW, this backwater begins to flood the first two storage areas when the east gage at the lock reaches 2.95 feet or higher. The lock master had been using 3.00 feet as his cue to open up the gates before this model was even calibrated, so the model is in complete agreement with the actual results. The two storage areas are SA-030 and SA-106, which are outlined in yellow in the drainage sequence chart shown in figure L-11 (0, 18, 90, and 180 hours after the peaks). Since this is an extremely large amount of data for GIS to handle, only those storage areas that are affected by sea level rise or lock openings were plotted.

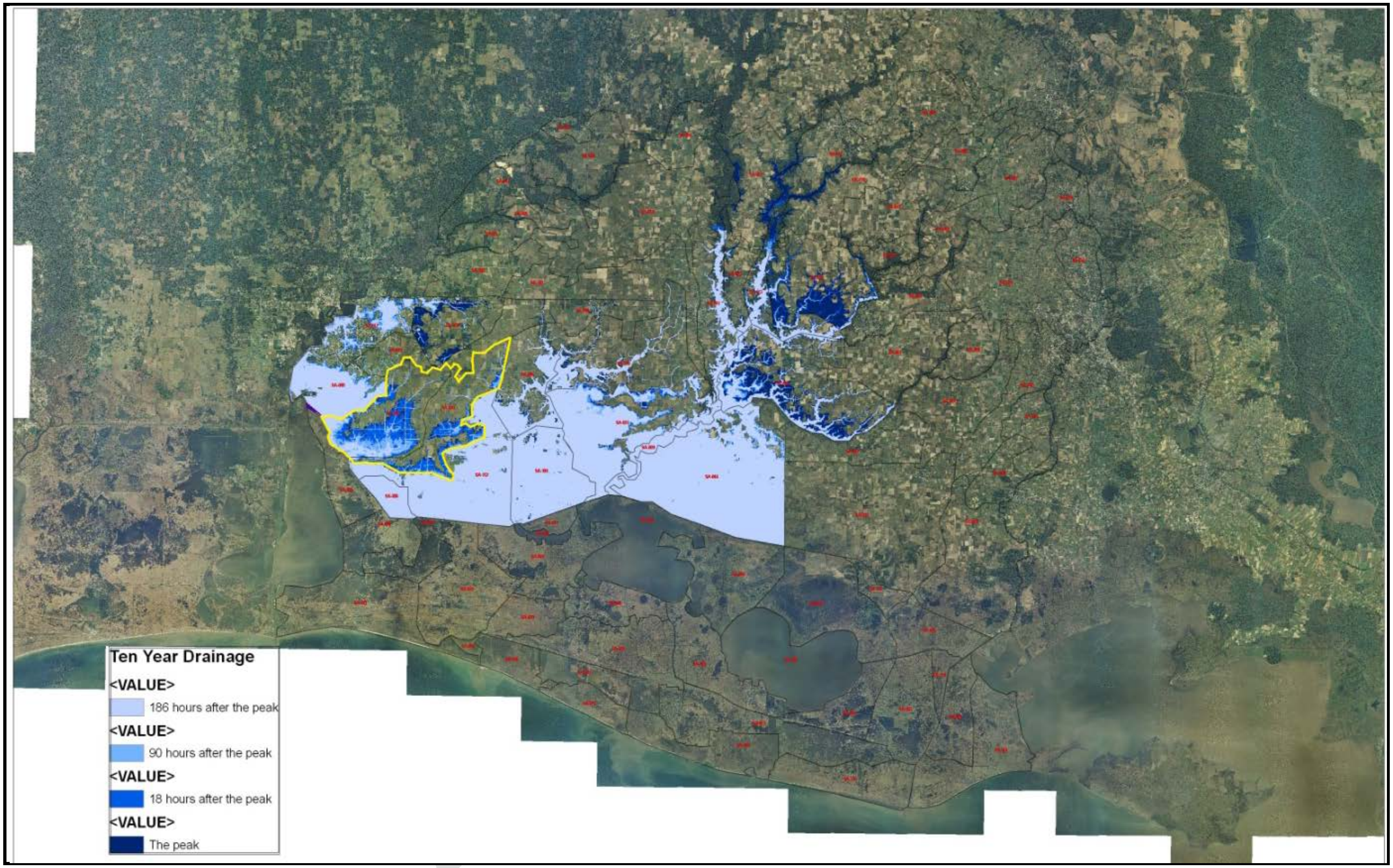

Figure L-11. Time Lapse of 10-year Rainfall Drainage in Problem Agricultural Area

D. Boundary Conditions. Since all flow was entered as one lateral inflow hydrograph for each storage area, a constant minimum flow of 10 cubic feet per second (cfs) was set for most channels to maintain stability of the HEC-RAS model. For the four locks or control structures, adjusted gulf stages were used for calibration purposes, while constant intermediate adjusted average stages were used for the all of the alternatives, which is 0.62 feet. In the case of Future without Project for the year 2070, (50 years after expected completion of construction), the intermediate sea level rise stage of 1. 70 feet was used at the Calcasieu Lock. Sea level rise for all four locks is shown in table L-9.

Table L-9. Relative Sea Level Rise for All Boundary Conditions

	Historic Rate	50 Year Relative Sea Level Rise Estimate				**Conctruction complete 2020**
	(mm/year)	Low (ft)	Intermediate (ft)	High (ft)	**Downstream B/C**	
Calcasieu Lock West	4.18	0.7	1.1	2.4	**1.7**	Calcasieu Lock West
Catfish Point South	7.04	1.2	1.6	2.9	**2.2**	Catfish Point South
Schooner Bayou East	5.70	0.9	1.3	2.6	**1.9**	Schooner Bayou East
Leland Bowman East	6.19	1.0	1.4	2.7	**2.0**	Leland Bowman East
		50 Year Estimated Stages				**Future w/o Project 2070**
		Low (ft)	Intermediate (ft)	High (ft)	**Downstream B/C**	
Calcasieu Lock West		2.7	3.1	4.4	**3.7**	Calcasieu Lock West
Catfish Point South		3.2	3.6	4.9	**4.2**	Catfish Point South
Schooner Bayou East		2.9	3.3	4.6	**3.9**	Schooner Bayou East
Leland Bowman East		3.0	3.4	4.7	**4.0**	Leland Bowman East

E. Roughness Coefficients. For roughness factors, Manning's "n" value was set to .09 for most channels and 0.10 for all overbanks for all conditions. Normally, a roughness of .045 would be assigned to channels, but these could only be used in a few of the smallest canals. The high channel roughness of 0.09 has already been justified in the calibration effort due to excessive debris in most of the channels. Since this project is composed primarily of storage areas, the coefficients for each connection were experimented with, but showed negligible results.

F. Drainage Criteria. Drainage of the entire basin can be improved by two means: lowering of sea level or adding another outlet such as a lock or gate.

Conversely, drainage is adversely affected by two means: increasing sea level or closing down the existing lock entirely. Ironically, a 50-year intermediate sea level rise will show less emptying and filling lock times due to less head differential because the remainder of the rise in stages winds up flooding the agricultural areas SA-030 and SA-106 even more. Applying these criteria of drainage to the possible alternatives, when given two channels, optimum drainage and improved locking times will happen when drainage is through the larger channel and locking is through the smaller channel. When the two channels are one and the same as for existing conditions, both drainage and locking times become less efficient.

G. Hydraulic Analysis. Since this is a navigation project and not a drainage project, the focus is not placed on water surface elevations for each of the 81 storage areas. Instead, the focus is how all of these storage areas drain into the GIWW and through the lock structures. The only way to improve navigation is to improve drainage; to do so, a gate or another lock could be constructed to add another larger channel adjacent to the existing lock. Lining the north side of the GIWW with a 4-foot high dike for about 33 miles upstream of the Calcasieu Lock would theoretically solve the flooding problems in these agricultural areas (with small pumps to drain over the dikes), but this is not part of the study and it is unknown what other areas would flood as a result.

VI. PLAN DESCRIPTION AND ANALYSIS

A. Description of Alternatives. Five alternatives were finally considered after trying many possible configurations, most of which showed no savings at all on locking times.

Improved locking times are also associated with improved drainage, even though this is not a drainage project.

Alternative 1. A 75-foot sluice gate that is generally within the alignment of the previously proposed south lock. The outfall and intakes will need to be excavated with material being beneficially used for marsh creation. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. Basically, rainfall runoff is causing large head differentials from the eastern side of the existing lock, which causes navigation delays. This proposed sluice gate on the south side of the existing lock would improve drainage and reduce navigation delays. To quantify this, third order polynomial equations were derived from a program used to compute emptying and filling times for a given size lock chamber. HEC-RAS was used to calculate upstream water surface elevations at any given time, with the downstream elevation being held to 0.62 feet. The difference between the two is the value known as lift that is needed for the third order polynomial equations. Comparing a 110-foot wide sluice gate and a 75-foot wide sluice gate to the existing conditions, the amount of minutes saved per locking time was computed and plotted for all nine rainfall events at hourly intervals for a period of 228 hours (figureL-12). In all cases, locking times are saved, but the larger 110-foot gate was not enough savings to justify the added cost. The equations used to compute filling and emptying times are:

110' Earthen chamber = -.0324*Lift^3+.4520*Lift^2+.4257*Lift+.0079
75' Earthen chamber = -.0083*Lift^3+.2286*Lift^2+.644*Lift+.0071

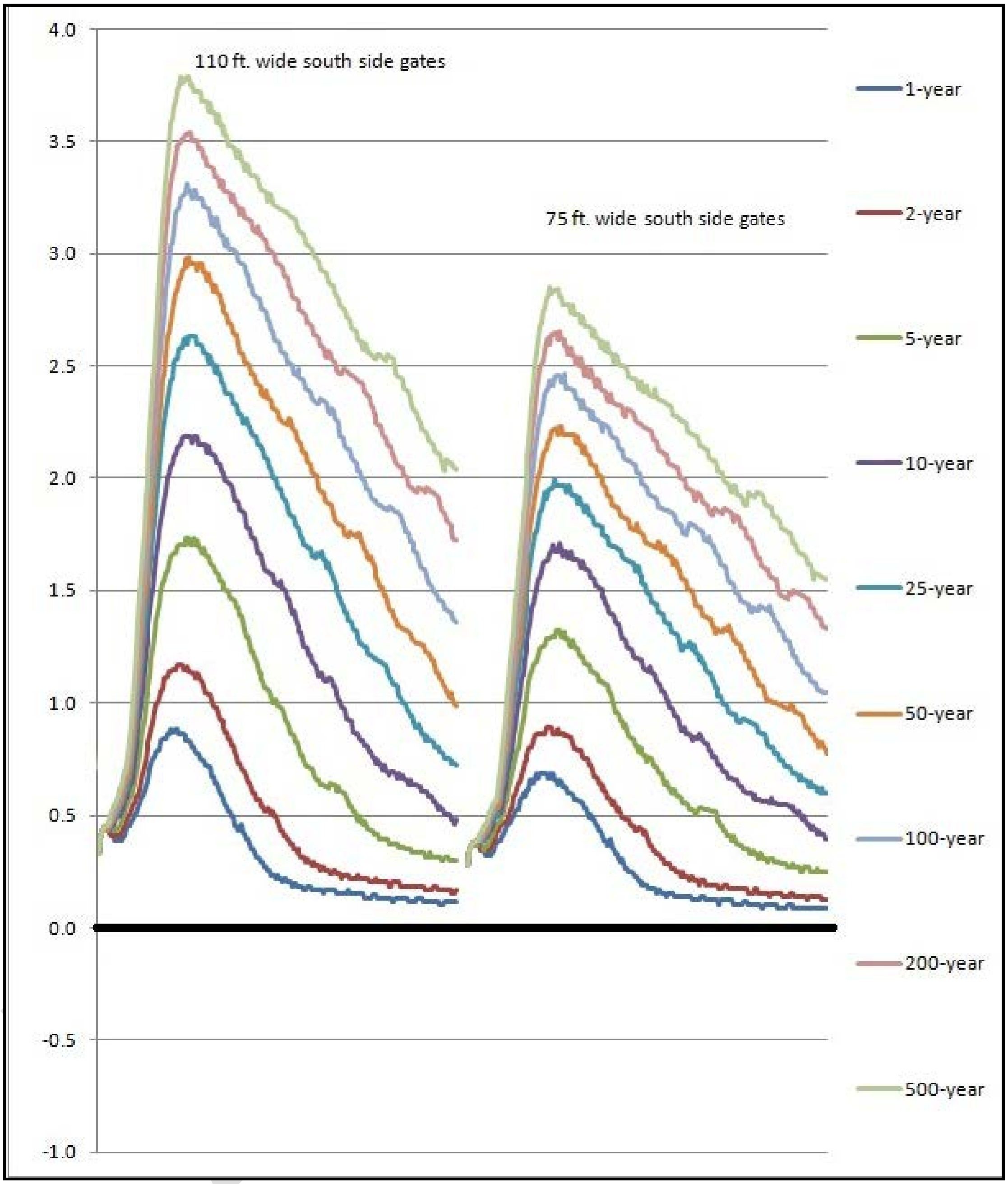

Figure L-12. Calcasieu Lock Study – Minutes Saved Per Locking
(Each line length represents 228 hours when compared to base location.)

For the remaining alternatives, various size pumps were placed at different locations and the 10-year rainfall event was run in HEC-RAS. Figures L-13 and L-14 show the results in the best possible way. Note that the second chart shows two different cross sections, with Black Bayou on the left and the GIWW on the right. The maximum size pump would clearly save locking times, but also introduce navigation hazards if placed where it is needed the most.

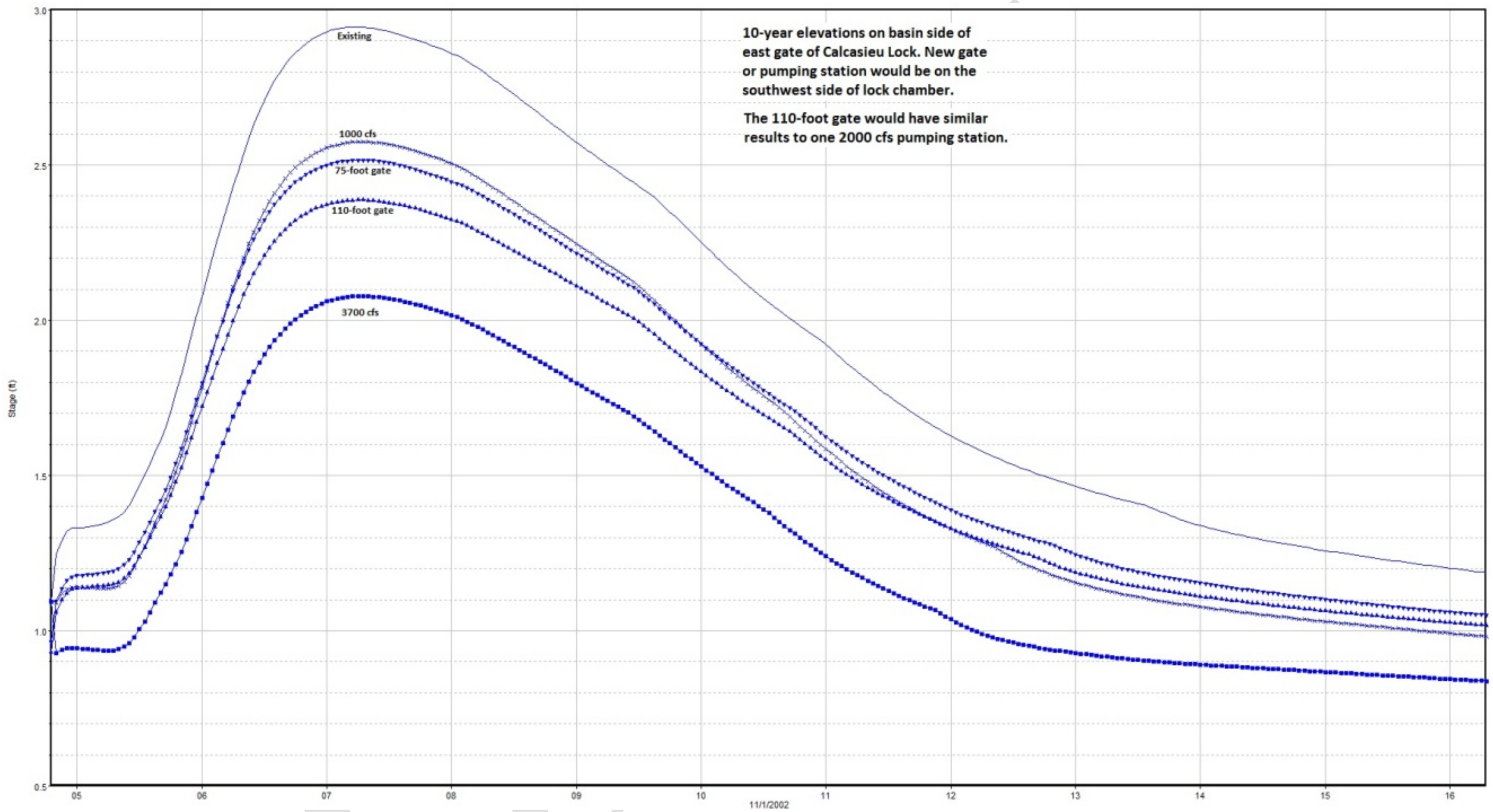

Figure L-13. 10-year Elevations at East Calcasieu Lock Gage for Alternatives and Existing Conditions

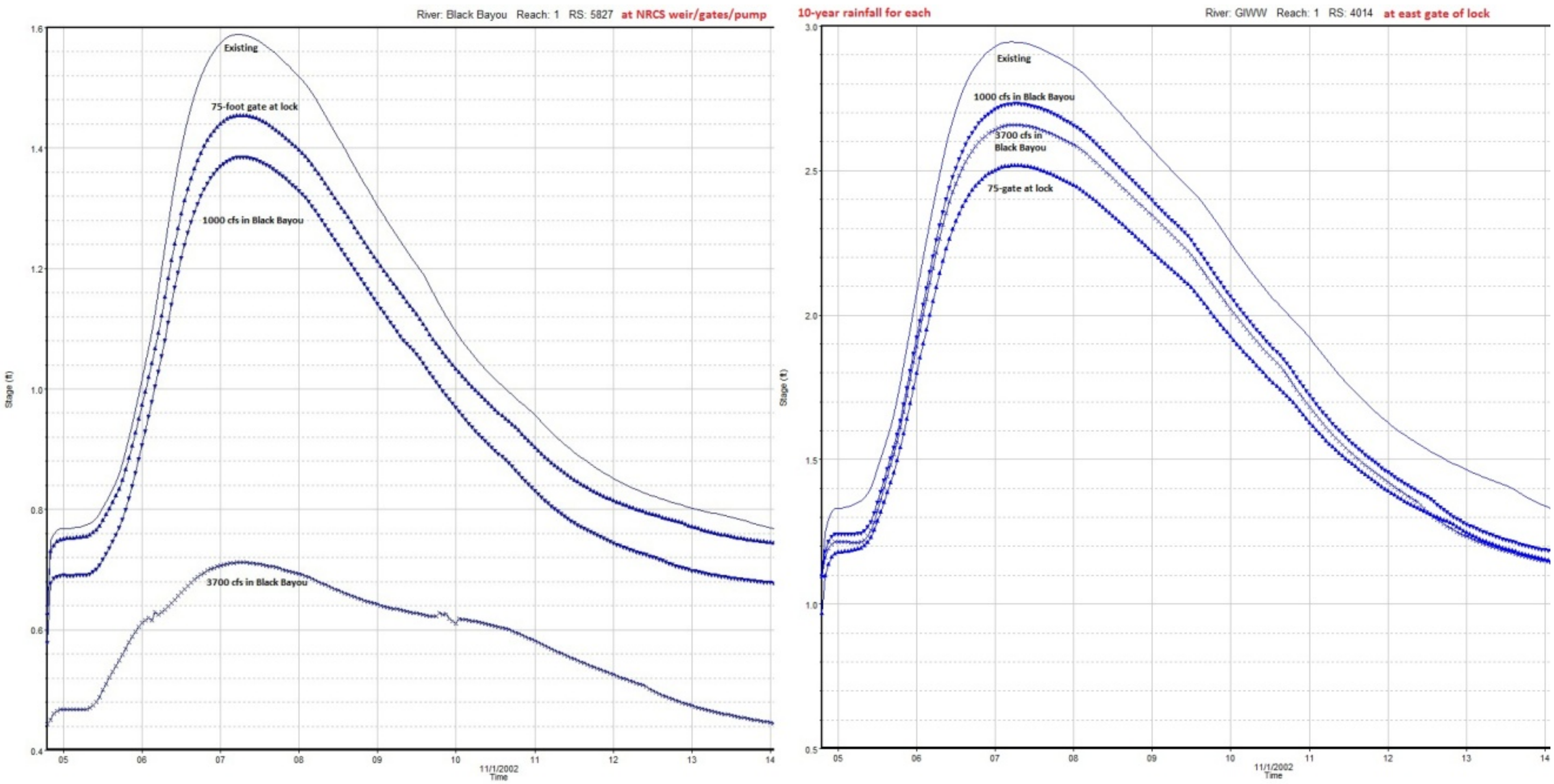

Figure L-14. 10-year Elevations at Black Bayou for Alternatives and Existing Conditions

Alternative 2. A 3,700 cfs pumping station would be constructed generally within the alignment of the previously proposed south lock. The outfall will need to be excavated with material being beneficially used for marsh creation. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. This pumping station was suggested by the Value Engineering team and was also the original suggestion from the Hydraulic Engineer for this project. However, due to the size of this pump, the cost would be prohibitive. The location of this pump also introduces a navigation hazard, and the pump may need to be turned off when locking through, which defeats the entire purpose of the pump.

Alternative 3. Supplemental Culverts would be added to the Black Bayou NRCS structure to increase its capacity and operate in conjunctions with it. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. The existing NRCS gates on Black Bayou were never manually operated as intended, which has caused a siltation problem in the channel. The proposed weir is designed to the same elevation of +3.0 feet NAVD88 that signifies the lock master to open up the lock gates for drainage. This would allow rainfall runoff to drain over the weir while keeping gulf stages from entering the freshwater area. When the gulf side reaches +2.0 NAVD88, the lock remains closed to prevent salt water intrusion.

Alternative 4. A 2,000 cfs Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure and operate in conjunction with it. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88**.** Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require the Corps to take over Operation and Maintenance, Repair, Replacement and Rehabilitation of the structure once its 20 project life under the Coastal Wetlands Protection & Restoration Act ends.[1]

Alternative 5. A 3,700 cfs Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure. The pumping station location is also too far away from the existing lock to be beneficial to drainage.

B. Future Without Project. Theoretically, the Future Without Project option would show improved locking times due to reduced head differentials, but this would be at the expense of induced damages in the two problematic agricultural areas of SA-030 and SA-106.

[1] Following IPR#1 in February 2013 it was determined that a 1,000 cfs pump would be insufficient to overcome the natural tendency to drain through the lock when the sector gates were open. Additional H&H analysis indicated that a 2,000 cfs pump operating in conjunction with the Black Bayou structure would be sufficient to provide the drainage capacity the lock currently provides. Alternative 4 basically adds a 2000 cfs pump to Alternative 2, working in conjunction with the proposed weir in Black Bayou. Initially, this pump was proposed to be placed near the existing NRCS gates, which was too far away to be beneficial to drainage. However, if the pump is moved closer to the GIWW, then drainage could be improved, but with a navigation hazard being added.

This has already been tested to find the results. If a 4-foot high dike were to be constructed on the north side of the GIWW next to these two areas to prevent induced damages, the excess water that would have flooded these areas would return to the GIWW and increase head differentials, thereby negating any improved locking times. This was not actually tested, since it was not part of the Scope of Work, however these results can be expected. Also, the Future Without Project is based solely upon 50-year projected intermediate sea level rise, which may not even happen.

As for the possibility of widening the existing lock, this is not feasible due to the fact that the lock cannot be shut down for any extended length of time, which would happen if this were to be constructed.

VII. RISK AND UNCERTAINTY

A. Introduction. This section addresses the hydrologic and hydraulic engineering portion of the risk and uncertainty analysis of the Calcasieu Lock Study as required under ER 1105-2-100 and ER 11105-2-101. Also the risk-based analysis performed follows the guidelines of Engineering Circular (EC) 1105-2-205.

The objective of this interdisciplinary approach is to conduct a probabilistic analysis of all key variables, parameters and components of flood damage reduction studies. Key economic variables in an urban situation normally include depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times and flood evacuation effectiveness. Furthermore, the hydrologic and hydraulic variables such as discharge and stage are included in the frequency analysis.

B. Methodology. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) numerical model developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center was used to perform the analysis. The HEC-FDA model provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood damage reduction plans. The model includes risk analysis methods to quantify uncertainty in discharge-exceedance probability, stage-discharge, and stage-damage functions and incorporate it into the economic and engineering performance analysis of alternatives. The program applies Monte Carlo simulation, a numerical analysis procedure that computes the expected value of damage while explicitly accounting for the uncertainty in the basic value to perform the computations. The individual plans and/or plan comparisons' evaluation is accomplished with the simulation's output reports.

Sufficient or appropriate stage gage observations are ideal to develop the frequency curves. Since this data is not available in this sub-basin, rainfall-runoff analysis is used to develop a synthetic frequency curve. The synthetic frequency curve or graphical stage-probability function was determined by using the Graphical Exceedance Probability Method. However, this method requires an estimate of the equivalent years of record. The equivalent years of record was estimated using the guidelines established in Engineer Technical Letter **(**ETL) 1110-2-537, *Engineering and Design Uncertainty Estimates for Non-analytical Frequency Curve*", 31 October 1997 and EC 1105-2-205, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics and Economics in Flood Damage Reduction Studies*, 25 February 1994. In addition, the magnitude of uncertainty related to the graphical stage-probability function is estimated with the order statistics methodology.

C. Application. The synthetic rainfall data used to develop the hydrologic and hydraulic analysis was obtained from the NWS TP No. 40. The NWS's network of rainfall stations includes three stations in the New Orleans Metropolitan Area. These stations are located at Audubon Park, Armstrong International Airport, and the New Orleans Airport with a rainfall record from 1961 to 1990, for a total of 29 years.

The NWS rainfall period of record and the guidelines as set forth in ETL 1110-2-537 and EC 1105-2-205 were used to determine the equivalent record length of 50 years. In addition, the synthetic stage-frequency coordinates for each storage area within the basin were input to develop its stage-probability function and confidence limits.

VIII. REFERENCES

HEC – Documentation for software from HEC-HMS, HEC-RAS, and HEC-FDA

SCS. Hydrology SCS National Engineering Handbook. Soil Conservation Service U.S. Department of Agriculture 1972

SURVEYS

I. GENERAL

In an effort to provide quantities for the Calcasieu Lock Feasibility Study, survey data for this project was gathered at the area surrounding the lock. The work was broken into two distinct areas: (1) surveys of the proposed culvert structure site and (2) hydro-surveys of the approach channels.

The delivery order for the surveys consisted of collecting data in the form of cross sections utilizing Real Time Kinematic GPS and single beam hydrographic survey techniques. A GPS network was performed to establish horizontal and vertical control to provided control values in the 2006.81 epoch.

II. BACKGROUND

The survey consisted of collecting 33 cross sections in three data sets. Specific line files were provided and named. In addition to the sections, a GPS network was established to orient control to the 2006.81 epoch. All of the coordinates shown and data computed are referenced to the North American Datum of 1983 (NAD83) and are using State Plane Coordinates for the Louisiana South Zone (1702) in U. S. Survey Feet 2006.81 epoch. The locations of the cross sections are shown in figure L-15.

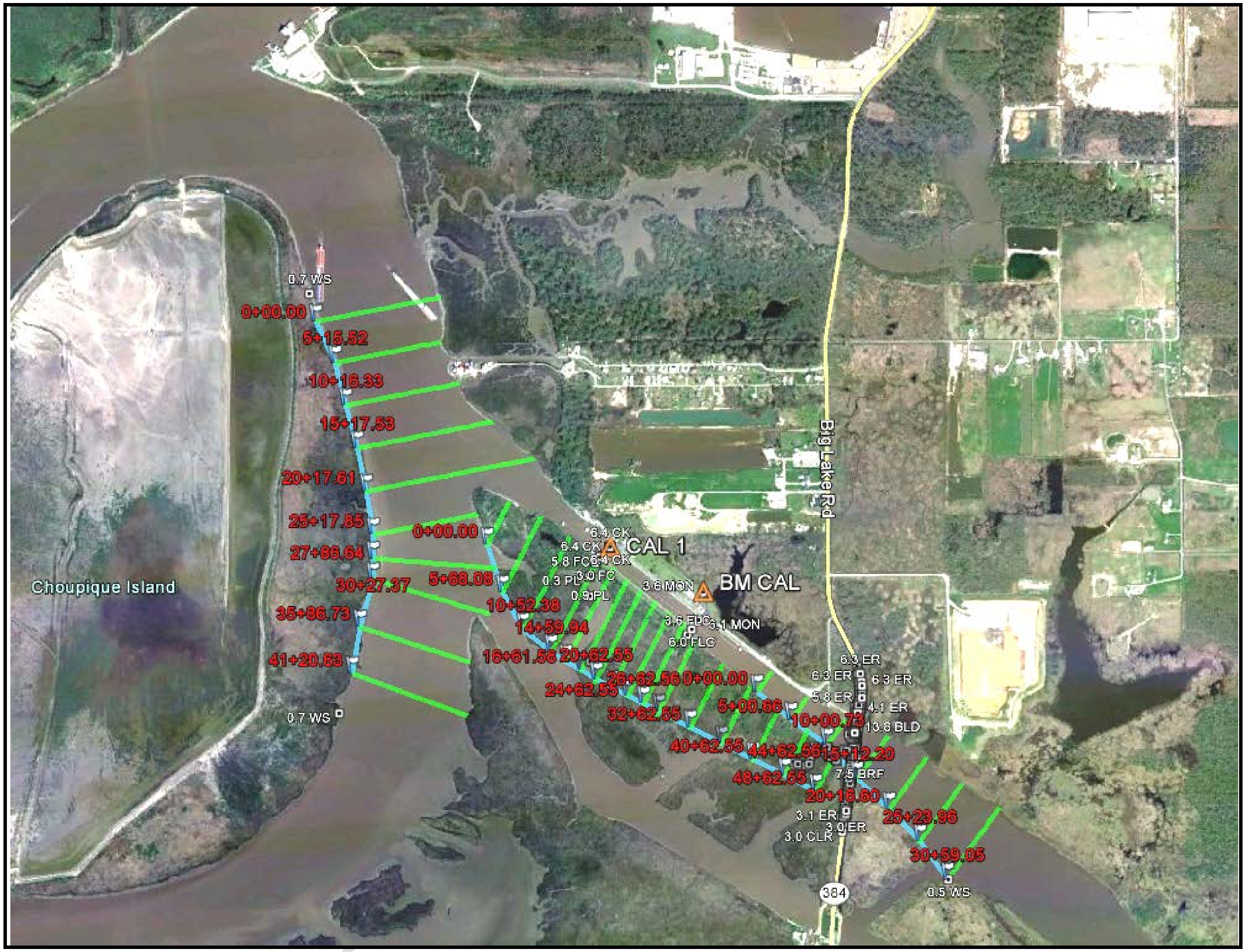

Figure L-15. Vicinity Map

GEOTECHNICAL

GEOLOGY AT CALCASIEU LOCK

Figure L-16 shows the location of two borings, CLR-3U and CLR-4U (both approximately 150 feet in depth) that were taken for this Project. Figures L-17 and L-18 show the results of the tests performed on these borings. Additional borings will be required for pile design, settlement analysis of the structure, stability analysis of the channel, and for the prevention of scour.

The Project area is located southwest of the Calcasieu Lock in Calcasieu Parish, La. Natural ground elevations are between 0 and (+) 5 feet NAVD88[2]*. Dominant physiographic features in the area consist of Calcasieu Lake, Intracoastal Waterway, Pleistocene Terrace, Calcasieu River and its associated natural levees and swamp. The surface is composed of fill material approximately 3 feet thick. Fill overlies swamp deposits consisting predominantly of organic and fat clays located between (+) 8 and (-) 4 feet in elevation. Pleistocene deposits composed of stiff to very stiff oxidized clays interbedded with layers and lenses of silts and sands are found beneath the swamp deposits. The top of the Pleistocene surface is approximately (+) 4 feet in elevation and extends to at least (-) 140 feet.

Groundwater is at or near the surface. The silts and silty sands within the Pleistocene deposits may be hydraulically connected to the Calcasieu River and the GIWW. Figure L-19 shows the Geologic Profile for this area.

Figures L-20 and L-21 are the Pile Capacity Curves.

[2] All elevations in NAVD88

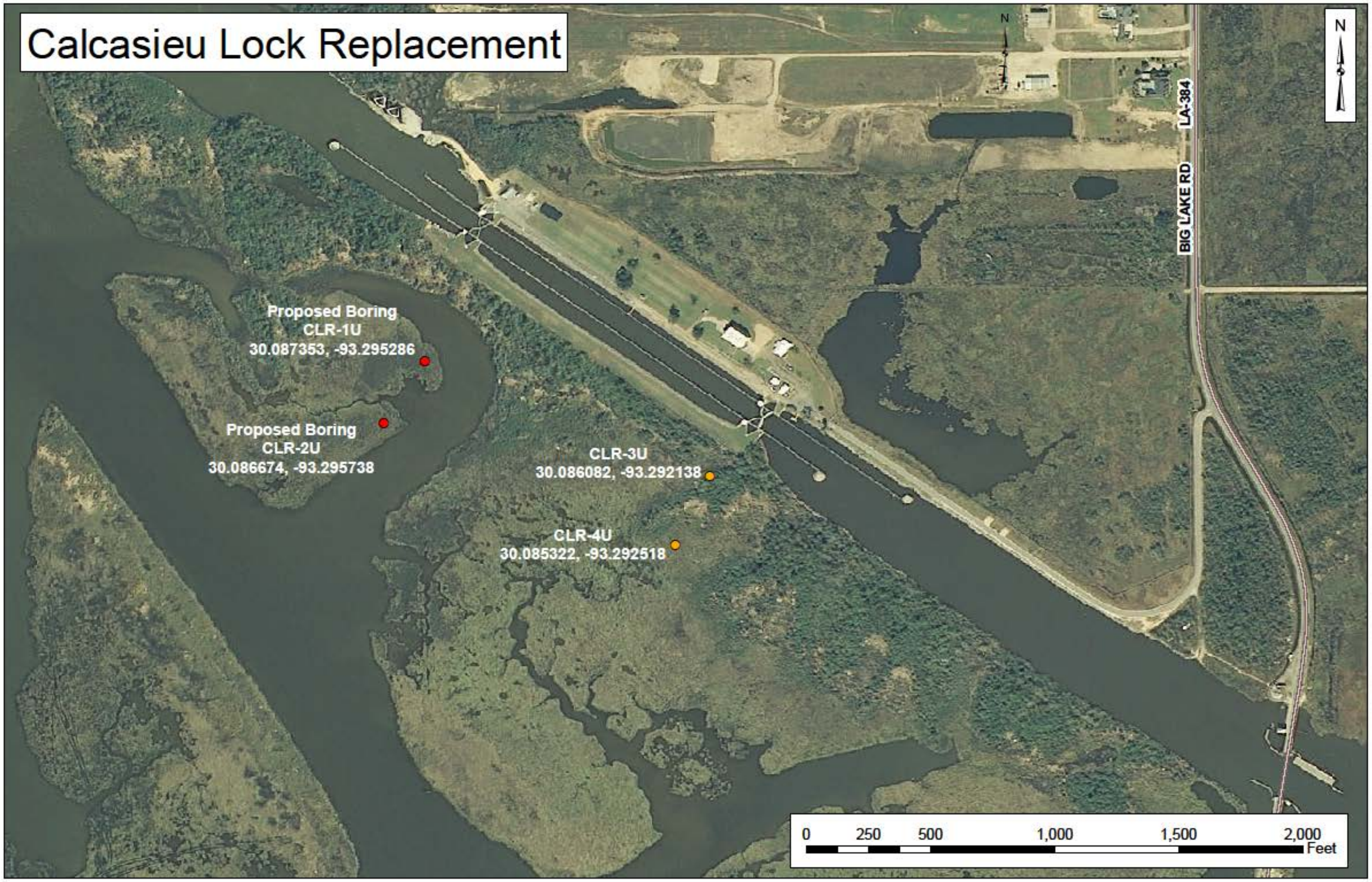

Figure L-16. Boring Location Map

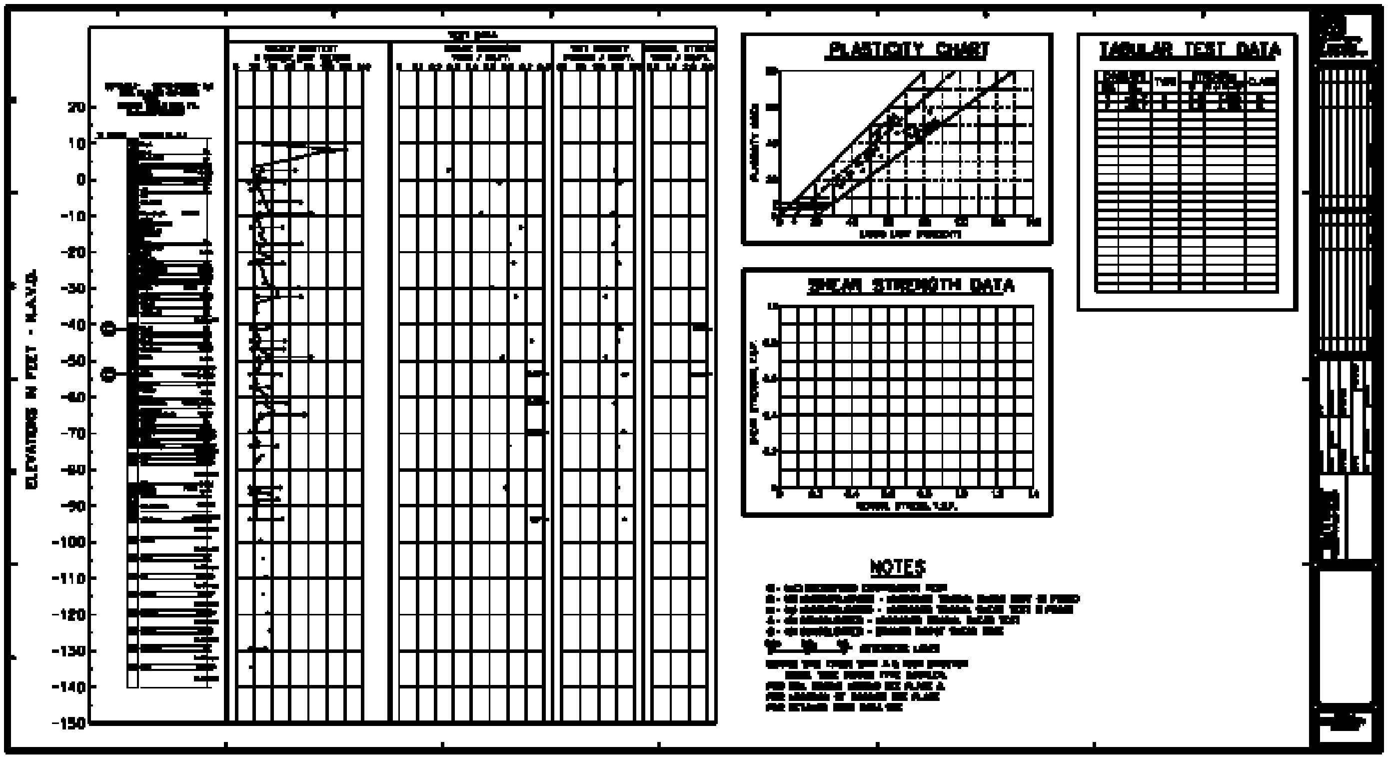

Figure L-17. CLR-3U Test Results

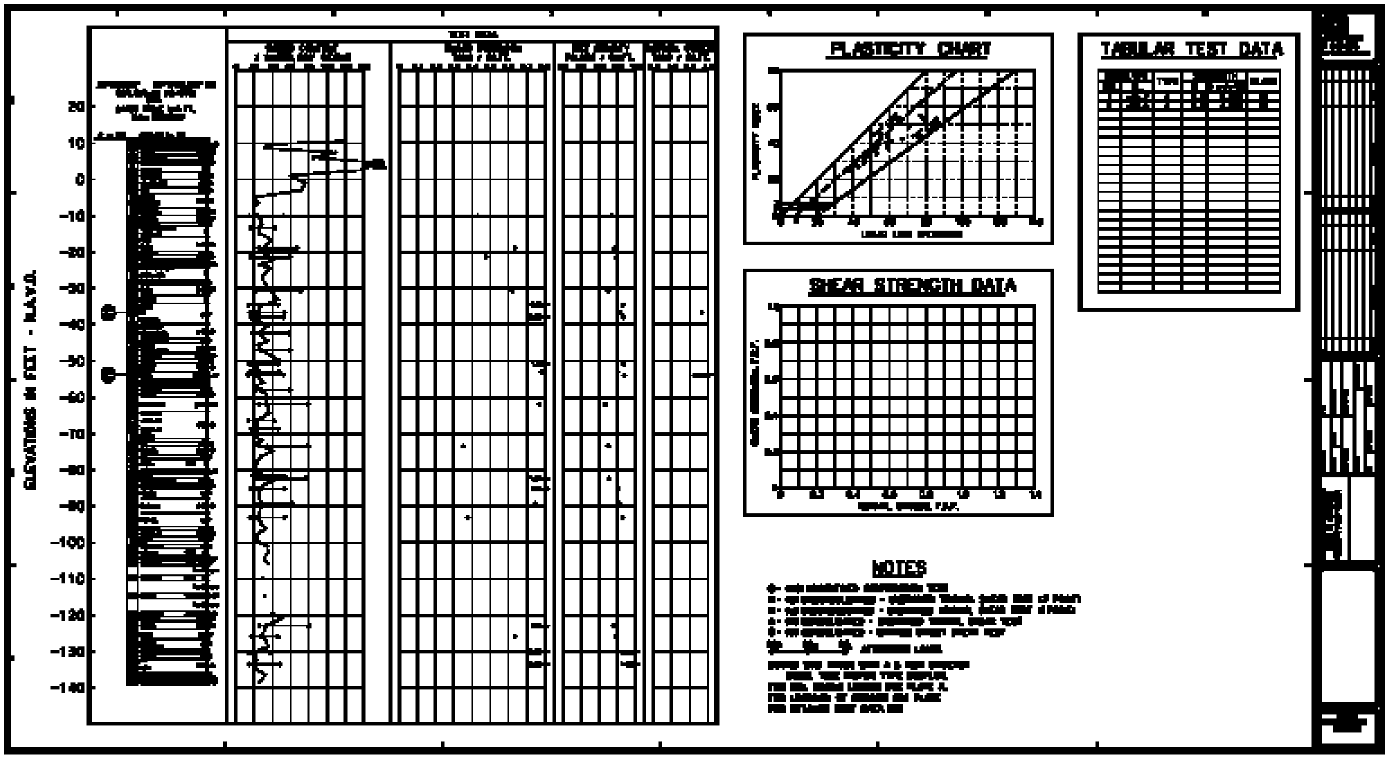

Figure L-18. CLR-4U Tests Results

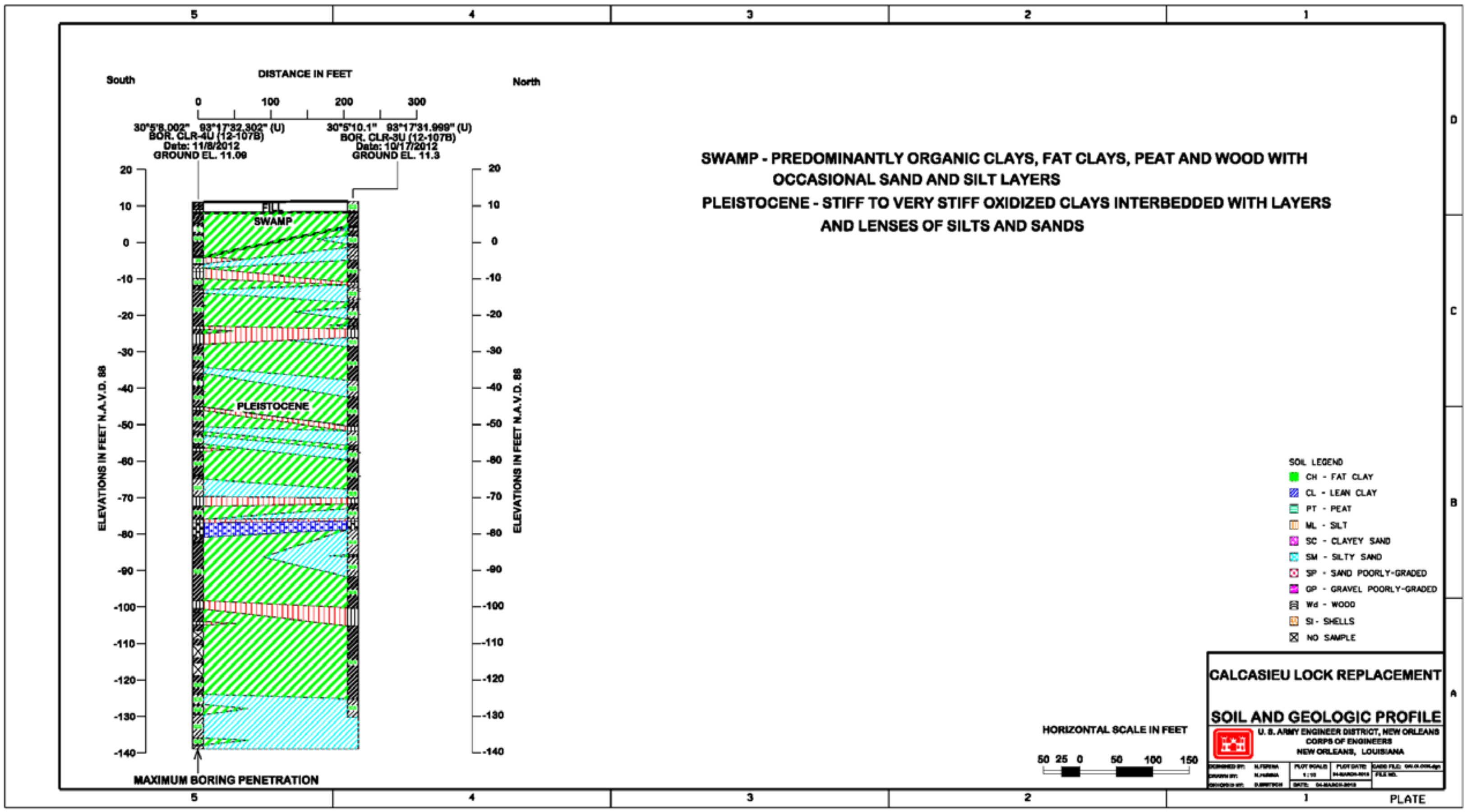

Figure L-19. Soil and Geologic Profile

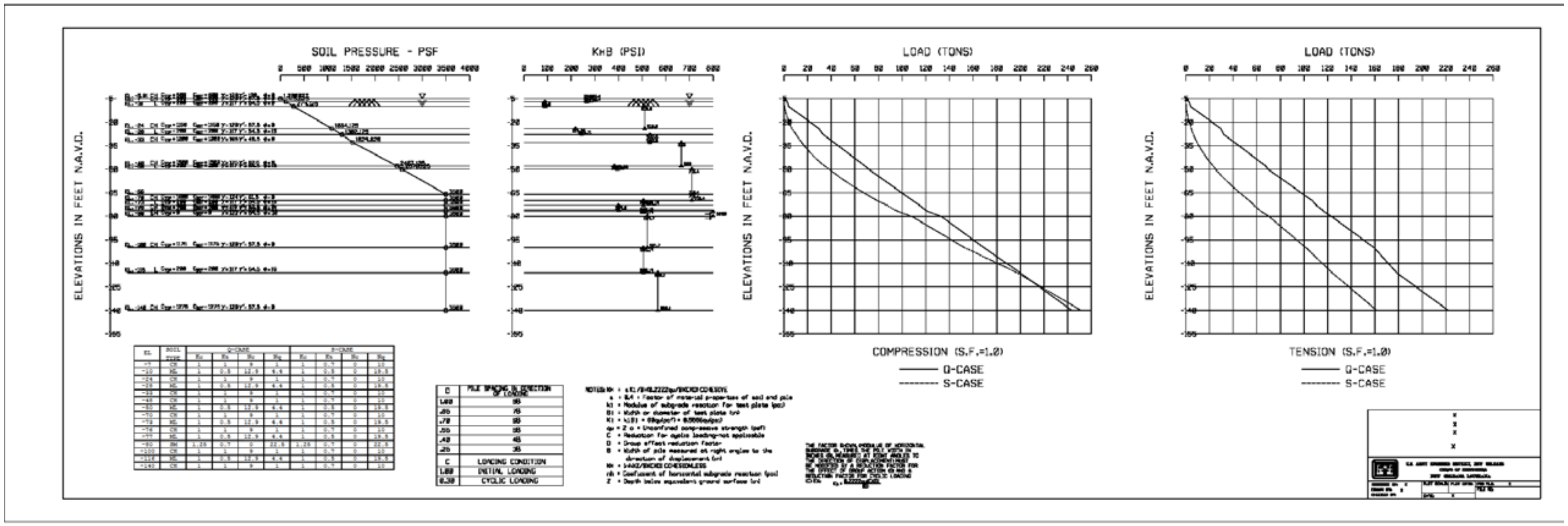

Figure L-20. Pile Capacity - Concrete

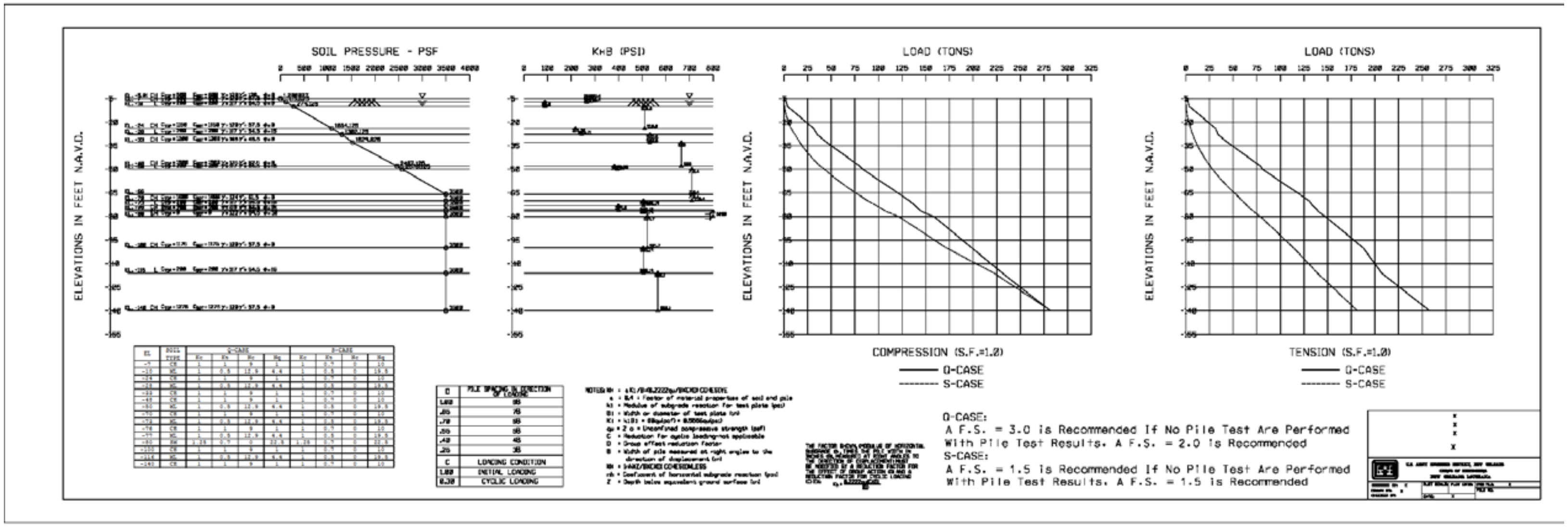

Figure L-21. Pile Capacity – HP14x73

CIVIL DESIGN

I. ALTERNATIVE 1 – CULVERT STRUCTURE AND ALTERNATIVE 2 – 3,700 CFS PUMP STATION

Approximately 3,650 linear feet of dredging for the inflow and outflow channels will be required to tie the GIWW to Bayou Choupique. The channel will be dredged to elevation (-) 12.0 NAVD88 and have an 80 foot bottom width (approximately 170,000 cubic yards) with 1:4 side slopes. Approximately 300 feet of riprap with a 3-foot thickness will placed on geotextile fabric, on either side of the structure. All material from the channel dredging will be hydraulically placed in the open water areas between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou.

Figure L-22 shows the location of the features for Alternatives 1 and 2.

II. ALTERNATIVE 3 – BLACK BAYOU CULVERTS

The channel will be dredged to elevation (-) 9.0 NAVD88 and have a 120 foot bottom width for 200 feet adjacent to the structure and transition to (-) 6.0 NAVD88 and an 80-foot bottom width on the inflow channel (approximately 64,000 cubic yards) with 1:4 side slopes. Approximately 200 feet of riprap with a 3-foot thickness will be placed on geotextile fabric, on either side of the structure. The dredge material from the channel will be hydraulically placed in the open water area adjacent to Hwy 384 and between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou and Hwy 384.

Figure L-23 shows the location of the features of Alternative 3.

III. ALTERNATIVE 4- 2,000 CFS PUMP STATION AND ALTERNATIVE 5 – 3,700 CFS PUMP STATION

The channel will be dredged to elevation (-) 12.0 NAVD88 and have an 80-foot bottom width (approximately 67,000 cubic yards). Approximately 300 feet of riprap with a 3-foot thickness will be placed on either side of the structure. The dredge material from the channel will be hydraulically placed in the open water areas adjacent to Hwy 384 and between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou and Hwy 384.

Figure L-24 shows the location of the features for Alternatives 4 and 5.

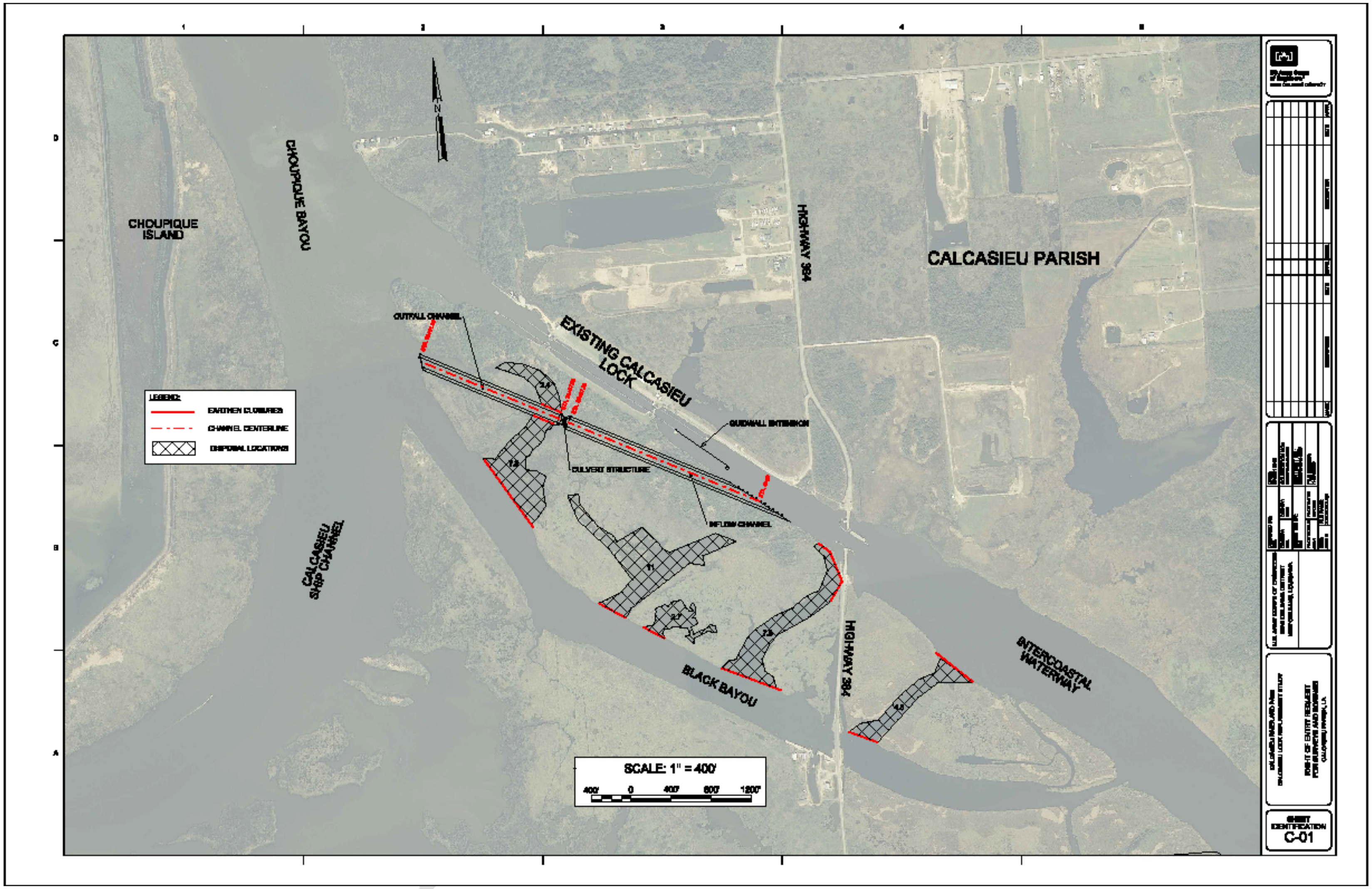

Figure L-22. Alternative 1 – Culvert Structure Dredging; Alternative 2 – 3,700 cfs Pump Station

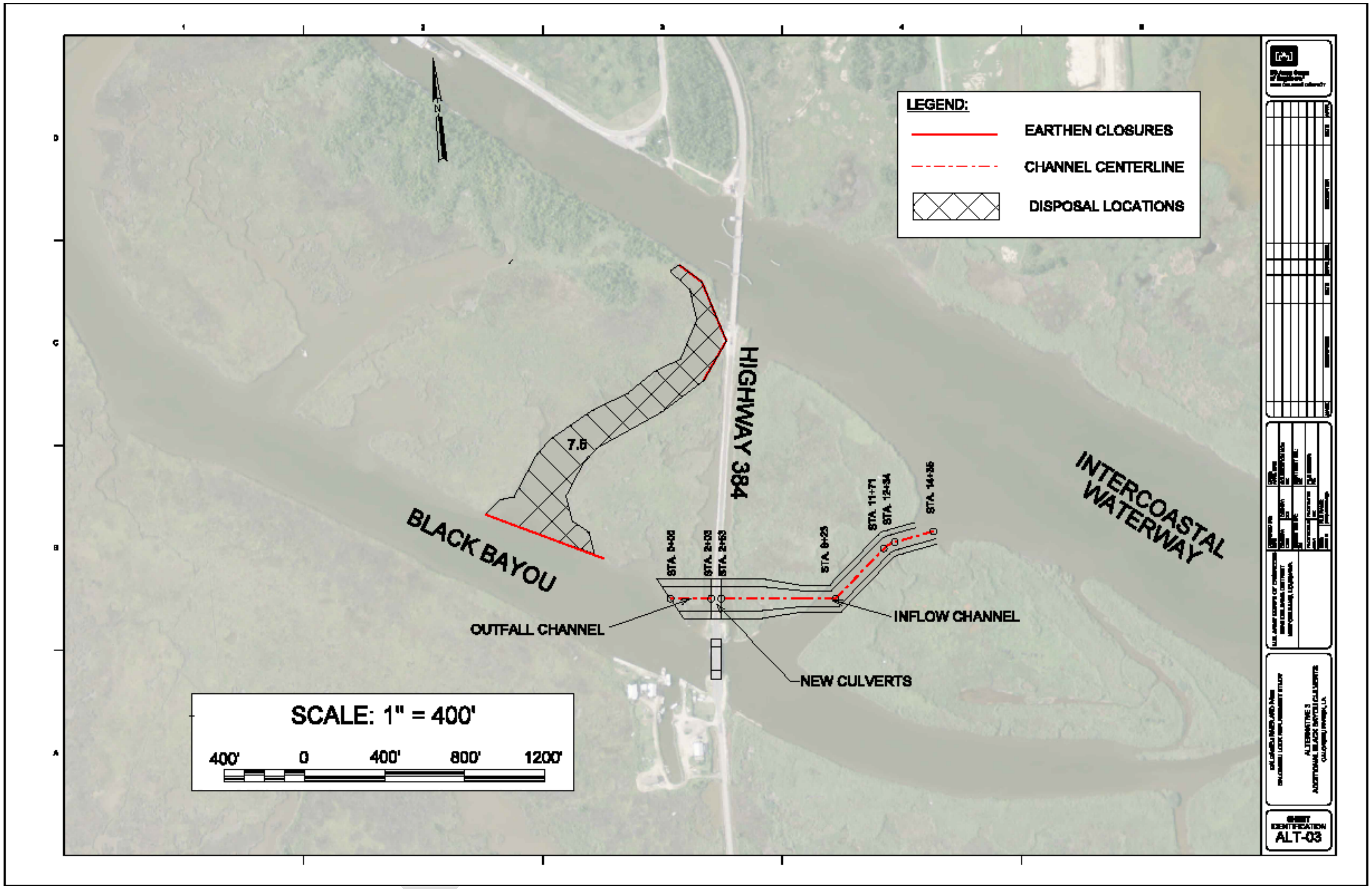

Figure L-23. Alternative 3 – Black Bayou Culverts

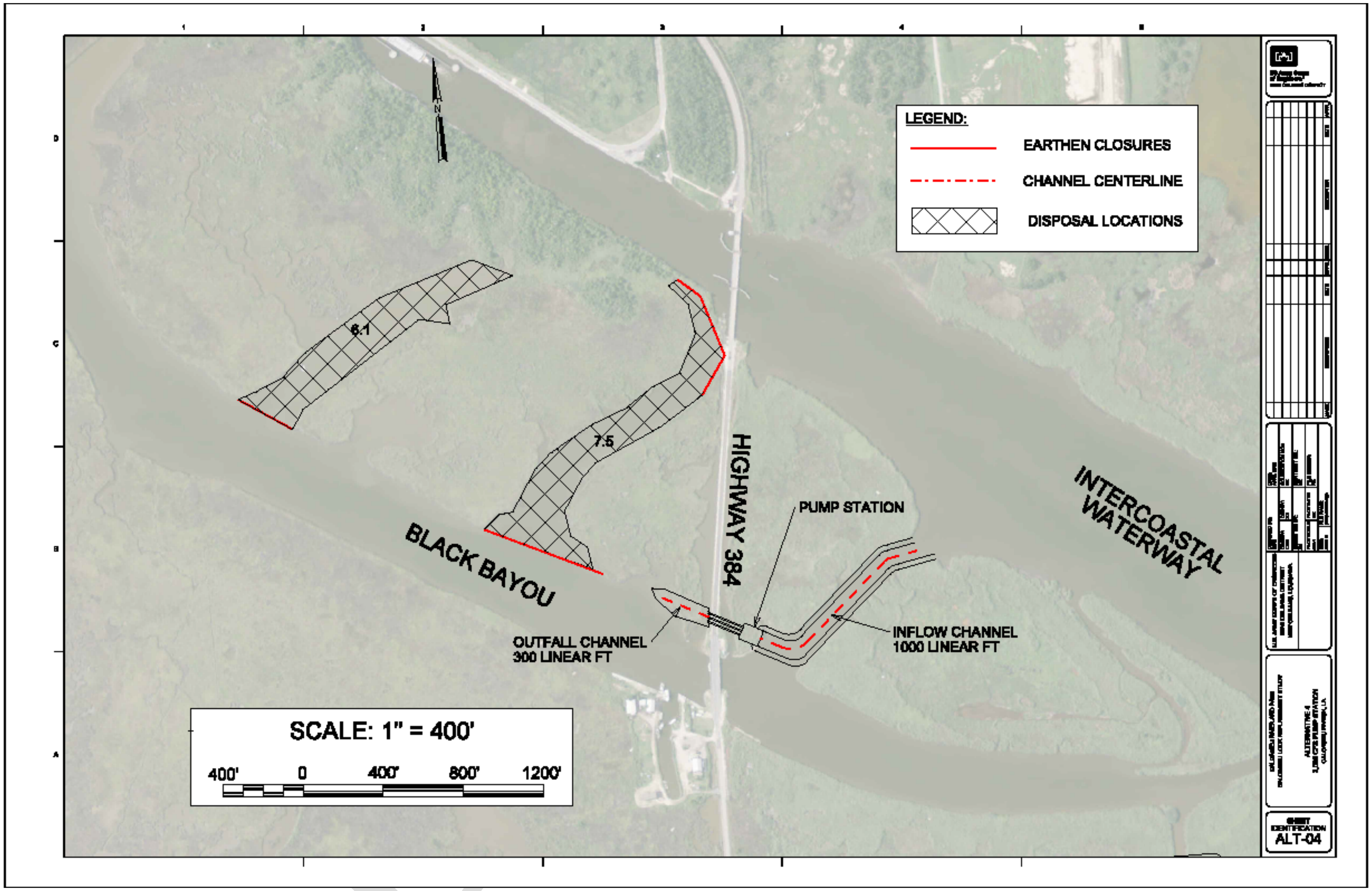

Figure L-24. Alternative 4- 2,000 cfs Pump Station; Alternative 5 – 3,700 cfs Pump Station

STRUCTURAL

GENERAL

The general configuration of the alternatives for this project were based on a variety of considerations, among them hydraulic requirements, similar structures performing the same function, and utilizing existing designs from other projects. All structures will be reinforced concrete and cast-in-place.

All designs were performed in accordance with applicable Corps of Engineers and technical publications, and industry codes. All structures will be constructed using conventional construction equipment and techniques. The contractor will be required to provide dewatering systems (where necessary) in order to construct foundations in a near dry atmosphere. The contractor will also be required to provide a system of shoring or open excavation to safely facilitate construction procedures.

The size and type of mechanical and electrical components for the project features were selected based on a variety of considerations, among them, similar features performing the same function, and utilizing existing designs from other projects.

I. ALTERNATIVE 1 – CULVERT STRUCTURE

The culvert structure consists of five 9-foot x 14-foot openings that will allow for the passage of the additional flow. The structure is pile-founded, reinforced concrete with cast iron sluice gates that can be closed when salinity levels in the ship channel are too high. The structure is 82-feet wide and 100-feet long. The invert of the structure is elevation (-) 6.0 NAVD88, with the top of the structure at (+) 14.0 NAVD88. The top of the culvert is at (+) 5.0 NAVD88, which is higher than the anticipated flow line thru the area, so water cannot overtop the structure. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this phase.

Preliminary assumptions of pile sizes, spacing, and pile tip elevations were based on the design of similar structures found in the vicinity. Verification of the pile assumptions, along with any adjustments, was accomplished with the use of pile capacity curves that were developed for similar soils. A more accurate determination of soil properties was not possible due to the absence of reliable borings; therefore pile tip elevations may be adjusted in the next stage of design.

The structure can be dewatered for maintenance purposes with the use of steel bulkheads on either side of the sluice gates. The operation of the gates can be done remotely with hydraulic motors; therefore, there is no requirement to man the structure during events in which the structure is opened. Power was assumed to be provided from the Calcasieu Lock area.

Refer to figures L-25, L-26 and L-27 for the location and layout of the culvert structure.

Figure L-25. Alternative 1 - Plan Location

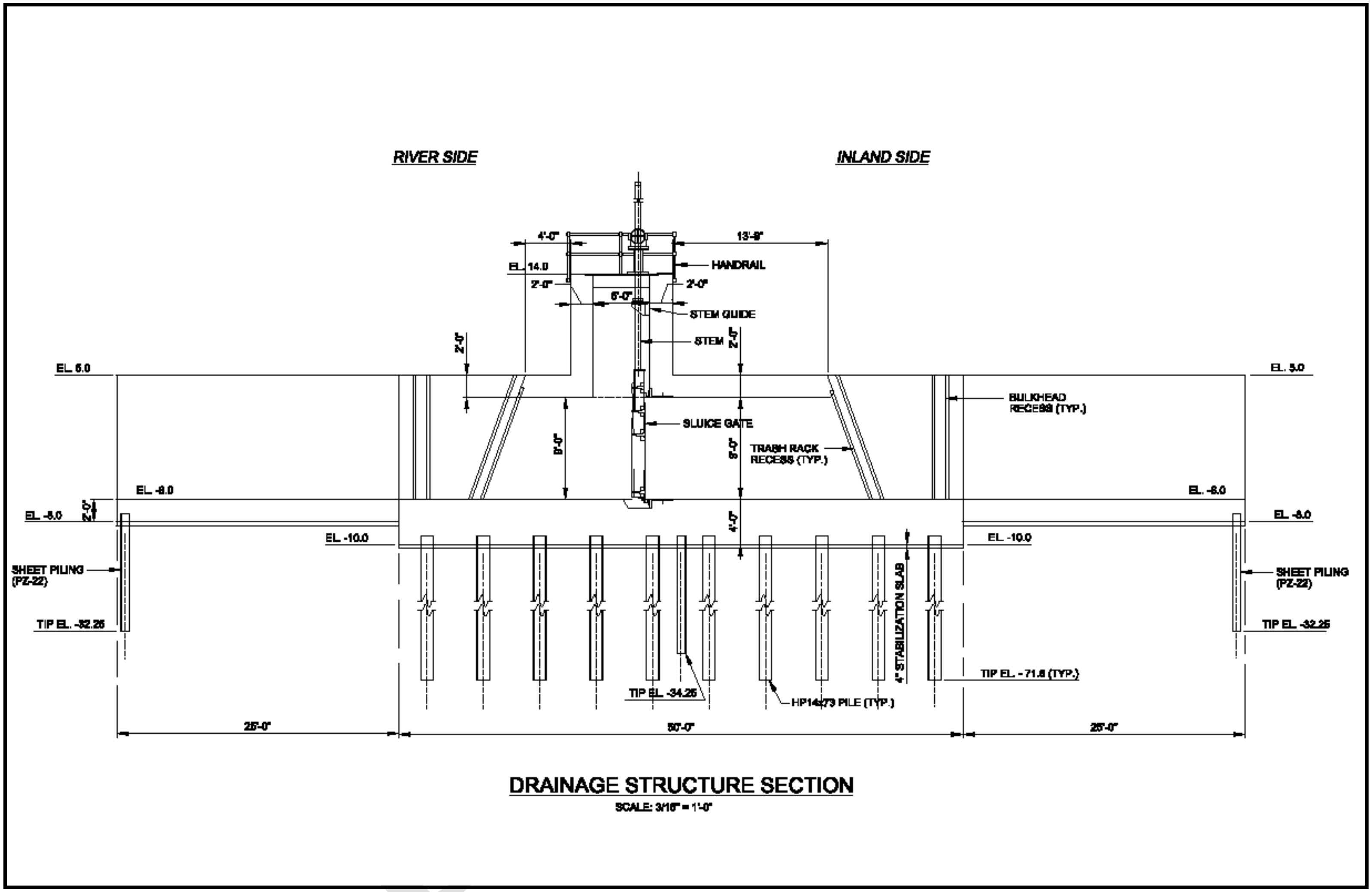

Figure L-26. Alternative 1 Structure – Section View

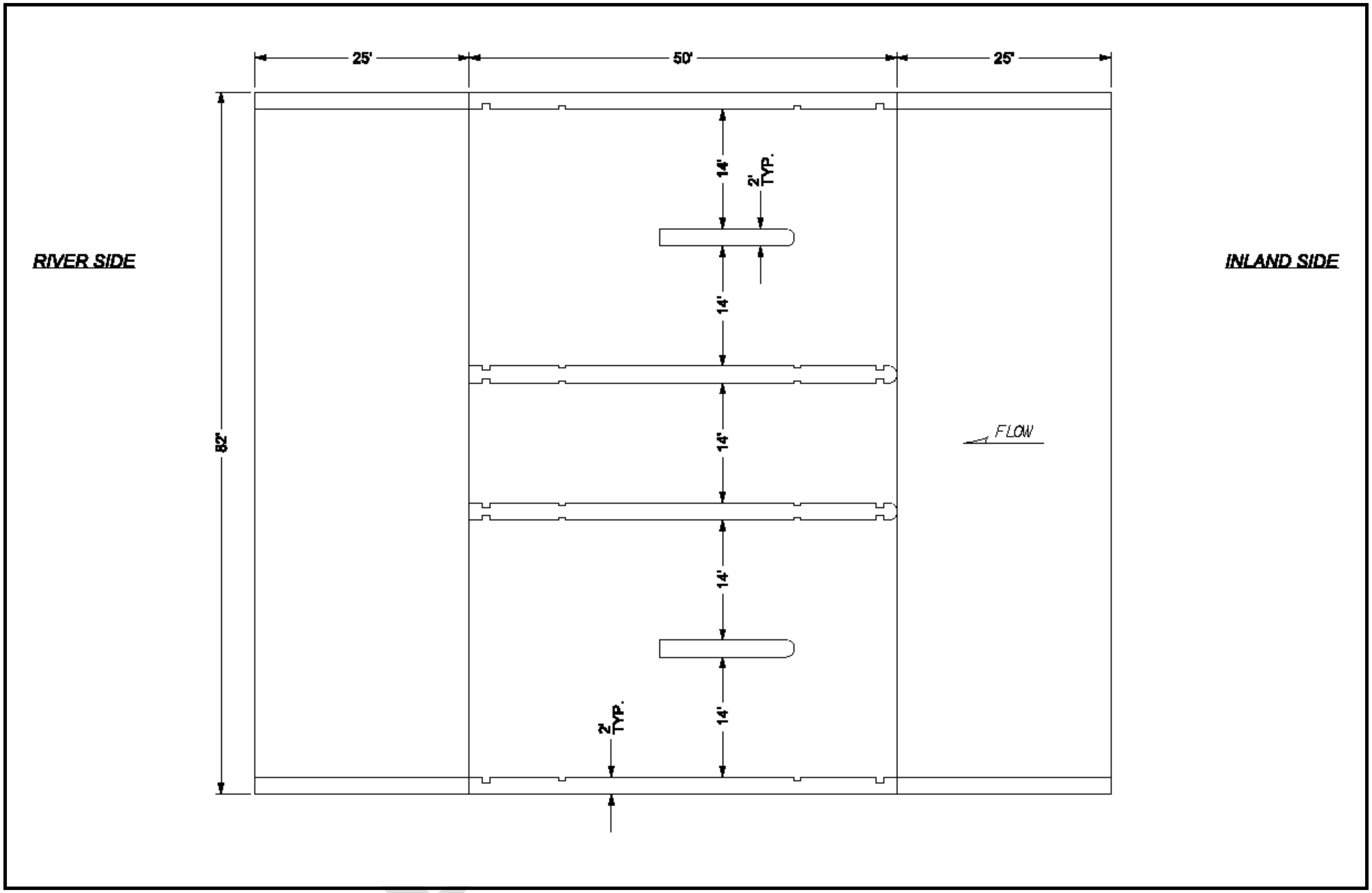

Figure L-27. Alternative 1 Structure – Plan View

II. ALTERNATIVE 2 – 3,700 CFS PUMP STATION

The pump station for this alternative was cost indexed from a 1,000 cfs, pump station used in the New Orleans to Venice project. The pump station consists of four 900 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Figures L-28 and L-29 show the location and layout of the pump station.

Since this alternative is adjacent to the existing lock, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Access to the proposed station. An access road would need to be constructed from Hwy 384 to the pump station, approximately 2 miles.

- Utilities needed for the station. Since this station would be manned during operation, a full service of utilities is required.

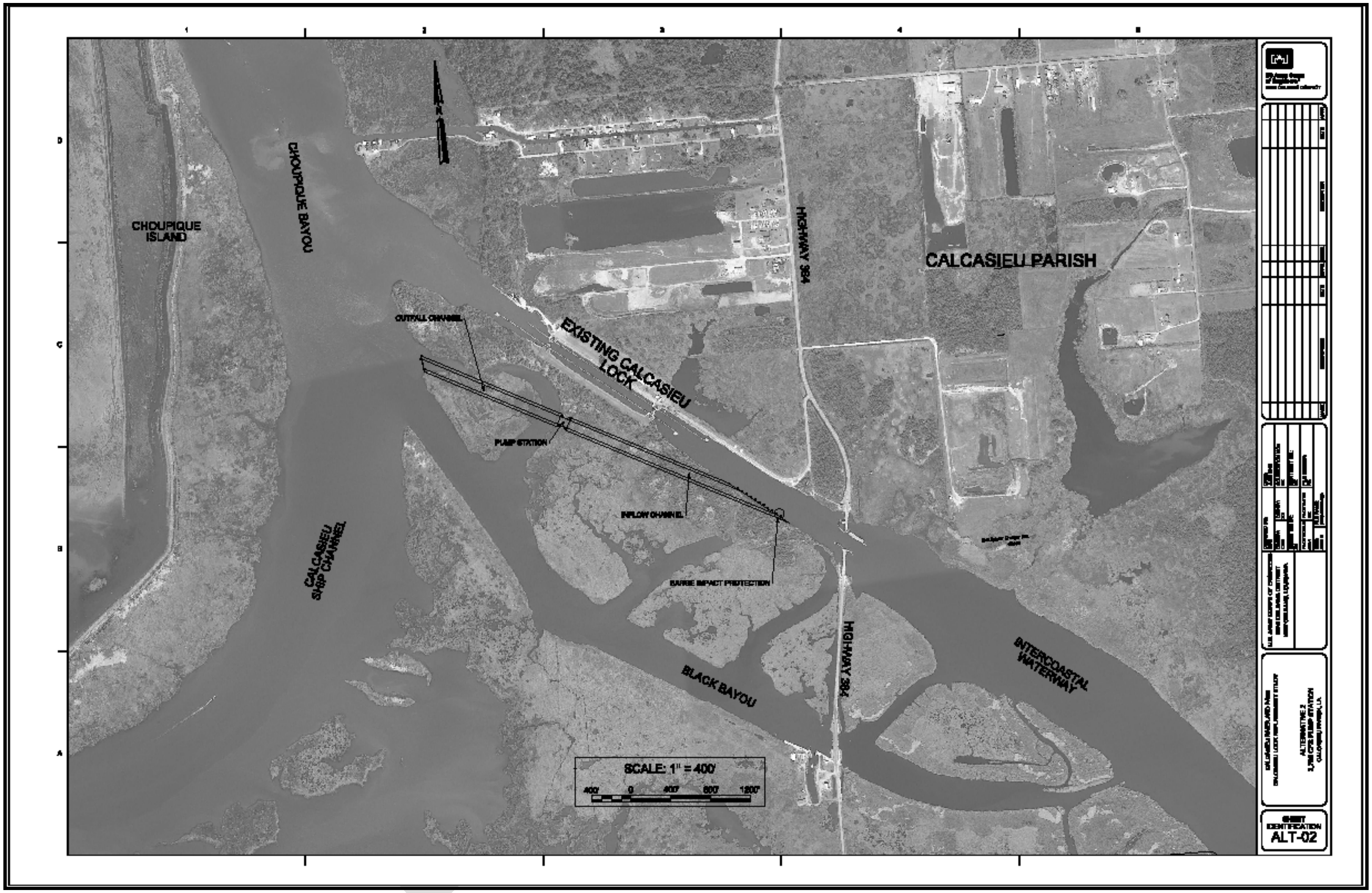

Figure L-28. Alternative 2 - Plan Location

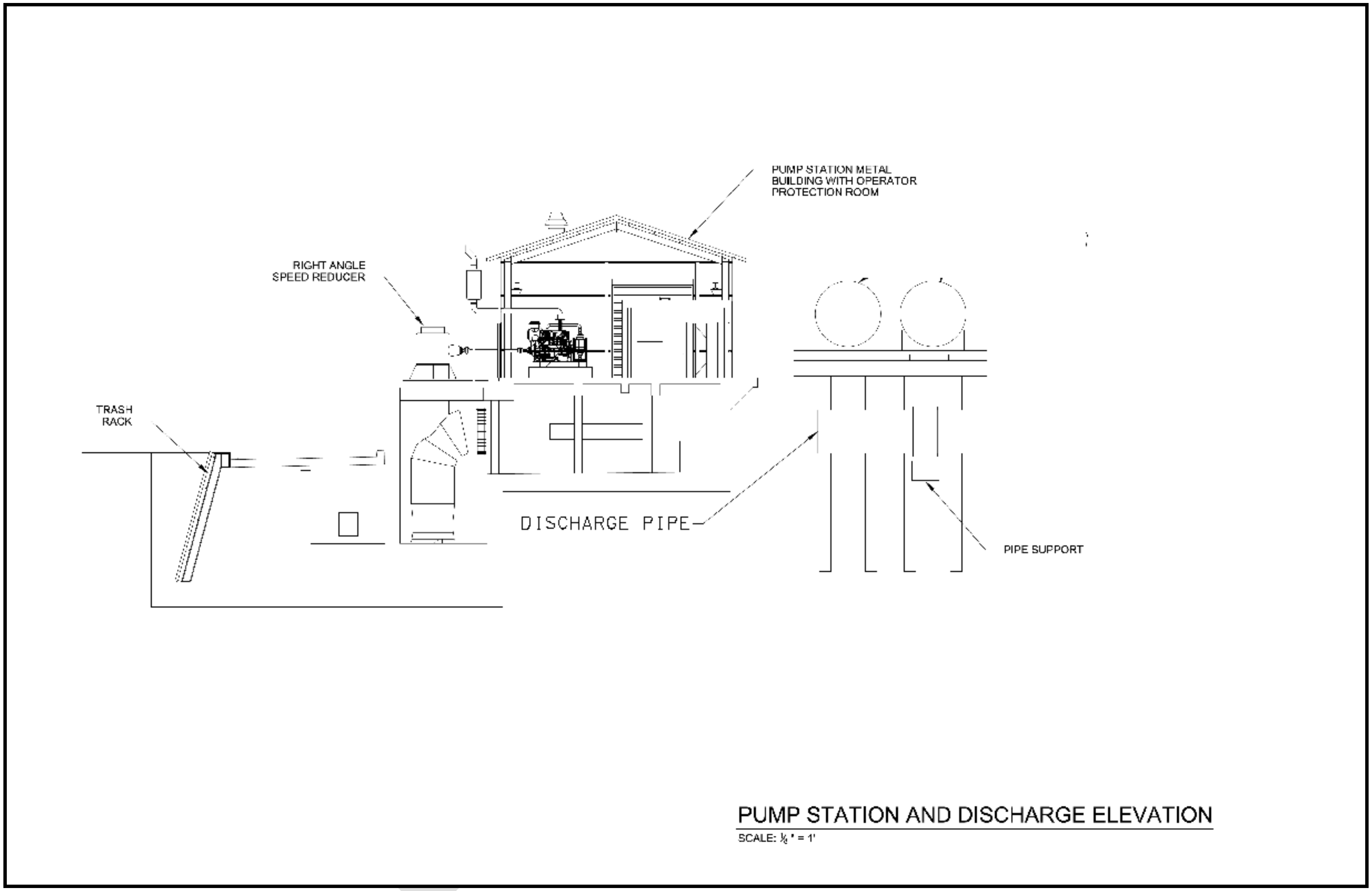

Figure L-29. Alternative 2 - Typical Pump Station

III. ALTERNATIVE 3 – BLACK BAYOU STRUCTURE

The structure for this alternative is similar to the existing Black Bayou structure already in place. The structure is ten 10-foot by 10-foot concrete box culverts, at invert elevation (-) 9.0 NAVD88. The structure is directly beneath Hwy 384. The culverts include flap gates which close when water from the Calcasieu Lake Basin is higher than the inland water elevation.

According to local and State officials, the existing structure is not able to operate as intended and has been closed for a few years. A team of engineers is currently evaluating the structure and will make a recommendation on repairs. The cost of these repairs is not included in the Engineering cost of this alternative. If the state's engineering team determines major changes are needed to the structure, then the same changes should be made to the structure used in this alternative.

Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of vinyl sheet pile and stone. The top of the weir is at elevation (+) 3.0 NAVD88.

Figure L-30 shows the location and layout of the culvert structure and structural weir.

Figure L-30. Alternative 3 - Plan View

IV. ALTERNATIVE 4 – 2,000 CFS PUMP STATION AT BLACK BAYOU

The pump station for this alternative was cost indexed from a 1,000 cfs pump station used in the New Orleans to Venice project. The pump station consists of four 500 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Figures L-31 and L-32 show the location and layout of the pump station.

Since this alternative is adjacent to Hwy 384, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Discharge pipes will need to pass under Hwy 384; therefore the pipes will need to be jack and bored.

- Another option would include constructing a new Hwy 384 Bridge over the discharge channel.

- Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of vinyl sheet pile and stone. The top of the weir is at elevation (+) 3.0 NAVD88.

Figure L-31. Alternative 4 - Plan View

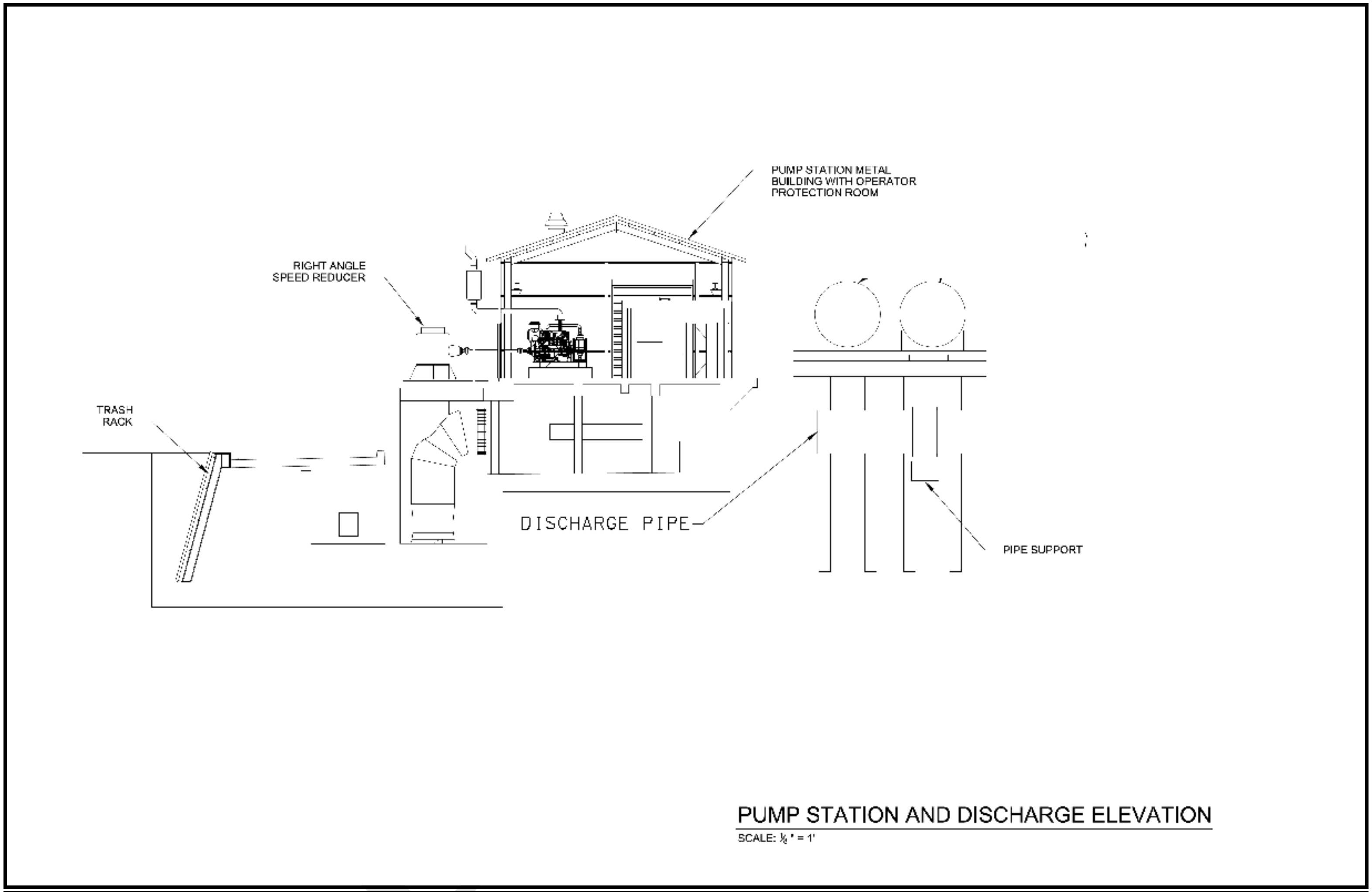

Figure L-32. Alternative 4 - Typical Pump Station

V. ALTERNATIVE 5 – 3,700 CFS PUMP STATION AT BLACK BAYOU

The pump station for this alternative was cost indexed from a 1,000 cfs pump station used in the New Orleans to Venice project. The pump station consists of 4 – 900 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Refer to Figures L33-34 for location and layout of pump station.

Since this alternative is adjacent to Hwy 384, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Discharge pipes will need to pass under Hwy 384; therefore the pipes will need to be jack and bored.
- Another option would include constructing a new Hwy 384 bridge over the discharge channel.
- Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of vinyl sheet pile and stone. The top of the weir is at elevation (+) 3.0 NAVD88.

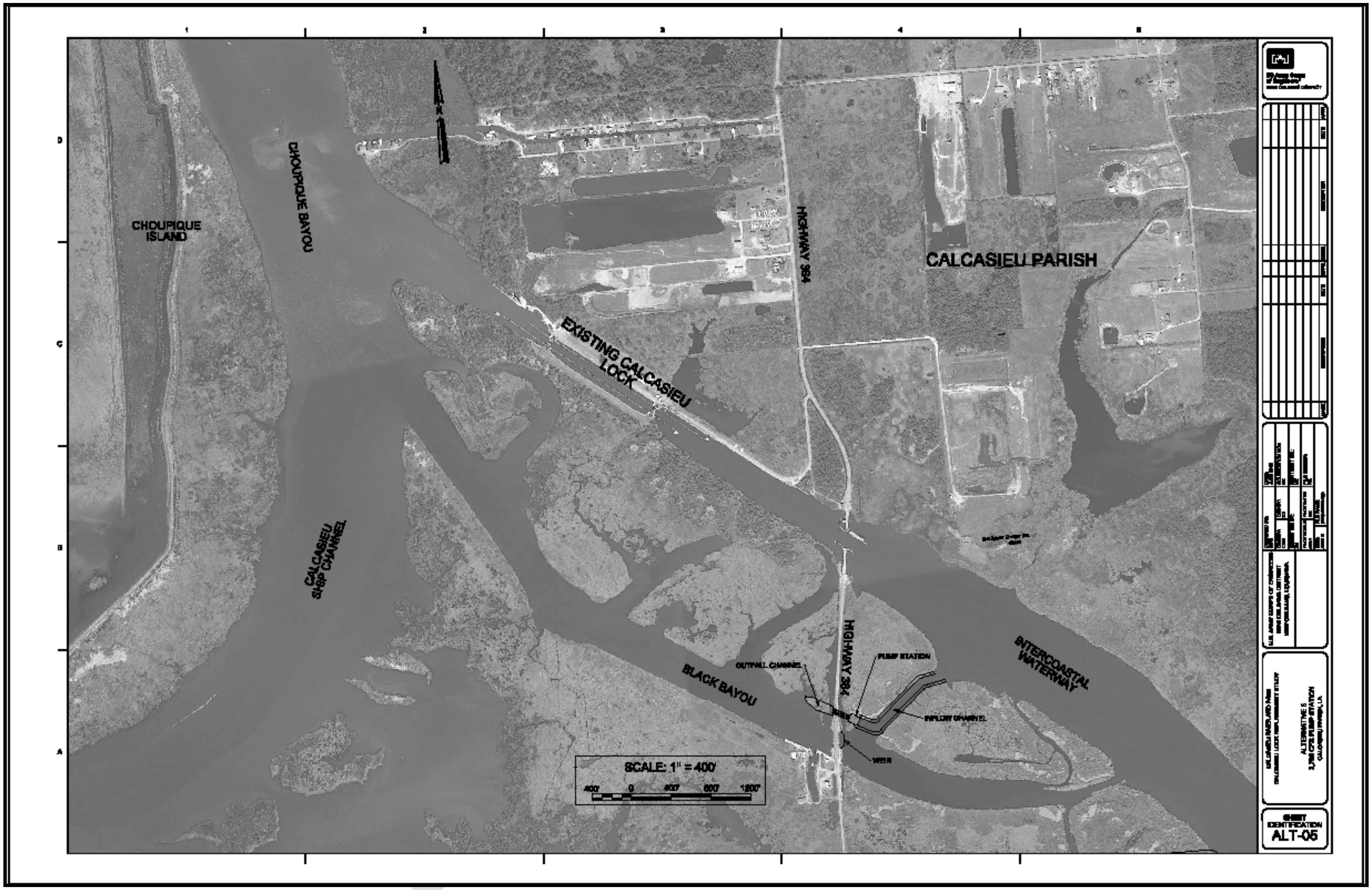

Figure L-33. Alternative 5 - Plan View

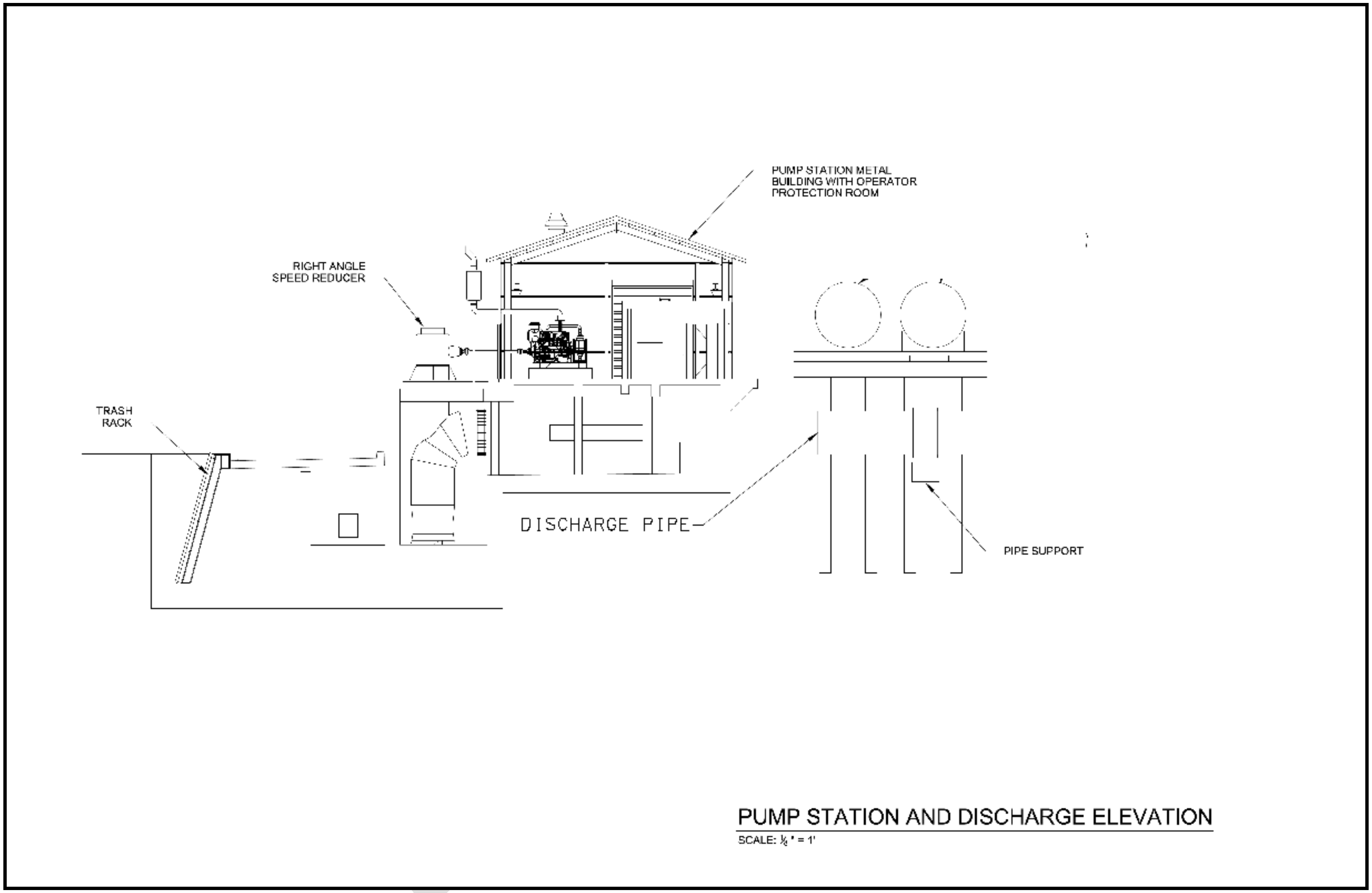

Figure L-34. Alternative 5 - Typical Pump Station

COST ENGINEERING

I. ROUGH ORDER OF MAGNITUDE ESTIMATES

A. Alternative 1 – Cost Estimate

Item	Quantity	Unit	Unit Price	Amount	Contingencies	Project Cost
Mobilization and Demobilization	1	EA	647,498.88	$647,498.88	$161,875	$809,374
Care & Diversion of Water						
Cofferdam - PZ-40	24,200	SF	46.35	$1,121,670.00	$280,418	$1,402,088
Dewatering System	LS	--------	170,460.36	$170,460.36	$42,615	$213,075
12" Bedding	900	CY	64.37	$57,933.00	$14,483	$72,416
Cofferdam Removal	24,200	SF	1.48	$35,816.00	$8,954	$44,770
Earthwork for Structure						
Clearing & Grubbing	0.25	AC	46,697.61	$11,674	$2,919	$14,593
Structural Excavation	7,900	CY	10.71	$84,609	$21,152	$105,761
Backfill - Semi-compacted	2,000	CY	87.62	$175,240	$43,810	$219,050
24" Riprap (dry)	1,800	TONS	44.39	$79,902	$19,976	$99,878
Geotextile	1,700	SY	4.55	$7,735	$1,934	$9,669
Access Road						
12" Stone	570	TONS	45.98	$26,209	$6,552	$32,761
Geotextile	1,100	SY	4.55	$5,005	$1,251	$6,256
Foundation						
25-ft long PZ-22 Steel Sheet Piling	6,200	SF	35.25	$218,550	$54,638	$273,188
OPTION 1: 62-foot long 14" x 14" PPC Piling	7,400	LF	50.92	$376,808	$94,202	$471,010
OPTION 2: 63-foot long HP 14"x73" Piling	6,100	LF	103.21	$629,581	$157,395	$786,976
Reinforced Concrete						
Base Slab	910	CY	339.12	$308,599	$77,150	$385,749
Walls	350	CY	582.17	$203,760	$50,940	$254,699
Roof	130	CY	741.20	$96,356	$24,089	$120,445
Unreinforced Concrete						
Stabilization Slab	100	CY	278.83	$27,883	$6,971	$34,854
Impact Protection						
5 Timber Pile Cluster (60 feet long)	14	EA	25,000	$350,000	$87,500	$437,500

A. Alternative 1 – Cost Estimate

Miscellaneous Metals						
Embedded Metals	34,100	LBS	7.18	$244,838	$61,210	$306,048
Hand Rail	180	LF	21.76	$3,917	$979	$4,896
Gates & Associated Items						
OPTION 1: 14’x9’ Cast Iron Sluice Gates	5	EA	350,439.03	$1,752,195	$438,049	$2,190,244
OPTION 2: 14’x9’ Stainless Slide Gates	5	EA	398,211.49	$1,991,057	$497,764	$2,488,822
Emergency Bulkheads	22,500	LBS	7.18	$161,550	$40,388	$201,938
Gate Hoist Support Beam	15,100	LBS	7.18	$108,418	$27,105	$135,523
Electrical						
Power & Lighting	LS	--------	481,363.48	$481,363	$120,341	$601,704
Emergency Generator	LS	--------	1,607.27	$1,607	$402	$2,009
Mechanical						
Remote Operating Machinery	LS	--------	673,398.84	$673,399	$168,350	$841,749
Dredging						
Mobilization and Demobilization	1	L.S.	$959,215.68	$959,215.68	$239,803.92	$1,199,019
Dredging - Inflow Channel (No overdepth	105,000	CYS	$7.17	$752,850.00	$188,212.50	$941,062.50
Dredging -Outflow Channel (No overdepth	65,000	CYS	$7.40	$481,000.00	$120,250.00	$601,250.00
Rip Rap	17,200	TONS	$42.17	$725,324.00	$181,331.00	$906,655.00
Earthen Closure	4,000	LF	$67.02	$268,080.00	$67,020.00	$335,100.00
Earthen Weir (2.5 cy/lf)	16,500	LF	$19.48	$321,420.00	$80,355.00	$401,775.00
			TOTAL	**$10,940,884**	**$2,735,220**	**$13,676,106**

B. Alternatives 2, 3, 4, and 5

		First Cost of Construction	Real Estate	First Cost of Mitigation	Total First Cost
Alternative 1	Culvert Structure	$13,676,106	$86,380	$550,000	$14,312,486
Alternative 2	South 3,700 Pump	$91,397,877	$86,380	$550,000	$92,034,257
Alternative 3	Black Bayou Culverts	$10,610,115	$89,380	$0	$10,699,495
Alternative 4	Black Bayou 2,000 Pump	$51,258,107	$89,380	$0	$51,347,487
Alternative 5	Black Bayou 3,700 Pump	$86,294,621	$89,380	$0	$86,384,001

II. OPERATIONS AND MAINTENANCE COSTS

A. Maintenance Cost Estimate - Culvert Structure

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$50,000	$2,500,000
Rewiring and Machinery Replacement	Every 20 Years	$100,000	$250,000
Maintenance by Hired Labor Units	Every 5 years	$250,000	$2,500,000
Dewatering & Monitoring/Major Repairs	Every 10 Years	$1,000,000	$4,500,000
Periodic Inspection Program	Every 5 Years	$60,000	$600,000
Sluice Gate Replacement	Every 25 Years	$3,000,000	$6,000,000
		TOTAL	**$16,350,000**

B. Maintenance Cost Estimate - Pump Station Alternatives

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$250,000	$12,500,000
Rewiring and Machinery Replacement	Every 30 Years	$750,000	$1,250,250
Maintenance by Hired Labor Units	Every 3 years	$675,000	$10,800,000
Pump Replacement	Every 30 Years	$5,000,000	$8,335,000
Periodic Inspection Program	Every 5 Years	$60,000	$600,000
		TOTAL	**$33,485,250**

C. Maintenance Cost Estimate - Black Bayou Culverts

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$20,000	$1,000,000
Maintenance by Hired Labor Units	Every 5 years	$250,000	$2,500,000
Dewatering & Monitoring/Major Repairs	Every 10 Years	$1,000,000	$4,500,000
Periodic Inspection (PI) Program	Every 5 Years	$60,000	$600,000
Existing CWPPRA Structure Rehab	Every 20 Years	$1,500,000	$5,250,000
Flap Gate Replacement	Every 20 Years	$1,000,000	$2,500,000
		TOTAL	**$16,350,000**

RELOCATIONS

The installation of a gated structure, borrowing of material, and the disposal of dredged or excavated material can be conducted with minimal to zero impact regarding utilities. No utilities within the project area were shown in the pipeline atlas.

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX M

HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

NOTE: Additional information relating to Hazardous, Toxic and Radioactive Waste of the Calcasieu Lock Feasibility Study is available upon request by contacting the New Orleans District Office at (504) 862-2201.

Phase I - Environmental Site Assessment Supplement

Calcasieu Lock Improvements
Calcasieu Parish, Louisiana

Prepared for:

U.S. Army Corps of Engineers
New Orleans District
New Orleans Louisiana

U.S. Army Corps of Engineers
St. Louis District
June 2013

Phase I - Environmental Site Assessment Supplement
Calcasieu Lock Improvements
Calcasieu Parish, Louisiana

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Phase I - Environmental Site Assessment Supplement
Calcasieu Lock Improvements
Calcasieu Parish, Louisiana
June 2013

Executive Summary

The objective of this limited Phase I Environmental Site Assessment (ESA) is to satisfy the All Appropriate Inquiry (AAI) requirements set by the Environmental Protection Agency to identify, to the extent feasible pursuant to the process described herein, recognized environmental conditions (RECs) in connection with a given property(s).

There are presently three alternatives proposed for the marsh area separating the GIWW and the Black Bayou immediately south of the existing Calcasieu Lock. A review of the reasonably ascertainable government records and telephone interviews of state and local officials revealed nothing of concern regarding HTRW materials or RECs within a two-mile radius of the project site. Historical topographic maps starts talking show the project site has always been an undeveloped marsh and historical aerial photographs show no evidence of surface staining, dumping, industrial land use, etc. that might indicate the presence of an REC.

A site inspection was conducted and no HTRW materials or RECs were observed or discovered at the sites of the three proposed alternatives or adjacent properties and concludes that a Phase II assessment is not necessary.

Purpose

The purpose of this document is to update and supplement the environmental assessment information found in the *Land-Use History of the Calcasieu Lock Facility and the Immediate Vicinity, Calcasieu Parish, Louisiana, August 2002* authored by R. Christopher Goodwin & Associates, Inc. This report is intended to serve as a modified Phase I Environmental Site Assessment to identify, to the extent feasible in the absence of sampling and analysis, the presence of recognized environmental conditions (RECs) within the scope of the U.S. Environmental Protection Agency's (EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The U.S. Army Corps of Engineers (USACE) regulations (ER-1165-132) and District policy requires procedures be established to facilitate early identification and appropriate consideration of potential hazardous, toxic, or radioactive waste (HTRW) in reconnaissance, feasibility, preconstruction engineering and design, land acquisition, construction, operations and maintenance, repairs, replacement, and rehabilitation phases of water resources studies or projects by conducting Phase I ESA. USACE specifies that these assessments follow the process/standard practices for conducting Phase I ESA's published by the American Society for Testing and Materials (ASTM).

This limited Phase I environmental site assessment was performed in general conformance with the scope and limitations of the ASTM standards E-1527-05 and E1528-06 and the Standards and Practices for All Appropriate Inquiries (AAI), 40 CFR Part 312. The information was obtained through reviews of readily available electronic records, reports, environmental databases and telephone interviews.

Project Description

Calcasieu Lock is located in the southwest corner of Louisiana approximately ten miles south of the City of Lake Charles in Calcasieu Parish. See Figure 1 attached. The structure sits at the Calcasieu River just east of the Calcasieu Ship Channel and is a feature of the Gulf Intracoastal Waterway (GIWW) that parallels the Gulf of Mexico coast. Calcasieu Lock serves as the entrance to the deep-water channel connecting the City of Lake Charles to the Gulf of Mexico and functions as a guard lock to prevent salt water in the ship channel from flowing east along the GIWW into the Mermentau Basin.

Completed in 1950, Calcasieu Lock is 13 ft. wide, 75 ft. deep, 1,206 ft. long and is reportedly structurally sound. However, navigation delays are occurring due to its authorized use to drain floodwaters from the Mermentau River Basin during flood events. A reconnaissance study completed in 1992, determined a need for capacity increases at Bayou Sorrel and Calcasieu Locks. The Calcasieu Lock Section 905(b) analysis found a favorable benefit-cost ratio and recommended proceeding with feasibility phase studies. The purpose of the current study is to determine the feasibility of reducing navigation delays caused by drainage events at the Calcasieu Lock.

There are presently three alternatives proposed for the marsh area separating the GIWW and the Black Bayou immediately south of the existing lock:

1. dredging a channel and constructing a new 75 foot gated structure; Figure 2.1
2. dredging a channel and constructing a pump station; Figure 2.2
3. dredging a channel in Black Bayou, installing additional culverts and constructing a pump station near the existing NCRS water control structure; Figure 2.3

Project Site Characteristics

The area is characterized as a brackish marsh with thick P*hragmites australis* (a tall reed) almost continuously along the GIWW and Black Bayou. Also found along the banks of the Black Bayou side channel are *Distichlis spicata* (saltgrass) and *Spartina alterniflora* (smooth cordgrass).

Forest is present along the south side of the lock on higher ground and extends south into the marsh along ridges. Tree species include Oak, Pine, Hackberry and Chinese tallowtree. The bayou water depth ranges between 1.5 ft and 5 ft. The soils are generally described as clayey with very slow infiltration rates, a high water table or shallow to an impervious layer.

Site Inspection

Using an airboat, the project area was inspected by Mr. Michael Henry, Industrial Hygienist, CEMVS-EC-EQ during the Wetland Value Assessment (WVA) on 13 December 2012. Accompanying him were Mr.Tim George, Real Estate Specialist, CEMVS-PD-C; Mr.Troy Mallach, USDA-NCRS, Baton Rouge; and Ms. Lisa Abernathy, NOAA-NMFS, Baton Rouge. Photographs taken during this inspection are attached.

No HTRW materials or RECs were observed or discovered during the site inspection.

Records Review

A search of reasonably ascertainable government records was conducted by Environmental Data Resources, Inc (EDR), a contractor specializing in environmental records review. The records search was designed to meet EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312) and the ASTM Standard Practice for Environmental Site Assessments (E 1527-05).

The EDR Radius Map Report found in Appendix A. The records review yielded the following sites within a two-mile radius of the project site. As shown on Figure 4, the majority of the sites are located approximately 1 mile northeast of the project site. Although there are no sites identified within the areas of the alternatives, it is noted the Calcasieu Lock was identified by the Federal ERNS database.

Environmental Records	Sites Identified	Database Description
RCRA non-gen	1	Resource Conservation and Recovery Act
RCRA-LQG	1	Large quantity generator:
RCRA-SQG	3	Small quantity generator
Federal ERNS	34	Emergency response organization system
UST	2	Underground storage tanks
SPI LLS	19	Emergency release reports
TRIS	2	Toxic Chemical Release Inventory System
TSCA	2	Manufacturers and importers on the Toxic Substances inventory
FTTS		Enforcement and compliance information
PADS	1	PCB generators, transporters, storers, brokers and disposers
FINDS	18	Facility Index System
RMP	2	Risk management plans for flammable and/or toxic substances
NPDES	8	National pollutant discharge elimination system
AIRS	6	Aerometric information retrieval system (air permits)
US AIRS	4	Federal air permits
ASBESTOS	1	Asbestos demolition and renovation projects

Additional Environmental Record Sources

Topographic Maps

Topographic maps collected by EDR from the United States Geologic Survey website, were reviewed for evidence of past use and activitieswhich could be of concern. Maps from 1932, 1955, 1975 and 1994 all show the site as swampy marsh. The EDR Historical Topographic Map Report is included in Appendix B.

Aerial Photographs

A search for historical aerial photographs was performed by EDR produced aerial imagery from 1975, 1978, 1989, 1994 and 1998. It appears, from the photographs, the project site has always been an undeveloped marsh. No evidence of surface staining, dumping, industrial land use, etc. that might indicate the presence of an REC are apparent in the photos.

The EDR aerial photos are found in Appendix C.

Interviews

Telephone interviews were conducted to obtain information indicating RECs in connection with this site. The content of the questions asked followed the questionnaire format of ASTM 1528.

Louisiana Department of Environmental Quality
Office of Environmental Assessment
Southwest Regional Office
Lake Charles, LA 70615
Scott Wilkinson, Regional Supervisor
Surveillance Division
337-491-2667
Contacted May 28, 2013: No HTRW issues reported

Calcasieu Parish Police Jury
Timothy Conner, Parish Engineer,
337-721-4100
Contacted May 23, 2013: No HTRW issues reported.

US Army Corps of Engineers
Calcasieu Lock
Kevin Galley, Lockmaster
337-477-1482
Contacted May 28, 2013: No HTRW issues reported.

Conclusions

This assessment did not reveal any evidence of RECs and found the likelihood of encountering HTRW materials in connection with this project unlikely. A Phase II ESA is not necessary for the proposed project alternatives.

Limiting Conditions

U.S. Army Corps of Engineers, Environmental Engineering Section, should be contacted with any known or suspected variations from the conditions described herein. If future development of the property indicates the presence of hazardous or toxic materials, USACE should be notified to perform a re-evaluation of the environmental conditions.

The scope of this assessment did not include any additional environmental investigation, not outlined herein, or analyses for the presence or absence of hazardous or toxic materials in the soil, ground water, surface water, or air, in on, under or above the subject tract.

This site assessment was performed in accordance with generally accepted practices of consultants undertaking similar studies at the same time and in the same geographical area, and USACE observed that degree of care and skill generally exercised by consultants under similar circumstances and conditions. The findings and conclusions stated herein must be considered not as scientific certainties, but rather as professional opinions concerning the significance of the limited data gathered during the course of the environmental site assessment. No other warranty, express or implied, is made.

Specifically, USACE does not and cannot represent that the site contains no hazardous waste or material, oil (including petroleum products), or other latent condition beyond that observed a by USACE during its site assessment.

The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely upon the services described therein, and not on scientific tasks or procedure beyond the scope of described services or the time and budgetary constraints imposed by the client. Furthermore, such conclusions are based solely on site condition, and rules and regulations, which were in effect, at the time of the study.

In preparing this report, USACE relied on certain information provided by state and local officials and other parties referenced therein, and on information contained in the files of state and/or local agencies available to USACE at the time of the site assessment. Although there may have been some degree of overlap in the information provided by these various sources, an attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this site assessment was not made.

Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the site or to structures on the site was unavailable or limited, USACE renders no opinion as to the presence of indirect evidence relating to hazardous waste or material or oil, or other petroleum products in that portion of the site or structure. In addition, USACE renders no opinion as to the presence of hazardous waste or material, oil or other petroleum products or to the presence of indirect evidence relating to hazardous material, oil, or petroleum products where direct observation of the interior walls, floor, roof, or ceiling of a structure on a site was obstructed by objects or coverings on or over these surfaces.

Unless otherwise specified in the report, USACE did not perform testing or analyses to determine if certain report the presence or concentration of asbestos, radon, formaldehyde, lead-based paint, lead in drinking water, electromagnetic fields (EMFs) or polychlorinated biphenyls (PCBs) at the site or in the environment at the site.

The purpose of this report was to assess the physical characteristics of the subject site with respect to the presence in the environment of hazardous waste or material, oil, or petroleum products. No specific attempt was made to check on the compliance of present or past owners or operators of the site with federal, state, or local laws and regulations, environmental or otherwise.

Qualifications

USACE EC-HE personnel have specific qualifications based on education, training and experience to assess a property of the nature, history, and setting of the subject properties and declare , to the best of our professional knowledge and belief meet the definitions of Environmental Professionals as defined under 40 CFR 312.

Report prepared by:____

Michael A. King, P.E.
Environmental Engineer
CEMVS- EC-EQ

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in 40 CFR 312.10. I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. I have developed and performed the all appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Report reviewed by:____

Michael Henry, CHMM
Industrial Hygienist
CEMVS- EC-EQ

Report approved by:____

Kevin Slattery
Section Chief
CEMVS- EC-EQ

FIGURES

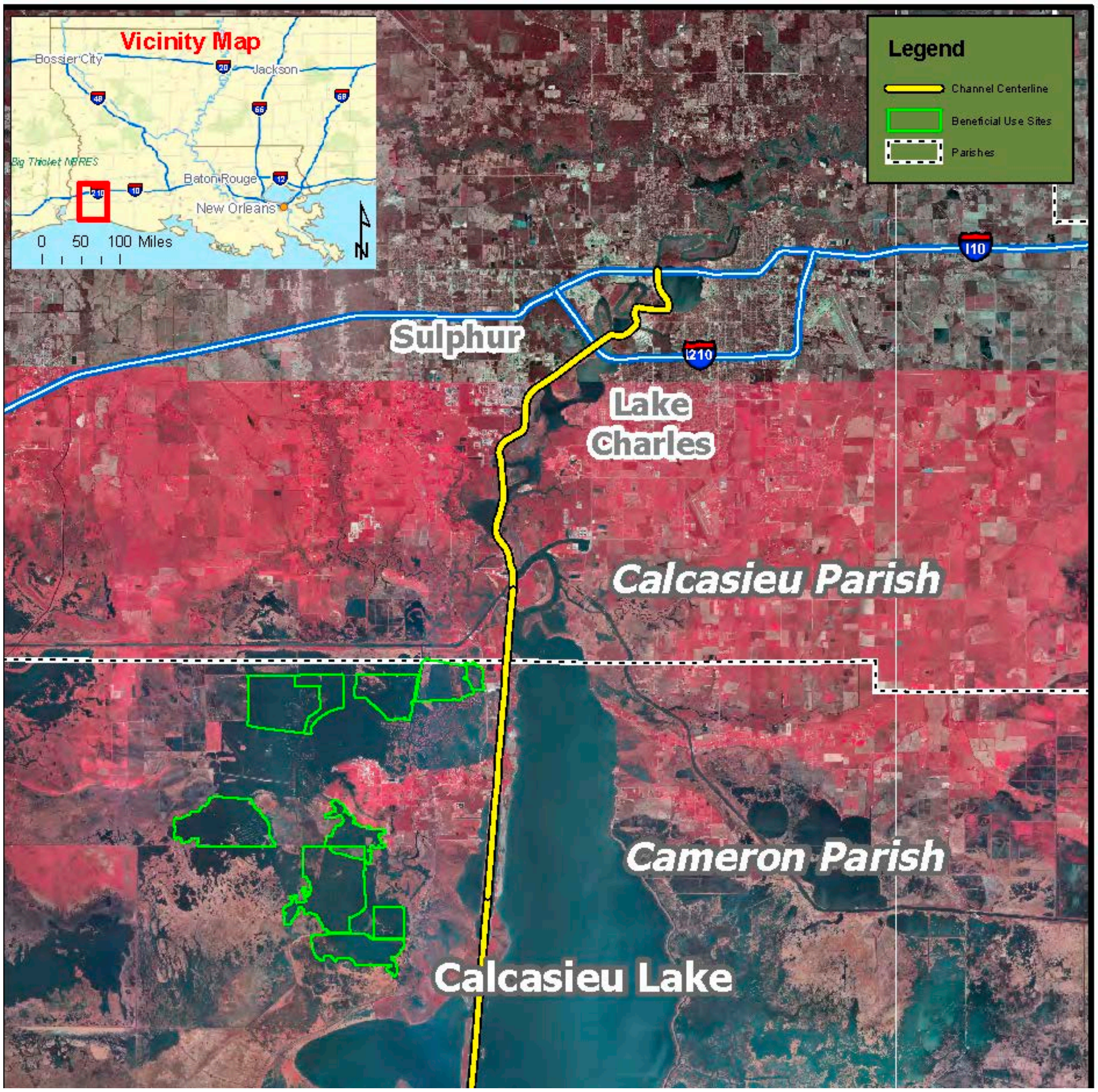

Figure 1 - Project vicinity map

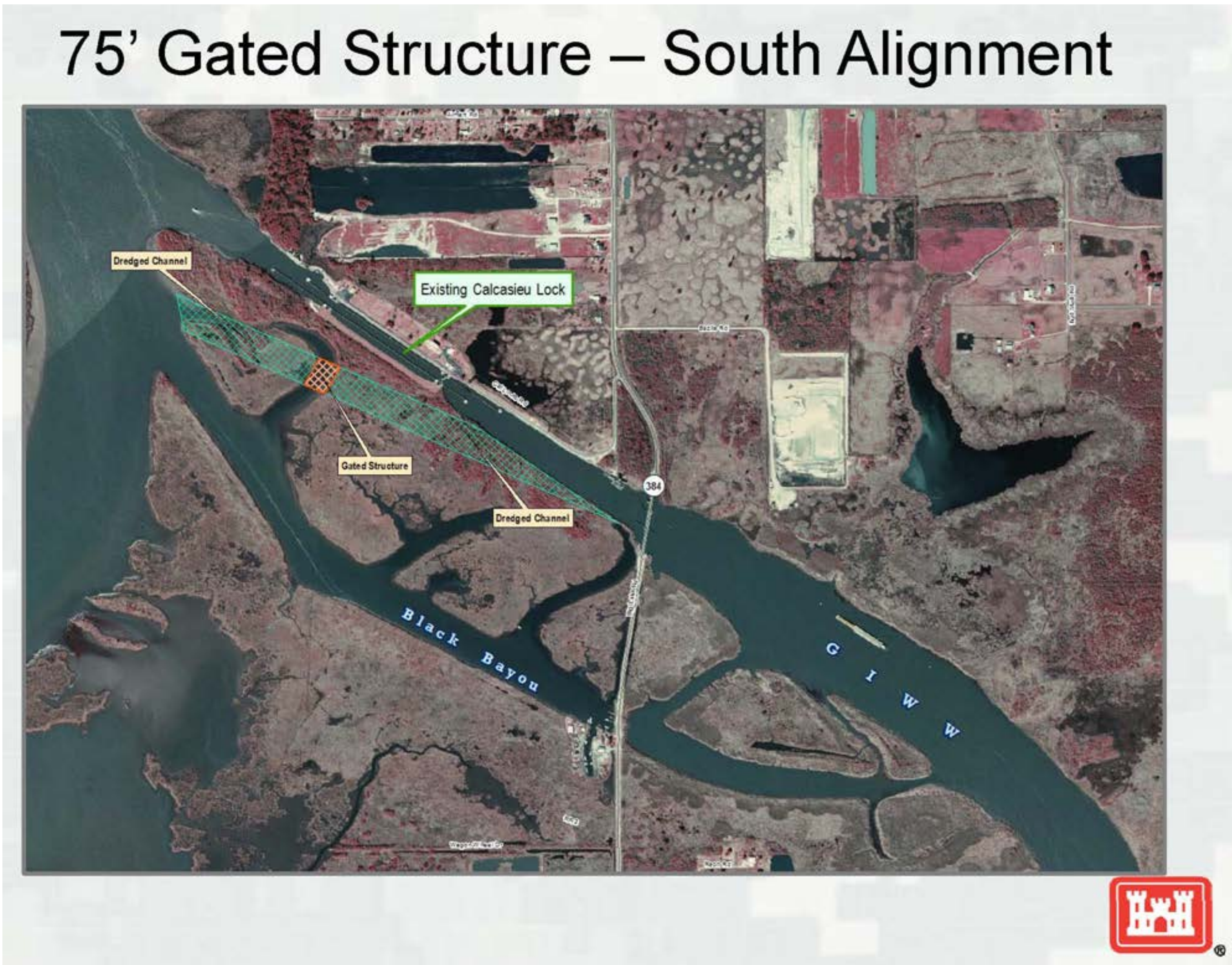

Figure 2.1 -- Gated structure alternative

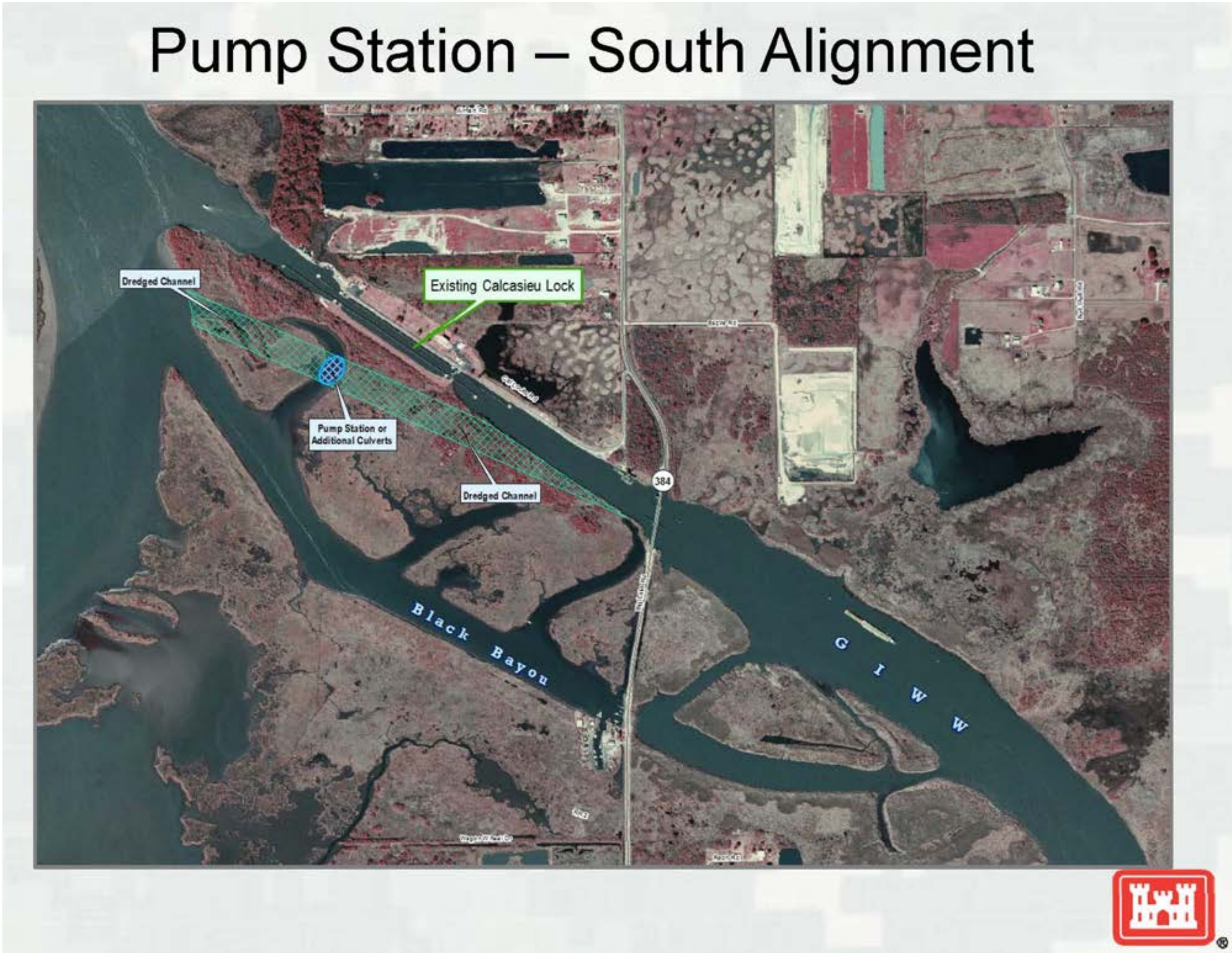

Figure 2.2 -- Pump station alternative

Figure 2.3 -- Black Bayou modifications alternative

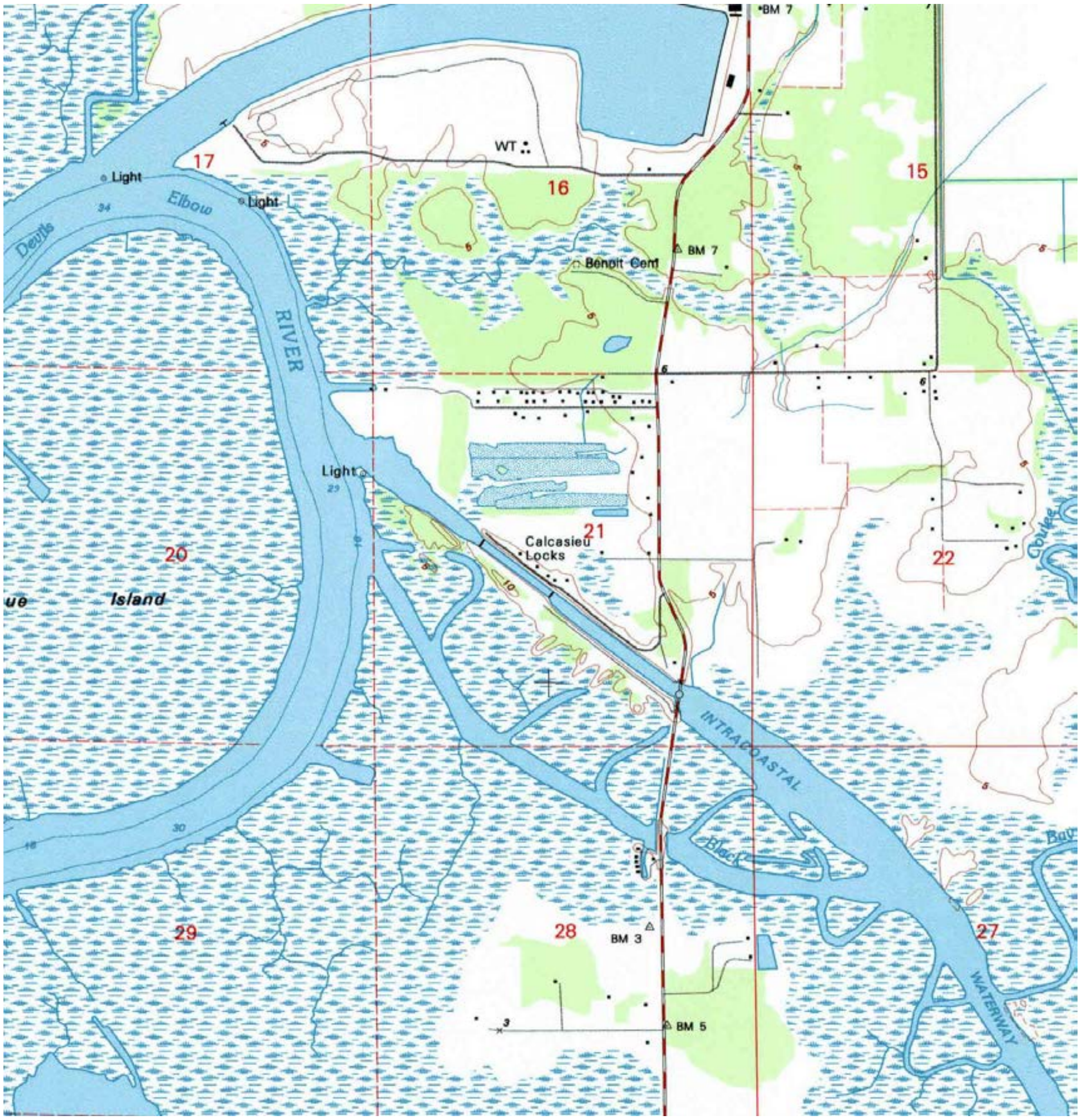

Figure 3 -- Site topographic map

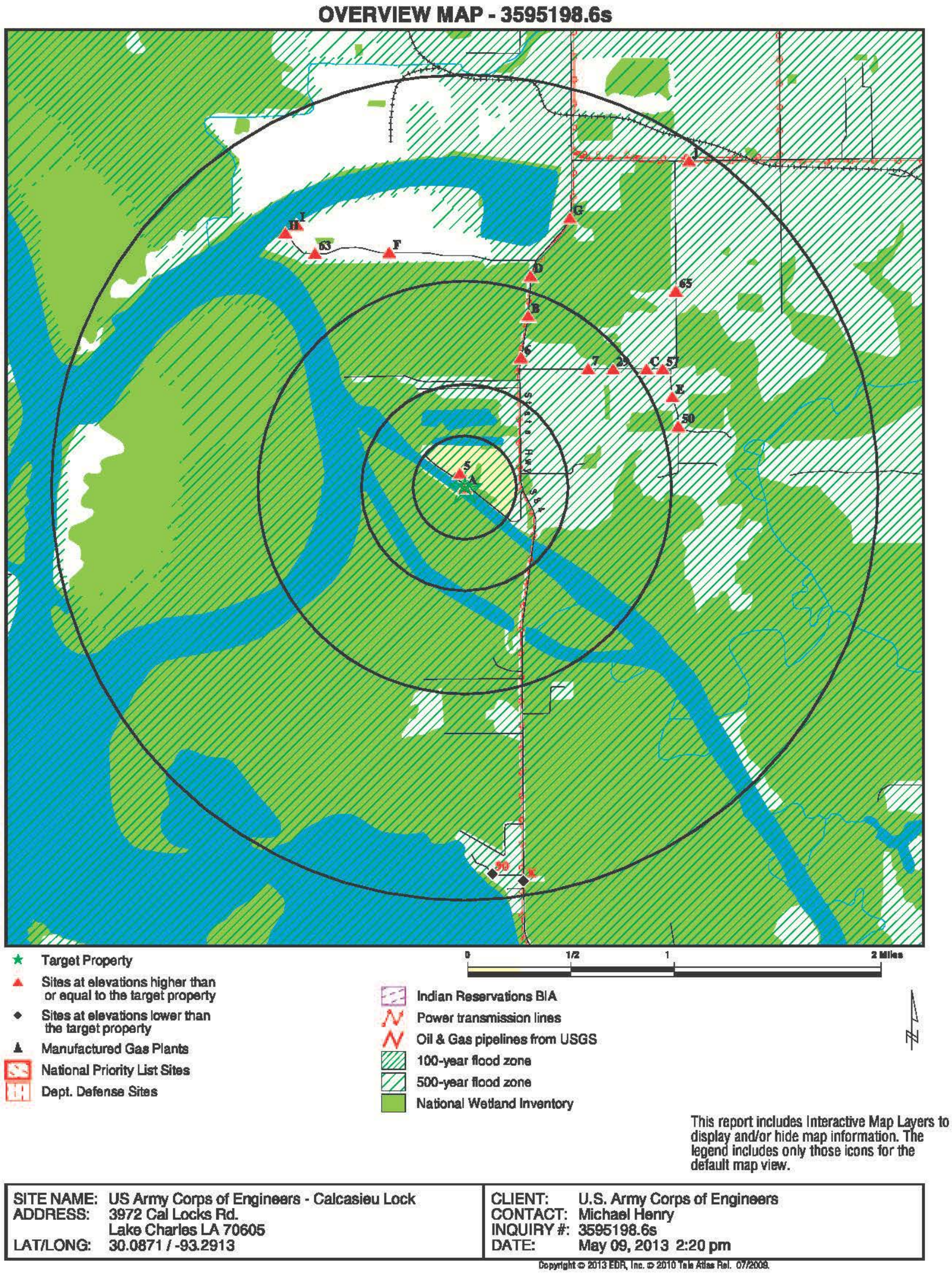

Figure 4 -- EDR radius map

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

FIGURES

TABLES

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

I. INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act, as amended, PL 104-297, addresses the authorized responsibilities for the protection of Essential Fish Habitat (EFH) by National Marine Fishery Service (NMFS) in association with regional Fishery Management Councils. The act establishes eight regional Fishery Management Councils responsible for the protection of marine fisheries within their respective jurisdictions. *Essential Fish Habitat* is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” This definition extends to habitat specific to an individual species or group of species; whichever is appropriate, within each Fishery Management Plan (FMP). The act also authorizes the designation of Habitat Areas of Particular Concern (HAPC) for marine fisheries. These areas are subsets of EFH that are rare, susceptible to human degradation, ecologically important or located in an ecologically stressed area. Any Federal agency that proposes any action that potentially affects or disturbs any EFH must consult with the Secretary of Commerce and Fishery Management Council authority per the Magnuson-Stevens Act, as amended (2005). Interim final rules were published on December 19, 1997, in the Federal Register (Vol. 62. No. 244) to establish guidelines for the identification and description of EFH in fishery management plans. These guidelines include impacts from fishing and non-fishing activities as well as the identification of actions needed to conserve and enhance EFH. The rule was established to provide protection, conservation, and enhancement of EFH.

Per 50 CFR 600.920(e)(3), all EFH assessments must include the following information:

1. Description of the action;
2. Analysis of the potential adverse effects of the action on EFH and the managed species;
3. Federal agency’s conclusions regarding the effects of the action on EFH; and
4. Proposed mitigation, if applicable

II. DESCRIPTION OF THE PROPOSED ACTION

A. Project Location. The study area is located in the north-central portion of the Calcasieu Estuary, in south-central Calcasieu Parish, Louisiana (figure N-1). There are two main types of aquatic habitat in the proposed project area. Coastal marsh, the predominant type, is represented by brackish marsh to the west of Louisiana Highway 384 (Big Lake Rd), and intermediate marsh to the east of this road. The marshes consist of emergent vegetation interspersed with and bordered by shallow open water. Deeper areas of open water distinct from marsh are represented by the GIWW, Black Bayou, and smaller contiguous water bodies.

Figure N-1. Calcasieu Lock Study Area

B. Description of the Viable Alternatives. A complete description of each of the proposed alternatives can be found in Section 5.6, *Final Array of Alternatives*, of the Main Report for the Calcasieu Lock, Louisiana, Feasibility Study. The final array of alternatives carried forward for consideration includes Alternatives 1 and 3. At this time, Alternative 1 is the Tentatively Selected Plan (TSP).

The main feature of Alternative 1 is a new channel to carry freshwater flows from the Mermentau Basin around the south side of the existing Calcasieu Lock. This channel, constructed by hydraulic dredging, would be about 3,600 feet long and 300 feet wide at the surface. The channel would be dredged to -12 MLG, with a channel bottom width of 80 feet, and 1V on 3H side slopes. A 75-foot wide gated water control structure would be constructed inside the channel at about its midpoint to control the passage of freshwater flows. To control scouring, riprap would be placed in the channel for approximately 300 feet on either side of the water control structure at a thickness of 3 feet (approximately 17,200 tons) (figure N-2). Construction access to the site would be via barge. A permanent access road would be constructed from the lock to the culvert structure for use by the lock personnel.

Alternative 3 involves adding Supplemental Culverts to the Black Bayou Natural Resources Conservation Service (NRCS) structure to increase its capacity and operate in conjunctions with it. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 Mean Low Gulf (MLG). Black Bayou Dredging to the east and west of the NRCS structure would also occur (figure N-3).

The potential for all project alternatives to adversely affect habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service, the NMFS, the NRCS, and the Corps.

With regard to the project alternatives as a whole, there would be unavoidable impacts to aquatic habitat including brackish marsh, that was considered by the HET to be permanent and for which compensatory mitigation would be required to offset such losses. In contrast, potential impacts to deeper open water habitats like Black Bayou were not regarded as permanent by the HET and did not warrant any such mitigation. Appendix I, *Mitigation Plan*, provides a description of the proposed mitigation plan developed for the Calcasieu Lock TSP.

Figure N-2. Alternative 1 General Location

Figure N-3. Alternative 3 General Location

III. ESSENTIAL FISH HABITAT AND MANAGED SPECIES IN THE PROJECT AREA

A. Types of Essential Fish Habitat in the Gulf of Mexico. The project area is located within the jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC) with representatives from Texas, Louisiana, Florida, Alabama, and Mississippi. The GMFMC has identified and described EFH for hundreds of species covered by six FMPs. The Council prepares fishery management plans designed to manage fishery resources from where state waters end out to the 200-mile limit of the Gulf of Mexico. These waters are also known as the Exclusive Economic Zone.

The GMFMC has identified several types of EFH that occur in estuarine and marine conditions for the entire region of jurisdiction and for the state of Louisiana. These EFH types and their corresponding categories can be found in table N-1.

Table N-1. Essential Fish Habitat and Habitat Areas of Particular Concern Identified for Management by the Gulf of Mexico Fishery Management Council

Essential Fish Habitat		HAPC
Estuarine Areas	**Marine Areas**	**Texas/Louisiana**
Estuarine emergent wetlands	Water column	Flower Garden Banks Nat'l Marine Sanctuary
Mangrove wetlands	Vegetated bottoms	
Submerged aquatic vegetation	Non-vegetated bottoms	
Algal flats	Live bottoms	
Mud, sand, shell, & rock substrates	Coral reefs	
Estuarine water column	Artificial reefs	
	Geologic features	
	West Florida Shelf	
	Mississippi/Alabama Shelf	
	Louisiana/Texas Shelf	
	South Texas Shelf	

Source: NMFS, 2013

The only noted HAPC, Flower Garden Banks National Marine Sanctuary, is actually the northernmost coral reefs in the United States. Located approximately 105 miles directly south of the Texas/Louisiana border, the Flower Gardens are perched atop two salt domes rising above the sea floor. This bank supports a coral/sponge habitat and rich assemblages of associated animals and plants where the siltstone bedrock can still be seen in many places. This noted HAPC for Louisiana is not within the project vicinity.

B. Types of Essential Fish Habitat in the Proposed Project Area. The estuarine waters of Calcasieu Parish are included in the EFH managed area. Essential Fish Habitat located within the proposed project area includes:

Estuarine Marsh. Of the four main types of emergent marsh (saline, brackish, intermediate, and freshwater), only brackish is currently present within the proposed project area. Brackish marsh is made up of wiregrass (*Spartina patens*), threecorner grass (*Scirpus olneyi*) and coco (*Scirpus robustus*).

Marsh-Water Interface (Marsh-edge). Marsh edge habitats serve as the defining border between the emergent marsh vegetation and open water and have been referred to as 'critical transition zones' that promote the movement of organisms and nutrients between intertidal and subtidal estuarine environments (Levin et al. 2001). These habitats serve as productive nursery areas for juvenile finfishes and decapod crustaceans of economic importance and provide productive feeding grounds for resident and transient predators (Birdsong 2002).

Mud/Sand/Shell/Rock Substrates. This habitat is comprised of unconsolidated mud, sand, shell, and/or rock substrates; which may support a large population of infaunal organisms as well as a variety of transient planktonic and pelagic organisms.

Estuarine Water Column. The estuarine water column includes the open waters of Calcasieu Lake, which are generally shallow with over half between 0 and 6 feet in depth.

Intermediate marsh, marsh-water interface, mud/sand/shell substrates, and estuarine water column located to the east of Calcasieu Lock and Louisiana Highway 384 are not considered to be EFH because these areas are not accessible by the managed species discussed below.

C. Gulf of Mexico Fishery Management Council Managed Species with Designated Essential Fish Habitat in the Proposed Project Area

Numerous publications and websites, with assistance from the Habitat Conservation Division of the NMFS Southeast Regional Office, Gulf Branch, were used to identify managed species and EFH for life cycle stages of these species within the proposed project area in Calcasieu Lake estuary (GMFMC 2004, 2005, 2012).

Essential Fish Habitat was identified for certain life stages of brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), and red drum (*Sciaenops ocellatus*). Table N-2 summarizes species managed under the Magnuson-Stevens Fishery Conservation and Management Act grouped by FMP for which EFH designations exist in the proposed project area.

Table N-3 provides monthly relative abundance codes for managed species life stages in Calcasieu Lake estuary.

Brown shrimp juveniles were categorized as common to highly abundant year round. Larvae were categorized as common to abundant between February and November and as rare in December and January.

White shrimp juveniles were categorized as common to abundant year round. Larvae were considered rare to abundant between May and November and as rare to not present between December and April.

Red drum adults are classified as rare to common between April and November, and as rare between December and March. Juveniles were classified as common throughout the year, except in areas with salinity ranging from 0-0.5, where they are classified as rare. Red drum larvae in Calcasieu Lake estuary was classified as rare to common between August and March, and not present between April and July.

Table N-2. Essential Fish Habitat Requirements for Species Managed by the Gulf of Mexico Fishery Management Council: Ecoregion 4, Mississippi River Delta (South Pass) to Freeport, TX

Species	Life Stage	Zone	EFH
Brown Shrimp	Larvae/Postlarvae	Marine/Estuarine	<82 m; planktonic; sand/shell/soft bottom, SAV, emergent marsh, oyster reef
	Juveniles	Estuarine	<18 m; SAV, sand/shell/soft bottom, emergent marsh, oyster reef
White Shrimp	Larvae/Postlarvae	Marine/Estuarine	<82 m; planktonic; soft bottom, emergent marsh
	Juveniles	Estuarine	<30 m; soft bottom, emergent marsh
Red Drum	Larvae/Postlarvae	Estuarine	all estuaries; planktonic; SAV, sand/shell/soft bottom, emergent marsh
	Juveniles	Estuarine/Marine	GOM <5 m; Vermilion Bay & E all estuaries SAV, sand/shell/soft/hard bottom, emergent marsh
	Adults	Estuarine/Marine	GOM 1-46 m; Vermilion Bay & E all estuaries; pelagic; SAV, sand/shell/soft/hard bottom, emergent marsh

Source: NMFS, 2013

Table N-3. Average Monthly Relative Abundance Codes [1] for Management Species Life Stages in Calcasieu Lake Estuary Over All Salinity Values [2]

Managed Species	Life Stage	Salinity (ppt)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brown Shrimp	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	4	5	5	4	4	4	4	3	3	3
		5-15	3	3	4	5	5	4	4	4	4	3	3	3
		0.5-5	3	3	4	5	5	4	4	4	4	3	3	3
		0-0.5	3	3	4	5	5	3	3	3	3	3	3	3
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	4	4	3	3	3	3	3	3	2
		5-15	2	4	4	4	4	3	3	3	3	3	3	2
		0.5-5	2	3	3	3	3	3	3	3	3	3	3	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0
White Shrimp	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	3	3	3	3	4	4	4	4	4	3
		5-15	3	3	3	3	3	3	4	4	4	4	4	3
		0.5-5	3	3	3	3	3	3	4	4	4	4	4	3
		0-0.5	3	3	3	3	3	3	3	3	3	3	3	3
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	2	3	4	4	3	4	4	3	2
		5-15	0	0	0	2	3	4	4	3	4	4	3	2
		0.5-5	0	0	0	0	2	3	3	3	3	3	3	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0
Red Drum	Adults	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	2	2	2	3	3	3	3	3	3	3	3	2
		5-15	2	2	2	3	3	2	2	2	3	3	3	2
		0.5-5	2	2	2	3	3	2	2	2	3	3	3	2
		0-0.5	0	0	0	2	2	2	2	2	2	2	2	0
	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	3	3	3	3	3	3	3	3	3	3
		5-15	3	3	3	3	3	3	3	3	3	3	3	3
		0.5-5	3	3	3	3	3	3	3	3	3	3	3	3
		0-0.5	2	2	2	2	2	2	2	2	2	2	2	2
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	0	0	0	0	2	3	3	3	3
		5-15	2	2	2	0	0	0	0	2	2	2	2	2
		0.5-5	2	2	2	0	0	0	0	2	2	2	2	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0

[1] 5 - Highly Abundant, 4 - Abundant, 3 - Common, 2 - Rare, 0 - Not Present
[2] The values for these codes were obtained from "The Estuarine Living Marine Resources" database (http://www8.nos.noaa.gov/biogeo_public/elmr.aspx).

IV. THE EFFECTS OF THE PROPOSED ACTION ON EFH AND MANAGED SPECIES

As defined by the Magnuson-Stevens Act (50 CFR 600.810), "Adverse Effect" includes any impact which reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

A. Effects on EFH. For Alternative 1, about 9.7 acres of emergent brackish marsh and 4.3 acres of open water would be directly impacted by constructible elements, based on geographic information system analysis. The emergent brackish marsh would be converted into open water (new channel) or an area occupied by the sluice gate (table N-4). Approximately 170,000 cubic yards (yd^3) of hydraulically dredged material would be obtained during construction of the new channel.

For Alternative 3, approximately 4.9 acres of emergent brackish marsh and 51.4 acres of open water would be directly impacted by constructible elements (table N-4). Approximately 45,500 yd^3 of hydraulically dredged material would be obtained during construction.

Table N-4. Pre- and Post-Construction Habitat Types (acre) by Proposed Feature for Alternative 1 and Alternative 3 (Excluding Placement of Dredged Material)

Habitat Type	Pre-Construction	Post-Construction
Alternative 1		
Bottomland Forest / Chenier	10.9	
Dredged Channel		10.9
Emergent Brackish Marsh	9.7	
Dredged Channel		9.7
Open Water Brackish Marsh	4.3	
Dredged Channel		3.3
Pump Station or Culverts		1.0
TOTAL	**24.9**	**24.9**
Alternative 3		
Developed	0.5	
Pump Station		0.5
Emergent Brackish Marsh	4.9	
Dredged Channel		2.0
Pump Outfall Channel		2.4
Pump Station		0.5
Open-Water Brackish Marsh	51.0	
Dredged Channel		49.4
Pump Outfall Channel		1.0
Pump Station		0.7
Open Water	0.4	
Dredged Channel		0.4
TOTAL	**56.8**	**56.9**

The dredged material would be placed in areas of nearby open water and surrounded by containment dikes, resulting in the conversion of open water to emergent marsh. The proposed placement sites are illustrated in figure N-4. Using an estimate of 4,800 yd^3 of fill per acre (assuming the existing substrate elevation of these placement locations is -2.0 MLG and they would be filled to +1.5), Alternative 1 (TSP) would result in approximately 35 acres of converted emergent marsh habitat; for Alternative 3, disposal was assumed to occur at the same locations, but would likely result in fewer acres of emergent marsh habitat because of the smaller amount of dredged material.

B. Effects on Managed Species. The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the extent practicable. Construction activities would be subject to seasonal restrictions if any Bald Eagle nest or nesting area of the Brown Pelican or other colonial waterbirds were to become established in the project area (see Appendix A, *Biological Assessment*). At least two life stages of brown shrimp, white shrimp, and red drum have the potential to be present within the Calcasieu Lake estuary throughout the year (table N-3).

Brown and White Shrimp (juveniles, larvae). Shrimp species include the brown shrimp (Farfantepenaeus *aztecus*), and white shrimp (*Litopenaeus setiferus*). Adult shrimp generally occupy offshore areas of higher salinity, where spawning occurs. After hatching, larvae enter estuaries and remain there throughout the juvenile stage. Estuarine habitat serves as a nursery area for shrimp, offering a suitable substrate, an abundant food supply, and protection from predators. Sub-adult shrimp consume organic matter, including marsh grasses and microorganisms, found in estuarine sediments. Adult shrimp are omnivorous. Essential Fish Habitat for shrimp is identified in table N-2.

Red Drum (adults, juveniles, larvae). Red drum (*Scianeops ocellatus*) is an important commercial and recreational gamefish found in coastal waters throughout the Gulf of Mexico. Adults inhabit nearshore waters, particularly areas within the surf zone or in the vicinity of inlets. Spawning occurs in nearshore areas, and eggs and larvae are transported by tides and wind currents into estuaries. Larvae and juveniles occupy estuarine environments until maturation. Red drum are predatory in all stages of life; however, the type of prey consumed varies with life stage. Sub-adult red drum primarily consume small marine invertebrates including mysids and copepods, while adult specimens feed on large marine invertebrates, including shrimp and crabs, and small fishes. Essential Fish Habitat for red drum is identified in table N-2.

C. Conclusion. Dredging and other construction activities would adversely impact EFH used by red drum and shrimp. There is a potential for the construction activities to impact red drum and/or shrimp larvae in the proposed areas of disturbance. However, based on the relative abundance of red drum larvae in the area during this life stage (table N-3), the probability of encounter is very low. Since adult and juvenile red drum and shrimp are mobile, it is expected that they would avoid the areas of disturbance and therefore will not be impacted. The dredging of emergent marsh and open water areas would also result in the temporary loss of benthic organisms (prey species) in the vicinity of the construction. However, they would recolonize available habitat within a relatively short time period. More mobile prey species would be expected to avoid the areas of disturbance and therefore would not be impacted.

Based upon the project design and the impacts associated with the dredging and other construction, the Corps believes the proposed project ***may adversely affect EFH***. Therefore, the Corps will coordinate with NMFS to determine whether for Alternative 1 the 10 acres of compensatory wetland mitigation and additional estimated 25 acres of dredged material placement in open water to create marsh are sufficient to compensate for EFH impacts.

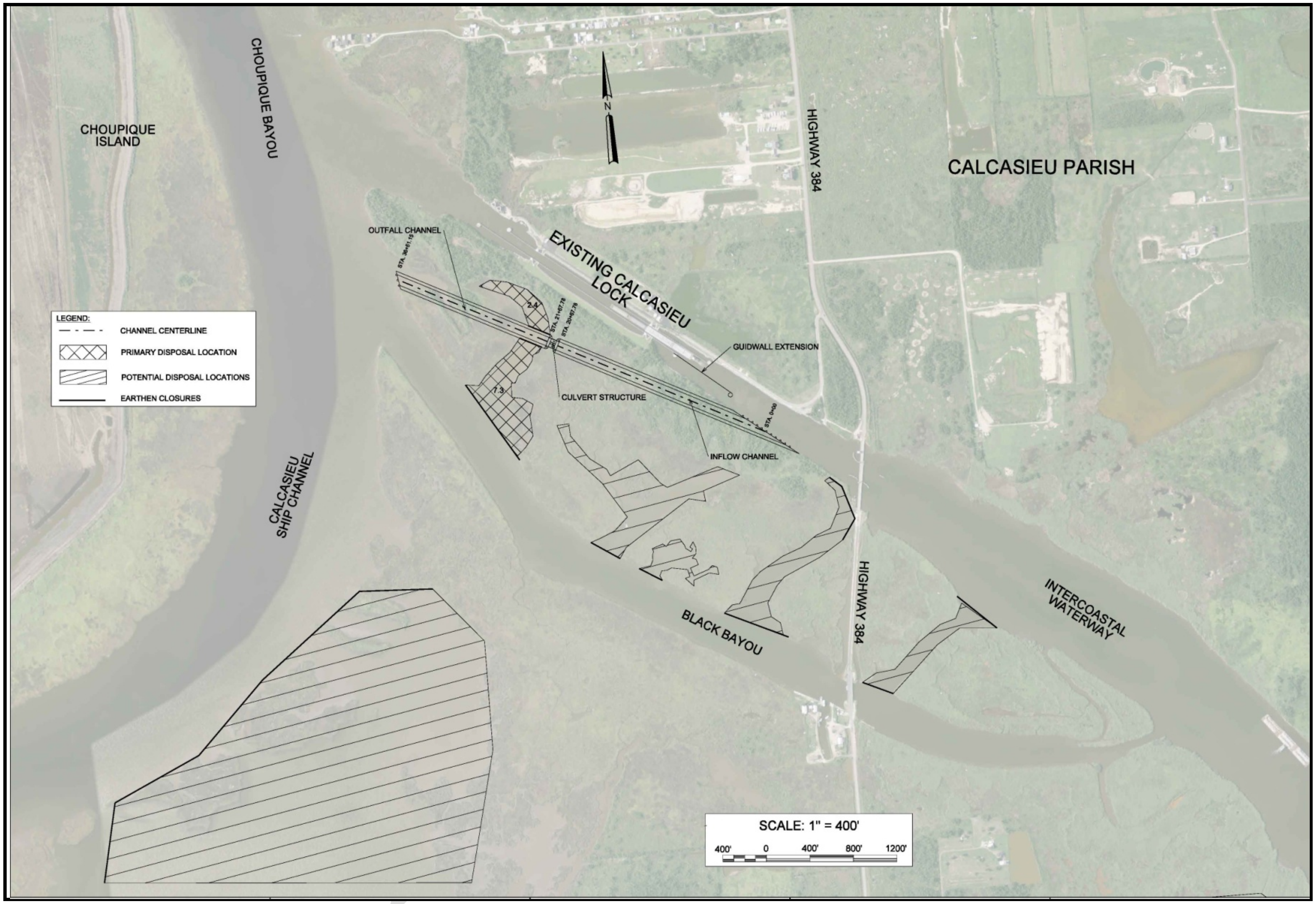

Figure N-4. Alternative 1 (TSP) and Proposed Dredged Material Disposal Sites

V. REFERENCES

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX O

CUMULATIVE IMPACTS

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX O

CUMULATIVE IMPACTS

APPENDIX O

CUMULATIVE IMPACTS

I. INTRODUCTION

Section 1508.8 of Title 40 of the Code of Federal Regulations, promulgated by the President's Council on Environmental Quality to implement the National Environmental Policy Act, defines cumulative impact as:

> *…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.*

In assessing cumulative impact, consideration is given to

1. the degree to which the proposed action affects public health or safety,
2. unique characteristics of the geographic area,
3. the degree to which the effects on the quality of the human environment are likely to be highly controversial,
4. the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks, and
5. whether the action is related to other actions with individually insignificant but cumulatively significant impacts on the environment.

Cumulative effects can result from many different activities, including the addition of materials to the environment from multiple sources, repeated removal of materials or organisms from the environment, and repeated environmental changes over large areas and long periods. Complicated cumulative effects occur when stresses of different types combine to produce a single effect or suite of effects. Large, contiguous habitats can be fragmented, making it difficult for organisms to locate and maintain populations in disjunct habitat fragments. Cumulative impacts may also occur when the timing of perturbations are so close in space that their effects overlap.

II. GEOGRAPHIC BOUNDARIES OF THE CALCASIEU-SABINE BASIN

Although the project area is limited to the Calcasieu Lock and vicinity, cumulative impacts involve the broader coastal basin. For that reason, most of the information in this cumulative impacts analysis applies to the Calcasieu-Sabine Basin in Louisiana's Chenier Plain. The information used in this report has been gathered from published sources and government documents.

The Calcasieu-Sabine Basin is the westernmost coastal basin in Louisiana's Chenier Plain. Composed of the Calcasieu-Sabine and Mermentau hydrologic basins, the Chenier Plain was formed 3,000 to 4,000 years ago during periods when the Mississippi River followed a westerly course [Louisiana Coastal Wetlands Conservation and Restoration Task Force, (LCWCRTF) 2002]. The sediments were reworked by marine forces into low ridges and intervening wetland swales parallel to the coastline. These ridges, which consisted mainly of sand and shell, were typically higher in elevation than surrounding marshes and were colonized by live oaks. The Chenier Plain extends from the western bank of the Freshwater Bayou Canal westward to the Sabine River on the Louisiana-Texas border, and from the marsh area north of the Gulf Intracoastal Waterway (GIWW) south to the Gulf of Mexico in Vermilion, Cameron, and Calcasieu Parishes (figure O-1).

The Calcasieu-Sabine Basin consists of approximately 630,000 acres, 50 percent of which is classified as marsh. The northern boundary of the basin is defined by the GIWW. The eastern boundary follows the eastern leg of State Highway 27; the western boundary is the Sabine River and Sabine Lake; and the southern boundary is the Gulf of Mexico (USGS, 2007).

The basin consists of two semi-distinct hydrologic units, the Calcasieu River Basin and the Sabine River Basin, which are continuous between Louisiana and Texas. The Calcasieu, Sabine, and Neches Rivers are the principal sources of freshwater inflow into this region. The Sabine and Calcasieu Rivers follow a north-south gradient, whereas the Neches River flows into Sabine Lake from the northwest. Additionally, an east-west flow occurs between the basins via the GIWW and existing canals on the Sabine National Wildlife Refuge(NWR) [U.S. Geological Survey (USGS), 2007).

Managed wetlands are a significant feature of the Calcasieu-Sabine Basin. Approximately 24 percent (148,600 acres) of the basin lands is publicly owned as Federal refuges (USGS, 2007).

III. TEMPORAL BOUNDARIES

The cumulative impacts on the Calcasieu-Sabine Basin began with the construction of navigation channels in the Calcasieu and Sabine Rivers in the early 1870s and 1880s, respectively. The channels were continuously deepened and widened for the next 100 years, causing saltwater intrusion coupled with significant marsh loss and vegetation change. More than 82 percent, over 100,000 acres, of documented marsh loss in the Calcasieu-Sabine Basin occurred between 1955 and 1974, the period in which the largest incremental changes were made to the navigation channels. Because the navigation channels would remain authorized until Congress determines otherwise, their status must be considered indefinite.

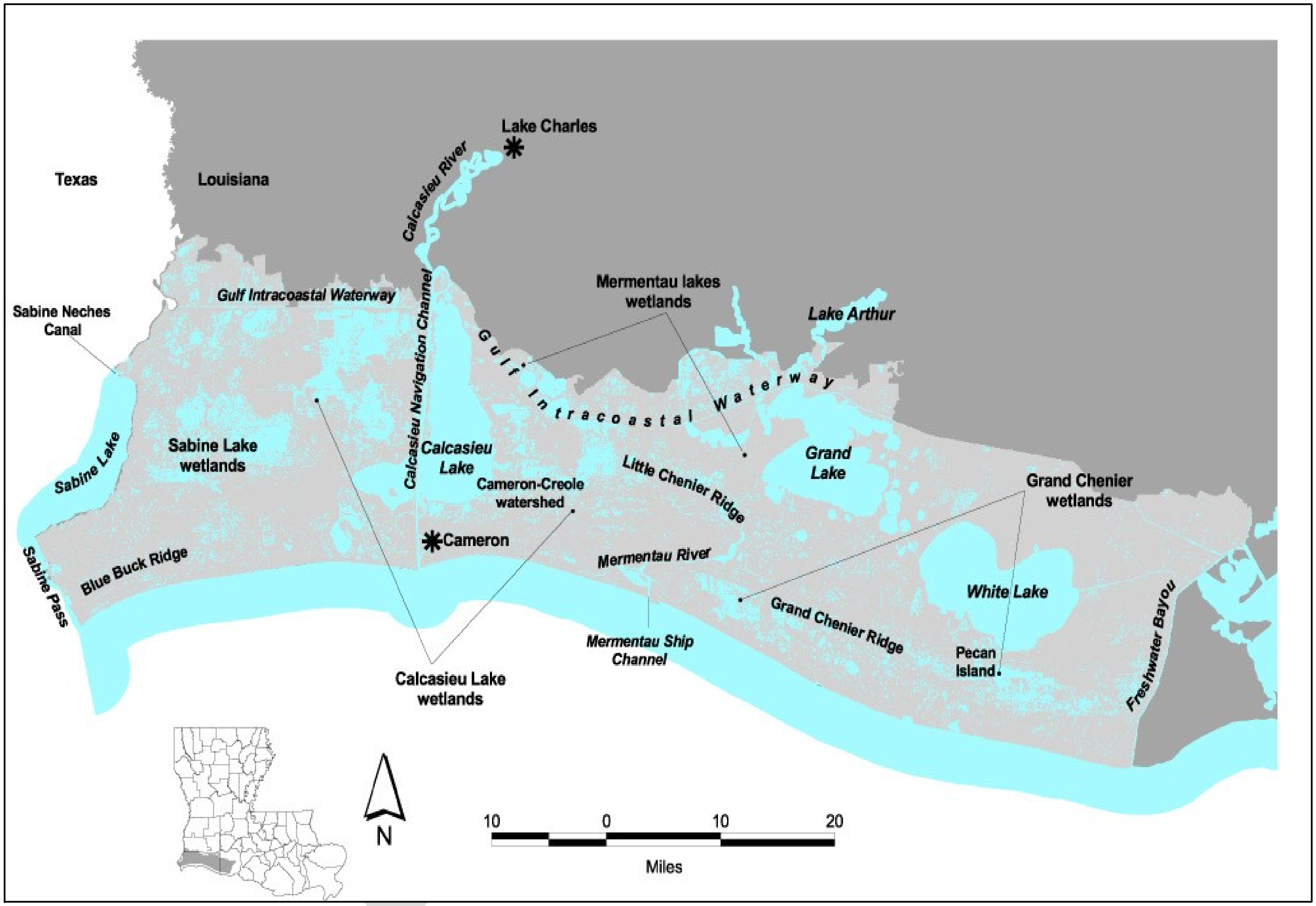

Figure O-1. Louisiana's Chenier Plain
(Source: CEMVN. 2004. Louisiana Coastal Area Ecosystem Restoration Study. Vol I: Main Report. Pages 2-16)

IV. NATURAL RESOURCES

This feasibility report/EIS includes considerations of the effects of creating a new freshwater bypass around Calcasieu Lock, and dredged material placement on natural resources of the area, including essential fish habitat, wetlands, and protected species. This cumulative impacts discussion focuses on the primary issue affecting these natural resources--land loss due to coastal subsidence and shoreline erosion, and plant community changes due to saltwater intrusion. The hydrologic alterations that have had the most significant impact on these resources are navigation corridors. The Calcasieu and Sabine-Neches navigation channels have been expanded incrementally to the extent that the existing channel cross-sections are more than 40 times larger than when the channels were first dredged in the late 1800s. These changes have affected hydrology by channeling saltwater into the historically low-salinity estuary. Secondary causes of landscape change include storms, petrochemical exploration, and herbivory.

A. Past Actions

1. Historical Landscape Change. Abundant evidence indicates that the Calcasieu-Sabine Basin was historically fresher than it is today. Both O'Neil (1949) and a 1951 Soil Conservation Service vegetation map of Cameron Parish show broad expanses of unbroken Jamaica swamp sawgrass (*Cladium mariscus*) marsh [U.S. Department of Agriculture (USDA), 1951, in LCWCRTF, 2002]. Sawgrass is found in fresh and intermediate marshes and tolerates salinities between 0 and 2 ppt (Penfound and Hathaway 1938). At the time of the 1951 survey, sawgrass marsh covered approximately 475 square-miles of Cameron Parish and was the dominant vegetative community.

Water from Calcasieu Lake was fresh enough to be used in the irrigation of rice fields in Cameron Parish around 1875-1910 (David Richard, Stream Companies, Inc., personal communication, in LCWCRTF, 2002). Water from Calcasieu Lake must have been essentially fresh during this period, because rice is adversely affected by water salinities that exceed 0.6 ppt (Hill, 2001). In the early 1900s, lower Calcasieu Lake was considered marginal habitat for oysters because of the frequency of freshwater and low-salinity events. Oysters, which cannot survive in fresh water, inhabit waters within the salinity range of 5-30 ppt (Galtsoff, 1964), are now found throughout much of the Calcasieu Lake bottom (USDA, 1994, in LCWCRTF, 2002). In contrast to these formerly fresh conditions in Calcasieu Lake, average salinities at five Cameron Prairie Refuge monitoring stations within Calcasieu Lake ranged from 8.01 to 11.66 ppt during 1994-95 (LCWCRTF, 2002).

A total of 116,791 acres of wetlands in the Calcasieu-Sabine Basin has converted to open water since 1932 (USGS, 2007). Biologists, ecologists, and natural resource managers who possess intimate knowledge of the historical events that shaped the ecosystem were interviewed by the LCWCRTF to determine specific causes of land changes in the basin. The scientists attribute virtually all of the habitat changes and land losses in the basin to a combination of human-induced hydrologic changes, sometimes accompanied by severe storm events. The hydrologic alteration that has had the most impact is the Calcasieu Ship Channel, a major avenue for saltwater and tidal intrusion, which has caused extremely severe marsh losses (LCWCRTF, 2002).

2. Hydrologic Modifications for Navigation. Freshwater inflow to the basin occurs primarily through the Calcasieu and Sabine Lakes via the Calcasieu and Sabine Rivers. Marshes within the basin historically drained into these two large lakes. This process was altered by the construction of channels to enhance navigation and mineral extraction activities. Navigation channels now dominate the hydrology of the basin.

a. Calcasieu River and Ship Channel. The lower Calcasieu River and the Calcasieu Ship Channel have been maintained for navigation since 1874, when the Corps first constructed a 5-foot-deep x 80-foot-wide x 7,500-foot-long navigation channel through the outer bar of Calcasieu Pass, between Calcasieu Lake and the Gulf of Mexico. Prior to the initial dredging of the Calcasieu Ship Channel, there was a 3.5-foot-deep shoal at the mouth of the Calcasieu River (War Department, 1897). This natural bar acted as a constriction, minimizing saltwater and tidal inflow into the basin. Removal of the channel mouth bar, coupled with subsequent widening, deepening, and lengthening of the ship channel, allowed increased saltwater and tidal intrusion into the estuary, resulting in catastrophic marsh loss, tidal export of vast quantities of organic marsh substrate, and an overall shift to more saline habitats in the region (USDA, 1994, in LCWCRTF, 2002). In addition, the ship channel permits the upriver flow of denser, more saline water as a saltwater wedge. Figure O-2 shows the historical channel dimensions of the Calcasieu Ship Channel.

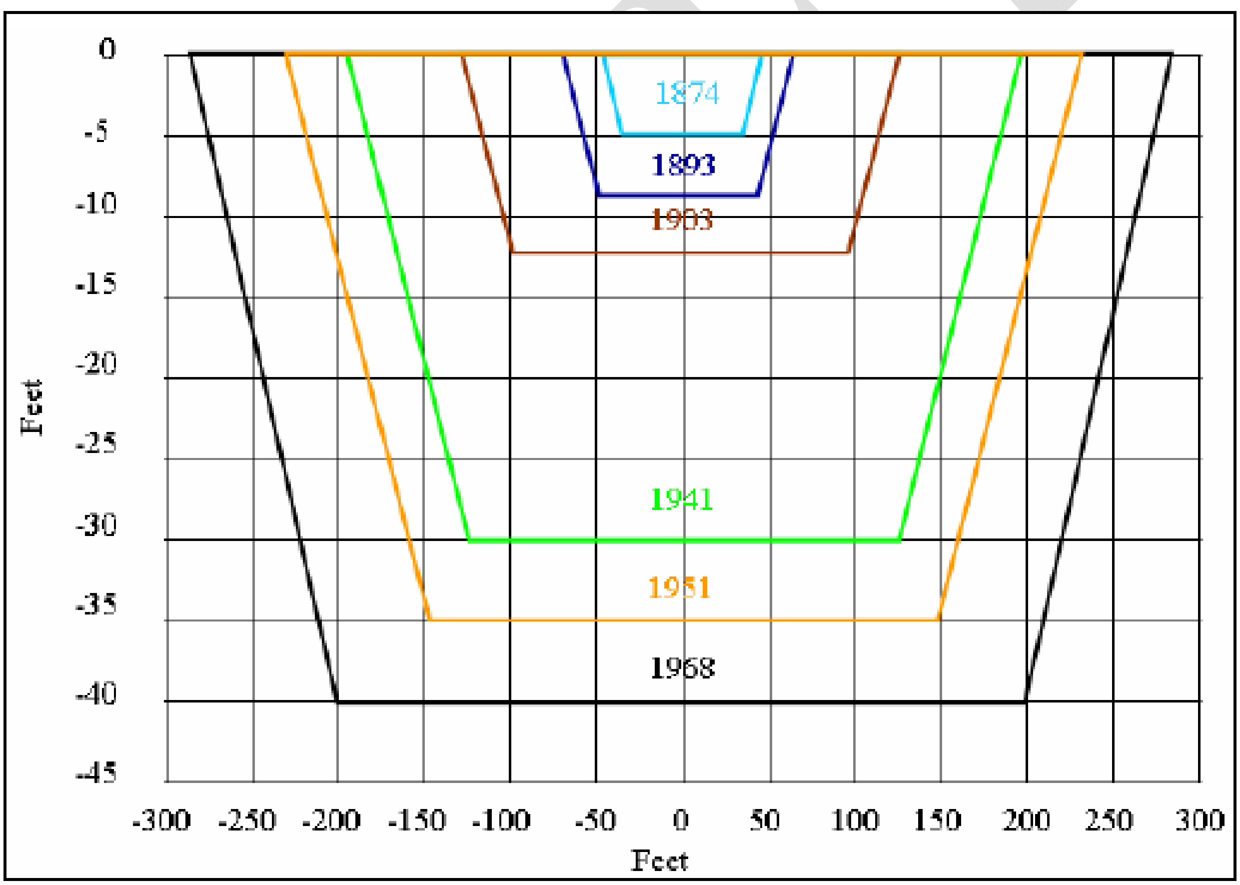

Figure O-2. Historical Channel Dimensions of the Calcasieu Ship Channel
(Source: LCWCRTF, 2002)

In 1968, the Corps completed construction of the Calcasieu River Saltwater Barrier on the Calcasieu River north of the City of Lake Charles. This barrier minimized the flow of the saltwater wedge into the upper reaches of the Calcasieu River to protect agricultural water supplies. The structure consists of navigation gates and a flood control barrier with five adjustable tainter gates.

b. Sabine River, Neches River, and Sabine Lake. The Sabine River is the dominant influence across most of the Calcasieu-Sabine Basin in moderating Gulf salinity and tidal fluctuations. Sabine Pass was first dredged for navigation in 1880. Prior to this, the River had an outer bar depth of 3.5 feet. In 1880, a channel 6 feet deep x 70-100 feet wide was dredged through the bar (War Department 1890). Over time, the channel was progressively deepened to its present depth of 40 feet. The Sabine-Neches Canal (later to become the Sabine-Neches Ship Channel) was constructed in the early 1900s, when the Corps dredged the channel along the west bank of Sabine Lake to a depth of 9 feet and a width of 100 feet. In 1914-1916, the channel was deepened to 25 feet and extended to Beaumont, Texas. This deepening led to the first reports of saltwater intrusion in the channel (Wilson 1981, in LCWCRTF, 2002). Since then, the channel has gradually been deepened and widened to its present dimensions of 40 feet deep and 400 feet wide (figure O-3).

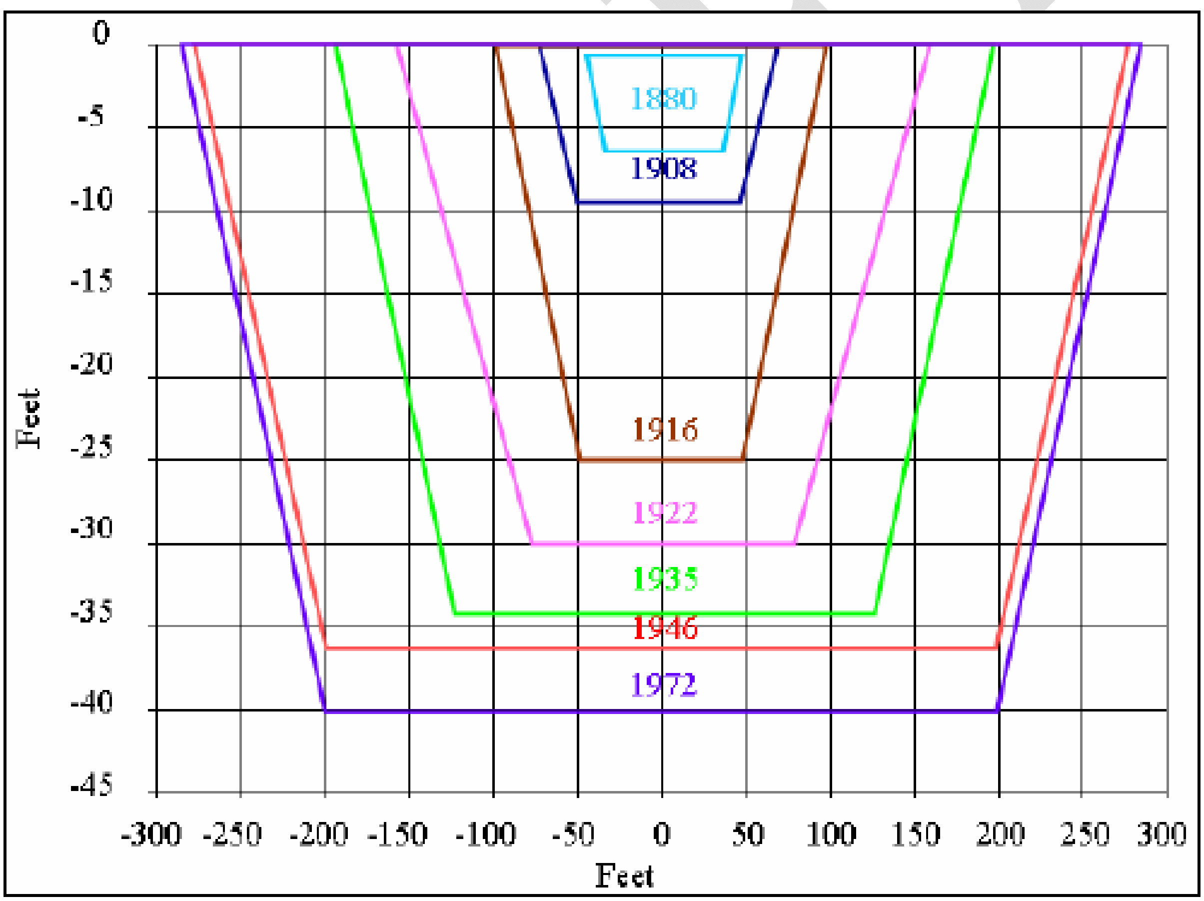

Figure O-3. Historical Channel Dimensions of the Sabine-Neches Ship Channel (Source: LCWCRTF, 2002)

Saline water from the Gulf of Mexico travels up the Sabine-Neches channel, resulting in an atypical estuarine salinity gradient. Construction of the Sabine-Neches Ship Channel and the deepening of both rivers, in conjunction with increased withdrawals of freshwater upstream for industry and agriculture, have resulted in major changes in system hydrology and saltwater intrusion in both Texas and Louisiana. The channel also funnels freshwater inflows more directly to the Gulf, largely bypassing the adjacent marshes in Louisiana and Texas (LCWCRTF, 2002).

c. The Gulf Intracoastal Waterway. The GIWW from the Sabine River to the Calcasieu River was constructed in 1913-1914 with a width of 40 feet and a depth of 5 feet. In 1925, the channel was enlarged to 100 feet wide by 9 feet deep. Prior to the deepening of the Calcasieu Ship Channel in the late 1930s, the GIWW reach from the Sabine River to the Calcasieu River was deepened to 30 feet to facilitate navigation to the Port of Lake Charles. This section was then known as the Lake Charles Deep Water Channel. In 1941, the channel was thereafter maintained as part of the GIWW, at a depth of 12 feet and a width of 125 feet (USDA, 1994, in LCWCRTF, 2002).

Construction of the GIWW significantly altered regional hydrology by connecting the two major ship channels. Prior to the construction of the GIWW, the Calcasieu and Sabine estuaries were mostly distinct and were more influenced by the Calcasieu and Sabine Rivers, respectively. The Gum Cove Ridge once separated the Sabine Basin from the Calcasieu Basin, with little water exchange between the two. Removing the mouth bars and deepening the Calcasieu and the Sabine-Neches channels, as well as the GIWW and interior canals bisecting the Gum Cove Ridge, dramatically altered the hydrology of what were once separate basins, merging them into the present-day Calcasieu-Sabine Basin. In addition to effectively combining the two basins, the GIWW cut off all the natural bayous and upland sheet flow that historically affected marshes, and channelized more freshwater inflow to the Gulf of Mexico (LCWCRTF 2002).

B. Present Action - Land Management and Wetland Restoration

1. Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Numerous land stewardship projects have been implemented in the Calcasieu- Sabine basin to help restore its estuaries and protect its shoreline. Table O-1 lists completed and ongoing restoration and management projects in the basin funded by CWPPRA. These projects have or are expected to have beneficial impacts on natural resources in the study area. The CWPPRA was the first Federal statutory mandate for restoration of Louisiana’s coastal wetlands. As of May 2013, 196 active CWPPRA projects have been approved, 99 have been constructed, 20 are under construction, and 43 have been de-authorized or transferred to other programs. Many of these projects have occurred in the Calcasieu River and Ship Channel project area, located mainly in Calcasieu Lake.

Table O-1. CWPPRA Restoration Sites for the Calcasieu-Sabine Basin
(Source: http://lacoast.gov/new/Projects/List.aspx)

Agency	Project Name	Type	Net Benefit After 20 Years (acres)
NRCS	Black Bayou Culverts Hydrologic Restoration	Hydrologic Restoration	540
NMFS	Black Bayou Hydrologic Restoration	Hydrologic Restoration	3,594
NRCS	Brown Lake Hydrologic Restoration	Hydrologic Restoration	282
USFWS	Cameron Creole Plugs	Hydrologic Restoration	865
NMFS	Cameron Meadows Marsh Creation and Terracing	Marsh Creation, Terracing	264
NRCS	Cameron-Creole Freshwater Introduction	Freshwater Diversion	473
NRCS	Cameron-Creole Maintenance	Hydrologic Restoration	2,602
USFWS	Cameron-Creole Watershed Grand Bayou Marsh	Marsh Creation	534
Corps	Clear Marais Bank Protection	Shoreline Protection	1,067
NRCS	East Mud Lake Marsh Management	Marsh Management	1,520
USFWS	East Sabine Lake Hydrologic Restoration	Hydrologic Restoration	225
NRCS	GIWW - Perry Ridge West Bank Stabilization	Shoreline Protection	83
NRCS	Highway 384 Hydrologic Restoration	Hydrologic Restoration	150
NRCS	Holly Beach Sand Management	Shoreline Protection	330
NRCS	Kelso Bayou Marsh Creation	Marsh Creation	274
NMFS	Oyster Bayou Marsh Restoration	Marsh Creation, Terracing	489
NRCS	Perry Ridge Shore Protection	Shoreline Protection	1,203
NRCS	Plowed Terraces Demonstration	Sediment and Nutrient Trapping, Demo	N/A
USFWS	Replace Sabine NWR Water Control Structures at HQ Canal, W Cove Canal, and Hog Island Gully	Marsh Management	953
USFWS	Sabine NWR Erosion Protection	Shoreline Protection	5,542
Corps	Sabine NWR Marsh Creation, Cycle 1	Marsh Creation	214
Corps	Sabine NWR Marsh Creation, Cycle 2	Marsh Creation	261
Corps	Sabine NWR Marsh Creation, Cycle 3	Marsh Creation	187
Corps	Sabine NWR Marsh Creation, Cycle 4	Marsh Creation	163
Corps	Sabine NWR Marsh Creation, Cycle 5	Marsh Creation	168
NRCS	Sweet Lake/Willow Lake Hydrologic Restoration	Shoreline Protection	5,796
NRCS	West Hackberry Vegetative Planting Demonstration	Vegetative Planting Demo	N/A

NRCS – Natural Resources Conservation Service
NMFS - National Marine Fisheries Service
USFWS – US Fish & Wildlife Service

2. Coastal Impact Assistance Program (CIAP). An Environmental Assessment has recently been completed by the Corps for the Black Lake (Marcantel) property. The Port and the state received CIAP funds and the Minerals Management Service (now the Bureau of Ocean Energy Management) agreed that such funds could be used as gratuitous contribution for 100 percent incremental cost for the beneficial use of dredged material at Black Lake. The Finding of No Significant Impact was signed November 7, 2008. This disposal site would restore approximately 350 acres of eroded marsh approximately 1 mile south of the GIWW, along the former northern/northwestern rim of Black Lake. The general purpose of the project would be to create a diversity of habitat from beneficially used dredged material from maintenance of the Calcasieu Ship Channel.

C. Reasonably Foreseeable Future Actions. The Corps anticipates continuing maintenance of the Calcasieu Lock indefinitely. Other reasonably foreseeable future actions, which may contribute to cumulative impacts, include:

1. Calcasieu River and Pass Navigation Dredged Material Management Plan (DMMP). The project was authorized by the River and Harbors Act of 1946 and subsequent amendments. The DMMP was being developed under the Operations & Maintenance of the Calcasieu River and Pass project. Dredged material management planning for all Federal harbor projects is conducted by the Corps to ensure that maintenance dredging activities are performed in an environmentally acceptable manner, use sound engineering techniques, are economically warranted, and that sufficient confined disposal facilities are available for at least the next 20 years. These plans address dredging needs, disposal capabilities, capacities of disposal areas, environmental compliance requirements, and potential for beneficial use of dredged material, and indicators of continued economic justification. The Corps anticipates continuing maintenance dredging of the Calcasieu Ship Channel indefinitely. The Final Report and Supplemental Environmental Impact State was completed in November 2010. It identified 23 disposal sites from Lake Charles to the Gulf along with 6 beneficial use sites. Two placements sites are near the Calcasieu Lock Project

2. Coastal Wetlands Planning, Protection and Restoration Act. It is anticipated that additional CWPPRA projects would be implemented in the vicinity of Calcasieu Lake.

3. Coastal Impact Assistance Program. The CIAP was originally authorized by Congress in 2001 in the Outer Continental Shelf (OCS) Lands Act, as amended (31 U.S.C. 6301-6305). Section 384 of the Energy Policy Act of 2005 (Public Law 109-58) authorized CIAP funds to be distributed to OCS oil and gas producing states to mitigate the impacts of OCS oil and gas activities for fiscal years 2007 through 2010. The state liaison for this program is the Louisiana Department of Natural Resources. The CIAP allocations have been used to fund various state and local coastal activities and projects including: monitoring, assessment, research, and planning; habitat, water quality, and wetland restoration; coastline erosion control; and control of invasive non-native plant and animal species.

4. Construction of a General Anchorage in the Calcasieu Ship Channel. Deep-draft vessel traffic on the Calcasieu Ship Channel suffers costly delays due to the width of the inland reach of the ship channel, which prohibits most deep-draft vessels from passing head-on in the channel. These delays are exacerbated by liquefied natural gas (LNG) vessel traffic, which cannot meet and pass in the ship channel, including the 32-mile long Gulf reach. The Corps undertook a feasibility study to construct anchorage areas along the channel where deep-draft vessels can layover closer to their destinations and to provide passing lanes where non-LNG vessels can meet and pass closer to their destinations. The study looked at a number of alternatives, including anchorage areas at RM 26 and 29, and a combination of both. The study recommended building an anchorage at RM 29. The data and findings were turned over to the Port in January 2011. At that time, the Port decided to terminate the study and pursue construction on its own due to the low cost of construction ($5.5M) and the time it may take to get the project

5. Construction of New LNG Terminals. Onshore regasification facilities that use imported LNG have been in existence in the U.S. since 1969. However, only four were constructed, the largest of which is the Trunkline facility. Two new LNG facilities have been approved by the Federal Energy Regulatory Commission to be constructed in the project area: the Cameron LNG, owned by Sempra Energy, and the Creole Trail LNG, owned by Cheniere LNG. Future installation of LNG terminals should be evaluated for environmental impacts and required mitigation.

6. The Trans-Texas Water Program. The 1968 Texas Water Plan was prepared by the Texas Water Development Board as a comprehensive 50-year plan for securing the future water supply needs of the State of Texas. Recommendations for the program include the transfer of surplus "state" waters from basins having surplus supplies to basins that experience water shortages. The Sabine River was identified as one source of freshwater for southeast Texas. Potential adverse effects of altering river inflows to the Sabine Basin should be mitigated or avoided.

7. Rycade Canal Hydrologic Restoration Project. The Rycade Canal project (C/S-02) is a semi-impounded marsh management project located in Cameron Parish, Louisiana. The project area consists of approximately 6,575 acres of brackish marsh in and adjacent to the Sabine NWR in Cameron Parish. Rycade Canal, built in the 1940s as an oil well location canal, is an avenue for salt water from the GIWW via Black Lake, and from the Calcasieu Ship Channel via Hog Island Gully. The project objectives are to protect low salinity marsh by reducing rapid water fluctuations and water circulation patterns that encourage salt water intrusion and tidal scouring, and reestablish historic hydrologic boundaries and flow patterns by structural repairs, levee repair/reconstruction, and embankment repair on the GIWW.

8. Southwest Coastal Louisiana Feasibility Study. The WRDA of 2007 authorized funding for a number of coastal restoration and hurricane protection projects in the Louisiana Coastal Area. Section 7010 included the *Southwest Coastal Louisiana Hurricane and Storm Damage Reduction Study*. A reconnaissance study completed in 2007, which recommended levee alternatives, was broadened in focus by the state and the Corps to include both levee and restoration alternatives. The Corps and the state have agreed to cost-share a feasibility study that will include building levees and undertaking coastal restoration projects to protect populated areas in Vermilion, Calcasieu, and Cameron Parishes while improving wildlife habitat. The Study will include an environmental impact statement engineering appendix with baseline cost estimates, and other supporting appendices documenting the formulation of hurricane protection and coastal restoration alternatives. The feasibility study is scheduled to produce a Chief's report in September 2014. The proposed action is likely to be based on some combination of flood risk management and ecosystem restoration projects. This represents the first time a coastal protection and hurricane protection study has been undertaken for Southwest Louisiana.

9. Section 204 Study, Calcasieu River and Pass Project, Mile 5-14. The WRDA 2007 provided for the funding of a Continuing Authorities Program (CAP) study under Section 204 of WRDA

1992 to use the material from maintenance dredging to restore/rehabilitate estuarine marsh habitat along the eastern shore of Lake Calcasieu. The CAP 204 program would be used to pay the incremental costs between the Federal standard and the beneficial use of the same material. Several potential sites have been identified for the receipt of material dredged from the Calcasieu River and Pass, Louisiana Project between channel miles 5.0 and 14.0. Sites covered by the 2010 proposed Dredged Material Management Plan/SEIS for Calcasieu River and Pass would be eliminated from consideration for the CAP 204 project, as those would become part of the definition of the Federal standard. A feasibility study conducted by MVN is currently ongoing.

10. *Louisiana's 2012 Coastal Master Plan,* 2012. The Master Plan was developed to fulfill the mandates of Act 8, which was passed by the Louisiana Legislature in November 2005. The Act created the Coastal Protection and Restoration Authority of Louisiana (CPRA) and charged it with coordinating the efforts of local, state, and Federal agencies to achieve long-term and comprehensive coastal protection and restoration. Act 8 also requires that the CPRA establish a clear set of priorities for making comprehensive coastal protection a reality in Louisiana. Toward that end, the CPRA set five major goals:

1. Present a conceptual vision for a sustainable coast.
2. Be a living document that changes over time as understanding of the landscape improves and technical advances are made.
3. Emphasize sustainability of ecosystems, flood protection, and communities.
4. Integrate flood control projects and coastal restoration initiatives to help both human and natural communities thrive over the long-term.
5. Be clear about unknowns. There is a need for additional scientific and technical advancements to better predict the future of the coast.

In 2007 a Comprehensive Plan was developed. Per the authorizing legislation, the Master Plan was updated in 2012. The Plan identifies hundreds of projects across south Louisiana. Two primary factors drove the States decision about future projects that should be in the 2012 Coastal Master Plan.

1. How well did the projects reduce flood risk?
2. How well did the projects build new land or sustain the land we already have?

The Plan identifies four Bank Stabilization, four Hydraulic Restoration and two Marsh Creation Projects in the vicinity of Calcasieu Lock with most being in and around Calcasieu Lake and the GIWW channel. The Calcasieu Lock Feasibility Study does address one project in the Hydrologic Restoration category which calls for a new lock to manage Mermentau Basin flows. The Master Plan can be found http://www.coastalmasterplan.louisiana.gov/

V. INCREMENTAL EFFECTS OF THE PROPOSED PROJECT

Cumulative impacts associated with past actions have produced a natural environment that is markedly different from that of 140 years ago. However, the Calcasieu estuary is still a valuable ecosystem. The proposed project would maintain a saltwater barrier at the lock, would not affect the overall dimensions of the GIWW, and therefore would not exacerbate existing salinity issues. The proposed project would result in the loss of about 14 acres of marsh, but also includes the restoration or creation of about 35 acres of marsh through the placement of dredge material for beneficial use. The environmental effects of the proposed project would not contribute adverse increments to the cumulative effects of past, present, and reasonably foreseeable actions.

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

CALCASIEU LOCK LOUISIANA
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WETLAND VALUE ASSESSMENT
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APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

I. INTRODUCTION

This appendix describes the Wetland Value Assessments(WVA) that were developed for the Calcasieu Lock Feasibility Study. The Project area, located in Calcasieu Parish, southwestern Louisiana, is within the state's designated coastal zone.

There are three main types of habitat in the Project area. Coastal marsh, the predominant type, is represented by brackish marsh to the west of Louisiana Highway 384 (Big Lake Rd) and intermediate marsh to the east. These marshes consist of emergent vegetation interspersed with and bordered by shallow open water. Deeper areas of open water distinct from marsh are represented by the Gulf Intracoastal. Waterway (GIWW), Black Bayou, and smaller contiguous water bodies. All these habitats are aquatic. Lastly, a small component of terrestrial habitat occurs along the south side of the GIWW in the vicinity of the existing lock. This upland habitat consists of a linear forested spoil bank. It was created about 60 years ago during construction of the lock when dredged material was deposited and eventually colonized by volunteer plant species. The higher elevations of the spoil bank are forested (about half the area), whereas the lower elevations which border the trees consist of scrub-shrub vegetation.

The potential for all project alternatives to adversely affect any of these habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Natural Resources Conservation Service, and the US Army Corps of Engineers (Corps).

With regard to the project alternatives as a whole, there would be unavoidable impacts to brackish marsh, intermediate marsh, and forested spoil bank that were considered by the HET to be permanent and for which compensatory mitigation would be required to offset such losses. In contrast, potential impacts to deeper open water habitats like Black Bayou were not regarded as permanent by the HET and did not warrant any such mitigation.

Alternatives 1 and 2 would provide a new channel through which freshwater flows stemming from rainfall events over the Mermentau Basin to the east would be diverted around the existing Calcasieu Lock. Construction of this channel would result in unavoidable direct impacts to brackish marsh and forested spoil bank that require mitigation. Alternatives 3, 4, and-5 would use Black Bayou to divert freshwater flows through, and unavoidable direct impacts would occur to brackish and intermediate marsh.

II. METHODOLOGY

For the Calcasieu Lock project, the WVA methodology relies on the use of the Coastal Marsh and Chenier/Ridge Community Models, which were developed by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Environmental Work Group (EnvWG) to determine the suitability of marsh and open water habitats as well as chenier/ridge habitats in the Louisiana coastal zone. The purpose of the WVA is to define an optimal combination of habitat conditions for all fish and wildlife species living in Louisiana coastal marsh and chenier/ridge ecosystems. Section II.A. and Section II.B. explain the methodology used to develop the Coastal Marsh and Chenier/Ridge Community Models, respectively. These sections are excerpts from the CWPPRA EnvWG Wetland Value Assessment Methodology for the Coastal Marsh Community Models (Roy 2012, pages 13 - 27) and the Coastal Chenier/Ridge Community Model (Roy 2010, pages 1 – 4). Please refer to those documents for more information.

The WVA methodology and three models used in this analysis have been approved for use as planning tools for habitat impact assessment of water resource projects in coastal Louisiana that are proposed by the Corps (USACE, undated). The models used include the following:

- Fresh/Intermediate Coastal Marsh Community Model, version 1.1 (dated Nov 15, 2011; Roy 2012);
- Brackish Coastal Marsh Community Model, version 1.1 (dated Nov 15, 2011; Roy 2012);
- Coastal Chenier/Ridge Community Model, version 1.1 (dated Nov 18, 2011; Roy 2010).

A. Coastal Marsh Community Model

(The following italicized sections are excerpts from Roy, 2012)

1. Variable Selection. *The foundation of each coastal marsh community model is a suite of habitat variables deemed important to coastal fish and wildlife species. Variables were selected through a two-part procedure. The first involved a listing of environmental variables thought to be important in characterizing fish and wildlife habitat in coastal marsh ecosystems. The second part involved reviewing variables used in species-specific HSI models published by the U.S. Fish and Wildlife Service. Review was limited to HSI models for those fish and wildlife species known to inhabit Louisiana coastal wetlands, and included models for 10 estuarine fish and shellfish, 4 freshwater fish, 12 birds, 3 reptiles and amphibians, and 3 mammals* (Table P-1). *The number of models included from each species group was dictated by model availability and those selected are intended to represent a composite of the overall fish and wildlife community. Exclusion of certain species groups is not intended.*

Selected HSI models were then grouped according to the marsh type(s) used by each species. Because most species are not restricted to one marsh type, most models were included in more than one marsh type group. Within each wetland type group, variables from all models were then grouped according to similarity (e.g., water quality, vegetation, etc.). Each variable was evaluated based on 1) whether it met the variable selection criteria; 2) whether another, more easily measured/predicted variable in the same or a different similarity group functioned as a surrogate; and 3) whether it was deemed suitable for the WVA application (e.g., some freshwater fish model variables dealt with riverine or lacustrine *environments). Variables that did not satisfy those conditions were eliminated from further consideration. The remaining variables, still in their similarity groups, were then further eliminated or refined by combining similar variables and/or culling those that were functionally duplicated by variables from other models (i.e., some variables were used frequently in different models in only slightly different format).*

Table P-1. *HSI Models Consulted for Variables for Possible Use in the Coastal Marsh Models*

Estuarine Fish and Shellfish	***Birds***	***Mammals***	***Freshwater Fish***	***Reptiles and Amphibians***
Pink Shrimp	*White-fronted Goose*	*Mink*	*Channel Catfish*	*Slider Turtle*
White Shrimp	*Clapper Rail*	*Muskrat*	*Largemouth Bass*	*American Alligator*
Brown Shrimp	*Great Egret*	*Swamp Rabbit*	*Redear Sunfish*	*Bullfrog*
Spotted Seatrout	*Northern Pintail*		*Bluegill*	
Gulf Flounder	*Mottled Duck*			
Southern Flounder	*American Coot*			
Gulf Menhaden	*Marsh Wren*			
Juvenile Spot	*Snow Goose*			
Juvenile Atlantic Croaker	*Great Blue Heron*			
Red Drum	*Laughing Gull*			
	Red-winged Blackbird			
	Roseate Spoonbill			

Source: Roy, 2012

Variables selected from the HSI models were then compared to those identified in the first part of the selection procedure to arrive at a final list of variables to describe wetland habitat quality. That list includes six variables for each marsh type; 1) percent of the wetland area covered by emergent vegetation, 2) percent open water covered by submerged aquatic vegetation, 3) marsh edge and interspersion, 4) percent of the open water area $\leq$ 1.5 feet deep, 5) salinity, and 6) aquatic organism access.

2. Suitability Index (SI) Graph Development. *Each model contains Suitability Index graphs for each variable. SI graphs are unique to each variable and define the relationship between that variable and habitat quality. A variety of resources was utilized to construct each SI graph, including the HSI models from which the final list of variables was partially derived, consultation with other professionals and researchers outside the EnvWG, published and unpublished data and studies, and personal knowledge of EnvWG members. A review of contemporary, peer-reviewed scientific literature was also conducted for each of the variables, providing ecological support for the form of the SI graph for each of the variables. The process of SI graph development was one of constant evolution, feedback, and refinement; the form of each SI graph was decided upon through consensus among EnvWG members.*

Nearly all of the SI graphs have a minimal SI of 0.1. This is because any area that falls into the cover types addressed by the WVA models provides some habitat value. For example, areas consisting of 100% open water have habitat value to many species of fish and wildlife. Likewise, if an area has no submerged aquatic vegetation, it still has habitat value. Even open water areas with no shallow water

(<=1.5 feet) still have habitat value as deep open water can serve as drought refugia for fish and alligators.

The Suitability Index graphs were developed according to the following assumptions:

Variable V_1 - Percent of Wetland Area Covered by Emergent Vegetation. *Persistent emergent vegetation (i.e., emergent marsh) plays an important role in coastal wetlands by providing foraging, resting, and breeding habitat for a variety of fish and wildlife species; and by providing a source of detritus and energy for lower trophic organisms that form the basis of the food chain. An area with no emergent vegetation (i.e., shallow open water) is assumed to have minimal habitat suitability in terms of this variable, and is assigned an SI of 0.1. Optimal vegetative coverage (i.e., percent marsh) is assumed to occur at 100 percent (SI=1.0). That assumption is dictated primarily by the constraint of not having graph relationships conflict with CWPPRA's purpose of long-term restoration and protection of vegetated wetlands. The EnvWG originally developed a strictly biologically-based graph defining optimal habitat conditions at marsh cover values between 50 and 70 percent, and sub-optimal habitat conditions outside that range. However, application of that graph, in combination with the time analysis used in the evaluation process (i.e., 20-year project life), often reduced project benefits or generated a net loss of habitat quality through time with the project. Those situations arose primarily when: existing (baseline) emergent vegetation cover exceeded the optimum (>70 percent); the project was predicted to maintain baseline cover values; and without the project the marsh was predicted to degrade, with a concurrent decline in percent emergent vegetation into the optimal range (50-70 percent). The time factor worsened the situation when the without-project degradation was not rapid enough to reduce marsh cover values significantly below the optimal range, or below the baseline SI, within the 20-year evaluation period. In those cases, the analysis would show net negative benefits for the project, and positive benefits for allowing the marsh to degrade rather than maintaining the existing marsh. Coupling that situation with the presumption that marsh conditions are not static*; Louisiana is losing marsh faster than any other place in the U.S. – one football field of marsh becomes water about every 30 minutes (Final Programmatic EIS for the LCA Ecosystem Restoration Study, 2004); and taking into account the purpose of CWPPRA, the EnvWG decided that, all other factors being equal, the models should favor projects that maximize marsh creation, maintenance, and protection. Therefore, the EnvWG agreed to deviate from a strictly biologically-based habitat suitability index graph for V_1 and established optimal habitat conditions at 100 percent marsh cover.

In each coastal marsh model, this variable is weighted the highest and thus influences project benefits the most. Of the six variables, future projections for V1 require the most thought and are usually discussed at length during the WVA process.

FWOP projections for V1 typically involve applying the baseline land loss rate to the existing marsh acreage for the project lifespan. Whichever method is selected, a spreadsheet which calculates land loss annually should be used. Under some FWOP scenarios, that loss rate may be increased or decreased depending on expected changes in the project area. The effects of salinity, subsidence, erosion, breaching of a shoreline/bank, constructed projects in the area, future projects in the area, and any other factor which may alter the loss rate should be considered. The evaluation should include a TY when those changes are expected to occur.

FWP projections should address the changes expected to occur as a result of project implementation. The effects of the project on salinity, subsidence, nutrient availability, sediment availability, and any other factor affecting marsh loss should be considered. The planner should carefully consider the causes of loss in the area and the effects of the project on those causes. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area. In some instances, best professional judgment provides the only basis for future projections. However, supporting data and other information should be thoroughly reviewed before relying solely on best professional judgment.

The EnvWG has adopted V1 conventions for certain project types. Although these conventions are generally applied, exceptions are sometimes proposed and may be accepted by the group. It is the responsibility of the project planner to provide justification in the Project Information Sheet for deviating from these conventions.

[The project types for which conventions have been developed include marsh creation, marsh nourishment, shoreline protection, diversions, and crevasses. Conventions for marsh creation only are presented here, since that is the only type applicable to this project]:

> <u>*Marsh Creation*</u> *– Marsh creation involves filling open water areas with dredged sediment to create marsh. Therefore, only the open water acres filled with sediment within the project area are considered as marsh creation. Emergent marsh which is covered with dredged material is considered as marsh nourishment and treated separately. Elevation (as surrogate for hydroperiod) and plant colonization are guiding factors for assignment of marsh functionality. At TY1, marsh creation projects typically receive credit for 25% of the created area if vegetative plantings are included as a project component and implemented in TY1. It is assumed that a standard vegetative planting design (10'X5' spacing), will yield 25% coverage at the end of TY1 (i.e., after one growing season). Even with vegetative plantings, coverage is not sufficient at TY1 for the entire marsh platform to be given credit as fully functional marsh. At TY3, it is assumed that containment dikes have degraded (i.e., naturally or by mechanical means) and that the marsh platform has vegetated and consolidated to the point where it can achieve minimum wetland functions as necessary for the overall fish and wildlife community. The entire marsh platform receives full credit at that time. If vegetative plantings are not included as a project component, then 10% credit is applied at TY1, 30% at TY3, and 100% credit at TY5. If design information (e.g., settlement curves) indicates higher elevations will prevail, full functionality will be delayed.*
>
> *Exceptions to these conventions are sometimes applied such as when the project area is located within a fresh system such as the Atchafalaya or Mississippi River deltas. Fresh environments can often naturally vegetate much more rapidly than brackish or saline areas, especially within river deltas.*
>
> *The inclusion of tidal creeks (dredged prior to or after construction) also increases functional marsh credit. Tidal creeks provide greater connectivity, increased edge, and overall greater habitat diversity. If the acreage of tidal creeks is at least 2% of the marsh platform, then functional marsh credit is increased from 30% to 35% at TY3 for unplanted sites. To avoid penalizing a project for the addition of this beneficial feature, the tidal creek acreage is not subtracted from the acreage of marsh when calculating the percent marsh value for V1.*

> *Doing so would negate the benefits received from the increase in functional marsh credit at TY3.*
>
> *Typically, a 50% reduction in the FWOP marsh loss rate is applied to marsh creation projects under FWP. It is assumed that the higher elevation and better soil conditions of the created marsh provide for a more resilient marsh which will be lost at a reduced rate. To date, CWPPRA marsh creation projects have performed well in terms of marsh loss. However, most CWPPRA marsh creation projects are early in their project life and little can be said regarding long-term performance. To assess performance over time, a frequency of inundation analysis may be conducted if sufficient data are available.*
>
> *Note: The above assumptions may not suffice for non-CWPPRA projects evaluated over a 50-year project life when sea level rise and subsidence have a greater impact on project performance or when the project premise is compensatory mitigation to ensure no net loss of habitat.*

Variable V_2 - Percent Open Water Covered by Submerged Aquatic Vegetation (SAV). *The baseline (TY0) value for this variable often cannot be estimated in coastal Louisiana via visual estimates of cover because turbidity generally is great enough to obscure SAV even when SAV almost covers pond bottoms (e.g. Merino et al. 2005). SAV abundance varies so much that neither estimates of biomass (via cores) nor objective measures of percent cover (estimated from presence/absence on a garden rake touched at numerous points across a pond) are effective alone. Biomass estimates are preferred but estimating biomass is inefficient when SAV beds are small and few. At the other end of the spectrum, estimating the percent of pond bottom covered by SAV fails to provide meaningful information when SAV beds cover virtually the entire pond bottom but plant stature varies spatially. Furthermore, SAV is temporally dynamic in coastal Louisiana with great differences among years (Nyman and Chabreck 1996) and within years but lacks seasonal patterns within years (Merino et al. 2005). For these reasons, the WVA often utilizes best professional judgment along with whatever data is available to generate input data for SAV. Greater emphasis is placed on salinity and marsh type, as indicated by the observations of Chabreck (1971), with secondary emphasis placed on turbidity as indicated by the observations that terraces improve water clarity and increase SAV abundance (Bush Thom et al. 2004, O'Connel and Nyman in press).*

Fresh and intermediate marshes often support diverse communities of floating-leaved and submerged aquatic plants that provide important food and cover to a wide variety of fish and wildlife species. A fresh/intermediate open water area with no aquatics is assumed to have low suitability (SI=0.1). Optimal conditions (SI=1.0) are assumed to occur when 100 percent of the open water is dominated by aquatic vegetation. Habitat suitability may be assumed to decrease with aquatic plant coverage approaching 100 percent due to the potential for mats of aquatic vegetation to hinder fish and wildlife utilization; to adversely affect water quality by reducing photosynthesis by phytoplankton and other plant forms due to shading; and contribute to oxygen depletion spurred by warm-season decay of large quantities of aquatic vegetation. The EnvWG recognized, however, that those effects were highly dependent on the dominant aquatic plant species, their growth forms, and their arrangement in the water column; thus, it is possible to have 100 percent cover of a variety of floating and submerged aquatic plants without the above-mentioned problems due to differences in plant growth form and stratification of plants through the water column. Because predictions of which species may dominate at any time in the future would be tenuous, at best, the EnvWG decided to simplify the graph and *define optimal conditions at 100 percent SAV cover.*

Brackish marshes also have the potential to support aquatic plants that serve as important sources of food and cover for several species of fish and wildlife. Although brackish marshes generally do not support the amounts and kinds of aquatic plants that occur in fresh/intermediate marshes, certain species, such as widgeon-grass, and coontail and milfoil in lower salinity brackish marshes, can occur abundantly under certain conditions. Those species, particularly widgeon-grass, provide important food and cover for many species of fish and wildlife. Therefore, the V_2 *Suitability Index graph in the brackish marsh model is identical to that in the fresh/intermediate model.*

Some low-salinity saline marshes may contain beds of widgeon-grass and open water areas behind some barrier islands may contain dense stands of seagrasses (e.g., Halodule wrightii and Thalassia testudinum). However, saline marshes typically do not contain an abundance of aquatic vegetation as often found in fresh/intermediate and brackish marshes. Open water areas in saline marshes typically contain sparse aquatic vegetation and are primarily important as nursery areas for marine organisms. Therefore, in order to reflect the importance of those open water areas to marine organisms, a saline marsh lacking aquatic vegetation is assigned a SI=0.3. It is assumed that optimal coverage of aquatic plants occurs at 100 percent.

Future projections for V2 should consider changes in salinity, freshwater introduction, nutrient input, turbidity, water depth, fetch, and other factors which affect SAV growth. Perhaps the two most important factors to consider under FWOP and FWP conditions are salinity and nutrient input as SAV growth is highly dependent on each of those factors. Few standard conventions have been adopted for projecting V2. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Variable V_3 ***- Marsh Edge and Interspersion.*** *This variable takes into account the relative juxtaposition of marsh and open water for a given marsh:water ratio. The baseline (TY0) value for this variable is determined by examining recent aerial photography of the project area and comparing it to the interspersion classes illustrated* in figures P-1 through P-4. T*he project area may be divided into different interspersion classes as many areas contain more than one class. As with all variables, the baseline interspersion classes are discussed by the group and there is usually a group examination of the aerial photos.*

Interspersion is especially important when considering the value of an area as foraging and nursery habitat for freshwater and estuarine fish and shellfish and associated predators (e.g., wading birds); the marsh/open water interface represents an ecotone where prey species often concentrate, and where post-larval and juvenile organisms can find cover. Isolated marsh ponds are often more productive in terms of aquatic vegetation than are larger ponds due to decreased turbidity, and, thus, may provide more suitable waterfowl habitat. However, certain interspersion classes can be indicative of marsh degradation, a factor taken into consideration in assigning suitability indices to the various interspersion classes.

A relatively high degree of interspersion in the form of tidal channels and small ponds (Class 1) is assumed to be optimal (SI=1.0); tidal channels and small ponds offer interspersion, yet are not indicative of active marsh deterioration. Numerous small marsh ponds (Class 2) offer a high degree of interspersion, but can be indicative of the onset of marsh break-up and deterioration, and are *therefore assigned a lower SI of 0.6.*

Large ponds (Class 3) and open water areas with little surrounding marsh (Class 4) offer lower interspersion values and usually indicate advanced stages of marsh loss. Therefore, Classes 3 and 4 are assigned SIs of 0.4 and 0.2, respectively. Also grouped within Class 3 are areas of "carpet" marsh which contain no or relatively insignificant tidal channels, creeks, trenasses, ponds, or other features of interspersion but may still provide habitat for aquatic organisms during tidal flooding.

Terrace fields are typically constructed in areas generally classified as Class 4 or Class 5. The addition of terraces can significantly increase the amount of marsh edge and interspersion. Depending on the distance between terrace rows, the addition of terraces can result in areas classified as Class 4/5 improving to Class 3. If the distance between terrace rows is 300 feet or less, the EnvWG assigns a Class 3 designation. Terrace rows spaced greater than 300 feet apart do not receive a Class 3 designation and will likely be classified as Class 4.

Class 5 is characterized as a very advanced stage of marsh deterioration consisting of small marsh islands (i.e., a range of 0% to 10% marsh) or areas made up entirely of open water. Habitat of this type provides little to no marsh edge and its function as nursery habitat for marine organisms or foraging habitat for avian predators has been significantly reduced. Although habitats represented by this classification are predominantly unvegetated open water areas, they still provide habitat for many fish and shellfish species and provide loafing areas for waterfowl and other waterbirds. Class 5 is assigned an SI of 0.1. Also grouped within Class 5 are areas characterized as solid land with no interspersion features and little to no vegetation. Newly created marsh with no ponds, creeks, or other tidal features would fall within this class.

Future projections for this variable can be difficult. It requires the project planner to develop a mental picture of what the project area will look like after 20 years (and for intermediate years) of marsh loss under FWOP and also under improved conditions for FWP. One technique which may assist with that process is reviewing aerial photos of other areas with similar conditions to those projected.

There are a few standard conventions which have been adopted for this variable. The percentages of marsh and open water can sometimes be used to determine the amount of the project area to assign to each interspersion class. For example, if an area is 50% marsh and 50% open water and the water area is large and contiguous, then the area could be classified as 40% Class 1 and 60% Class 4. A small amount of marsh is included within or around the large open water area associated with Class 4; thus, 60% of the area is characterized as Class 4. Assignment of interspersion Class 5 should be reserved for those areas which are entirely open water or contain a very small percentage of marsh (< 5%).

Marsh creation/nourishment projects are assigned Class 5 (i.e., no interspersion) at TY1, Class 3 (i.e., marsh platform with little interspersion features) at TY3, and Class 1 at TY5. Incorporation of tidal creeks and ponds may expedite the level of interspersion assigned after TY1.

Figure P-1. Marsh Edge and Interspersion Class 1 (Roy, 2012)

Figure P-2. Marsh Edge and Interspersion Class 2 (Roy, 2012)

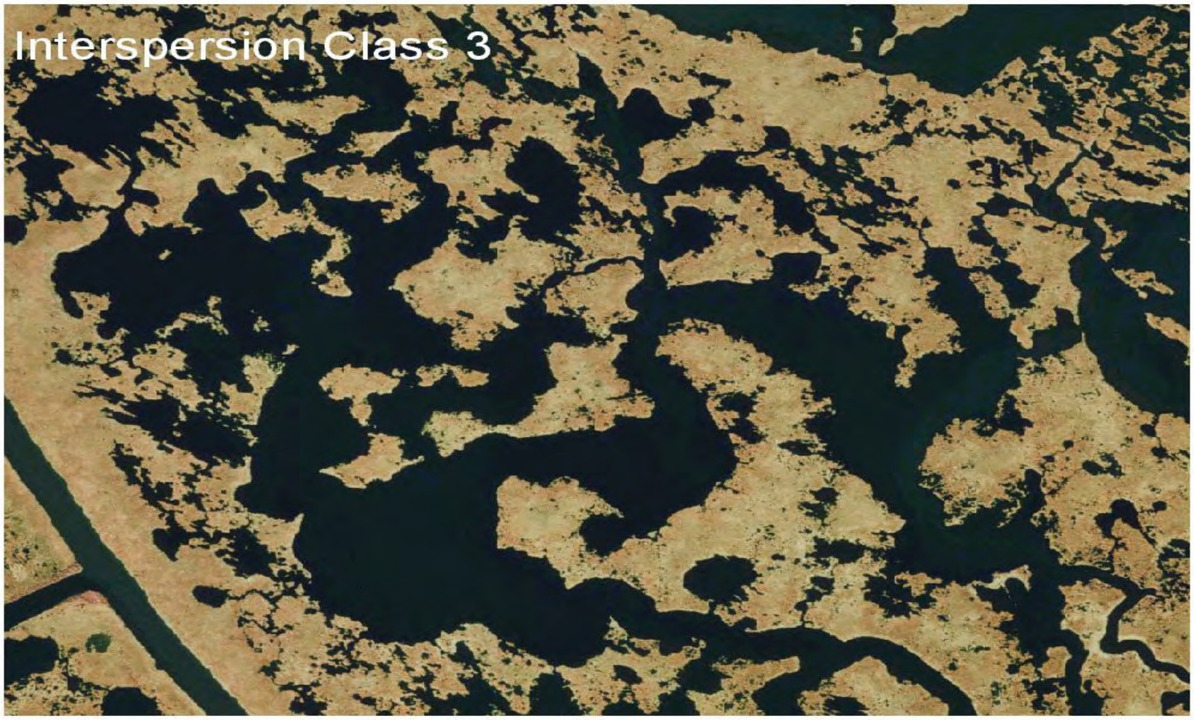

Figure P-3. Marsh Edge and Interspersion Class 3 (Roy, 2012)

Figure P-4. Marsh Edge and Interspersion Class 4 (Roy, 2012)

Variable 4 - Percent of the Open Water Area <= 1.5 Feet Deep. *This variable is the water depth based on the average water elevation in the project area. The baseline (TY0) value for this variable is usually determined based on data from field investigations, from elevation surveys, or from the personal knowledge of project planners, landowners, or land managers in the area. Water level data from staff gages or continuous recorders should be used whenever possible to determine the average water elevation, in the project area. Water depths should be recorded during the site visit at multiple locations throughout the project area. In many cases, the water depths recorded during the site visit can then be used with the water elevation data from the closest recording station for the same date and time as the site visit to determine the approximate bottom elevation. This will allow for an estimate of the depths in the project area with an average water elevation.*

A time series (~3 years) of water level data from a recording station (in the project area or close by) can be used to produce a cumulative distribution curve of the observed water levels. The water depths observed during the project site visit can then be placed in the overall water level frame. For example, if the measured depths were 2.5 feet and the site visit occurred during a time when the water levels were 1.0 foot higher than average, then the water depths under average conditions would be 1.5 feet. Previous WVAs for other projects in the area can also be helpful.

Future projections for V4 should consider marsh loss trends, the historic formation of open water habitat in the project area, subsidence, tidal exchange, sedimentation, and other factors which affect water depths. Few standard conventions have been adopted for projecting V4. One convention that has been adopted is the addition of a subsidence rate to the water depth measurements to determine a value for TY20 under FWOP. Subsidence rates can be obtained from the Coast 2050 Supplemental Appendices (Louisiana Coastal Wetlands Conservation and Restoration Task Force 1999). Essentially, subsidence (e.g., 0.5 in/yr) will result in increased water depths, and thus less shallow open water, over the project life.

For shoreline protection projects, the existing slope along the shoreline is usually held constant during future years, making the calculation of this variable somewhat easier. Open water habitat $\leq$ 1.5 feet created by terraces or unconfined dredged material disposal should also be considered. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Shallow water areas are assumed to be more biologically productive than deeper water due to a general reduction in sunlight, oxygen, and temperature as water depth increases. Also, shallower water provides greater bottom accessibility for certain species of waterfowl, better foraging habitat for wading birds, and more favorable conditions for aquatic plant growth. Optimal open water conditions in a fresh/intermediate marsh are assumed to occur when 80 to 90 percent of the open water area is less than or equal to 1.5 feet deep. The value of deeper areas in providing drought refugia for fish, alligators and other marsh life is recognized by assigning an SI=0.6 (i.e., sub-optimal) if all of the open water is less than or equal to 1.5 feet deep.

Shallow water areas in brackish marsh habitat are also important. However, brackish marsh generally exhibits deeper open water areas than fresh marsh due to tidal scouring. Therefore, the SI graph is constructed so that lower percentages of shallow water receive higher SI values relative to fresh/intermediate marsh. Optimal open water conditions in a brackish marsh are assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep.

The SI graph for the saline marsh model is similar to that for brackish marsh, where optimal conditions are assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep. However, at 100 percent shallow water, the saline graph yields an SI= 0.5 rather than 0.6 as for the brackish model. That change reflects the increased abundance of tidal channels and generally deeper water conditions prevailing in a saline marsh due to increased tidal influences and the importance of those tidal channels to estuarine organisms.

Variable V_5 – Salinity. *The baseline (TY0) value for this variable is usually obtained from salinity data collected along the coast. Salinity data can be obtained from published research (e.g., Swenson and Turner 1998, Steyer, et al. 2008) and from a number of sources online:*

NOS:	*http://co-ops.nos.noaa.gov*
USGS:	*http://la.water.usgs.gov/*
USACE:	*http://www.mvn.usace.army.mil/eng/edhd/watercon.htm* *http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm* *http://www.mvn.usace.army.mil/ops/locks/OTHER_lock_stat.htm*
CWPPRA:	*http://sonris-www.dnr.state.la.us*
CRMS:	*http://sonris-www.dnr.state.la.us*

It is preferable to use time series data for a station within or close to the project area as opposed to data from a field investigation which provides a one-time observation. The chief concern is locating an appropriate station for use in the analysis. Analysis of open water salinity data from the Barataria system by Swenson and Turner (1998) indicated R-squared values of ~0.7 for stations 20 kilometers apart and ~0.95 for stations 5 kilometers apart. Assuming that a correlation of 0.7 is acceptable then stations should be within 20 kilometers of the site. This approach is based on the assumption that the salinity in the freely connected open water at the site is indicative of the salinity in the marsh. Wiseman and Swenson (1988) investigated the relationship between salinity and water levels in the marsh (using continuous recording instruments along a 75 meter edge-inland transect) to salinity and water levels in the adjacent channel. The marsh water levels were highly coherent (coherence squared values of 0.8 to 0.98) with the channel water levels across time scales from hours to days. The marsh salinities exhibited much lower coherences (coherence squared values were all less than 0.8 with many below 0.5). They concluded that although overbank flooding is the dominant mechanism for salt to enter the marshes (on time scales of days to weeks) this input is not a simple linear relationship. Based on this, it is preferable to use salinity records from the marsh system as opposed to adjacent open water sites whenever possible. Internal marsh water level and salinity data are available (online) from CWPPRA monitoring records and through the Coastwide Reference Monitoring system (CRMS).

The salinity data is usually available at several sampling scales ranging from continuous hourly to discrete monthly. The preferred data is the continuous hourly or daily (daily 8 am or daily summary) both of which are also useful for identifying shorter term salinity spikes that may be affecting the system. Regression analysis of daily and monthly mean salinity estimates calculated from daily 8 am readings to means calculated from hourly data resulted in R-square values greater than 0.9 for ten locations in the Barataria-Terrebonne system (Swenson and Swarzenski, 1995). They concluded that daily readings are adequate to characterize the system. The salinity data is then used to calculate the *annual mean or growing season mean using as long a record as possible (a minimum of three years is desirable).*

It is assumed that periods of high salinity are most detrimental in a fresh/intermediate marsh when they occur during the growing season (defined as March through November, based on dates of first and last frost contained in Natural Resources Conservation Service soil surveys for coastal Louisiana). Therefore, mean salinity during the growing season is used as the salinity parameter for the fresh/intermediate marsh model. Optimal conditions in fresh marsh are assumed to occur when mean salinity during the growing season is 0.5 parts per thousand (ppt) or less. Optimal conditions in intermediate marsh are assumed to occur when mean salinity during the growing season is 2.5 ppt or less.

For the brackish and saline marsh models, average annual salinity is used as the salinity parameter. The SI graph for brackish marsh is constructed to represent optimal conditions when salinities are between 0 ppt and 10 ppt. The EnvWG acknowledges that average annual salinities below 5 ppt will effectively define a marsh as fresh or intermediate, not brackish. However, the SI graph makes allowances for lower salinities to account for occasions when there is a trend of decreasing salinities through time toward a more intermediate condition. Implicit in keeping the graph at optimum for salinities less than 5 ppt is the assumption that lower salinities are not detrimental to a brackish marsh. However, average annual salinities greater than 10 ppt are assumed to be progressively more harmful to brackish marsh vegetation. Average annual salinities greater than 16 ppt are assumed to be representative of those found in a saline marsh, and thus are not considered in the brackish marsh model.

The SI graph for the saline marsh model is constructed to represent optimal salinity conditions at between 0 ppt and 21 ppt. The EnvWG acknowledges that average annual salinities below 10 ppt will effectively define a marsh as brackish, not saline. However, the suitability index graph makes allowances for lower salinities to account for occasions when there is a trend of decreasing salinities through time toward a more brackish condition. Implicit in keeping the graph at optimum for salinities less than 10 ppt is the assumption that lower salinities are not detrimental to a saline marsh. Average annual salinities greater than 21 ppt are assumed to be slightly stressful to saline marsh vegetation.

Future projections for this variable are very important in determining the benefits for wetland restoration projects. Salinity is one of the most important factors affecting coastal land loss and decreasing salinities is the goal of many restoration projects. Salinity projections often directly affect projections for percent emergent marsh and percent SAV coverage and indirectly affect projections for marsh edge/interspersion and percent shallow open water. Future projections should consider changes in freshwater introduction and distribution, changes in the hydrology of the project area, and any other factors which may affect salinities. Historical data from the project area and recent trends can assist with future projections, especially under FWOP conditions. Monitoring data from freshwater diversion projects (e.g., Caernarvon Freshwater Diversion or West Point a la Hache Siphons) can also be helpful in determining FWP conditions for diversion projects. Modeling conducted for various projects (e.g., Brown Lake Hydrologic Restoration, Black Bayou Hydrologic Restoration, Hydrologic Investigation of the Chenier Plain, Hopedale Hydrologic Restoration) and COE feasibility studies (e.g., Lower Atchafalaya River Re-Evaluation Study, Morganza to the Gulf) can also be helpful.

Projects which reduce salinities under FWP are typically given credit for doing so at TY1. Those projects typically include features to either reduce saltwater intrusion or introduce fresh water to the system, both of which would have an immediate effect. Few standard conventions have been adopted for projecting V5. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Variable V_6 - Aquatic Organism Access. *Access by estuarine aquatic organisms (i.e., transient and resident species), is considered to be a critical component in assessing the quality of a given marsh system. Additionally, a marsh with a relatively high degree of access by default also exhibits a relatively high degree of hydrologic connectivity with adjacent systems, and therefore may be considered to contribute more to nutrient exchange than would a marsh exhibiting a lesser degree of access. The SI for V6 is determined by calculating an "access value" based on the interaction between the percentage of the project area wetlands considered accessible by aquatic organisms during normal tidal fluctuations, and the type of man-made structures (if any) across identified points of ingress/egress (bayous, canals, etc.). Standardized procedures for calculating V6 have been established (refer to pages 60-63). It should be noted that access ratings for man-made structures were determined by consensus among EnvWG members and that scientific research has not been conducted to determine the actual access value for each of those structures. Optimal conditions are assumed to exist when all of the study area is accessible and the access points are entirely open and unobstructed.*

A fresh marsh with no access is assigned an SI=0.3, reflecting the assumption that, while fresh marshes are important to some species of estuarine fishes and shellfish, such a marsh lacking access continues to provide benefits to a wide variety of other wildlife and fish species, and is not without habitat value. An intermediate marsh with no access is assigned an SI=0.2, reflecting that intermediate marshes are somewhat more important to estuarine organisms than fresh marshes. The general rationale and procedure behind the V6 Suitability Index graph for the brackish marsh model is identical to that established for the fresh/intermediate model. However, brackish marshes are assumed to be more important as habitat for estuarine species than fresh/intermediate marshes. Therefore, a brackish marsh providing no access is assigned an SI of 0.1. The Suitability Index graph for aquatic organism access in the saline marsh model is the same as that in the brackish marsh model.

The baseline (TY0) value for this variable is determined by a standardized methodology described in the model documentation. *A field investigation of the project area and examination of aerial photos is usually necessary to determine the baseline access value. Previous WVAs for other projects can also be helpful.*

Future projections for V6 should consider changes in access routes under FWOP and FWP conditions. In most FWOP scenarios, the access value does not change from the baseline value. Access may change under FWP depending on what types of structures are built as part of project implementation.

[Standard conventions for determining V6 have been adopted for various project types, including hydrologic restoration/marsh management, marsh creation, and shoreline protection. Conventions for marsh creation only are presented below because this is the only type applicable to this project]:

Marsh Creation - Marsh creation projects consist of an elevated marsh platform and typically utilize containment dikes to contain dredged material, thus impacting fisheries access. Marsh creation projects are typically designed to settle to an intertidal elevation by TY3 or TY5 and containment dikes are breached upon project completion or by TY3. Therefore, marsh creation projects are typically assigned an access value of 0.0001 (i.e., no access) at TY1 as the elevation of the marsh platform and/or presence of containment dikes do not allow fisheries access. The access value would increase to 1.0 when (typically TY3) it is estimated that the platform will settle (i.e., based on project design settlement curves, if available) to an intertidal elevation and the containment dikes are breached.

3. Habitat Suitability Index Formulas. *For all marsh models, V1 receives the strongest weighting* (Table P-2). *The relative weights of V1, V2, and V6 differ by marsh model to reflect differing levels of importance for those variables between the marsh types. For example, the amount of aquatic vegetation was deemed more important in a fresh/intermediate marsh than in a saline marsh, due to the relative contributions of aquatic vegetation between the two marsh types in terms of providing food and cover. Therefore, V2 receives more weight in the fresh/intermediate HSI formula than in the saline HSI formula. Similarly, the degree of aquatic organism access was considered more important in a saline marsh than a fresh/intermediate marsh, and V6 receives more weight in the saline HSI formula than in the fresh/intermediate formula. As with the SI graphs, the HSI formulas were developed by consensus among the EnvWG members.*

Table P-2. *Relative Contribution (%) of Each Variable to the Marsh and Water HSI Equations and the Overall (Total) HSI Equation*

	Fresh/Intermediate			Brackish			Saline		
Variable	Marsh	Water	Total	Marsh	Water	Total	Marsh	Water	Total
V1	64.8%	0.0%	43.9%	59.8%	0.0%	43.2%	58.3%	0.0%	45.4%
V2	0.0%	58.3%	18.8%	0.0%	46.7%	13.0%	0.0%	22.2%	4.9%
V3	11.1%	7.4%	9.9%	11.1%	7.4%	10.1%	11.1%	7.4%	10.3%
V4	0.0%	7.4%	2.4%	0.0%	7.4%	2.1%	0.0%	7.4%	1.6%
V5	11.1%	7.4%	9.9%	11.1%	7.4%	10.1%	11.1%	7.4%	10.3%
V6	13.0%	19.4%	15.1%	17.9%	31.1%	21.6%	19.4%	55.6%	27.5%

Source: Roy, 2012

In order to ensure that the value of open water components of the marsh environments to fish and wildlife communities is appropriately represented in the model, a spilt model approach is utilized. The split model utilizes two HSI formulas for each marsh type; one HSI formula characterizes the emergent habitat within the project area and another HSI formula characterizes the open water habitat. The HSI formula for the emergent habitat contains only those variables important in assessing habitat quality for marsh (i.e., V1, V3, V5, and V6). Likewise, the open water HSI formula contains only those variables important in characterizing the open water habitat (i.e., V2, V3, V4, V5, and V6). Individual HSI formulas were developed for marsh and open water habitats for each marsh type.

As with the development of a single HSI model for each marsh type, the split models follow the same conventions for weighting and grouping of variables as previously discussed.

4. Benefit Assessment. *As previously discussed, the coastal marsh models are split into marsh and open water components and an HSI is determined for both. Subsequently, net AAHUs are also determined for the marsh and open water habitats within the project area. Net AAHUs for the marsh and open water habitat components must be combined to determine total net benefits for the project.*

The weighting of the open water and marsh components reflects the relative value of these environments for fish and wildlife in each marsh type. A weighted average of the net benefits (net AAHUs) for marsh and open water is calculated with the marsh AAHUs weighted proportionately higher than the open water AAHUs. The weighted formulas to determine net AAHUs for each marsh type are shown below. Table P-2 shows the overall value of each of the variables after weighting.

Fresh Marsh: $$\frac{2.1(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{3.1}$$

Brackish Marsh: $$\frac{2.6(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{3.6}$$

Saline Marsh: $$\frac{3.5(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{4.5}$$

(The following italicized sections are excerpts from Roy, 2010)

5. ***Subsidence and Sea Level Rise***. *Subsidence and sea level rise (SLR) are assumed to affect FWOP and FWP scenarios. For most CWPPRA project evaluations (e.g., those within interior coastal areas), it is assumed that historical wetland loss rates calculated from a recent time period (e.g., 1985 to 2010) adequately capture the effects of subsidence and SLR for the relatively short analysis period of 20 years. However, for barrier island project evaluations, measures of subsidence and SLR are incorporated into many of the analytical modeling tools (e.g., SBEACH) used to determine project performance.*

B. Coastal Chenier/Ridge Community Model

1. ***Variable Selection.*** *Several existing Habitat Suitability Index (HSI) models were considered for use in determining migratory landbird stopover habitat quality, including the models for roseate spoonbill, great egret, brown thrasher, swamp rabbit, veery and yellow warbler. However, the emphasis for all these models was breeding habitat requirements. None addressed the set of variables that were determined to be most pertinent to assessment of stopover habitat quality, where a variety of species with differing foraging strategies occupy the habitat for a relatively brief time period. Selection of the variables used for this model was based upon a review of available literature, interviews with specialists who have studied various aspects of migratory landbird ecology in coastal stopover habitats, and the field knowledge of those involved with development of this model.*

More than 80 species of neotropical migratory landbirds from at least eleven Families pass through Louisiana during the spring and fall (Sauer et al. 2000). At the peak of spring migration, it is estimated that as many as 50,000 birds per day per mile of coastline enter the state (Conner *and Day 1987). During favorable weather conditions, the majority of these birds will bypass small wooded areas embedded in coastal marsh and land in extensive forested areas north of the marshes, but during thunderstorms or other unfavorable conditions, a large percentage of these individuals may stop in these small coastal wood patches (Gauthreaux 1971). Identifying the optimal stopover habitat characteristics for such a varied group of birds is challenging. Martin (1980) stated that migrants often select habitats en route that superficially resemble their breeding habitat. Moore et al. (1995) concluded that spring migrants on the northern Gulf of Mexico coast preferentially select structurally diverse stopover sites, consisting of forested areas with mixed shrub layers, and that maintenance of plant species and structural diversity should be a goal at migratory landbird stopover sites. Similarly, Martin (1980) found that habitat structure in shelterbelt "island" habitat in the Great Plains influences migrant diversity and abundance. Robinson and Holmes (1984) determined that the diversity of bird species in terrestrial habitats is correlated with factors associated with vegetation structure or composition, including diversity of foliage height, and stated that, in general, the number of bird species increases with the addition of vertical vegetation layers. Based upon the findings above and upon prior field investigations, we proposed three habitat assessment variables: 1) percent tree canopy cover, 2) percent shrub/midstory canopy cover, and 3) the number of native woody species planted/present on the site. We also identified some tentative variables, including percent herbaceous ground cover, minimum patch size, average tree height, and proximity of the site to other forested patches.*

We asked three specialists with expertise in the arena of migratory landbird habitat requirements to comment on our proposed habitat variables: William C. Hunter, U.S. Fish and Wildlife Service, Atlanta, GA; Mark Woodrey, U.S. Fish and Wildlife Service, Jackson, MS; and Wylie Barrow, U.S.G.S., National Wetlands Research Center, Lafayette, LA. Their comments have been incorporated into the model and referenced as personal communications.

All specialists queried concurred that structural and floristic diversity were key factors to consider. Additionally, they all stressed the importance of fresh water sources for springg trans-Gulf migrants. However, we did not develop a variable to capture this factor, as the model was being designed for created habitat in an area where fresh water input would probably be limited to precipitation. A variable to measure fresh water proximity should probably be created for assessing extant stopover sites. We decided not to use a variable for percent herbaceous ground cover because for the majority of birds that would be likely to use forested coastal areas, the amount of herbaceous ground cover would not be as critical a habitat need as would tree and shrub cover (Moore et al. 1995). Neotropical migratory landbirds dependent upon grasslands would not typically use forested cheniers, spoil banks, etc., instead gravitating towards marshes, pastures, and agricultural fields. No minimum patch size for sites was established, because while larger patches are accepted to be more valuable to birds than small patches, a small patch surrounded by non-forested habitat could be very important at times to migrants (Barrow, pers. comm.). The same basic rationale was used in determining that a variable to rank sites on the basis of their proximity to other forested patches was not practical. Sites adjacent to other forested sites are assumed to facilitate migration of forest birds by reducing the distance needed to travel through open and potentially inhospitable terrain, but an isolated woodland could be important during periods of inclement weather (Barrow, pers. comm.). Canopy height was ruled out as a variable because no data was discovered that addressed minimum canopy heights at stopover sites. The developers of this model assumed that percent canopy cover was a more pertinent variable to consider.

Variable 1 - Percent Tree Canopy Cover. *Neotropical migratory landbirds preferentially use stopover sites exhibiting high structural and floristic diversity (Moore et al.1995). To achieve the desired vertical plant diversity (i.e., a mix of trees, tree saplings, shrubs, vines, and herbaceous plants), a moderately closed tree canopy would be preferred to over a totally closed canopy (Hunter, pers. comm.; Barrow, pers. comm.; Woodrey, pers. comm.). Tree canopy coverage ranging from 65 - 85% is assumed to provide optimal conditions to allow for establishment of midstory trees, shrubs, vines, and herbaceous plants, provided that the site is not grazed. Tree species that may occur at coastal stopover sites include sugarberry (Celtis laevigata), toothache tree (Zanthoxylum clava-herculis), live oak (Quercus virginiana), water oak (Q. nigra), honey locust (Gleditsia triacanthos), red mulberry (Morus rubra), and green haw (Crataegus viridis) (Louisiana Natural Heritage Program 1988, Materne 2000, Gosselink et al. 1979,Thomas and Allen 1996, Thomas and Allen 1998).*

Variable 2 - Percent Shrub/Midstory Cover. *Shrub-scrub habitats provide important foraging and resting areas for migrant landbirds (Moore et al. 1995). Shrub-scrub habitats are also presumed to be important to migratory passerine birds as refuges from raptor predators (Moore et al. 1990). For the purposes of this model, shrub/midstory means multi-stemmed shrubs, single-stemmed midstory trees, single-stemmed saplings of overstory tree species, and woody vines. Shrub/midstory canopy coverage ranging from 35 - 65% is assumed to represent optimal conditions at a forested site. Species of shrubs, small trees, and woody vines that may be found at stopover sites include Small's acacia (Acacia minuta), wax myrtle (Morella cerifera), dwarf palmetto (Sabal minor), yaupon holly (Ilex vomitoria), saltbush (Baccharis halimifolia), greenbriars (Smilax spp.), grapes (Vitis spp.), prickly pear cactus (Opuntia spp.), Virginia creeper (Parthenocissus quinquefolia), pepper vine (Ampelopsis arborea), blackberries (Rubus spp.), rattlebox (Sesbania drummondii), marshelder (Iva frutescens), poison ivy (Toxicodendron radicans), Carolina wolf-berry (Lycium carolinianum), marine vine (Cissus incisa) and elderberry (Sambucus canadensis) (Louisiana Natural Heritage Program 1988, Materne 2000, Gosselink et al. 1979, Thomas and Allen 1996, Thomas and Allen 1998).*

Variable 3 - Native Woody Species Diversity. *A wide variety of fruits, flowers, nectars, and animals, primarily invertebrates, are consumed by migrant landbirds (Moore et al. 1995, Fontenot 1999, Barrow, pers. comm.). Robinson and Holmes (1984) concluded that vegetation provides birds with foraging opportunities and constraints depending upon the structure of individual plants, aggregations of plants, and the arthropods that these plants host. The resulting foraging conditions define the diversity of bird species in the habitat. While some exotic plant species provide foraging opportunities to migrant landbirds, others are of limited value to spring and fall migrant birds (Barrow and Renne, 2001, Barrow, pers. comm.). It is assumed that a variety of native shrubs, midstory trees, woody vines and overstory trees will provide sufficiently diverse foraging and resting habitat to enable spring and fall transient birds to continue their migration. Woody plant species composition and diversity in stopover habitat is influenced by elevation, soil type, and salinity levels (Materne 2000, Louisiana Natural Heritage Program 1988), and the capacity of sites to support certain species will depend upon these and other factors. Based upon a review of available written information and upon the field knowledge of those involved in development of this model, and upon the range of conditions likely to be encountered in stopover habitat in the area the model addresses, presence of 10 species of native trees, shrubs, and woody vines is assumed to represent optimal conditions. It is also assumed that the parameters defining optimal conditions for variables V1 and V2 will moderate the potential for variable V3 to exert a* *false reading of habitat value for migrant landbirds, should the diversity of plant species be confined only to trees, or to shrubs, or to woody vines.*

2. Habitat Suitability Index Formula. *The final step in model development was to construct a mathematical formula that combines all Suitability Indices into a single Habitat Suitability Index (HSI) value. Because the Suitability Indices range from 0.1 to 1.0, the HSI also ranges from 0.1 to 1.0, and is a numerical representation of the overall or "composite" habitat quality of the area being evaluated. Within the HSI formula, any Suitability Index can be weighted by various means to increase the power or "importance" of that variable relative to the other variables in determining the HSI. For this model, it was assumed that the variables are of equal weight in determining the habitat quality of a coastal chenier/ridge.*

To combine the variables into an HSI formula, a geometric mean was chosen, as opposed to an arithmetic mean, to convey the weak compensatory relationship between the three variables. An arithmetic mean is often used when it is assumed that the model variables have a strong compensatory relationship (i.e., a high value for one variable can compensate for the low value of another variable). The geometric mean is used to discourage a variable with a marginal or low suitability from being offset by the high suitability of the other variables (U.S. Fish and Wildlife Service1981). It was assumed that the three variables in this model do not have a strong compensatory relationship.

$$\text{HSI Calculation: } HSI = (SIV_1 \times SIV_2 \times SIV_3)^{1/3}$$

3. Benefit Assessment. *The net benefits of a proposed project are determined by predicting future habitat conditions under two scenarios: future without-project and future with-project. Specifically, predictions are made as to how the model variables will change through time under the two scenarios. Through that process, HSIs are established for baseline (pre-project) conditions and for future without- and future with-project scenarios for selected "target years" throughout the expected life of the project. Those HSIs are then multiplied by the project area acreage at each target year to arrive at Habitat Units (HUs). Habitat Units represent a numerical combination of quality (HSI) and quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with-project scenarios are annualized, averaged over the project life, to determine Average Annual Habitat Units (AAHUs). The "benefit" of a project is quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference in AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality.*

III. APPLICATION OF WETLAND VALUE ASSESSMENT

For this project, a HET conducted the WVA assessments. The HET included representatives from the USFWS, the NMFS, and the Corps. The project site was visited by the HET on December 13, 2012 to observe where constructible elements for the alternatives would be located, and assess current habitat conditions.

Because the footprints of Alternatives 1 and 2 are identical, as are the footprints for Alternatives 3, 4, and 5, WVAs were prepared for each of these sets of alternatives for impact assessment. Unavoidable habitat impacts for these sets of alternatives are displayed in Table P-3 by acres. Alternative 1 is identified as the Tentatively Selected Plan. The WVA habitat assessment for Alternatives 1 and 2 employed the brackish marsh and chenier/ridge models, whereas the assessment for Alternatives 3, 4, and 5 used the brackish marsh and fresh/intermediate marsh models.

A 50-year planning period of analysis was used for these assessments. Intermediate target years were evaluated. In the case of WVAs for marsh impacts and marsh mitigation measures, as many as five intermediate target years for the future with project condition were assessed.

Coastal land loss rates accounting for subsidence and shoreline erosion were established for the project area, and this information was used in all marsh project impact and mitigation assessments. Land loss rates for the Calcasieu Ship Channel South subunit, an area larger than the immediate Calcasieu Lock project area, were used to represent land loss rates the project area (Barras et al. 2008). Land loss rates were adjusted by the projected effects of three Relative Sea Level Rise scenarios. The medium Relative Sea Level Rise scenario was chosen for the marsh WVA analyses. In contrast, for forested spoil bank habitat it was assumed that land loss due to subsidence and shoreline erosion would not affect the spatial extent or habitat conditions of this terrestrial resource, which is located along the south side of Calcasieu Lock. Therefore, land loss was not incorporated into the chenier/ridge project impact and mitigation assessments.

Salinity conditions for the project area were determined by analyzing available salinity measurements taken at the Calcasieu Lock West and East Gages. For salinity conditions in brackish marsh, data from the West Gage was used, and for intermediate marsh, readings from the East Gage were used.

A. WVAs for Impact Assessment

Information sheets describing the WVA habitat impact assessments are provided in Attachment 1. In addition to land loss rate information, these sheets include explanations of information used or assumptions made for each variable in the models, whether under existing, future without project, or future with project conditions.

B. WVAs for Mitigation

Because these habitat impacts are unavoidable, compensatory mitigation for the losses to coastal marsh and forested spoil bank habitat is required. In addition to assessing habitat impacts, WVAs were prepared for assessing potential compensatory mitigation measures to replace lost marsh and forested spoil bank habitat. Based on these WVA mitigation assessments, a proposed mitigation plan Alternatives 3, 4, and 5 was then developed.

Table P-3. Unavoidable Direct Impacts by Habitat Type for Calcasieu Lock Alternatives

Impacts	Upland Forested Ridge Habitat-Existing Spoil Disposal Area	Brackish Marsh-Emergent Vegetated & Associated Water	Brackish Marsh-Open Water Within Marsh (Bayous, Ponds)	Intermediate Marsh-Emergent	Intermediate Marsh-Open Water	Deeper Open Water-Not a WVA Calculation (GIWW, Black Bayou)	Total
ALTERNATIVES 1 AND 2							
Acres	11	9.7	4.3	0	0	0	25.0
AAHUs	-7.2	-3.78		0	0	0	-
ALTERNATIVES 3,4,5							
Acres	0	4.9	5.5	18.9	4.3	(51)	33.6
AAHUs	0	-1.56		-7.51		0	-9.07

1. Potential Marsh Mitigation. Information sheets describing the WVA marsh mitigation assessments are provided in Attachment 2. To develop a mitigation potential for brackish marsh losses, an assumed mitigation alternative was assessed and consisted of converting three open water remnants of historic Black Bayou on the west side of Highway 384 into brackish marsh using hydraulically dredged material obtained from construction of the project. These open water areas are surrounded by brackish marsh and total about 30.9 acres. Similarly, to develop a mitigation potential for intermediate marsh losses, an assumed mitigation alternative was evaluated and consisted of converting one open water remnant of historic Black Bayou on the east side of Highway 384 into intermediate marsh using hydraulically dredged material obtained from the project. This 4.3-acre open water area is surrounded by intermediate marsh.

To develop marsh mitigation plans, the benefit of these assumed mitigation alternatives in AAHUs was compared with the project impact of losing marsh habitat in AAHUs, such that the scale of these mitigation alternatives could be adjusted either up or down to identify how much mitigation would be needed to offset project impacts. Whereas a marsh mitigation plan with an identified mitigation site was developed for Alternatives 1 and 2 (see Appendix I, *Mitigation Plan*), a similar plan for Alternatives 3, 4, and 5 with the same level of detail was not developed.

Potential marsh mitigation sites would be confined by earthen dikes constructed to contain the dredged material. The site would then be filled with dredged material, which would consolidate to form a substrate for the establishment of intertidal marsh. A WVA was prepared to identify marsh and estuarine habitat improvements as a result of dredged material placement.

The dikes around the cells would be designed to slowly deteriorate and subside to the level of the adjacent marsh substrate, thereby promoting the tidal exchange of water. Earthen dikes may require mechanical degradation to the settled elevations of the disposal area if natural erosive processes do not degrade them sufficiently to meet fisheries and tidal access needs. Such breaches would be undertaken after consolidation of the dredged sediments and vegetative colonization of the exposed soil surface—approximately two to five years after pumping. For the purposes of the WVAs, it was assumed that dikes would be degraded 3 years after pumping.

The following features are applicable to the assumed marsh mitigation alternatives:

- Dredge material slurry would be allowed to overflow existing emergent marsh vegetation within the project area, but would not be allowed to exceed a height of approximately
- 1foot above the existing marsh elevation. Tidal inlets and channels may be created during the pumping of dredge material and by natural tidal fluctuations.
- The target elevation of placed and consolidated fill at each site would be determined through geotechnical analyses during the preparation of plans and specifications for the project. These analyses would consider long-term settlement of the dredged materials and placement area foundations, as well as elevation surveys of adjacent marsh to determine the appropriate target range. These elevation targets would be coordinated with resource agencies prior to construction.
- Vegetation of marsh mitigation areas would not rely on natural recruitment but active planting.

2. Potential Forested Spoil Bank Mitigation. Information sheets describing the WVA chenier/ridge mitigation assessments are provided in Attachment 3. Mitigation potentials were assessed for two assumed mitigation alternatives: 1) restoring 16 acres of degraded natural forested ridge habitat, and 2) implementing tree strand improvements in approximately 15 acres of remaining forested spoil bank habitat.

Restoring degraded natural ridge habitat would consist of replacing lost native woody vegetation on intact natural ridges that have only herbaceous groundcover by planting tree and shrub species. Tree stand improvements would consist of measures to increase the abundance and diversity of native woody species in the existing forest, including the planting of native tree and shrub species, creation of selective clearings or removal of undesirable vegetation, and removal of invasive species using accepted mechanical or chemical methods, such as Chinese tallow tree which is prevalent in the forested spoil bank habitat.

IV. RESULTS

The WVA models forecast the net marsh and forested spoil bank/ridge habitat losses of implementing Alternatives 1 and 2 and Alternatives 3, 4, and 5, for a period of analysis starting the year project construction begins and ending 50 years after the start of the project. Table P-3 shows a summary of these net losses for the two sets of alternatives.

Table P-4. Potential Compensatory Mitigation Measures Evaluated for Unavoidable Impacts to Marsh and Forested Spoil Bank/Ridge Habitats

Potential Mitigation Measures	Acres	Net Gain AAHUs	Mitigation Potential (AAHU/acre)
Brackish Marsh - convert open water to marsh in a beneficial use manner at three historic remnants of Black Bayou on west side of Hwy 384	30.9	14.78	0.48
Intermediate Marsh - convert open water to marsh in a beneficial use manner at one historic remnant of Black Bayou on east side of Hwy 384	4.3	1.85	0.43
Forested Spoil Bank/Ridge Habitat – restore natural degraded ridge habitat south of project area at unidentified site	16.0	7.91	0.49
Forested Spoil Bank/Ridge Habitat – implement tree stand improvements within remaining forested spoil bank habitat	15.0	3.12	0.20

As displayed in Table P-3, Alternatives 1 and 2 would result in the unavoidable losses of 3.78 AAHUs (14.0 acres) of brackish marsh and 7.2 AAHUs (11.0 acres) of forested spoil bank/ridge habitat. Similarly, for Alternatives 3, 4, and 5 these losses were forecasted as 7.51 AAHUs (23.2 acres) to intermediate marsh and 1.56 AAHUs (10.4 acres) to brackish marsh.

The WVA models also forecast the net benefits of potential mitigation measures to compensate for these unavoidable losses, for the same period of analysis. Table P-4 displays a summary of these net potential mitigation benefits by habitat type.

As displayed in Table P-4, an assumed creation of brackish marsh in a beneficial use manner at several open water sites totaling about 31 acres within the project area would generate nearly 15

AAHUs of habitat benefits. This potential benefit is considerably more than the 3.78 AAHU loss associated with Alternatives 1 and 2 (Table P-3). Creating brackish marsh in a smaller amount of open water areas would be expected to offset the loss forecasted by the WVA assessment. This smaller amount can be estimated by dividing the forecasted habitat loss in AAHUs by the mitigation potential in AAHUs per acre (Table P-4). Doing so yields an estimate of 7.9 acres of compensatory brackish marsh mitigation to offset the brackish marsh losses associated with Alternatives 1 and 2. A separate WVA assessment was not conducted on a smaller area of potential marsh mitigation sites, but would be appropriate for the Preliminary Engineering and Design (PED) phase for this project.

To compensate for forested spoil bank/ridge habitat losses associated with Alternatives 1 and 2, the WVA assessments forecast potential benefits for two different kinds of mitigation measures or alternatives. One of these, restoring an assumed 16 acres of degraded natural ridge habitat, would potentially offset the losses associated with Alternatives 1 and 2 (Tables P-3 and Table P-4). This particular WVA assessment was for an unidentified site, as natural chenier/ridge habitat occurs to the south of the project area at least 15 miles away, and a search of potential restoration sites was not conducted by the HET as part of this study. The feasibility of implementing this mitigation alternative could be examined during the PED phase.

The second forested spoil bank/ridge mitigation alternative—implementing tree stand improvements in the remaining 15 acres of habitat—forecast that the benefits generated from doing this (3.12 AAHUs) would not be enough to offset the losses (7.2 AAHUs) associated with Alternatives 1 and 2.

Appendix I, *Mitigation Plan*, provides detailed information about the mitigation planning and mitigation plan development that was conducted for this project.

V. REFERENCES

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

APPENDIX P-1
Wetland Value Assessment of Alternative 1 & 2 Impacts Site
Project Information Sheets and Worksheets

Prepared for:
U.S. Army Corps of Engineers

Prepared by
U.S. Fish and Wildlife Service
David Castellanos
David_Castellanos@fws.gov

Project Name: Calcasieu Lock Alternatives 1&2 Impacts Site

Project Area: The Calcasieu Lock site is located immediately to the south of the existing lock.

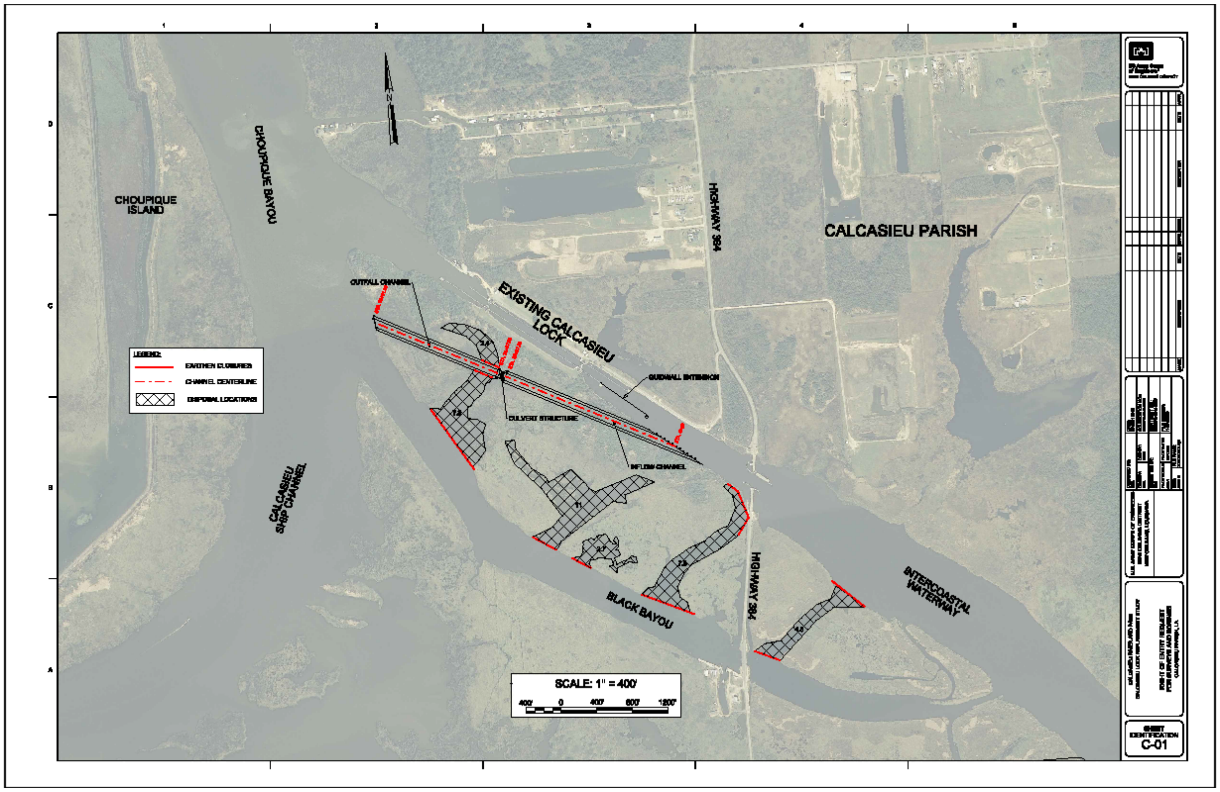

Figure 1. Alternatives 1&2 Project Area

The Calcasieu Lock Alternatives 1&2 would impact approximately 14 acres of brackish marsh resulting in the loss of 3.78 Average Annual Habitat Units (AAHUs).

Habitat Assessment Method

The WVA operates under the assumption that optimal conditions for general fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of a mathematical model developed specifically for each wetland type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values, and 3) a mathematical formula that combines Suitability Index for each variable into a single value for wetland habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI.

The WVA model for marsh habitat attempts to assess the suitability of each habitat type for providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. While the model does not specifically assess other wetland functions and values such as storm-surge protection, floodwater storage, water quality improvement, nutrient import/export, and aesthetics, it can be generally assumed that these functions and values are positively correlated with fish and wildlife habitat quality.

The procedure for evaluating project benefits on fish and wildlife habitats, the WVA model, uses a series of variables that are intended to capture the most important conditions and functional values of a particular habitat. Values for these variables are derived for existing conditions and are estimated for conditions projected into the future if no restoration efforts are applied (i.e., future-without-project), and for conditions projected into the future if the proposed restoration project is implemented (i.e., future-with-project), providing an index of quality or habitat suitability of the habitat for the given time period. The habitat suitability index (HSI) is combined with the acres of habitat to get a number that is referred to as “habitat units”. Expected project benefits are estimated as the difference in habitat units between the future-with-project (FWP) and future-without project (FWOP). To allow comparison of WVA benefits to costs for overall project evaluation, total benefits are averaged over a 50-year period, with the result reported as Average Annual Habitat Units (AAHUs).

Variable V_1 – Percent of wetland area covered by emergent vegetation

Existing – The project area is open water and surrounding marsh has been classified as brackish marsh consistently from 1968 to 2007 (O’Neil 1949, Chabreck and Linscombe 1997, Sasser et al. 2007).

The two major soil types in the project area are classified by the United States Department of Agriculture (USDA) (1987) as Clovelly muck and Udifluvent. Covelly much is a very poorly drained, very fluid organic soils typical of brackish marsh. They are generally flooded and ponded most of the time and have a high subsidence potential. Undifluvent soils are sandy and clayey soil material that has been excavated from other places (in this case from the GIWW channel) and have a higher elevation then the surrounding area.

Land Loss Data

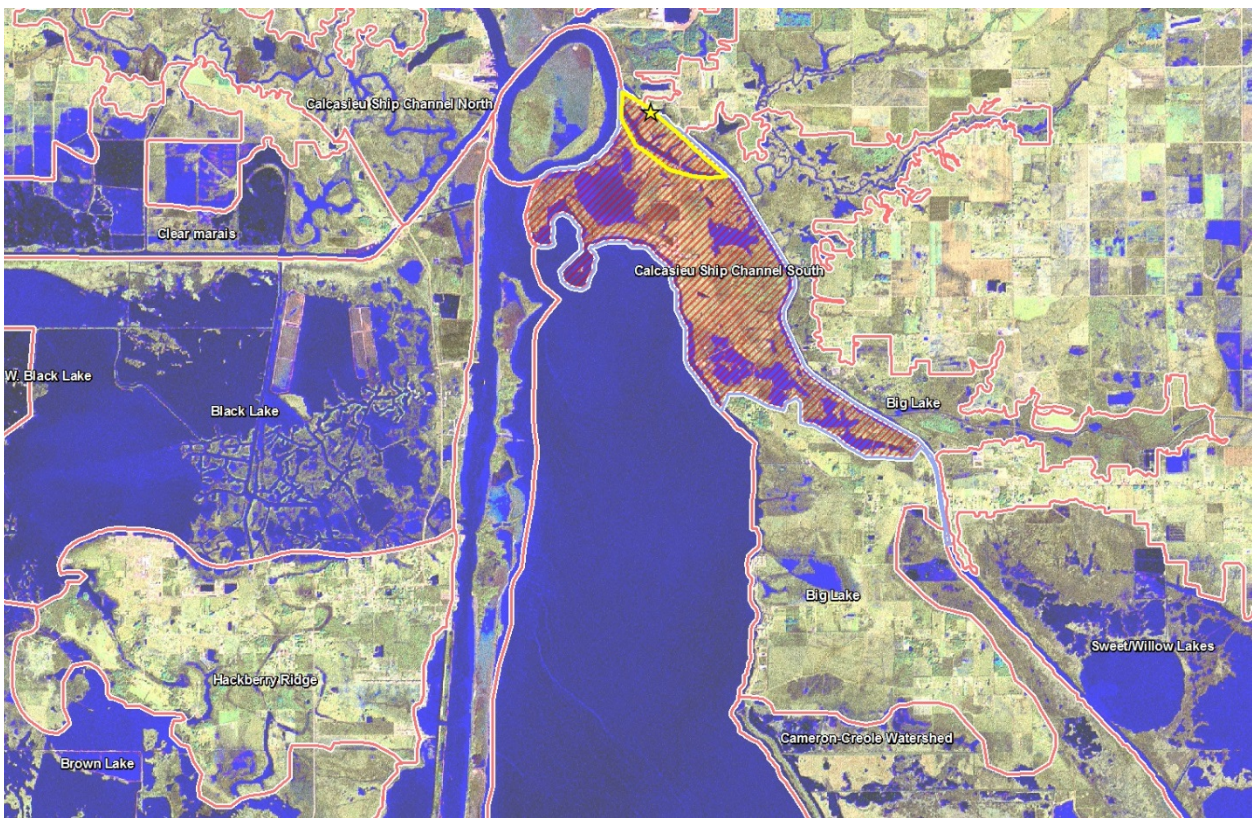

Figure: 2. USGS Extended Boundary for Land Loss Rates In Calcasieu Lock Area

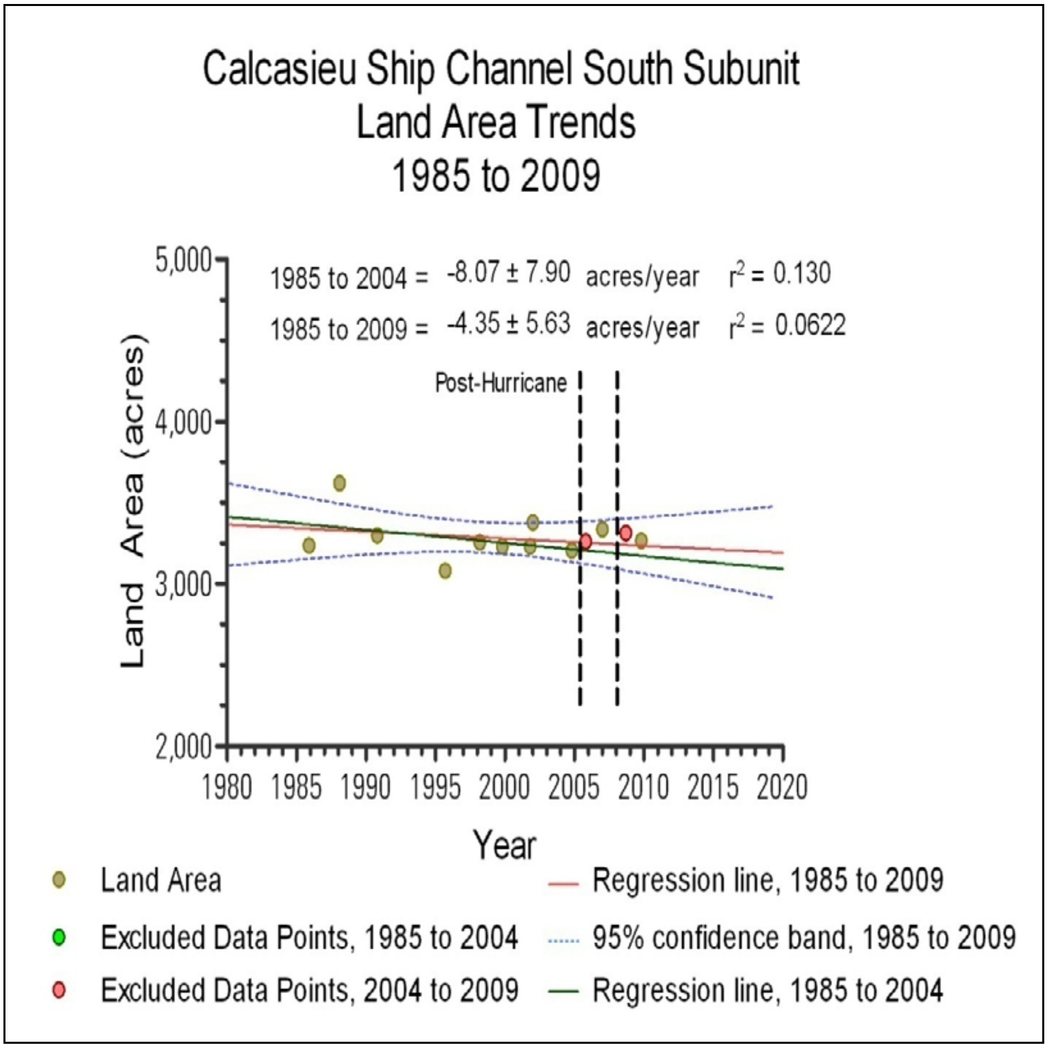

Figure 3. USGS Land Loss Regression for Extended Boundary.

Project Area Acre per year lost rate

The acre/year rate is adjusted for the size of the project area relative to the size of the extended boundary.

FWOP
=-0.0476 acres/year

FWP rate is the same but marsh is eliminated by project construction

Land loss rates were adjusted by the projected effects of three Relative Sea Level Rise (RSLR) scenarios. The medium RSLR scenario was chosen for these analyses.

FWOP – Under the medium RSLR scenario, the adjusted marsh loss rate would result in the losses as below. Percent is of the entire project area acreage and are rounded to be accepted into excel model. The extent of marsh area was determined by digitizing an impacts polygon in ArcMap and then also creating water and emergent marsh polygons so that the % emergent marsh in the area could be reported.

TY0
Marsh: 9.71 acres (69%)
Water: 4.29 acres (31%)

TY50
Marsh: 7.5 acres (53%)
Water: 6.5 acres (47%)

FWP – It is assumed that 13.5 within the project area would be converted to deep water and 0.5 acres would consist of water control structures.

TY0
Marsh: 9.71 acres (69%)
Water: 4.29 acres (31%)

TY1-TY50
Marsh: 0 acres (0%)
Water 13.5 acres (96%)

Variable V_2 – Percent of open water covered by aquatic vegetation

Existing Conditions –The project area is primarily shallow open water with no SAV observed at the site.

FWOP – Existing conditions are expected to continue,

TY 0 0%
TY 50 0%

FWP – Because there was no SAV found in the area, we assume that it will not be present after the mitigation project is constructed.

TY 0 0%
TY 50 0%

Variable V_3 – Marsh edge and interspersion

Existing Conditions – The project area contains fairly intact marsh among areas of shallow water. The marsh area is 69% of the total project area; therefore the project area is assigned a Class 2 value for TY 0.

FWOP – Land loss causes interspersion to increase and by TY 50 the emergent land portion is only 53 % of the project area.

TY 0: 100% Class 2
TY 50: 10% Class 2 and 90% Class 3 (no new marsh is gained; existing marsh converts to open water)

FWP – All emergent marsh is converted to water or non-marsh with construction of project.

TY 0:	100 % Class 2
TY 1	100% Class 5

Variable V_4 – Percent of open water area <=1.5 feet deep in relation to marsh surface

Existing
Water depths were measured with a survey rod in some parts of the project area on 13 December 2012 and the area that had a depth of 1.5 ft or less was estimated to be 12%. Using field trip notes that documented that the bayou remnant "finger" that occurs in the project area was very shallow, and optical survey, we attempted to extrapolate an estimate of shallow water amount for the area. The Corps' RSLR estimates predict a sea-level rise of approximately 1.61 feet by the year 2070 under the Intermediate RSLR scenario (Appendix). It was assumed that RSLR will reduce the existing shallow open water for FWOP at TY50 by 1/3.

FWOP Marsh that is lost is assumed to become open water <= 1.5 feet deep until TY50. At that point, it is assumed that 1/3 of the shallow open water would become deeper than 1.5 feet

TY0	50%
TY1	50%
TY50	33%

FWP- When new channel is excavated it is assumed that all water will become deep.

TY0	50%
TY1 - TY50	0%

Variable V_5 - Salinity

Existing conditions – The average annual salinity estimate for the brackish marsh area was 13.7 ppt., and was obtained from the Calcasieu Lock West Gage which is within a few hundred feet of the project area. The lock modification project is not expected to affect water salinity.

FWOP & FWP

TY0 – TY50	13.7 ppt

Variable V_6 – Aquatic organism access

Existing conditions – The existing marsh is not impounded or hydrologically controlled by any structures. Access to all parts of project area is assumed to be equal.

FWOP Existing conditions are expected to persist.
TY0 – TY50 = 1.0

FWP After construction the area will be open water and accessible to all aquatic organisms.

TY0	1.0
TY1- TY50	1.0

Literature Cited

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices. Appendix C – Region 1 Supplemental Information. Louisiana Department of Natural Resources. Baton Rouge, La.

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WETLAND VALUE ASSESSMENT COMMUNITY MOD

Brackish Marsh

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) M** Project Area:

Condition: Future Without Project

Variable		TY	0	TY	1	TY
		Value	SI	Value	SI	Value
V1	% Emergent	69	0.72	69	0.72	67
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.60	0	0.60	0
	Class 2	100		100		100
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	0		0		0
V4	%OW <= 1.5ft	50	0.74	50	0.74	50
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
	Emergent Marsh HSI =		0.72	EM HSI =	0.72	EM HSI =
	Open Water HSI =		0.33	OW HSI =	0.33	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR** Project Area:

FWOP

Variable		TY	20	TY	30	TY
		Value	SI	Value	SI	Value
V1	% Emergent	64	0.68	61	0.65	53
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.60	0	0.50	0
	Class 2	100		50		10
	Class 3	0		50		90
	Class 4	0		0		0
	Class 5	0		0		0
V4	%OW <= 1.5ft	50	0.74	50	0.74	50
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
		EM HSI =	0.69	EM HSI =	0.66	EM HSI =
		OW HSI =	0.33	OW HSI =	0.32	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR** Project Area:

FWOP

Variable		TY		TY		TY
		Value	SI	Value	SI	Value
V1	% Emergent					
V2	% Aquatic					
V3	Interspersion	%		%		%

		Class 1					
		Class 2					
		Class 3					
		Class 4					
		Class 5					

V4	%OW <= 1.5ft					
V5	Salinity (ppt)					
V6	Access Value					
		EM HSI =		EM HSI =		EM HSI =
		OW HSI =		OW HSI =		OW HSI =

WETLAND VALUE ASSESSMENT COMMUNITY MODI

Brackish Marsh

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR** Project Area:

Condition: Future With Project

Variable		TY	0	TY	1	TY
		Value	SI	Value	SI	Value
V1	% Emergent	69	0.72	0	0.10	0
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.60	0	0.10	0
	Class 2	100		0		0
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	0		100		100
V4	%OW <= 1.5ft	50	0.74	0	0.10	0

V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
	Emergent Marsh HSI =		0.72	EM HSI =	0.19	EM HSI =
	Open Water HSI =		0.33	OW HSI =	0.24	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR** Project Area:

FWP

Variable		TY	20	TY	30	TY
		Value	SI	Value	SI	Value
V1	% Emergent	0	0.10	0	0.10	0
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.10	0	0.10	0
	Class 2	0		0		0
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	100		100		100
V4	%OW <= 1.5ft	0	0.10	0	0.10	0
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
		EM HSI =	0.19	EM HSI =	0.19	EM HSI =
		OW HSI =	0.24	OW HSI =	0.24	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR** Project Area:

FWP

Variable		TY		TY		TY
		Value	SI	Value	SI	Value
V1	% Emergent					
V2	% Aquatic					
V3	Interspersion	%		%		%
	Class 1					
	Class 2					
	Class 3					
	Class 4					
	Class 5					
V4	%OW <= 1.5ft					
V5	Salinity (ppt)					
V6	Access Value					
		EM HSI =		EM HSI =		EM HSI =
		OW HSI =		OW HSI =		OW HSI =

AAHU CALCULATION - EMERGENT MARSH

Project: **Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR**

Future Without Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	9.71	0.72	7.00	

1	9.68	0.72	6.98	6.99
10	9.39	0.71	6.66	61.36
20	9.01	0.69	6.23	64.44
30	8.57	0.66	5.68	59.53

50	7.5	0.61	4.54	102.01
Max TY=	50		AAHUs =	5.89

Future With Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	9.71	0.72	7.00	
1	0	0.19	0.00	2.65
10	0	0.19	0.00	0.00
20	0	0.19	0.00	0.00
30	0	0.19	0.00	0.00
50	0	0.19	0.00	0.00
Max TY=	50		AAHUs	0.05

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Emergent Marsh AAHUs =	0.05
B. Future Without Project Emergent Marsh AAHUs =	5.89
Net Change (FWP - FWOP) =	-5.83

AAHU CALCULATION - OPEN WATER

Project: Calcasieu Lock Project Impact Alt. 1 & 2 (Pumps or Culverts) MedSLR

Future Without Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	4.29	0.33	1.41	
1	4.32	0.33	1.42	1.41
10	4.61	0.33	1.51	13.17
20	4.99	0.33	1.64	15.74
30	5.43	0.32	1.74	16.88
50	6.5	0.31	2.04	37.86
Max TY=	50		AAHUs =	1.70

Future With Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	4.29	0.33	1.41	
1	13.5	0.24	3.28	2.47
10	13.5	0.24	3.28	29.54
20	13.5	0.24	3.28	32.82
30	13.5	0.24	3.28	32.82

50	13.5	0.24	3.28	65.65
Max TY=	**50**		**AAHUs**	**3.27**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Open Water AAHUs =	3.27
B. Future Without Project Open Water AAHUs =	1.70
Net Change (FWP - FWOP) =	**1.57**

TOTAL BENEFITS IN AAHUs DUE TO PROJECT	
A. Emergent Marsh Habitat Net AAHUs =	-5.83
B. Open Water Habitat Net AAHUs =	1.57
Net Benefits= (2.6xEMAAHUs+OWAAHUs)/3.6	**-3.78**

EL

14

10
SI
0.70
0.10
0.60
0.74
0.45
1.00
0.71
0.33

14

50
SI
0.58
0.10
0.42
0.74
0.45
1.00
0.61
0.31

14

SI

EL

14

10
SI
0.10
0.10
0.10
0.10

0.45
1.00
0.19
0.24

14

50
SI
0.10
0.10
0.10
0.10
0.45
1.00
0.19
0.24

14

SI

WETLAND VALUE ASSESSMENT COMMUNITY MODI

Brackish Marsh

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

Condition: Future Without Project

Variable		TY	0	TY	1	TY
		Value	SI	Value	SI	Value
V1	% Emergent	46	0.51	46	0.51	45
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	50	0.80	50	0.80	0
	Class 2	50		50		100
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	0		0		0
V4	%OW <= 1.5ft	100	0.60	100	0.60	100
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
	Emergent Marsh HSI =		0.60	EM HSI =	0.60	EM HSI =
	Open Water HSI =		0.33	OW HSI =	0.33	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

FWOP

Variable		TY	20	TY	30	TY
		Value	SI	Value	SI	Value
V1	% Emergent	43	0.49	41	0.47	36
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.60	0	0.50	0
	Class 2	100		50		15
	Class 3	0		50		85
	Class 4	0		0		0
	Class 5	0		0		0
V4	%OW <= 1.5ft	100	0.60	100	0.60	100
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
		EM HSI =	0.56	EM HSI =	0.54	EM HSI =
		OW HSI =	0.32	OW HSI =	0.31	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

FWOP

Variable		TY		TY		TY
		Value	SI	Value	SI	Value
V1	% Emergent					
V2	% Aquatic					
V3	Interspersion	%		%		%

		Class 1					
		Class 2					
		Class 3					
		Class 4					
		Class 5					

V4	%OW <= 1.5ft					
V5	Salinity (ppt)					
V6	Access Value					
		EM HSI =		EM HSI =		EM HSI =
		OW HSI =		OW HSI =		OW HSI =

WETLAND VALUE ASSESSMENT COMMUNITY MODI
Brackish Marsh

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

Condition: Future With Project

Variable		TY	0	TY	1	TY
		Value	SI	Value	SI	Value
V1	% Emergent	46	0.51	0	0.10	0
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	50	0.80	0	0.10	0
	Class 2	50		0		0
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	0		100		100
V4	%OW <= 1.5ft	100	0.60	0	0.10	0

V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
	Emergent Marsh HSI =		0.60	EM HSI =	0.19	EM HSI =
	Open Water HSI =		0.33	OW HSI =	0.24	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

FWP

Variable		TY	20	TY	30	TY
		Value	SI	Value	SI	Value
V1	% Emergent	0	0.10	0	0.10	0
V2	% Aquatic	0	0.10	0	0.10	0
V3	Interspersion	%		%		%
	Class 1	0	0.10	0	0.10	0
	Class 2	0		0		0
	Class 3	0		0		0
	Class 4	0		0		0
	Class 5	100		100		100
V4	%OW <= 1.5ft	0	0.10	0	0.10	0
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000
		EM HSI =	0.19	EM HSI =	0.19	EM HSI =
		OW HSI =	0.24	OW HSI =	0.24	OW HSI =

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)** Project Area:

FWP

Variable		TY		TY		TY
		Value	SI	Value	SI	Value
V1	% Emergent					
V2	% Aquatic					
V3	Interspersion	%		%		%
	Class 1					
	Class 2					
	Class 3					
	Class 4					
	Class 5					
V4	%OW <= 1.5ft					
V5	Salinity (ppt)					
V6	Access Value					
		EM HSI =		EM HSI =		EM HSI =
		OW HSI =		OW HSI =		OW HSI =

AAHU CALCULATION - EMERGENT MARSH

Project: **Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)**

Future Without Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	4.86	0.60	2.94	

1	4.84	0.60	2.93	2.93
10	4.7	0.58	2.71	25.34
20	4.5	0.56	2.53	26.21
30	4.3	0.54	2.32	24.26

50	3.7	0.50	1.85	41.59
Max TY=	50		AAHUs =	2.41

Future With Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	4.86	0.60	2.94	
1	0	0.19	0.00	1.14
10	0	0.19	0.00	0.00
20	0	0.19	0.00	0.00
30	0	0.19	0.00	0.00
50	0	0.19	0.00	0.00
Max TY=	50		AAHUs	0.02

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Emergent Marsh AAHUs =	0.02
B. Future Without Project Emergent Marsh AAHUs =	2.41
Net Change (FWP - FWOP) =	-2.38

AAHU CALCULATION - OPEN WATER

Project: Calcasieu Lock Project Impact Alt. 3(Black Bayou dredge)

Future Without Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	5.5	0.33	1.83	
1	5.66	0.33	1.88	1.85
10	5.8	0.32	1.84	16.74
20	6	0.32	1.90	18.72
30	6.5	0.31	2.01	19.59
50	6.8	0.30	2.07	40.86
Max TY=	50		AAHUs =	1.96

Future With Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	5.5	0.33	1.83	
1	10.5	0.24	2.55	2.26
10	10.5	0.24	2.55	22.98
20	10.5	0.24	2.55	25.53
30	10.5	0.24	2.55	25.53

50	10.5	0.24	2.55	51.06
Max TY=	**50**		**AAHUs**	**2.55**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Open Water AAHUs =	2.55
B. Future Without Project Open Water AAHUs =	1.96
Net Change (FWP - FWOP) =	**0.59**

TOTAL BENEFITS IN AAHUs DUE TO PROJECT	
A. Emergent Marsh Habitat Net AAHUs =	-2.38
B. Open Water Habitat Net AAHUs =	0.59
Net Benefits= (2.6xEMAAHUs+OWAAHUs)/3.6	**-1.56**

EL

11

10
SI
0.51
0.10
0.60
0.60
0.45
1.00
0.58
0.32

10.5

50
SI
0.42
0.10
0.43
0.60
0.45
1.00
0.50
0.30

10.5

SI

EL

10.5

10
SI
0.10
0.10
0.10
0.10

0.45
1.00
0.19
0.24

10.5

50
SI
0.10
0.10
0.10
0.10
0.45
1.00
0.19
0.24

10.5

SI

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Fresh/Intermediate Marsh

Project: **Calc. Lock Intermediate Marsh impacts**

Project Area:	23
% Fresh	0
% Intermediate	100

Condition: Future Without Project

Variable		TY	0	TY	1	TY	10
		Value	SI	Value	SI	Value	SI
V1	% Emergent	82	0.84	81	0.83	79	0.81
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	100	1.00	100	1.00	90	0.96
	Class 2	0		0		10	
	Class 3	0		0		0	
	Class 4	0		0		0	
	Class 5	0		0		0	
V4	%OW <= 1.5ft	52	0.69	52	0.69	52	0.69
V5	Salinity (ppt)						
	fresh		0.10		0.10		0.10
	intermediate	7		7		7	
V6	Access Value						
	fresh		1.00		1.00		1.00
	intermediate	1.0000		1.0000		1.0000	
	Emergent Marsh HSI =		0.79	EM HSI =	0.79	EM HSI =	0.77
	Open Water HSI =		0.27	OW HSI =	0.27	OW HSI =	0.27

Project: **Calc. Lock Intermediate Marsh impacts**

FWOP

Variable		TY	20	TY	30	TY	50
		Value	SI	Value	SI	Value	SI
V1	% Emergent	76	0.78	72	0.75	63	0.67
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	50	0.80	0	0.60	0	0.58
	Class 2	50		100		90	
	Class 3	0		0		10	
	Class 4	0		0		0	
	Class 5	0		0		0	
V4	%OW <= 1.5ft	52	0.69	52	0.69	52	0.69
V5	Salinity (ppt)						
	fresh		0.10		0.10		0.10
	intermediate	7		7		7	
V6	Access Value						
	fresh		1.00		1.00		1.00
	intermediate	1.0000		1.0000		1.0000	
		EM HSI =	0.74	EM HSI =	0.69	EM HSI =	0.63
		OW HSI =	0.26	OW HSI =	0.24	OW HSI =	0.24

Project: **Calc. Lock Intermediate Marsh impacts**

FWOP

Variable		TY		TY		TY	
		Value	SI	Value	SI	Value	SI
V1	% Emergent						
V2	% Aquatic						
V3	Interspersion	%		%		%	
	Class 1						
	Class 2						
	Class 3						
	Class 4						
	Class 5						

V4	%OW <= 1.5ft						
V5	Salinity (ppt)						
	fresh						
	intermediate						
V6	Access Value						
	fresh						
	intermediate						
		EM HSI =		EM HSI =		EM HSI =	
		OW HSI =		OW HSI =		OW HSI =	

WETLAND VALUE ASSESSMENT COMMUNITY MODEL

Fresh/Intermediate Marsh

Project: **Calc. Lock Intermediate Marsh impacts**

Condition: Future With Project

Project Area:	
% Fresh	
% Intermediate	

Variable		TY	0	TY	1	TY	10
		Value	SI	Value	SI	Value	SI
V1	% Emergent	82	0.84	0	0.10	0	0.10
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	100	1.00	0	0.10	0	0.10
	Class 2	0		0		0	
	Class 3	0		0		0	
	Class 4	0		0		0	
	Class 5	0		100		100	
V4	%OW <= 1.5ft	52	0.69	0	0.10	0	0.10

V5	Salinity (ppt)						
	fresh		0.10		0.10		0.10
	intermediate	7		7		7	
V6	Access Value						
	fresh		1.00		1.00		1.00
	intermediate	1		1.0000		1.0000	
	Emergent Marsh HSI =		0.79	EM HSI =	0.14	EM HSI =	0.14
	Open Water HSI =		0.27	OW HSI =	0.16	OW HSI =	0.16

Project: **Calc. Lock Intermediate Marsh impacts**

FWP

Variable		TY	20	TY	30	TY	50
		Value	SI	Value	SI	Value	SI
V1	% Emergent	0	0.10	0	0.10	0	0.10
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	0	0.10	0	0.10	0	0.10
	Class 2	0		0		0	
	Class 3	0		0		0	
	Class 4	0		0		0	
	Class 5	100		100		100	
V4	%OW <= 1.5ft	0	0.10	0	0.10	0	0.10
V5	Salinity (ppt)						
	fresh		0.10		0.10		0.10
	intermediate	7		7		7	
V6	Access Value						
	fresh		1.00		1.00		1.00
	intermediate	1.0000		1.0000		1.0000	
		EM HSI =	0.14	EM HSI =	0.14	EM HSI =	0.14
		OW HSI =	0.16	OW HSI =	0.16	OW HSI =	0.16

Project: **Calc. Lock Intermediate Marsh impacts**

FWP

Variable		TY		TY		TY	
		Value	SI	Value	SI	Value	SI
V1	% Emergent						
V2	% Aquatic						
V3	Interspersion	%		%		%	
	Class 1						
	Class 2						
	Class 3						
	Class 4						
	Class 5						
V4	%OW <= 1.5ft						
V5	Salinity (ppt)						
	fresh						
	intermediate						
V6	Access Value						
	fresh						
	intermediate						
		EM HSI =		EM HSI =		EM HSI =	
		OW HSI =		OW HSI =		OW HSI =	

AAHU CALCULATION - EMERGENT MARSH

Project: Calc. Lock Intermediate Marsh impacts

Future Without Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	18.94	0.79	15.03	

1	18.88	0.79	14.87	14.95
10	18.32	0.77	14.12	130.45
20	17.57	0.74	12.91	135.15
30	16.71	0.69	11.50	122.02
50	14.62	0.63	9.22	206.82
Max=	50		AAHUs =	12.19

Future With Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	18.94	0.79	15.03	
1	0	0.14	0.00	5.44
10	0	0.14	0.00	0.00
20	0	0.14	0.00	0.00
30	0	0.14	0.00	0.00
50	0	0.14	0.00	0.00
Max=	50		AAHUs	0.11

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Emergent Marsh AAHUs =	0.11
B. Future Without Project Emergent Marsh AAHUs =	12.19
Net Change (FWP - FWOP) =	-12.08

AAHU CALCULATION - OPEN WATER

Project: Calc. Lock Intermediate Marsh impacts

Future Without Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	4.26	0.27	1.15	
1	4.32	0.27	1.17	1.16
10	4.88	0.27	1.31	11.14
20	5.63	0.26	1.44	13.74
30	6.49	0.24	1.56	15.04
50	8.58	0.24	2.05	36.19
Max=	50		AAHUs =	1.55

Future With Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	4.26	0.27	1.15	
1	22.7	0.16	3.64	2.74
10	22.7	0.16	3.64	32.80

20	22.7	0.16	3.64	36.44
30	22.7	0.16	3.64	36.44
50	22.7	0.16	3.64	72.88
Max=	**50**		**AAHUs**	**3.63**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Open Water AAHUs =	3.63
B. Future Without Project Open Water AAHUs =	1.55
Net Change (FWP - FWOP) =	**2.08**

TOTAL BENEFITS IN AAHUs DUE TO PROJECT	
A. Emergent Marsh Habitat Net AAHUs =	-12.08
B. Open Water Habitat Net AAHUs =	2.08
Net Benefits=(2.1xEMAAHUs+OWAAHUs)/3.1	**-7.51**

MEMORANDUM

DATE: 16 August 2013

TO: File Calcasieu Lock Alternatives 1&2 Forested ridge (Chenier-type) Impacts

FROM: David Castellanos

SUBJECT: Determination of Habitat Variables for WVA

Habitats used in the WVA Analysis for Calc. Lock Alts. 1&2 forested ridge impacts.

V1 – Tree Canopy Cover (%)
According to field observations, the canopy trees in the area are not close together and do not have large crowns. Canopy cover at TY0 estimated to be 20%. Percent cover is assumed to increase over time but not surpass 50% by TY50 because we know that the trees have been in place for many years and do not seem to be growing very fast; possibly because of the soil type.

V2 – Shrub/Midstory Cover (%)
According to field observations, the midstory is very robust and much denser than the canopy layer. We estimated a midstory cover of 75%. We assume that over time, the percent cover may decrease slightly due to shading from the canopy layer that is assumed to increase somewhat over time. The shrub/midstory decreases to only 45% by TY50.

V3 – Native tree and woody shrub and vine Species Diversity
According to field observations 6 tree and shrub species were documented. One, the Chinese tallow tree is an invasive exotic and thus was not counted. Also, because the Chinese tallow tree was dominant compared to the native species and thus reducing the Chenier function of the forested ridge we decreased the species number to 4 to account for the adverse effect of an invasive, lower functional value tree being dominant.

Model Name	Wetland Value Assessment - Coastal Chenier/Ridg
Model Version	1.1
Date of Last Update	November 18, 2011
Original Model Version	1.0 - March 10, 2010
Objective of Model	The model utilizes a set of variables considered im determining the suitability of non-grazed barrier hea cheniers, and spoil areas in Louisiana that are, or a vegetated in primarily non-obligate wetland plant sp the habitat necessary to support transient migratory
Instructions	Enter data in green cells. Always error check data following entry. Click on variable name in column B for a brief desc Refer to WVA documents for model structure and b
Notes	1) Enter data in units noted. 2) All percentages should be entered as whole num

Color Coding Key:

Input
Calculation
Output

ge Community Model

portant in
adland ridges,
are proposed to be,
pecies, to provide
y landbirds in the

cription of the variable.
background.

nbers between 0 and 100.

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

Condition: Future Without Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	20	0.38	25	0.45	35	0.59
V2	Shrub/Midstory Cover (%)	75	0.85	75	0.85	60	1.00
V3	Species Diversity	4	0.57	4	0.57	4	0.57
		HSI =	0.57	HSI =	0.60	HSI =	0.69

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

FWOP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	40	0.66	50	0.80		
V2	Shrub/Midstory Cover (%)	55	1.00	45	1.00		
V3	Species Diversity	4	0.57	5	0.69		
		HSI =	0.72	HSI =	0.82	HSI =	

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

Condition: Future With Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	20	0.38	0	0.10	0	0.10
V2	Shrub/Midstory Cover (%)	75	0.85	0	0.10	0	0.10
V3	Species Diversity	4	0.57	0	0.10	0	0.10
		HSI =	0.57	HSI =	0.10	HSI =	0.10

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

FWP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	0	0.10	0	0.10		
V2	Shrub/Midstory Cover (%)	0	0.10	0	0.10		
V3	Species Diversity	0	0.10	0	0.10		
		HSI =	0.10	HSI =	0.10	HSI =	

Project: **Calcasieu Lock: Gate/Pump Alternative** Project Area: 11

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

AAHU CALCULATION

Project: **Calcasieu Lock: Gate/Pump Alternative**

Future Without Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	11	0.57	6.25	
10	11	0.60	6.61	64.32
20	11	0.69	7.64	71.27
30	11	0.72	7.93	77.86
50	11	0.82	9.00	169.33
Max TY =	50		Total	
			CHUs =	382.77
			AAHUs =	7.66

Future With Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	11	0.57	6.25	
10	0	0.10	0.00	22.67
20	0	0.10	0.00	0.00
30	0	0.10	0.00	0.00
50	0	0.10	0.00	0.00
Max TY =	**50**		Total	
			CHUs =	**22.67**
			AAHUs =	**0.45**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project AAHUs =	0.45
B. Future Without Project AAHUs =	7.66
Net Change (FWP - FWOP) =	**-7.20**

Original Model Version	1.0 - March 10, 2010

Model Revisions

Version 1.1 - 11/18/2011	1) Spreadsheet formatted to populate FWP TY0 with FWOP TY0 values.
	2) Spreadsheet formatted to allow entry of any value in acreage cells in AAHU calculation section.
	3) Minor formatting changes to font type, font size, font color, etc.

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

APPENDIX P-2
Wetland Value Assessment of Potential Marsh Mitigation
Project Information Sheets and Worksheets

August 16, 2013

Prepared for:
U.S. Army Corps of Engineers

Prepared by
U.S. Fish and Wildlife Service
David Castellanos
David_Castellanos@fws.gov

***Mitigation Potential:** 0.48 (AAHUs/acre)

Project Type(s): Marsh Creation

Project Area: The Calcasieu Lock Mitigation Marsh Creation site is located adjacent to the Lock project alternatives project areas.

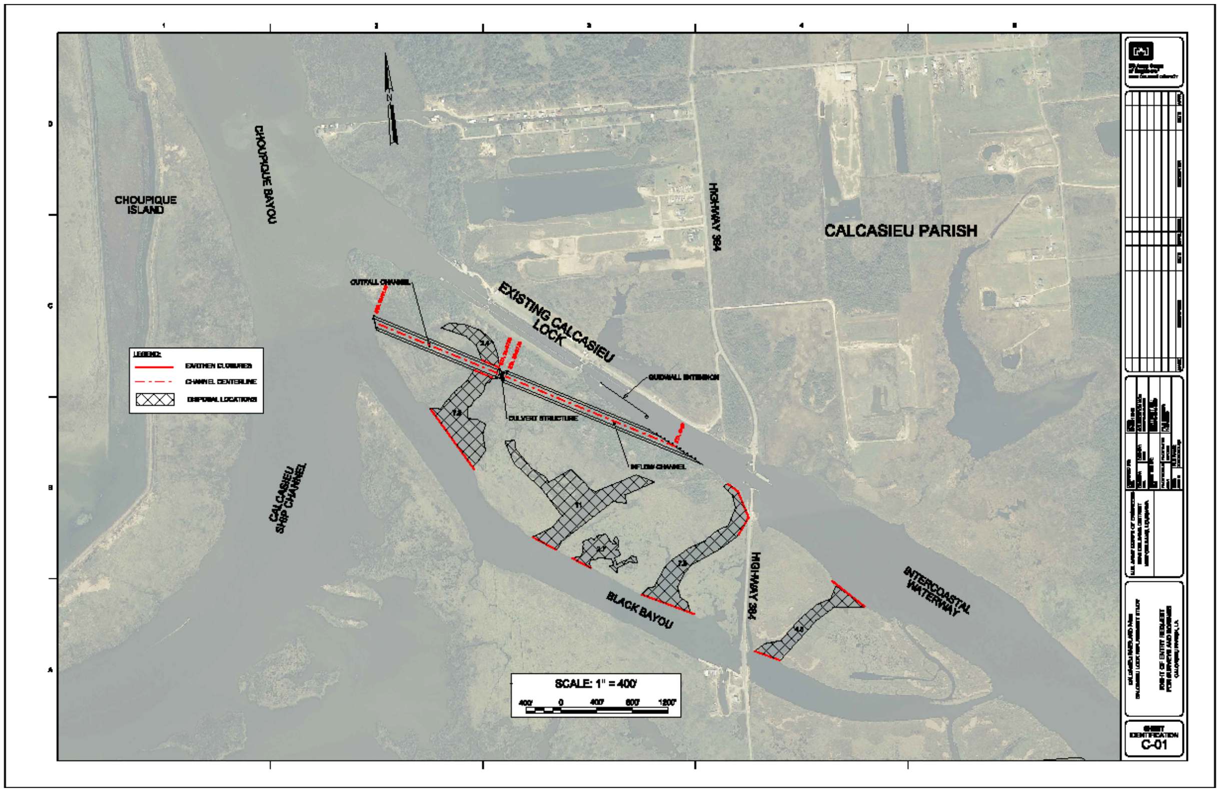

Figure 1. Mitigation Project Area

Project Goal

Marsh impacts due to the Calcasieu Lock Tentatively Selected Plan would require mitigation of approximately 7.9 Average Annual Habitat Units (AAHUs). The creation of approximately 10 acres of brackish tidal marsh would achieve this mitigation requirement.

Initial target elevation for dredge fill would be to an elevation that would allow the development of marsh. More detailed design will be required for mitigation planning, but this report describes the projected outcome of marsh creation for mitigation and the net benefit provided.

Habitat Assessment Method

The WVA operates under the assumption that optimal conditions for general fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of a mathematical model developed specifically for each wetland type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values, and 3) a mathematical formula that combines Suitability Index for each variable into a single value for wetland habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI.
The WVA model for marsh habitat attempts to assess the suitability of each habitat type for providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species.

While the model does not specifically assess other wetland functions and values such as storm-surge protection, floodwater storage, water quality improvement, nutrient import/export, and aesthetics, it can be generally assumed that these functions and values are positively correlated with fish and wildlife habitat quality.

The procedure for evaluating project benefits on fish and wildlife habitats, the WVA model, uses a series of variables that are intended to capture the most important conditions and functional values of a particular habitat. Values for these variables are derived for existing conditions and are estimated for conditions projected into the future if no restoration efforts are applied (i.e., future-without-project), and for conditions projected into the future if the proposed restoration project is implemented (i.e., future-with-project), providing an index of quality or habitat suitability of the habitat for the given time period. The habitat suitability index (HSI) is combined with the acres of habitat to get a number that is referred to as "habitat units". Expected project benefits are estimated as the difference in habitat units between the future-with-project (FWP) and future-without project (FWOP). To allow comparison of WVA benefits to costs for overall project evaluation, total benefits are averaged over a 50-year period, with the result reported as Average Annual Habitat Units (AAHUs).

Variable V_1 – Percent of wetland area covered by emergent vegetation

Existing – The project area is open water and surrounding marsh has been classified as brackish marsh consistently from 1968 to 2007 (O'Neil 1949, Chabreck and Linscombe 1997, Sasser et al. 2007).

The two major soil types in the project area are classified by the United States Department of Agriculture (USDA) (1987) as Clovelly muck and Udifluvent. Covelly much is a very poorly drained, very fluid organic soils typical of brackish marsh. They are generally flooded and ponded most of the time and have a high subsidence potential. Undifluvent soils are sandy and clayey soil material that has been excavated from other places (in this case from the GIWW channel) and have a higher elevation then the surrounding area.

Land Loss Data

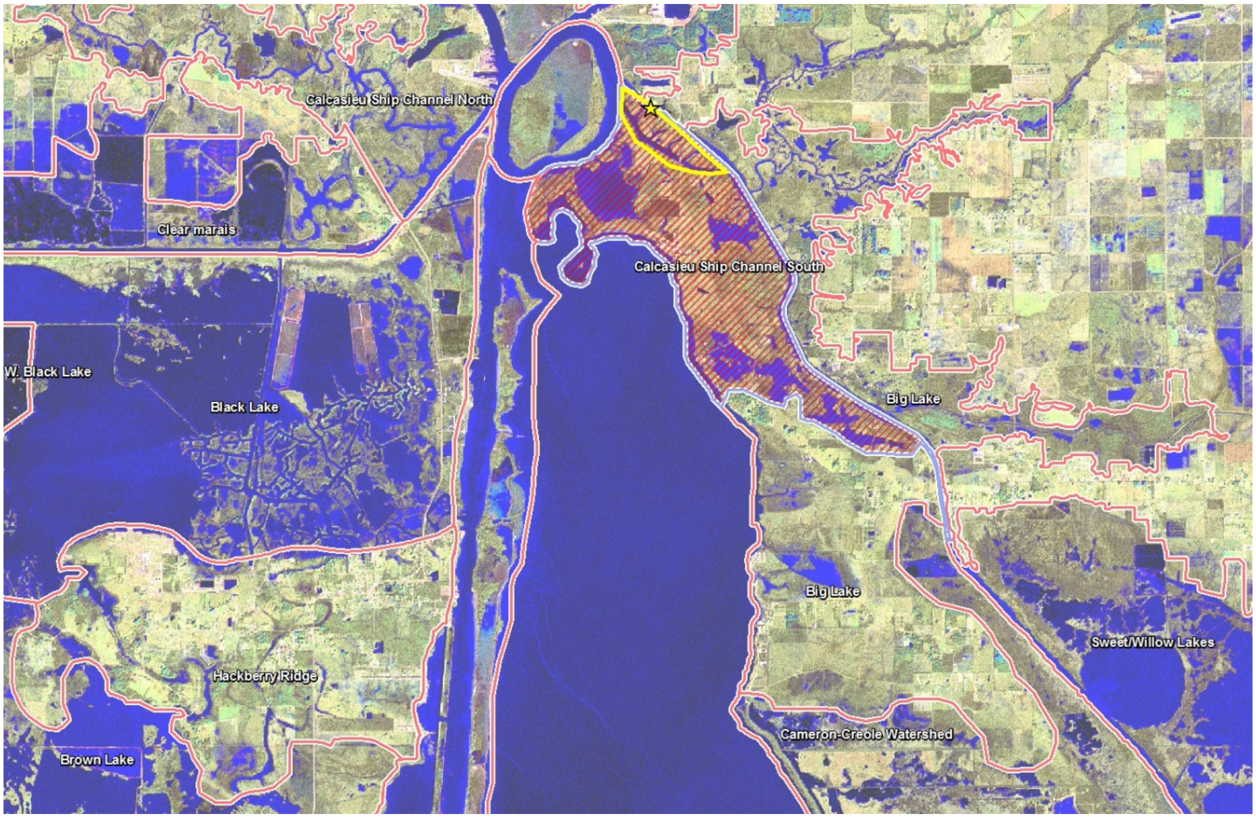

Figure: 2. USGS Extended Boundary For Land Loss Rates in Calcasieu Lock Area

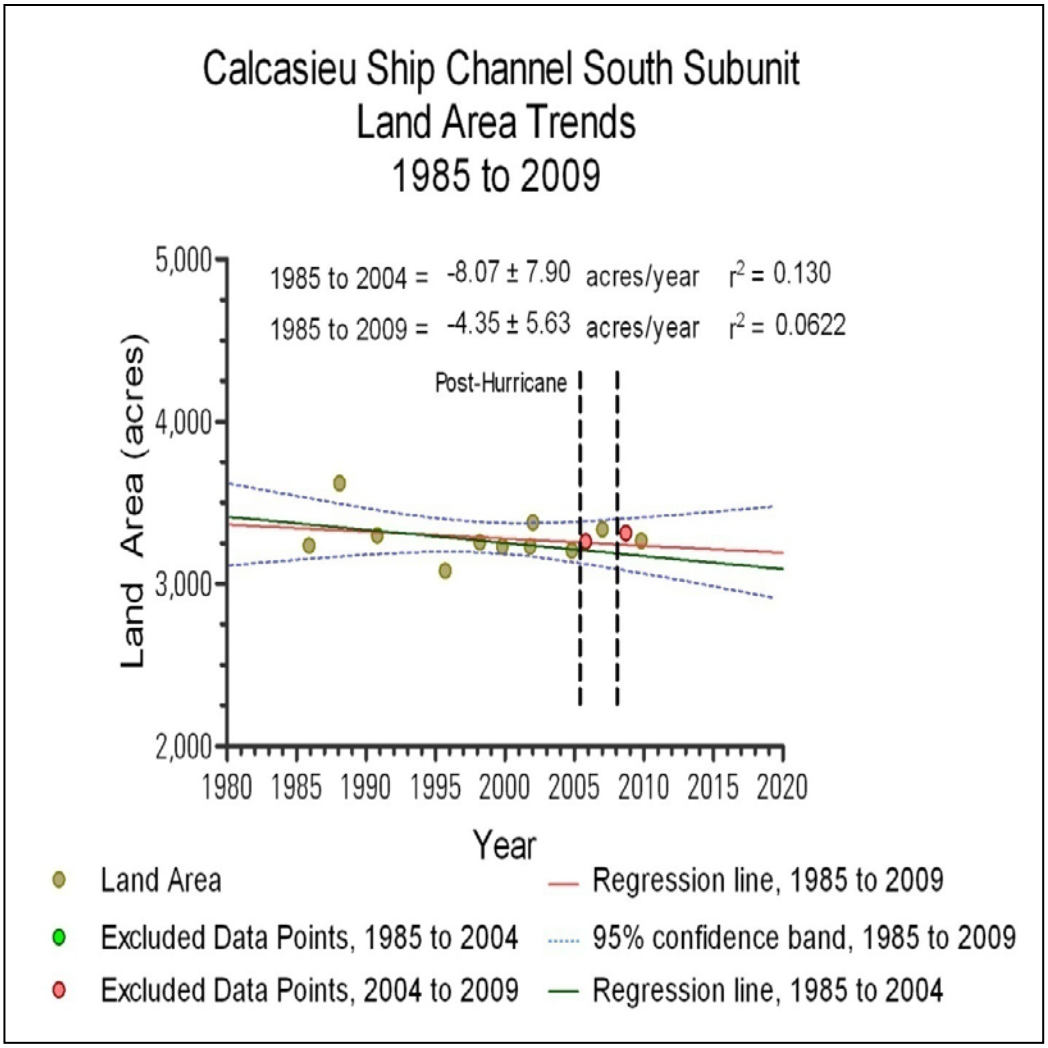

Figure 3. USGS Land Loss Regression for Extended Boundary

Project Area Acre per year lost rate

The acre/year rate is adjusted for the size of the project area relative to the size of the extended boundary.

FWOP
No rate used here because project area is open water with no marsh, but would be -0.0476 acres/year if area was all marsh.

FWP assume rate is 50% less because marsh is newly created (but rate reverts back to FWOP rate when accretion is assumed to be 10 inches and marsh is assumed to behave similar to surrounding marsh)
= -0.02 acres/year

Land loss rates were adjusted by the projected effects of three Relative Sea Level Rise (RSLR) scenarios. The medium RSLR scenario was chosen for these analyses.

FWOP – Under the medium RSLR scenario, the adjusted marsh loss rate would result in the losses as below. Percent is of the entire project area acreage and are rounded to be accepted into excel model.

TY0-TY50
Marsh: 0 acres (0%)
Water: 30.9 acres (100%)

FWP – It is assumed that all acres within the project area would be marsh creation (i.e., no marsh nourishment assumed). Created marsh platform has limited marsh function until settlement and breaching of retention dikes. Land loss is applied at the time of marsh creation. The rate is 50% of the background loss rate until TY43 when at least10 inches of water is assumed to cover the marsh and background loss rate is resumed. Percent is of the entire project area acreage and are rounded to be accepted into excel model.

TY0
Marsh: 0 acres (0%)
Water: 30.9 acres (100%)

TY1
Non-functional
marsh platform: 27.82 acres (90%)
Marsh: 3.08 acres (10.00% [0.1 credit factor applied])
Water: 0 acres (0%)

TY3
Non-functional
marsh platform: 23.2acres (75%)
Marsh: 7.7 acres (25% {0.25 credit factor applied})
Water: 0 acres (0%)

TY5:
Non-functional
marsh platform: 0 acres (0%);
Marsh: 30.74 acres (99.22% - assume all existing created marsh platform converted to marsh [full credit; 1.0 credit factor])
Water: 0.16 acres (%)

TY6:
Marsh: 30.67 acres (99%)
Water: 0.23 acres (1%)

TY43
Marsh: 26.53 acres (86%)
Water: 4.37 acres (14%)

TY50:
Marsh: 25.32 acres (82%)
Water 5.58 acres (18%)

Variable V_2 – Percent of open water covered by aquatic vegetation

Existing Conditions –The project area is primarily shallow open water with no SAV observed at the site.

FWOP – Existing conditions are expected to continue,

TY 0 0%
TY 50 0%

FWP – Because there was no SAV found in the area, we assume that it will not be present after the mitigation project is constructed.

TY 0 0%
TY 50 0%

Variable V_3 – Marsh edge and interspersion

Existing Conditions – The project area contains only small marsh fragments in three of the four sites that make up the project area. The marsh area is 5% of the total project area; therefore the project area is assigned a Class 5 value for TY 50.

FWOP –.
TY 0 – 50: 100% Class 5 (no new marsh is gained; existing marsh converts to open water)

FWP –

TY 0:	100 % Class 5
TY 1	100% Class 5
TY 3	100% Class 3 ("carpet marsh")
TY 5	50% Class 3, 50% Class 1
TY 6	100% Class 1
TY 43	95% Class 1; 5% Class 2 (emergent marsh is ~95%)
TY 50	50% Class 2; 50% Class 3 (emergent marsh is ~81%)

Variable V_4 – Percent of open water area <=1.5 feet deep in relation to marsh surface

Existing
Water depths were measured with a survey rod in some parts of the project area on 13 December 2012 and the area that had a depth of 1.5 ft or less was estimated to be 12%. Using field trip notes that documented that at least one of the other bayou remnant "fingers" was very shallow, we attempted to extrapolate an estimate of shallow water amount for the area. The Corps' RSLR estimates predict a sea-level rise of approximately 1.61 feet by the year 2070 under the Intermediate RSLR scenario (Appendix). It was assumed that RSLR will reduce the existing shallow open water for FWOP and FWP at TY50 by 1/3 and 1/6 respectively.

FWOP

TY0	20%
TY1	20%
TY3	20%
TY5	20%
TY6	20%
TY25	20%
TY50	13%

FWP- the mitigation project land platform would be built to a subaerial elevation with dredged material. Marsh that is lost is assumed to become open water <= 1.5 feet deep until TY50. At that point, it is assumed that 1/6 of the shallow open water would become deeper than 1.5 feet.

TY0	20%
TY1	100%
TY3	100%
TY5	100%
TY6	100%
TY24	100%
TY50	83% (of acres of shallow water becomes deep)

<u>Variable V_5 - Salinity</u>

Existing conditions – The average annual salinity estimate for the brackish marsh area was 13.7 ppt., and was obtained from the Calcasieu Lock West Gage which is within a few hundred feet of the project area. The lock modification project is not expected to affect water salinity.

FWOP & FWP
TY0 – TY50 13.7 ppt

<u>Variable V_6 – Aquatic organism access</u>

Existing conditions – The open water areas considered for marsh creation are not impounded or hydrologically controlled by any structures. Access to all parts of project area is assumed to be equal.

FWOP Existing conditions are expected to persist.
TY0 – TY50 = 1.0

FWP After construction, retention dikes will block all aquatic organism access. After the dikes are breached in TY3, it is assumed that aquatic organisms will have total and equal access to sites that make up the project area.

TY0	1.0
TY1	0
TY3	0
TY5 – TY50	1.0

Literature Cited

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices. Appendix C – Region 1 Supplemental Information. Louisiana Department of Natural Resources. Baton Rouge, La.

United States Department of Agriculture, Soil Conservation Service. 1988. Soil Conservation Service Soil Survey of Calcasieu Parish, Louisiana. United States Department of Agriculture, Soil Survey Service. June 1988.

Model Name	Wetland Value Assessment - Brackish M
Model Version	1.1
Date of Last Update	November 15, 2011
Original Model Version	1.0 - March 10, 2010
Objective of Model	The coastal marsh models were develop Louisiana coastal zone. These models w define an optimal combination of habitat ecosystems.
Instructions	Enter data in green cells. All green cells compute for that year.
	Always error check data following entry.
	Click on variable name in column B for a
	Intermediate Calculations are "over flow' table.
	Refer to WVA documents for model stru
Notes	1) Enter data in units noted.
	2) All percentages should be entered as

Color Coding Key:

Input
Calculation
Output

larsh Community Model

ıed to determine the suitability of marsh and open water habitats in the
were designed to function at a community level and therefore attempt to
conditions for all fish and wildlife species utilizing coastal marsh

must contain values (including 0's) in order for the HSI calculation to

. brief description of the variable.
' calculations that were too long or complex to fit within one cell within the

cture and background.

whole numbers between 0 and 100.

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Brackish Marsh

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 31

Condition: Future Without Project password is unlock

Variable		TY	0	TY	1	TY	3
		Value	**SI**	**Value**	**SI**	**Value**	**SI**
V1	% Emergent	0	0.10	0	0.10	0	0.10
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	0	0.10	0	0.10	0	0.10
	Class 2	0		0		0	
	Class 3	0		0		0	
	Class 4	0		0		0	
	Class 5	100		100		100	
V4	%OW <= 1.5ft	20	0.36	20	0.36	20	0.36
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7	0.45
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000	1.00
	Emergent Marsh HSI =		**0.19**	**EM HSI =**	**0.19**	**EM HSI =**	**0.19**
	Open Water HSI =		**0.26**	**OW HSI =**	**0.26**	**OW HSI =**	**0.26**

Intermediate Calculations		
Interspersion		
0	0	0
0	0	0
0	0	0
0	0	0
0.1	0.1	0.1

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 30.9

FWOP

Variable		TY	5	TY	6	TY	43
		Value	**SI**	**Value**	**SI**	**Value**	**SI**
V1	% Emergent	0	0.10	0	0.10	0	0.10
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	0	0.10	0	0.10	0	0.10
	Class 2	0		0		0	
	Class 3	0		0		0	
	Class 4	0		0		0	
	Class 5	100		100		100	
V4	%OW <= 1.5ft	20	0.36	20	0.36	20	0.36
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7	0.45
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000	1.00
		EM HSI =	**0.19**	**EM HSI =**	**0.19**	**EM HSI =**	**0.19**
		OW HSI =	**0.26**	**OW HSI =**	**0.26**	**OW HSI =**	**0.26**

Intermediate Calculations		
Interspersion		
0	0	0
0	0	0
0	0	0
0	0	0
0.1	0.1	0.1

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 30.9

FWOP

Variable		TY	50	TY		TY	
		Value	SI	Value	SI	Value	SI
V1	% Emergent	0	0.10				
V2	% Aquatic	0	0.10				
V3	Interspersion	%		%		%	
	Class 1	0	0.10				
	Class 2	0					
	Class 3	0					
	Class 4	0					
	Class 5	100					
V4	%OW <= 1.5ft	13	0.27				
V5	Salinity (ppt)	13.7	0.45				
V6	Access Value	1.0000	1.00				
		EM HSI =	0.19	EM HSI =		EM HSI =	
		OW HSI =	0.26	OW HSI =		OW HSI =	

Intermediate Calculations

Interspersion

0	0	0
0	0	0
0	0	0
0	0	0
0.1	0	0

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Brackish Marsh

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 30.9

Condition: Future With Project

Variable		TY	0	TY	1	TY	3
		Value	SI	Value	SI	Value	SI
V1	% Emergent	0	0.10	10	0.19	25	0.33
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	0	0.10	0	0.10	0	0.40
	Class 2	0		0		0	
	Class 3	0		0		100	
	Class 4	0		0		0	
	Class 5	100		100		0	
V4	%OW <= 1.5ft	20	0.36	100	0.60	100	0.60
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7	0.45
V6	Access Value	1.0000	1.00	0.0000	0.10	0.0000	0.10
	Emergent Marsh HSI =		0.19	EM HSI =	0.19	EM HSI =	0.29
	Open Water HSI =		0.26	OW HSI =	0.16	OW HSI =	0.18

Intermediate Calculations

Interspersion

0	0	0
0	0	0
0	0	0.4
0	0	0
0.1	0.1	0

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 30.9

FWP

Variable		TY	5	TY	6	TY	43
		Value	SI	Value	SI	Value	SI
V1	% Emergent	99	0.99	99	0.99	86	0.87
V2	% Aquatic	0	0.10	0	0.10	0	0.10
V3	Interspersion	%		%		%	
	Class 1	50	0.70	100	1.00	100	1.00
	Class 2	0		0		0	
	Class 3	50		0		0	
	Class 4	0		0		0	
	Class 5	0		0		0	
V4	%OW <= 1.5ft	100	0.60	100	0.60	100	0.60
V5	Salinity (ppt)	13.7	0.45	13.7	0.45	13.7	0.45
V6	Access Value	1.0000	1.00	1.0000	1.00	1.0000	1.00
		EM HSI =	**0.90**	**EM HSI =**	**0.93**	**EM HSI =**	**0.86**
		OW HSI =	**0.32**	**OW HSI =**	**0.35**	**OW HSI =**	**0.35**

Intermediate Calculations

Interspersion

1	1	1
0	0	0
0.4	0	0
0	0	0
0	0	0

Project: **Calc Lock Brack Marsh Mitigation Option 1 Brackish Only** Project Area: 30.9

FWP

Variable		TY	50	TY		TY	
		Value	SI	Value	SI	Value	SI
V1	% Emergent	82	0.84				
V2	% Aquatic	0	0.10				
V3	Interspersion	%		%		%	
	Class 1	95	0.98				
	Class 2	5					
	Class 3	0					
	Class 4	0					
	Class 5	0					
V4	%OW <= 1.5ft	83	0.94				
V5	Salinity (ppt)	13.7	0.45				
V6	Access Value	1.0000	1.00				
		EM HSI =	**0.84**	**EM HSI =**		**EM HSI =**	
		OW HSI =	**0.37**	**OW HSI =**		**OW HSI =**	

Intermediate Calculations

Interspersion

1	0	0
0.6	0	0
0	0	0
0	0	0
0	0	0

AAHU CALCULATION - EMERGENT MARSH

Project: Calc Lock Brack Marsh Mitigation Option 1 Brackish Only

Future Without Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	0	0.19	0.00	
1	0	0.19	0.00	0.00
3	0	0.19	0.00	0.00
5	0	0.19	0.00	0.00
6	0	0.19	0.00	0.00
43	0	0.19	0.00	0.00
50	0	0.19	0.00	0.00
Max TY=	50		AAHUs =	0.00

Future With Project			Total	Cummulative
TY	Marsh Acres	x HSI	HUs	HUs
0	0	0.19	0.00	
1	3.08	0.19	0.58	0.29
3	7.7	0.29	2.21	2.63
5	30.74	0.90	27.65	25.15
6	30.67	0.93	28.61	28.13
43	26.53	0.86	22.86	950.50
50	25.32	0.84	21.20	154.18
Max TY=	50		AAHUs	23.22

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Emergent Marsh AAHUs =	23.22
B. Future Without Project Emergent Marsh AAHUs =	0.00
Net Change (FWP - FWOP) =	23.22

AAHU CALCULATION - OPEN WATER

Project: Calc Lock Brack Marsh Mitigation Option 1 Brackish Only

Future Without Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	30.9	0.26	8.10	
1	30.9	0.26	8.10	8.10
3	30.9	0.26	8.10	16.20
5	30.9	0.26	8.10	16.20
6	30.9	0.26	8.10	8.10
43	30.9	0.26	8.10	299.77
50	30.9	0.26	7.90	55.99
Max TY=	50		AAHUs =	8.09

Future With Project			Total	Cummulative
TY	Water Acres	x HSI	HUs	HUs
0	30.9	0.26	8.10	
1	0	0.16	0.00	3.54
3	0	0.18	0.00	0.00
5	0.16	0.32	0.05	0.04
6	0.23	0.35	0.08	0.07
43	4.37	0.35	1.52	29.52
50	5.58	0.37	2.07	12.51
Max TY=	**50**		**AAHUs**	**0.91**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project Open Water AAHUs =	0.91
B. Future Without Project Open Water AAHUs =	8.09
Net Change (FWP - FWOP) =	**-7.17**

TOTAL BENEFITS IN AAHUs DUE TO PROJECT	
A. Emergent Marsh Habitat Net AAHUs =	23.22
B. Open Water Habitat Net AAHUs =	-7.17
Net Benefits= (2.6xEMAAHUs+OWAAHUs)/3.6	**14.78**

Original Model Version	1.0 - March 10, 2010

Model Revisions

Version 1.1 - 11/16/2011	1) Spreadsheet formatted to populate FWP TY0 with FWOP TY0 va
	2) Spreadsheet formatted to allow entry of any value in Marsh and \
	3) Minor formatting changes to font type, font size, font color, etc.

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Water acreage cells in AAHU calculation sect

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

APPENDIX P-3
Wetland Value Assessment of Potential Forested Spoil Bank /Ridge Mitigation Worksheets

Model Name	Wetland Value Assessment - Coastal Chenier/Ridg
Model Version	1.1
Date of Last Update	November 18, 2011
Original Model Version	1.0 - March 10, 2010
Objective of Model	The model utilizes a set of variables considered im determining the suitability of non-grazed barrier hea cheniers, and spoil areas in Louisiana that are, or a vegetated in primarily non-obligate wetland plant sp the habitat necessary to support transient migratory
Instructions	Enter data in green cells. Always error check data following entry. Click on variable name in column B for a brief desc Refer to WVA documents for model structure and b
Notes	1) Enter data in units noted. 2) All percentages should be entered as whole nun

Color Coding Key:

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WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fo** Project Area: 16

Condition: Future Without Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	0	0.10	0	0.10	2	0.13
V2	Shrub/Midstory Cover (%)	2	0.15	20	0.62	50	1.00
V3	Species Diversity	1	0.22	1	0.22	2	0.33
		HSI =	0.15	HSI =	0.24	HSI =	0.35

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fo** Project Area: 16

FWOP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	5	0.17	10	0.24		
V2	Shrub/Midstory Cover (%)	60	1.00	75	0.85		
V3	Species Diversity	3	0.45	3	0.45		
		HSI =	0.42	HSI =	0.45	HSI =	

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fo** Project Area: 16

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fc** Project Area: 16

Condition: Future With Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	0	0.10	15	0.31	65	1.00
V2	Shrub/Midstory Cover (%)	2	0.15	30	0.88	60	1.00
V3	Species Diversity	1	0.22	10	1.00	10	1.00
		HSI =	0.15	HSI =	0.65	HSI =	1.00

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fc** Project Area: 16

FWP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	80	1.00	70	1.00		
V2	Shrub/Midstory Cover (%)	45	1.00	40	1.00		
V3	Species Diversity	10	1.00	11	1.00		
		HSI =	1.00	HSI =	1.00	HSI =	

Project: **Calcasieu Lock: Gate/Pump Alternative Mitigation for fc** Project Area: 16

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

AAHU CALCULATION

Project: Calcasieu Lock: Gate/Pump Alternative Mitigation for forested ridge habiata

Future Without Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	16	0.15	2.38	
10	16	0.24	3.81	30.94
20	16	0.35	5.59	47.00
30	16	0.42	6.80	61.96
50	16	0.45	7.22	140.20
Max TY =	50		Total CHUs =	280.10
			AAHUs =	5.60

Future With Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	16	0.15	2.38	
10	16	0.65	10.38	63.79
20	16	1.00	16.00	131.88
30	16	1.00	16.00	160.00
50	16	1.00	16.00	320.00
Max TY =	50		Total CHUs =	675.68
			AAHUs =	13.51

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project AAHUs =	13.51
B. Future Without Project AAHUs =	5.60
Net Change (FWP - FWOP) =	7.91

Original Model Version	1.0 - March 10, 2010

Model Revisions

Version 1.1 - 11/18/2011	1) Spreadsheet formatted to populate FWP TY0 with FWOP TY0 values.
	2) Spreadsheet formatted to allow entry of any value in acreage cells in AAHU calculation section.
	3) Minor formatting changes to font type, font size, font color, etc.

Model Name	Wetland Value Assessment - Coastal Chenier/Ridg
Model Version	1.1
Date of Last Update	November 18, 2011
Original Model Version	1.0 - March 10, 2010
Objective of Model	The model utilizes a set of variables considered im determining the suitability of non-grazed barrier hea cheniers, and spoil areas in Louisiana that are, or a vegetated in primarily non-obligate wetland plant sp the habitat necessary to support transient migratory
Instructions	Enter data in green cells. Always error check data following entry. Click on variable name in column B for a brief desc Refer to WVA documents for model structure and b
Notes	1) Enter data in units noted. 2) All percentages should be entered as whole num

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WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

Condition: Future Without Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	20	0.38	25	0.45	35	0.59
V2	Shrub/Midstory Cover (%)	75	0.85	75	0.85	60	1.00
V3	Species Diversity	4	0.57	4	0.57	4	0.57
		HSI =	0.57	HSI =	0.60	HSI =	0.69

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

FWOP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	40	0.66	50	0.80		
V2	Shrub/Midstory Cover (%)	55	1.00	45	1.00		
V3	Species Diversity	4	0.57	5	0.69		
		HSI =	0.72	HSI =	0.82	HSI =	

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Coastal Chenier/Ridge

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

Condition: Future With Project

Variable		TY	0	TY	10	TY	20
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	20	0.38	40	0.66	60	0.94
V2	Shrub/Midstory Cover (%)	75	0.85	80	0.78	65	1.00
V3	Species Diversity	4	0.57	10	1.00	10	1.00
		HSI =	0.57	HSI =	0.80	HSI =	0.98

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

FWP

Variable		TY	30	TY	50	TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)	70	1.00	55	0.87		
V2	Shrub/Midstory Cover (%)	55	1.00	65	1.00		
V3	Species Diversity	10	1.00	10	1.00		
		HSI =	1.00	HSI =	0.95	HSI =	

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExis** Project Area: 15

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Canopy Cover (%)						
V2	Shrub/Midstory Cover (%)						
V3	Species Diversity						
		HSI =		HSI =		HSI =	

AAHU CALCULATION

Project: **Calcasieu Lock: Gate/Pump AlternativeMitigationonExistingChen**

Future Without Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	15	0.57	8.52	
10	15	0.60	9.02	87.70
20	15	0.69	10.42	97.18
30	15	0.72	10.82	106.17
50	15	0.82	12.27	230.91
Max TY =	**50**		**Total**	
			CHUs =	**521.97**
			AAHUs =	**10.44**

Future With Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0	15	0.57	8.52	
10	15	0.80	12.02	102.73
20	15	0.98	14.69	133.58
30	15	1.00	15.00	148.47
50	15	0.95	14.32	293.20
Max TY =	**50**		**Total**	
			CHUs =	**677.97**
			AAHUs =	**13.56**

NET CHANGE IN AAHUs DUE TO PROJECT	
A. Future With Project AAHUs =	13.56
B. Future Without Project AAHUs =	10.44
Net Change (FWP - FWOP) =	**3.12**

Original Model Version	1.0 - March 10, 2010

Model Revisions

Version 1.1 - 11/18/2011	1) Spreadsheet formatted to populate FWP TY0 with FWOP TY0 values.
	2) Spreadsheet formatted to allow entry of any value in acreage cells in AAHU calculation section.
	3) Minor formatting changes to font type, font size, font color, etc.