APPENDIX S

WATER QUALITY FOR LPV AND WBV BASINS

1.1.1 WATER QUALITY

1.1.1.1 AFFECTED ENVIRONMENT

The Clean Water Act established a process for states to assess water quality. Section 305(b) of the Act requires states to develop a surface water quality monitoring program, and a report describing the water quality status of its waterbodies with respect to support of designated uses. Section 303(d) of the Act requires states to develop and list Total Maximum Daily Loads (TMDLs) for impaired waterbodies (waterbodies with water quality unsupportive of one or more designated uses). A TMDL is the maximum amount of the pollutant(s) contributing to an impairment that can enter a waterbody from all sources (including nonpoint sources) and still meet water quality criteria. LDEQ implements a watershed-based approach to reduce pollutant loads in the waterbodies where TMDLs have been established, through the Louisiana Pollutant Discharge Elimination System (LPDES) and Louisiana Nonpoint Source (NPS) programs. For the purpose of state water quality assessment, Louisiana is divided into twelve major basins, which are further divided into waterbodies known as subsegments. The *Louisiana Water Quality Inventory Report: Integrated Report* is the biennial publication prepared by the Louisiana Department of Environmental Quality (LDEQ) describing the status of Louisiana waters in accordance with Sections 305(b) and 303(d) (LDEQ 2013).

Designated Uses - Louisiana Surface Water Quality Standards (*LAC 33:IX.11*) include eight designated uses for surface waters: Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR), Fish and Wildlife Propagation (FWP), Drinking Water Supply (DWS), Outstanding Natural Resource (ONR), Oyster Propagation (OYS), Agriculture (AGR), and Limited Aquatic Life and Wildlife (LAL). Designated uses for each waterbody, and water quality criteria for each designated use, are included in the standards. For definitions regarding the designated uses refer to https://deq.louisiana.gov/page/water-quality

If a designated use is not fully supported, support for the designated use is impaired, and suspected causes and sources of impairment are identified. A suspected cause of impairment is a water quality criteria violation associated with impairment (e.g., low dissolved oxygen, non-native aquatic plants), while a suspected source of impairment is an activity, event, or condition associated with a suspected cause of impairment (e.g., agriculture, chemical spills, natural conditions).

Water Quality Criteria - Water quality criteria are elements of state water quality standards expressed as constituent concentrations, levels, or narrative statements representing the quality of surface waters supporting a designated use. When all

criteria are met for a designated use, surface water quality is expected to support the designated use. Louisiana has both general and numeric criteria (*LAC 33:IX.1113*). General criteria are expressed in a narrative form, and include aesthetics, color, suspended solids, taste and odor, toxic substances (in general), oil and grease, foam, nutrients, turbidity, flow, radioactive materials, and biological and aquatic community integrity. Numeric criteria are generally expressed as concentrations or scientific units, and include pH, chloride, sulfate, total dissolved solids, dissolved oxygen, temperature, bacteria, and specific toxic substances.

Louisiana Pollutant Discharge Elimination System - The LPDES Program administers permitted wastewater discharges into state surface waters, allowing the state to control the amounts and types of wastewaters discharged into its waters in order to meet water quality standards. The program began in 1996, when LDEQ adopted responsibility for administering the permitting, compliance, and enforcement activities of the National Pollutant Discharge Elimination System (NPDES) from the EPA.

Louisiana Nonpoint Source Program **-**The Louisiana NPS Program administers nonpoint source pollution management in accordance with Section 319(h)(11) of the Clean Water Act, as another measure for meeting water quality standards. It includes partnering with stakeholders and other statewide nonpoint source pollution management programs for the development and execution of watershed implementation plans for reducing nonpoint source pollution, as well as educational outreach with the same objective (LDEQ 2014).

1.1.1.1.1 Existing Conditions

Mississippi River **-** The LPV and WBV is dissected by the Mississippi River (Figure 4-6), the largest watershed in the U.S., draining 41% of the land area of the lower 48 states. Natural erosion and weathering of land surface materials influences river water quality, by releasing dissolved solids along with small amounts of metals, nutrients, and organic materials. Human activities in the basin affect both river water quality and quantity, and include industry, development, natural resource extraction, agriculture, and river engineering. Human-induced changes to river water quality are related to population increases within the river's watershed and development practices, including the adoption of agricultural soil conservation practices beginning in the 1930s; the construction of major river engineering works throughout the 20th century; increasing use of fertilizers and pesticides, particularly for industrial farming; and inadequate regulation of point source pollution prior to effective enforcement of the Clean Water Act.

Fertilizer and pesticide application within the watershed under post-World War II industrial farming practices has been correlated with increases in river and tributary nitrate concentrations, and the presence of pesticides in these waterbodies. During the latter half of the 20th century, nitrate concentrations in the lower river increased from 0.56 to 1.45 mg/L, correlating strongly with a shift to intensive farming of corn and soybeans in the basin, especially in the Midwest (NSTC/CENR 2000, Broussard 2008). Atrazine, developed in the 1950s and therefore previously nonexistent in river water, is now present in river water at concentrations ranging from 0.1-1.4 µg/L (Demcheck and Swarzenski 2003). The combination of elevated nitrate and atrazine in the river has been linked to wetland losses in areas of coastal Louisiana receiving chronic river water

inflows (Swarzenski et al. 2005). Additionally, there is evidence that farming practices in the watershed have led to increasing river discharge:precipitation and bicarbonate load:river discharge relationships, suggesting that agricultural activities in the basin may also affect river discharge and alkalinity, and loadings of major ions and agricultural pollutants in addition to nitrate and atrazine (Raymond et al. 2008).

Decreasing suspended sediment concentrations in the lower river have been linked to river engineering and agricultural soil conservation practices within the basin. The construction of river engineering works in the 1950s and 1960s (particularly the dams along the Lower Missouri River, the largest tributary source of sediment to the lower river), construction of dikes and revetments along the lower river, and agricultural soil conservation practices implemented within the basin in response to the Dust Bowl are believed to be the major factors contributing to the 60% reduction in the suspended sediment load of the lower river since 1900 (Meade and Moody 2010). Based on watershed and riverine modeling, a 17% reduction has occurred when comparing present loads with those prior to European settlement within the watershed during the 18th century, suggesting that watershed development before the adoption of agricultural soil conservation practices contributed to unnaturally high suspended sediment loads in the lower river (Tweel and Turner 2012).

River water quality has also been impacted by inflows of industrial and municipal effluent, as well as unpermitted point source discharges. Inadequate regulation of point source pollution until the late 20th century contributed to water quality problems related to organic enrichment, thermal pollution, and the introduction of synthetic organic compounds and heavy metals. The passing of the Clean Water Act and improved regulation of point sources of pollution has reduced or eliminated many of the water quality problems in the river. However, nonpoint source pollution within the watershed—primarily agricultural runoff—continues to generate water quality problems (COMRACWA 2008).

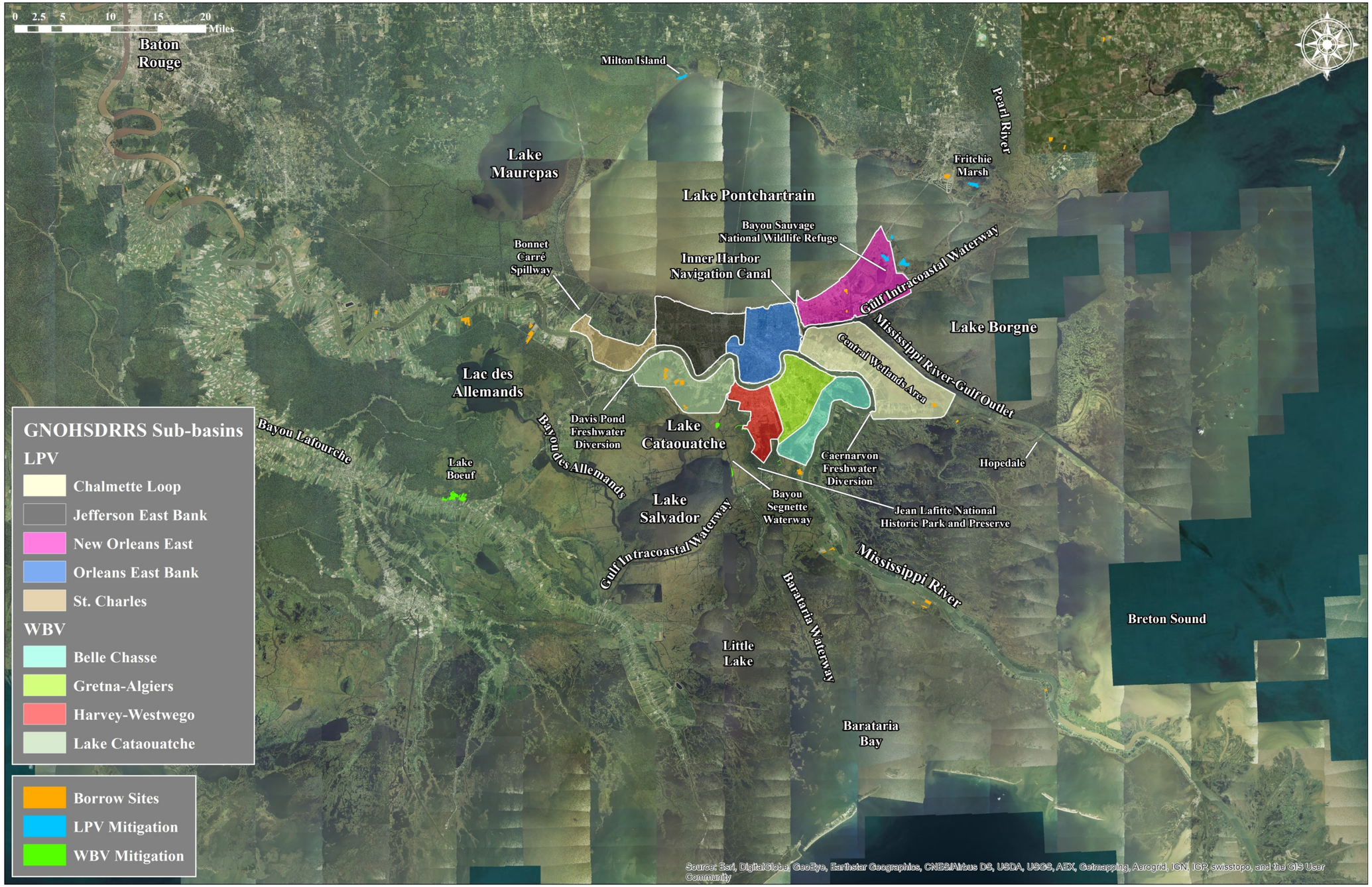
Estuaries - The HSDRRS is mostly located within the Pontchartrain and Barataria Estuaries (Figure 4-6). Surface waters in these estuaries include shallow open water habitat and wetland communities reflective of adjacent surface water salinities, which decrease inland and with proximity to riverine inflows (Linscombe and Hartley 2011). The estuaries include several large, shallow embayments which ultimately drain into bay systems through passes and bayous, as well as abandoned distributaries of the Mississippi River and their associated natural levees (Conner et al. 1987, McCorquodale et al. 2009). Marsh areas become progressively fragmented gulfward (towards the Gulf of Mexico) as a result of increasing tidal energy gulfward.

The Pontchartrain Estuary receives freshwater from several tributaries, while the Barataria Estuary, which is situated between Bayou Lafourche and the Mississippi River corridor, has no tributaries. Both estuaries receive Mississippi River water inflows via small and medium freshwater diversions; the Barataria Estuary also receives Mississippi River water via the Gulf Intracoastal Waterway (GIWW), which serves as a conduit for Atchafalaya River water (the primary water source for the Atchafalaya River is the Mississippi River; Kearney et al. 2011, Swarzenski 2003). The lower end of both

estuaries—especially near the Mississippi River delta, where the river debouches into the gulf—is also influenced by Mississippi River water. Occasional but significant Mississippi River water introduction occurs in the upper Pontchartrain Estuary, when the Bonnet Carré Spillway is operated to prevent flooding of downriver communities during flood conditions on the river.

Man-made hydromodification features (constructed features which alter water level, flow, and distribution patterns) within the estuaries include oil exploration, cypress logging, and navigation channels. Major navigation channels in the Pontchartrain Estuary include the GIWW and Inner Harbor Navigation Canal, and in the Barataria Estuary include the GIWW, Harvey and Algiers Canals, Bayou Segnette Waterway, and Barataria Bay Waterway. As a result of hydromodification in combination with other factors (both natural and human), the Pontchartrain and Barataria estuaries have lost over 750 square miles of land in the past 80 years (Boesch et al. 1994, Couvillion et al. 2011).

Figure 4-6. Waterways and Features within and adjacent to the HSDRRS Project Area



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The water quality of the estuaries is the result of human development and activities imposed upon watershed settings. The low relief and small tidal range promote sluggish water flows that increase in magnitude gulfward. Because of the abundance and high productivity of estuary wetlands, surface waters can be highly organic; the combination of slow-moving and organic waters can foster low dissolved oxygen conditions, particularly in the more stagnant upper estuary and during the summer when water temperatures are warmest. Saline gulf waters promote flocculation of dissolved organic and inorganic material and precipitation of trace elements, causing reductions in metals, nutrients, and suspended sediment concentrations (Conner et al. 1987, McGee and Demcheck 1998). Additionally, normal surface water quality conditions can be disrupted by natural events such as hurricanes, droughts, and Mississippi River flooding. Human establishment in the region has led to alterations in estuary surface water quality and habitat, most notably in the forms of eutrophication (excessive dissolved nutrients in the water column), magnified low dissolved oxygen conditions, hydromodification, and wetlands loss (Conner et al. 1987).

The Pontchartrain Estuary receives freshwater inflows from the Pearl River and from its tributaries, whose watersheds include a mixture of undeveloped, agricultural, and urban land; the agricultural Mississippi River corridor within the Pontchartrain Estuary watershed; the urban greater New Orleans area; and the Mississippi River. While runoff from undeveloped areas is generally associated with good water quality, the quality of runoff from agricultural and urban land use areas is reflective of anthropogenic sources, which primarily include regional farming practices, sanitary inflows, and stormwater runoff (Demcheck et al. 2004). Within the estuary, the freshwater inflows mix with rainfall over the estuary and gulf waters introduced from the Mississippi and Breton Sounds, forming a gulfward gradient of increasing salinities. This gradient is further affected by seasonal weather (especially wind patterns) and tides, which aid in generating estuary currents (Swenson and Swarzenski 1995). The regions of the estuary with water quality most affected by human activities include those under the influence of Mississippi River water; at the mouths of tributary rivers; in pump station outfall areas; and in regions of the upper estuary with naturally stagnant waters, which in some cases are further impounded by hydromodification in the form of oil exploration and logging canals and their associated spoil banks (Hyfield et al. 2008, McCorquodale et al. 2009, Keddy et al. 2007). Episodic Mississippi River water influence occurs in Lake Pontchartrain from operation of the Bonnet Carré spillway, while more continuous Mississippi River water influence occurs in receiving areas for river diversions such as the Caernarvon Freshwater Diversion, and along the lowermost reach of the Mississippi River East Bank where there are no artificial levees. The MRGO formerly provided another variant of hydromodification affecting estuary water quality: the direct hydraulic connection of the Gulf of Mexico with inland areas, which led to regional changes in salinity gradients and localized salinity stratification and hypoxia (dissolved oxygen concentrations less than 2 mg/L in surface waters)(Sikora and Kjerfve 1985, Poirrier 2013). The MRGO closure near Hopedale, which was completed in 2009, severed this connection, and appears to have relocated salinity stratification and hypoxia from Lake Pontchartrain near the Inner Harbor Navigation Canal to upstream and downstream of

the closure in the MRGO channel (Poirrier 2013, Swarzenski and Mize 2014).

Estuary water quality is also significantly influenced by estuary wetlands and shallow waterbodies. Depending factors such as wetland type, season, hydrologic regime, regional flow patterns, and duration of constituent (e.g., metals and nutrients) loading, wetlands and waterbottom sediments of shallow waterbodies can serve as either a source of or sink for constituents, and can promote chemical transformations (Mitsch and Gosselink 2000). The interaction of wetlands and surface waters in some areas has changed due to regional geology, changing watershed land use, and hydromodification, leading to changes in water quality, hydrology, and wetlands abundance and health (Turner 2014).

Development within the watershed prior to the establishment and adequate enforcement of environmental regulations during the 20th century has been cited as the primary cause of historical water quality problems in the Pontchartrain Estuary (Hastings 2009). Major pollution sources to the estuary have included untreated sewage discharges, urbanization, agriculture, waterbottom mining, and oil and gas activities. While in recent decades many of the historical point sources of pollution to the estuary have been reduced or eliminated, nonpoint sources of pollution such as urbanization and agriculture continue to affect watershed water quality, and in some regions are intensifying or expanding (Patil and Deng 2008, Turner et al. 2002, Wu and Xu 2007). A statistical summary of water quality in the Pontchartrain Basin is provided in Garrison (1999). Recently, estuary water quality has been impacted by the diversion of Mississippi River water via the Bonnet Carré Spillway and the Caernarvon Freshwater Diversion, both of which have been found to impact estuary salinity gradients and aid in the formation of harmful algal blooms, while Caernarvon Freshwater Diversion inflows may additionally have contributed to the proliferation of aquatic vegetation and the loss of over forty square miles of wetlands (Mize and Demcheck 2009, Lane et al. 2007, Wissel et al. 2005, Kearney et al. 2011).

A depiction of average estuary salinity gradients based on long-term monitoring data is included in Georgiou et al. (2007). The salinity and water quality of southern Lake Borgne and eastern Lake Pontchartrain has been impacted by the construction of the MRGO, which provided a direct hydraulic connection between Lake Pontchartrain and the Gulf of Mexico, facilitating an increase in the salinity of adjacent, hydraulically connected waterbodies (Sikora and Kjerfve 1985, Tate et al. 2002). The MRGO closure at Bayou La Loutre, which was completed in 2009, may have restored salinity patterns in eastern Lake Pontchartrain and adjacent Lake Borgne, while relocating salinity stratification and hypoxia from Lake Pontchartrain near the IHNC to within the MRGO channel (Tate et al. 2002, Martin et al. 2010, Poirrier 2013, Swarzenski and Mize 2014).

Barataria Estuary water quality influences also originate both within and outside of the estuary. However, unlike the Pontchartrain Estuary, it does not have any tributaries, as except at its southern reaches where it meets the gulf, it is bordered by the back levees along the Mississippi River and Bayou Lafourche corridors. Agricultural land use occurs in the upland areas bordering the estuary, and to a lesser extent on areas of land within

the estuary, while the West Bank area across the river from New Orleans is the major urban area along its perimeter (Demcheck et al. 2004). Water quality influences originating outside of the Barataria Basin primarily include Mississippi River water and saltwater from the gulf. Within the estuary, freshwater inflows mix with rainfall over the estuary and gulf waters introduced at its southern end, forming gradients of decreasing salinity inland and with proximity to riverine inflows. This gradient is further affected by seasonal weather (especially wind patterns) and tides, which aid in generating estuary currents (Swenson and Swarzenski 1995). Water quality north of the GIWW is generally more influenced by human activities, due to local inputs of agricultural and urban runoff, comparatively higher surface water residence times, hydromodification in the form of oil and gas canals, and Mississippi River water inflows (Conner et al. 1987, Frye and Chumchal 2012). Lower estuary water quality is influenced by relatively clean, saline gulf waters, which promote the removal of organic and inorganic materials and trace elements from surface waters, and by Mississippi River water. As with the Pontchartrain Estuary, Barataria Estuary water quality is also influenced by wetlands and shallow waterbodies. Conner et al. (1987) and Rabalais et al. (1995) provide summaries of historical surface water quality in the Barataria Basin. According to Conner et al. (1987), runoff from urban and agricultural areas in the northern basin contains high nutrient and suspended sediment concentrations that affect water quality. As a result of artificial channelization in northern estuary wetlands, runoff interaction with wetlands is hampered, preventing filtration of nutrients and sediment, leading to highly eutrophic conditions in northern estuary waterbodies. Surface waterbodies in the vicinity of urban and industrial areas, particularly in the Bayou Segnette Region, can sometimes have poor water quality with respect to water quality criteria (Rabalais et al. 1995). In recent years, northern estuary water quality has also been affected by the Davis Pond Freshwater Diversion, which may be contributing to increases in the abundance of aquatic vegetation and the formation of harmful algal blooms, as well as increases in the bioaccumulation of some metals and organic contaminants in fish tissue (Poirrier et al. 2009, Frye and Chumchal 2012, Ren et. al 2009, Jenkins et al. 2012). A depiction of lower estuary salinity gradients based on long-term monitoring data is included in Swenson and Turner (1998). Pre-Davis Pond Freshwater Diversion construction salinity monitoring data in the lower estuary suggest historical increases in Barataria Waterway salinity and salinity variability and decreases in Barataria Bay salinity (Swenson and Swarzenski 1995, Swenson and Turner 1998, Steyer et al. 2008).

Louisiana Water Quality Inventory Summary - To assess historical and existing water quality, *Louisiana Water Quality Inventory Report: Integrated Report* data for the 2002-2014 reporting periods were summarized for all project area subsegments (see Tables 4-11 and 4-12 for subsegment information and CED IER/ EA-subsegment relationships, and Figures 4-7, 4-8, or 4-9 for subsegment locations). To spatially and temporally depict water quality, an average designated use support value for each subsegment was calculated and mapped, using 2002-2014 data, 2002-2006 data only, and 2008-2014 data only. Breakpoints for the table and figures of 0.25, 0.5, and 0.75 were used for color-coding.

HSDRRS construction began in July 2007 and the majority ended in July 2015; therefore, the 2002-2006 reporting periods were used to evaluate designated use support prior to HSDRRS construction, while the 2008-2014 reporting periods were used to evaluate designated use support during HSDRRS construction. Possible support values for each combination of subsegment, reporting period, and designated use included 0 (no support), 0.25 (support threatened), 0.5 (partial support), and 1 (full support). The average support value calculated for each subsegment serves as a metric for subsegment water quality with respect to designated uses (i.e., lower values indicate relatively poor water quality while higher values indicate relatively good water quality). Data for the 1998 and 2000 reporting periods were not used for this assessment due to use of a different method for determining designated use support during these reporting periods. Counts of suspected causes and sources of impairment were tabulated by reporting period, in order to summarize historical causes and sources of impairment.

Designated use support and average support values are listed in Table 4-13. According to Table 4-6, Fish and Wildlife Propagation is the most impaired designated use for project area subsegments, followed by Primary Contact Recreation.

Average support values for the 2002-2014 reporting periods reveal some spatial patterns (Table 4-6 and Figure 4-3). Subsegments that include the Mississippi River (070301), Lake Pontchartrain and several of its connecting waterbodies (040601, 040911, 041001, 041002, 041101, 041203, 041301, 041501, 041601, 041701, and 041702), most of the Chalmette Loop sub-basin (041801-041807), the marsh area bordering the western lobe of Lake Borgne (042002 and 042004), the MRGO (041901), east of Bayou Terre Aux Boeufs (042101), the Caernarvon Freshwater Diversion receiving area (042105), and marsh areas south of the WBV sub-basins (020303, 020802, 020904, and 021001) are generally supportive of their designated uses, with 2002-2014 average support values greater than 0.75.

Designated use support is generally fair to poor for subsegments in the Jefferson and Orleans East Bank and New Orleans East sub-basins (041302 and 041401), adjacent to the Mississippi River East Bank from the Baton Rouge area to the St. Charles sub-basin (040201, 040403, 040404, 041201, and 041202), along the north shore of Lake Pontchartrain (040803 and 040910), in the southern portion of the Chalmette Loop sub-basin (041808), southwest of the Caernarvon Freshwater Diversion receiving area (042102), the majority of project area subsegments in the Barataria Basin (020102, 020103, 020202, 020301, 020302, 020501, 020601, and 020701), and along Bayou Petit Calliou in the Terrebonne Estuary (120504), with 2002-2014 average support values between 0 and 0.75. Designated use support was not assessed for subsegment 041809 during any of the reporting periods evaluated. Figure 4-3 suggests that

Table 4-11. Project area subsegments

Subsegment	Subsegment Description	Type	Size	Size Units
020102	Bayou Boeuf, Halpin Canal and Theriot Canal	River	19	mi
020103	Lake Boeuf	Lake	6,100	acres
020202	Lac Des Allemands	Lake	14,720	acres
020301	Bayou Des Allemands U.S. Hwy. 90 to Lake Salvador (Scenic)	River	14	mi
020302	Bayou Gauche	River	4	mi
020303	Lake Cataouatche and Tributaries	Lake	9,280	acres
020501	St. Charles Parish Canals and Bayous in Segment 0205	River	26	mi
020601	Intracoastal Waterway-Bayou Villars to Mississippi River (Estuarine)	River	15	mi
020701	Bayou Segnette-origin to Bayou Villars	River	12	mi
020802	Bayou Barataria/Barataria Waterway-Intracoastal Waterway to Bayou Rigolettes (Estuarine)	River	6	mi
020904	Wilkinson Canal and Wilkinson Bayou (Estuarine)	River	14	mi
021001	Bastian Bay, Adams Bay, Scofield Bay, Coquette Bay, Tambour Bay, Spanish Pass and Bay Jacques (Estuarine)	Estuary	33	mi^2
040201	Bayou Manchac-Headwaters to Amite River	River	18	mi
040403	Blind River-Source to confluence with Amite River Diversion Canal (Scenic)	River	20	mi
040404	New River-Headwaters to New River Canal	River	24	mi
040601	Pass Manchac-Lake Maurepas to Lake Pontchartrain	River	7	mi
040803	Lower Tchefuncte River-From La. Hwy. 22 to Lake Pontchartrain (Estuarine)	River	2	mi
040910	Salt Bayou-Headwaters to Lake Pontchartrain (Estuarine)	River	5	mi
040911	Grand Lagoon and associated canals (Estuarine)	River	25	mi
041001	Lake Pontchartrain-West of La. Hwy. 11 Bridge (Estuarine)	Estuary	559	mi^2
041002	Lake Pontchartrain-East of La. Hwy. 11 Bridge (Estuarine)	Estuary	62	mi^2
041101	Bonnet Carre Spillway	Wetland	7,680	acres
041201	Bayou Labranche-Headwaters to Lake Pontchartrain (Scenic) (Estuarine)	River	4	mi
041202	Bayou Trepagnier-Norco to Bayou Labranche (Scenic) (Estuarine)	River	4	mi
041203	Duncan Canal (Parish Line Canal)-From source at Kenner Corporation Limits to Lake Pontchartrain (Estuarine)	River	3	mi
041301	Bayou St. John (Scenic) (Estuarine)	River	4	mi
041302	Lake Pontchartrain Drainage Canals, Jefferson and Orleans Parishes (Estuarine)	River	30	mi
041401	New Orleans East Leveed Waterbodies	River	47	mi
041501	Inner Harbor Navigation Canal-Mississippi River Lock to Lake Pontchartrain (Estuarine)	River	5	mi
041601	Intracoastal Waterway-Inner Harbor Navigation Canal to Chef Menteur Pass (Estuarine)	River	15	mi
041701	The Rigolets (Estuarine)	Estuary	7	mi^2
041702	Bayou Sauvage-New Orleans hurricane protection levee to Chef Menteur Pass and Chef Menteur Pass (Estuarine)	River	3	mi
041801	Bayou Bienvenue-Headwaters to Hurricane Gate at Mississippi River Gulf Outlet (Estuarine)	River	6	mi
041802	Bayou Chaperon-origin to end (Scenic) (Estuarine)	River	8	mi
041803	Bashman Bayou-Origin to Bayou Dupre (Scenic) (Estuarine)	River	1	mi
041804	Bayou Dupre-Lake Borgne Canal to Terre Beau Bayou (Scenic) (Estuarine)	River	2	mi
041805	Lake Borgne Canal (Violet Canal)-Mississippi River siphon at Violet to Bayou Dupre (Scenic) (Estuarine)	River	1	mi
041806	Pirogue Bayou-Bayou Dupre to New Canal (Scenic) (Estuarine)	River	3	mi
041807	Terre Beau Bayou-Bayou Dupre to New Canal (Scenic)(Estuarine)	River	2	mi
041808	New Canal (Estuarine)	River	5	mi
041809	Poydras-Verret Marsh Wetland-forested wetland located 1.5 miles north of St. Bernard, LA in St. Bernard Parish-south of Violet Canal and northeast of Forty Arpent Canal	Wetland	3,840	acres
041901	Mississippi River Gulf Outlet-Intracoastal Waterway to Breton Sound (mile 30)	River	36	mi
042002	Bayou Bienvenue-Bayou Villere to Lake Borgne (Scenic) (Estuarine)	River	3	mi
042004	Bayou Bienvenue-Mississippi River Gulf Outlet to Bayou Villere (Estuarine)	River	3	mi
042101	Bayou Terre Aux Boeufs (Estuarine)	River	25	mi
042102	River Aux Chenes (Oak River) (Estuarine)	River	22	mi
042105	Lake Lery	Estuary	7	mi^2
070301	Mississippi River-From Monte Sano Bayou to Head of Passes	River	259	mi
120504	Bayou Petit Caillou-Klondyke Road Bridge to boundary between segments 1205 and 1207 (Estuarine)	River	12	mi

Table 4-12. IER/EA-Subsegment Relationships

IER/EA Type	Sub-basin / Parish (LA) / County (MS)	Sub-basin / Parish / County Name	IER/EA	Borrow Areas	Mitigation Projects	Subsegment
Borrow	Sub-basin	Belle Chasse	IER #22	Westbank N		020601
		Chalmette Loop	IER #19	DK Aggregates		041808
			IER #30	Contreras Dirt Cell Z		041808
		Lake Cataouatche	IER #18	Churchill Farms		020501
			IER #19	River Birch Phase 2		020501
			IER #25	Westbank D		020501
			IER #26	South Kenner Road		020501
			IER #31	River Birch Landfill Expansion		020501
			IER #35	Assumption Land Company		020501
		New Orleans East	IER #18	Maynard		041401
			IER #19	Eastover Phase 1		041401
	Parish	Plaquemines	IER #23	Myrtle Grove		020802
						020904
			IER #31	Idlewild Stage 2		020802
			IER #32	Citrus Lands		021001
				Plaquemines Dirt & Clay		021001
				Idlewild Stage 1		020802
		St. Bernard	IER #23	1025 Florissant		042101
				Acosta		042101
		St. Charles	IER #18	Bonnet Carré North		041101
			IER #23	3C Riverside Phases 1 and 2		020202
		St. James	IER #30	Big Shake		040403
		St. John the Baptist	IER #26	Willow Bend Phase 1		020202
			IER #29	Willow Bend Phase 2		020202
			IER #35	RBEND II		040601
				Robert Brothers Farm		020202
		St. Tammany	IER #29	Tammany Holding		040911
		Terrebonne	IER #35	Houma Excavation		120504
	County	Hancock	IER #19	Pearlington Dirt Phase 1		
			IER #25	Pearlington Dirt Phase 2		
			IER #31	Port Bienville		
LPV HSDRRS	Sub-basin	Chalmette Loop	EA #526			041801
			IER #10			041801
						041804
						041808
						041901
						042101
						042105
			IER #8			041804
						041901
			IER #9			042105
			IERS #8, 9, 10.a			041801
						041802
						041803
						041804
						041805
						041806
						041807
						041808
						041809
						041901
						042105
		Jefferson East Bank	EA #496			041001
						041302
			IER #2			041203
						041302
			IER #3			041001
						041302
			IER #5			041302
			IERS #2			041203
						041302
			IERS #3.a			041001
						041302
			IERS #5.a			041001
						041302
		New Orleans East	IER #11 Tier 2 Borgne			041601
						041901
						042004
			IER #6			041001
						041401
			IER #7			041001
						041401
						041601
						041702
			IERS #11 Tier 2 Borgne			041601
						041901
						042004
			IERS #6			041001
						041401

Table 4-12. IER/EA-Subsegment Relationships (Continued)

IER/EA Type	Sub-basin / Parish (LA) / County (MS)	Sub-basin / Parish / County Name	IER/EA	Borrow Areas	Mitigation Projects	Subsegment
LPV HSDRRS	Sub-basin	New Orleans East	IERS #7			041401
						041601
						041702
		Orleans East Bank	EA #496			041001
						041302
			IER #11			041001
						041302
						041401
						041501
						041601
						041801
						041901
						042004
			IER #11 Tier 2 Pontchartrain			041001
						041501
						041601
						041901
						042002
						042004
			IER #4			041001
						041301
						041302
			IER #5			041001
						041301
			IERS #11.d Tier 2 Pontchartrain			041001
						041501
						041601
						041901
						042002
						042004
			IERS #5.a			041001
						041302
		St. Charles	IER #1			041101
						041201
						041202
						041203
			IERS #1			041101
						041201
						041202
						041203
			IERS #1.b			041201
LPV HSDRRS Mitigation	Sub-basin	New Orleans East	PIER #36		Turtle Bayou Protected-Side Intermediate Marsh	041401
			PIER #36 Supplement 1		Turtle Bayou Protected-Side Intermediate Marsh	041401
	Parish	Orleans	PIER #36		Bayou Sauvage Flood-Side Brackish Marsh	041702
			PIER #36 Supplement 1		Bayou Sauvage Flood-Side Brackish Marsh	041702
		St. Tammany	PIER #36		Bayou Sauvage Flood-Side Brackish Marsh	041002
					Milton Island Intermediate Marsh	040803
						041001
					New Zydeco Ridge Bottomland Hardwoods-Wet and Brackish Marsh	040910
						041002
					Turtle Bayou Protected-Side Intermediate Marsh	041002
			PIER #36 Supplement 1		Bayou Sauvage Flood-Side Brackish Marsh	041002
					New Zydeco Ridge Bottomland Hardwoods-Wet and Brackish Marsh	040910
						041002
					Turtle Bayou Protected-Side Intermediate Marsh	041002
			PIER #36 Tier I		Milton Island Intermediate Marsh	040803
						041001
WBV HSDRRS	Sub-basin	Belle Chasse	IER #13			020601
						020802
			IER #33			070301
			IERS #12/13 Waterline			020601
			IERS #33.a			070301
		Gretna-Algiers	IER #12			020601
						020802
		Harvey-Westwego	IER #14			020601
						020701
			IERS #12.a			020601
			IERS #14.a			020701
			SEA #306.c			020601
		Lake Cataouatche	IER #15			020303
						020501
						020701
			IER #16			020303
			IER #17			020501
						020601
						020701
			IERS #15.a			020303
						020501
						020701

Table 4-12. IER/EA-Subsegment Relationships (Continued)

IER/EA Type	Sub-basin / Parish (LA) / County (MS)	Sub-basin / Parish / County Name	IER/EA	Borrow Areas	Mitigation Projects	Subsegment
WBV HSDRRS	Sub-basin	Lake Cataouatche	IERS #15.b			020303
						020501
						020701
			IERS #16.a			020303
			IERS #16.b			020303
WBV HSDRRS Mitigation	Parish	Jefferson	PIER #37		Jean Lafitte Flood-Side Freshwater Marsh, Bottomland Hardwoods-Wet, and Swamp	020601
						020701
		Lafourche	PIER #37		Lake Boeuf	020102

subsegments that include undeveloped areas and areas lower in the estuary gradient are generally supportive of their designated uses, while subsegments that include developed areas and areas higher in the estuary gradient are less commonly supportive of their designated uses.

Comparison of 2002-2006 and 2008-2014 average support values (Table 4-6, Figures 4-4 and 4-5) reveal some differences in average support values according to color-coding. 2008-2014 average support values are higher for subsegments along the Mississippi River East Bank between Lake Maurepas and Baton Rouge (040201, 040403, and 040404), within LPV sub-basins (041302, 041401, and 041808), bordering WBV sub-basins (020303 and 020701), and in the vicinity of Milton Island (040803), suggesting recent water quality improvements with respect to designated uses for these subsegments during reporting periods coincident with HSDRRS construction, while 2008-2014 average support values are lower for the subsegment that includes the Bonnet Carré Spillway (041101), southwest of the Caernarvon Freshwater Diversion receiving area (042102), WBV sub-basins (020501 and 020601), and Bayou Boeuf (020102), suggesting diminished water quality with respect to designated uses for these subsegments during reporting periods coincident with HSDRRS construction. Comparison of 2002-2006 and 2008-2014 average support values using the paired t-test reveals 2008-2014 average support for project area subsegments was slightly higher than 2002-2006 average support ($p<0.003$), suggesting an increase in designated use support in the project area as a whole during the reporting periods coincident with HSDRRS construction.

Table 4-1. Subsegment average support values (color coding groups average support values see Figure 4-3 or 4-4 for site specific color-coding information)

Subsegment	2002							2004							2006							2008							2010							2012							2014							Average Support		
	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	PCR	SCR	FWP	DWS	ONR	OYS	AGR	2002-2014	2002-2006	2008-2014
020102	1	1	0				1	1	1	0				1	1	1	0				1	1	1	0					1	1	0				1	1	1	0				1	1	1	0				1	0.741	0.750	0.733
020103	1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					0.667	0.667	0.667
020202	1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					0.667	0.667	0.667
020301	1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		0			0.500	0.500	0.500
020302	1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					0.667	0.667	0.667
020303	1	1	0					1	1	0					1	1	0					0	1	0					1	1	1					1	1	1					1	1	1					0.762	0.667	0.833
020501	1	1	0					1	1	0					0	1	0					0	1	0					0	1	0					0	1	0					1	1	0					0.476	0.556	0.417
020601	1	1	1					1	1	1					0	1	1					0	1	1					0	1	0					0	1	0					1	1	1					0.714	0.889	0.583
020701	0	1	0					0	1	0					1	1	0					1	1	0					1	1	1					1	1	1					1	1	1					0.714	0.444	0.917
020802	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
020904	1	1	0			1		1	1	0			1		1	1	1			0		1	1	1			1		1	1	1			0		1	1	0			0		1	1	1			1		0.786	0.750	0.813
021001	1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		0	1	0			0		1	1	1			1		0.893	1.000	0.813
040201	0	0	0					0	0	0					0	0	0					0	1	0					0	1	0					0	1	0					1	1	0					0.238	0.000	0.417
040403	1	1	0		0			1	1	0		0			1	1	0		0			1	1	0			1		1	1	0		1			1	1	0			1		1	1	0		1			0.643	0.500	0.750
040404	0	0	0					0	0	0					0	0	0					0	1	0					0	1	0					0	1	0					0	1	0					0.190	0.000	0.333
040601	1	1	1					1	1	1					1	1	1					1	1	0					1	1	0					1	1	1					1	1	1					0.905	1.000	0.833
040803	0	1	0					0	1	0					0	1	0					1	1	0					1	1	0					0	1	0					0	1	0					0.429	0.333	0.500
040910	0	1	1					0	1	1					0	1	1					0	1	1					0	1	1					0	1	1					0	1	1					0.667	0.667	0.667
040911	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
041001	0	1	1					0	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					0.905	0.778	1.000
041002	1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		1.000	1.000	1.000
041101	1	1	0					1	1	0					1	1	0					0	1	0					0	1	0					0	1	0					0	1	0					0.476	0.667	0.333
041201	0	1	0		1			1	1	0		1			1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		1			1	1	0		1			0.643	0.667	0.625
041202	1	1	0		0			1	1	0		0			1	1	0		0			1	1	0		1			1	1	0		1			0	1	0		1			0	1	0		1			0.571	0.500	0.625
041203	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
041301	1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			1.000	1.000	1.000
041302	0	0	0					0	0	1					0	0	1					0	1	0					0	1	0					0	1	0					0	1	0					0.286	0.222	0.333
041401	0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					1	1	1					1	1	1					0.286	0.000	0.500
041501	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
041601	1	1	1			1		1	1	1			0		1	1	1			0		1	1	1			1		1	1	1			0		1	1	1			1		1	1	1			1		0.893	0.833	0.938
041701	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
041702	1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1.000	1.000	1.000
041801	1	1	0					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					1	1	1					0.952	0.889	1.000
041802	1	1	0		1			1	1	0		1			1	1	0		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			0.893	0.750	1.000
041803	1	1	0		1			1	1	0		1			1	1	0		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			0.893	0.750	1.000
041804	1	1	0		1			1	1	0		1			1	1	0		1			1	1	1		1			1	1	1		1			1	1	1		1			1	1	1		1			0.893	0.750	1.000
041805	1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		0			1	1	0		0			1	1	1		1			1	1	1		1			0.750	0.750	0.750
041806	1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			0.750	0.750	0.750
041807	1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			1	1	0		1			1	1	1		1			1	1	1		1			0.821	0.750	0.875
041808	1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	0					1	1	1					0.714	0.667	0.750
041809																																																		No Data	No Data	No Data
041901	1	1	1			1		1	1	1			0		1	1	1			0		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		0.929	0.833	1.000
042002	1	1	1			1		1	1	1			0		1	1	1			0		1	1	1		1	1		1	1	1		1	0		1	1	1		1	0		1	1	1		1	1		0.875	0.833	0.900
042004	1	1	1			0		1	1	1			0		1	1	1			0		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		0.893	0.750	1.000
042101	1	1	1			0		1	1	1			0		1	1	1			0		1	1	1			1		1	1	1			0		1	1	0			0		1	1	1			0		0.750	0.750	0.750
042102	1	1	1			0		1	1	1			0		1	1	1			0		1	1	1			0		1	1	1			0		1	1	0			0		1	1	1			0		0.714	0.750	0.688
042105	1	1	1			1		1	1	1			1		1	1	1			0		1	1	1			1		1	1	1			1		1	1	1			1		1	1	1			1		0.964	0.917	1.000
070301	0	1	1	1				1	1	1	1				1	1	1	1				1	1	1	1				1	1	1	1				1	1	1	1				1	1	1	1				0.964	0.917	1.000
120504	1	1	0			0		0	0	0			0		1	1	0			0		1	1	0			0		1	1	0			0		0	1	0			0		0	1	0			0		0.357	0.333	0.375

(PCR=Primary Contact Recreation, SCR=Secondary Contact Recreation, FWP=Fish and Wildlife Propagation, DWS=Drinking Water Supply, ONR=Outstanding Natural Resource, OYS=Oyster Propagation, AGR=Agriculture)

Figure 4-7. Project area basins, subsegments, and 2002-2014 subsegment average support

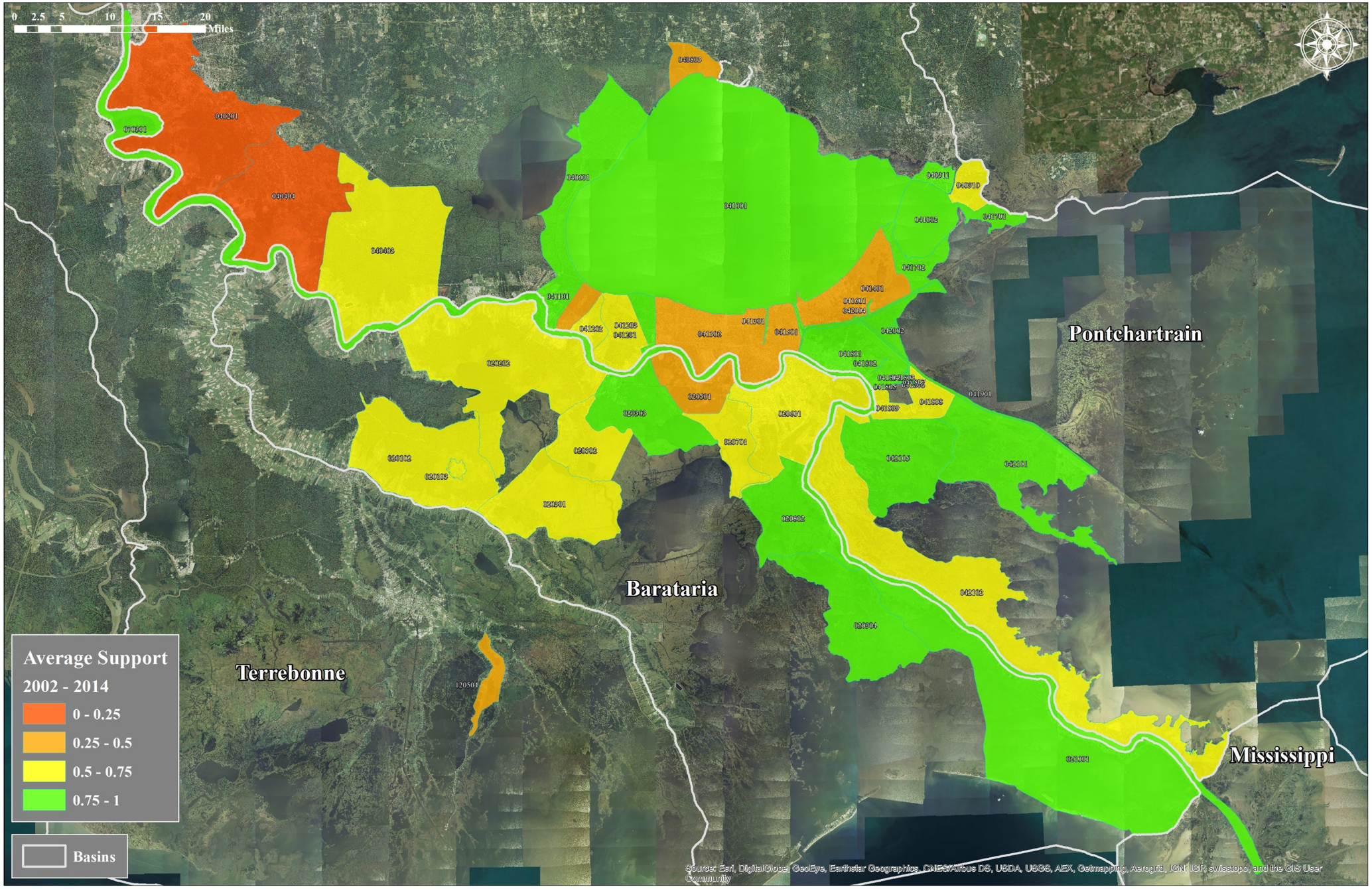


Figure 4-8. Project area basins, subsegments, and 2002-2006 subsegment average support

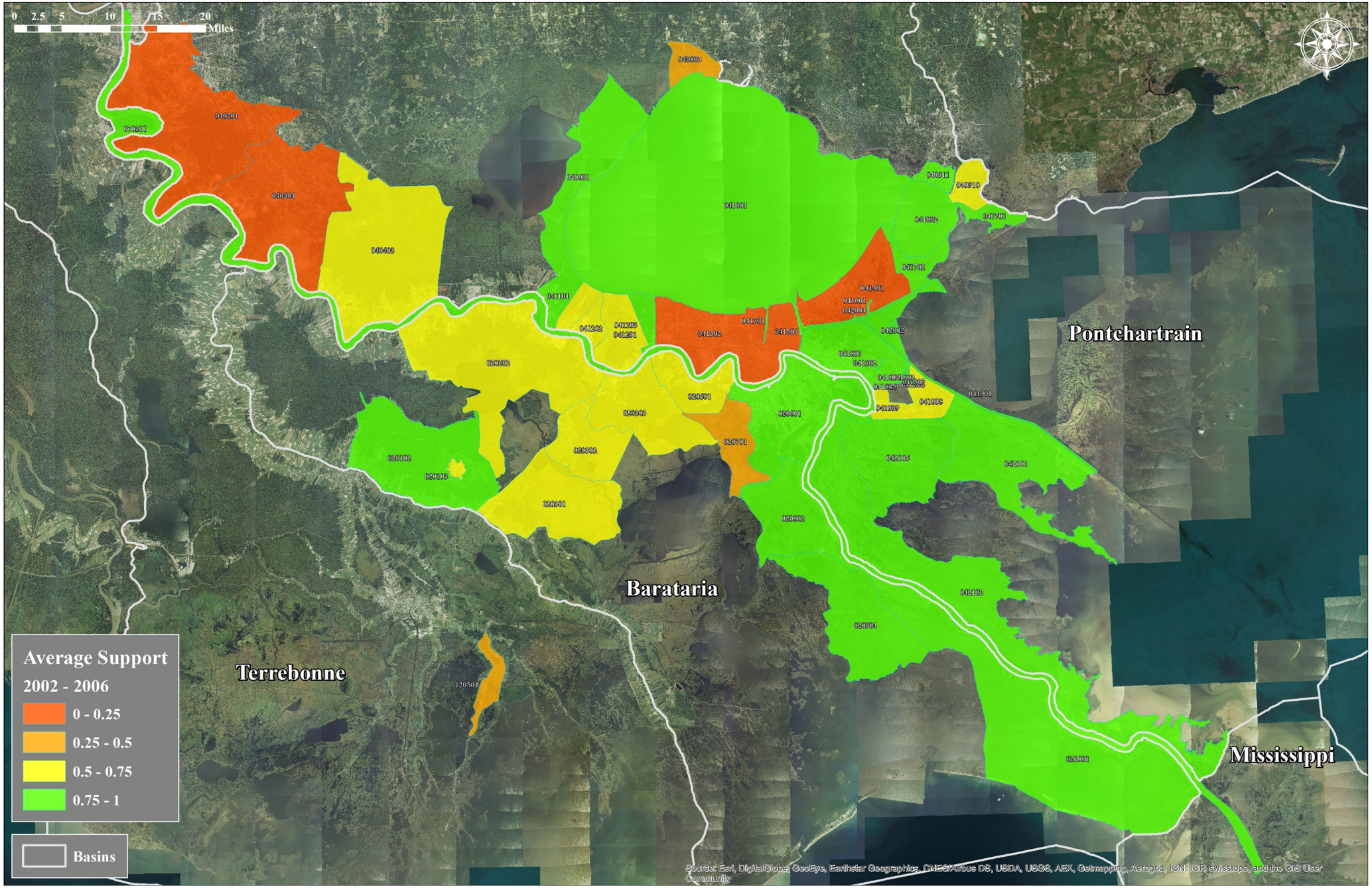
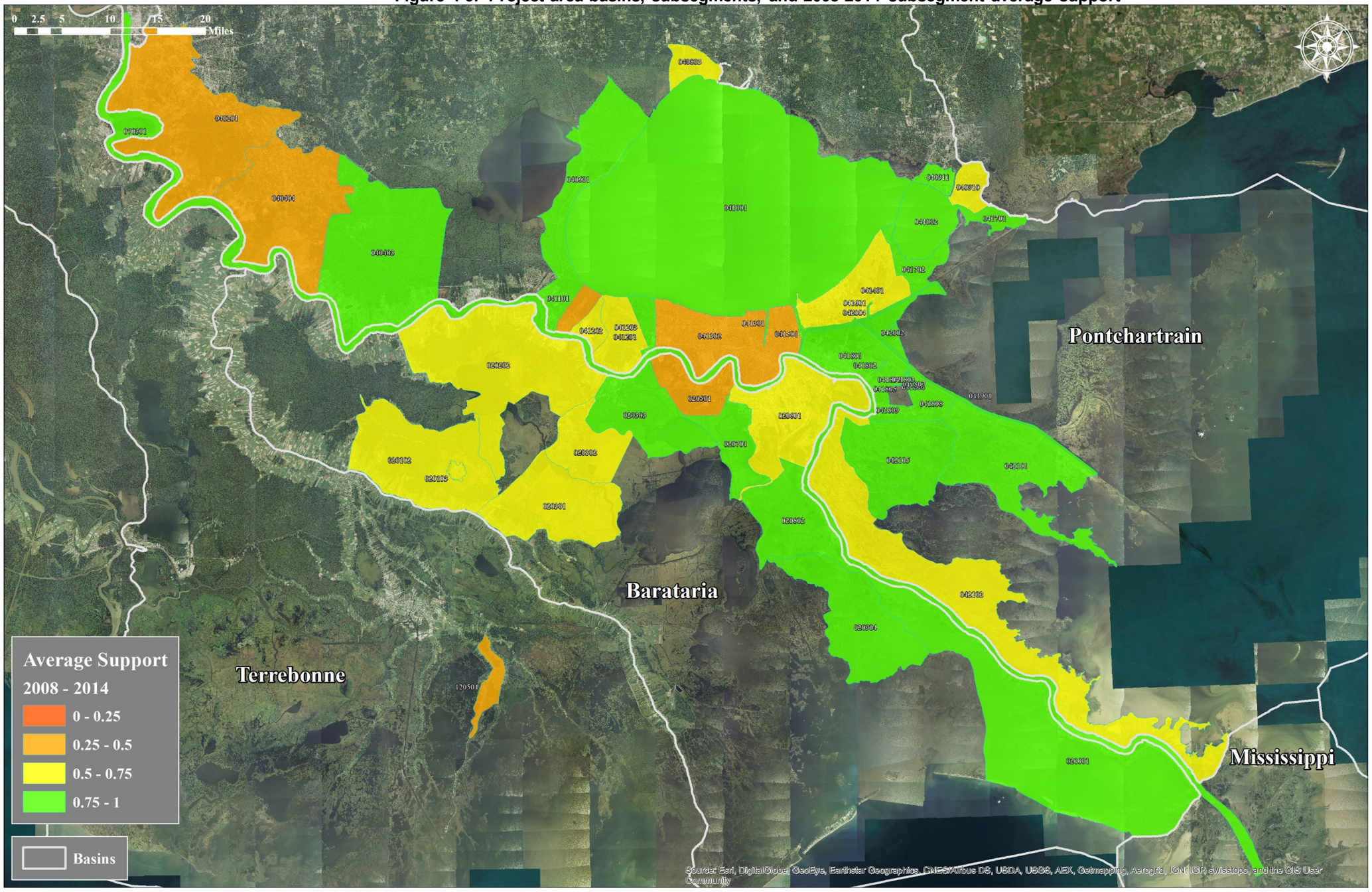


Figure 4-9. Project area basins, subsegments, and 2008-2014 subsegment average support



Tables 4-7 and 4-8 list counts of suspected causes and sources of impairment by reporting period. In order to identify reporting periods with elevated counts of suspected causes and sources of impairment, counts exceeding the upper limit of 68% (average plus one standard deviation) and 95% (average plus two standard deviations) confidence intervals for each suspected cause or source have been highlighted. The most common suspected causes of impairment in the project area include low dissolved oxygen concentrations, elevated pathogen densities, and non-native aquatic plants. The most common suspected sources of impairment include natural and unknown sources and on-site treatment systems.

Table 4-7. Count of suspected sources of impairment by reporting period

Suspected Cause of Impairment	Year							2002-2014		2002-2006		2008-2014	
	2002	2004	2006	2008	2010	2012	2014	Total	Average	Total	Average	Total	Average
Dissolved Oxygen	23	23	24	19	14	11	11	**125**	**17.86**	**70**	**23.33**	**55**	**13.75**
Fecal Coliform	13	15	17	10	13	12	8	**88**	**12.57**	**45**	**15**	**43**	**10.75**
Non-Native Aquatic Plants	8	8	8	8	8	8	8	**56**	**8**	**24**	**8**	**32**	**8**
Total Phosphorus	2	10	10	9	6	5	5	**47**	**6.71**	**22**	**7.33**	**25**	**6.25**
Nitrate/Nitrite	1	10	10	9	6	5	5	**46**	**6.57**	**21**	**7**	**25**	**6.25**
Chloride	9	10	7	5	5	4	4	**44**	**6.29**	**26**	**8.67**	**18**	**4.5**
Total Dissolved Solids	8	10	7	5	5	4	4	**43**	**6.14**	**25**	**8.33**	**18**	**4.5**
Sulfates	8	9	8	6	5	3	3	**42**	**6**	**25**	**8.33**	**17**	**4.25**
Mercury	3	3	2	2	2	6	2	**20**	**2.86**	**8**	**2.67**	**12**	**3**
Turbidity	3	3	3	3	4	2	1	**19**	**2.71**	**9**	**3**	**10**	**2.5**
Oil and Grease	1	1	1	1	1	5	0	**10**	**1.43**	**3**	**1**	**7**	**1.75**
Copper	0	4	2	0	0	0	0	**6**	**0.86**	**6**	**2**	**0**	**0**
Total Suspended Solids	1	1	1	1	1	0	0	**5**	**0.71**	**3**	**1**	**2**	**0.5**
pH	1	1	0	0	0	0	0	**2**	**0.29**	**2**	**0.67**	**0**	**0**
Taste and Odor	0	1	0	0	0	0	0	**1**	**0.14**	**1**	**0.33**	**0**	**0**
Nutrients	0	1	0	0	0	0	0	**1**	**0.14**	**1**	**0.33**	**0**	**0**
Total	81	110	100	78	70	65	51	**555**	**79.29**	**291**	**97**	**264**	**66**

Count exceeds upper limit of 68% confidence interval of biennial cause counts

Count exceeds upper limit of 95% confidence interval of biennial cause counts

Table 4-8. Count of suspected sources of impairment by reporting period

Suspected Source of Impairment	Year							2002-2014		2002-2006		2008-2014	
	2002	2004	2006	2008	2010	2012	2014	Total	Average	Total	Average	Total	Average
Natural Sources	12	12	11	10	10	8	10	73	10.43	35	11.67	38	9.5
Source Unknown	15	21	13	5	5	3	2	64	9.14	49	16.33	15	3.75
On-site Treatment Systems	6	6	6	4	7	6	6	41	5.86	18	6	23	5.75
Introduction of Non-native Organisms	0	0	8	8	8	8	8	40	5.71	8	2.67	32	8
Drought-Related Impacts	9	10	7	0	0	2	2	30	4.29	26	8.67	4	1
Forced Drainage Pumping	4	4	4	4	3	3	3	25	3.57	12	4	13	3.25
Sanitary Sewer Overflows	4	4	3	3	5	4	2	25	3.57	11	3.67	14	3.5
Wildlife Other than Waterfowl	2	2	2	2	4	4	3	19	2.71	6	2	13	3.25
Industrial Point Source Discharges	3	3	3	3	2	2	1	17	2.43	9	3	8	2
Package Plant or Other Permitted Small Flows Discharges	4	4	3	2	2	1	1	17	2.43	11	3.67	6	1.5
Agriculture	2	2	3	3	2	3	2	17	2.43	7	2.33	10	2.5
Atmospheric Deposition	2	2	2	2	2	2	2	14	2	6	2	8	2
Wetland Habitat Modification	0	0	0	5	4	4	0	13	1.86	0	0	13	3.25
Flow Alteration	1	1	1	3	3	2	1	12	1.71	3	1	9	2.25
Municipal Nonpoint Sources	2	2	2	2	2	1	1	12	1.71	6	2	6	1.5
Municipal Point Source Discharges	2	1	2	2	2	2	0	11	1.57	5	1.67	6	1.5
Upland Habitat Modification	0	0	0	4	3	3	0	10	1.43	0	0	10	2.5
Bank Modification/Destabilizaiton	0	0	0	4	3	3	0	10	1.43	0	0	10	2.5
Marina/Boating Sanitary On-vessel Discharges	0	0	2	1	4	3	0	10	1.43	2	0.67	8	2
Sediment Resuspension	1	1	1	1	2	2	1	9	1.29	3	1	6	1.5
Total Retention Domestic Sewage Lagoons	1	1	1	1	1	1	0	6	0.86	3	1	3	0.75
Urban Runoff	1	1	1	1	0	1	0	5	0.71	3	1	2	0.5
Sewage Discharges in Unsewered Areas	0	0	2	1	1	1	0	5	0.71	2	0.67	3	0.75
Miscellaneous Spills	0	0	0	0	0	4	0	4	0.57	0	0	4	1
Waterfowl	0	0	0	1	0	1	1	3	0.43	0	0	3	0.75
Internal Nutrient Recycling	0	0	1	1	0	0	0	2	0.29	1	0.33	1	0.25
Runoff from Forest/Grassland/Parkland	0	0	1	1	0	0	0	2	0.29	1	0.33	1	0.25
Unpermitted Waste Discharges	0	0	0	1	0	0	0	1	0.14	0	0	1	0.25
Total	71	77	79	75	75	74	46	497	71	227	75.67	270	67.5

Count exceeds upper limit of 68% confidence interval of biennial source counts

Count exceeds upper limit of 95% confidence interval of biennial source counts

TMDLs have been established for many of the subsegments with consistently poor support of designated uses, including Bayou Manchac, Bayou Petit Calliou, the Blind River, the Lower Tchefuncte River, New Orleans East, Salt Bayou, and Violet Canal, subsegments, and most of the Barataria Estuary subsegments (USEPA 2015). Additionally, a Use Attainability Analysis has been prepared for establishment of regional dissolved oxygen criteria in the Barataria and Terrebonne Basins (LDEQ 2008).

1.1.1.2 ENVIRONMENTAL IMPACTS

1.1.1.2.1 HSDRRS Construction Impacts

In general, several water quality impacts occurred that were common to all sub-basins. Where wetland and open water fill occurred, filling of this habitat permanently eliminated habitat capable of water quality functions, causing a major permanent impact on water quality.

Fill material used for levee construction was determined in advance to be free of contaminants that would adversely affect water quality. The major indirect impacts on water quality from placement of fill and construction materials in aquatic habitat included local increases in suspended sediment and turbidity and hydromodification. To help minimize indirect water quality impacts during construction, contractors employed BMPs (such as silt fences and curtains) and SWPPPs (which are required for construction projects with a footprint greater than one acre). In general, any water quality-related

impacts associated with utilities relocations were assessed by contractors and have not been included in this assessment.

Construction activities modified surface hydrology, both temporarily and permanently; temporarily increased suspended sediment, turbidity, biochemical oxygen demand, and water temperature, and decreased dissolved oxygen concentrations in adjacent aquatic habitat; and altered or eliminated aquatic habitat and associated water quality functions. As part of the LPDES permit process, a General Stormwater Permit, which included a site-specific Stormwater Pollution Prevention Plan (SWPPP) and Notice of Intent, was required prior to each construction activity. Temporary water quality impacts generally included stormwater runoff from construction sites and staging areas; excavation and dredging; and placement of dredged, fill, and construction materials in aquatic habitat. Although SWPPPs were prepared for all HSDRRS construction activities, they were not prepared for borrow site use; instead, they were, along with implementation of BMPs, the responsibility of the construction contractors, who were required to follow all local, state, and federal regulations for stormwater discharges.

All USACE contractors were required to prepare and administer a site-specific Spill Prevention, Control, and Countermeasure Plan (SPCCP). During construction activities, several small spills occurred that involved regulated waste (petroleum products) and hydraulic grade vegetable oil. In March 2011, an unknown but small amount of diesel fuel was discharged into the Keyhole Canal at Pump Station Westwego #2 in Jefferson Parish. The spill reportedly dispersed, and no water quality impacts from the spill were observed. In February 2011, approximately 2 gallons of hydraulic grade vegetable oil were discharged into the Algiers Canal near the Planters Pump Station in Plaquemines Parish. In August 2013, approximately 20 gallons of diesel fuel were spilled at the fuel farm area of the Western Closure Complex in Plaquemines Parish. In July and December 2013, spills of 120 gallons of hydraulic oil, 47 gallons of fuel, and 50 gallons of hydraulic oil occurred at the 17th Street temporary pump station in Orleans Parish. In October 2014, a spill of approximately 60 gallons of hydraulic fluid occurred at the London Avenue Canal temporary pump station in Orleans Parish. In addition, two minor spills were reported during construction of LPV-144 and LPV-146 in St. Bernard Parish that involved hydraulic grade vegetable oil. Except for the spill at Pump Station Westwego #2 (which was reported to have dispersed), all spills were contained using oil booms when necessary and were cleaned up.

Construction activities with more permanent water quality impacts included alteration and elimination of aquatic habitat (conversion of aquatic habitat to upland habitat from placement of dredged, fill, and construction materials; and construction of wetlands in open water habitat from placement of dredged or fill material) and hydromodification. Specific impacts listed in Table 4-9. This information was compiled from IERs, supplementals and EAs, and associated Clean Water Act (CWS) Section 404(b)(1) evaluations. Water quality certification as required by CWA Section 401 was obtained for each IER and EA. For all activities involving placement of dredged or fill material in the aquatic environment, actions to minimize adverse effects as described in §230.70-230.77 of the CWA Section 404(b)(1) guidelines were implemented when appropriate and practicable. Any specific BMPs that were implemented are discussed in section 5.

Table 4-2. Water Quality Impacts Summary

Sub-basin / Parish (LA) / County (MS)	Sub-basin / Parish / County Name	IER/EA	Summary of Activities with Water Quality Impacts	Water Quality Impacts	Magnitude of Permanent Impacts
Sub-basin	Belle Chasse	IER #13; IER #22 (Westbank N Borrow Area); IER #33; IERS #12/13 Waterline; IERS #33.a	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; elimination of wetlands habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; elimination of habitat capable of providing water quality benefits	Moderate
	Chalmette Loop	IER #8; IER #9; IER #10; IER #19 (DK Aggregates Borrow Area); IER #30 (Contreras Dirt Borrow Area); IERS #8, 9, 10.a; EA #526	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary hydromodification; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary hydromodification-induced water quality changes; elimination of habitat capable of providing water quality benefits	Moderate
	Gretna-Algiers	IER #12	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials; temporary and permanent hydromodification-induced water quality changes; elimination of habitat capable of providing water quality benefits	Moderate
	Harvey Westwego	IER #14; IERS #14.a; IERS #12.a; SEA #306.c	Construction stormwater runoff; placement of fill/construction materials in aquatic habitat; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from placement of fill/construction materials in aquatic habitat; elimination of habitat capable of providing water quality benefits	Moderate
	Jefferson East Bank	IER #2; IER #3; IER #5 (ongoing); IERS #2; IERS #3.a; IERS #5.a (17th Street Canal; ongoing); EA #496	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; elimination of habitat capable of providing water quality benefits	Minor
	Lake Cataouatche	IER #15; IER #16; IER #17; IER #18 (Churchill Farms Borrow Area); IER #19 (River Birch Phases 1 and 2 Borrow Areas); IER #25 (Westbank D Borrow Area); IER #26 (South Kenner Borrow Area); IER #31 (River Birch Landfill Expansion); IER #35 (Assumption Land Company Borrow Area); IERS #15.a; IERS #15.b; IERS #16.a; IERS #16.b	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity/biochemical oxygen demand from excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification-induced water quality changes; elimination of habitat capable of providing water quality benefits	Moderate
	New Orleans East	IER #6; IER #7; IER #18 (Manyard Borrow Area); IER #19 (Eastover Phase 1 Borrow Area); IERS #6; IERS #7; PIER #36; PIER #36 Supplement 1 (Turtle Bayou Protected-Side Intermediate Marsh; to be constructed)	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; construction/elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; construction/elimination of habitat capable of providing water quality benefits	Moderate
	Orleans East Bank	IER #4; IER #5 (ongoing); IERS #5.a (Orleans and London Avenue Canals; ongoing); EA #496	Construction stormwater runoff; placement of dredged/fill/construction materials in aquatic habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat	Negligible
	St. Charles	IER #1; IERS #1; IERS #1.b	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification; elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification-induced water quality changes; elimination of habitat capable of providing water quality benefits	Moderate
Parish	Jefferson	PIER #37 (Jean Lafitte Flood-Side Freshwater Marsh, Bottomland Hardwoods-Wet, and Swamp; to be constructed)	Construction stormwater runoff; excavation/placement of dredged/fill material in aquatic habitat; herbicide application; construction of wetlands habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill material in aquatic habitat; runoff of herbicides; construction of habitat capable of providing water quality benefits	Minor[1]
	Lafourche	PIER #37 (Lake Boeuf Flood-Side Bottomland Hardwoods-Wet and Swamp)	Construction stormwater runoff; excavation/land clearing/dredging; dredged/fill material placement in surface waterbodies; herbicide application; construction of wetlands habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/land clearing/dreding and dredged/fill material placement; runoff of herbicides; construction of habitat capable of providing water quality benefits	Minor[1]
	Orleans	IER #11; IER #11 Tier 2 Borgne; IER #11 Tier 2 Pontchartrain; IERS #11 Tier 2 Borgne; IERS #11.d Tier 2 Pontchartrain; PIER #36; PIER #36 Supplement 1 (Bayou Sauvage Flood-Side Brackish Marsh; to be constructed)	Construction stormwater runoff; excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification; construction/elimination of wetland habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged/fill/construction materials in aquatic habitat; temporary and permanent hydromodification-induced water quality changes; construction/elimination of habitat capable of providing water quality benefits	Moderate
	Plaquemines	IER #22 (Westbank N Borrow Area); IER #23 (Myrtle Grove Borrow Area); IER #31 (Idlewild Stage 1); IER #32 (Citrus Lands, Idlewild Stage 2, and Plaquemines Dirt and Clay Borrow Areas)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible

Table 4-9. Water Quality Impacts Summary (Continued)

Sub-basin / Parish (LA) / County (MS)	Sub-basin / Parish / County Name	IER/EA	Summary of Activities with Water Quality Impacts	Water Quality Impacts	Magnitude of Permanent Impacts
Parish	St. Bernard	IER #23 (1025 Florissant and Acosta Borrow Areas)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible
	St. Charles	IER #18 (Bonnet Carré North Borrow Area); IER #23 (3C Riverside Phases 1 and 2 Borrow Areas)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible
	St. James	IER #30 (Big Shake Borrow Area)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible
	St. John the Baptist	IER #26 (Willow Bend Phase 1 Borrow Area); IER #29 (Willow Bend Phase 2 Borrow Area)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible
	St. Tammany	IER #29 (Tammany Holding Borrow Area); PIER #36; PIER #36 Supplement 1; PIER #36 Tier 1 (New Zydeco Ridge Bottomland Hardwoods-Wet and Brackish Marsh, Milton Island Intermediate Marsh; to be constructed)	Construction stormwater runoff; excavation/placement of dredged material in aquatic habitat; construction of wetlands habitat	Stormwater runoff of sediment and miscellaneous construction discharges; suspended sediment/turbidity from excavation/placement of dredged material in aquatic habitat; construction of habitat capable of providing water quality benefits	Minor
County	Hancock	IER #19 (Pearlington Dirt Phase 1 Borrow Area); IER #23 (Pearlington Dirt Phase 2 Borrow Area); IER #31 (Port Bienville Borrow Area)	Construction stormwater runoff	Stormwater runoff of sediment and miscellaneous construction discharges	Negligible

[1]Permanent water quality impacts are associated with wetlands creation projects, and are therefore expected to be beneficial

It should be noted that many of the impacts described below are based on anticipated impacts as described in IERs, supplemetals and EAs, and that actual impacts may differ if there were any contractor modifications to the project and associated water quality management practices that USACE was unaware occurred

St. Charles - Construction of the Labranche Wetlands levee, floodwalls, breakwaters, drainage structures; permanent access bridges and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff (IER #1, IERS #1). Breakwaters locally affected long-term sediment deposition and re-suspension patterns. Placement of materials converted approximately 281 acres of swamp, 12.5 acres of bottomland hardwood forest wet, and 0.5 acre of open water to upland habitat.

Relocation of a portion of the Fox Lane access road and adjacent drainage canal caused temporary, construction-related impacts to the water quality of adjacent waterbodies due to excavation and placement of dredged and fill materials in aquatic habitat and construction site runoff (IERS #1.b). Excavation of existing roadway materials, placement of fill materials for road construction, the infilling of part of the existing drainage canal, and excavation generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Placement of materials converted approximately 1.5 acres of bottomland hardwood forest wet to upland habitat.

Jefferson East Bank - Construction activated (IER #2, IERS #2.a) generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Approximately 59 acres of waterbottoms were temporarily impacted by access channel construction. Placement of materials converted approximately 31.5 acres of marsh, 2 acres of swamp, and 75 acres of open water to upland habitat.

Construction of the Jefferson Lakefront Levee and associated structures (IER #3, IERS #3.a) caused temporary, construction-related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff. Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Approximately 327 acres of waterbottoms were temporarily impacted by access channel construction. Placement of materials converted approximately 301 acres of open water to upland habitat.

Construction of the 17th Street Canal permanent pump station (IER #5) generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. In addition, the breakwater is expected to locally affect long-term sediment deposition and re-suspension patterns. Placement of materials for would convert approximately 3.6 acres of open water to upland habitat. Use of an additional permanent and temporary right of way for construction of the permanent pump stations at the 17th Street Canal (IERS #5a) generated local, temporary increases in suspended sediment and turbidity of adjacent waters. Use of a mechanical dredge and turbidity curtains during excavation and dredging minimized and confined water quality impacts of these

activities. An additional 0.267 acres of waterbottoms was permanently filled in the 17th Street Canal by project features such the pump station, riprap, and bypass gate. Construction and use of a staging area west of the 17th Street Canal and placement of riprap along the inner western bankline of the canal caused temporary, construction-related impacts to water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (EA #496). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Riprap reduces erosion of adjacent shorelines, thereby reducing erosion-induced increases in suspended sediment and turbidity during pump station operation.

Orleans East Bank - Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. In addition, the breakwater for the Orleans Avenue Canal Pump Station locally affected long-term sediment deposition and re-suspension patterns. Placement of materials converted approximately 3.6 acres of open water to upland habitat.

Use of an additional permanent and temporary right of way for construction of the permanent pump station at the Orleans and London Avenue Canals, and excavation and mechanical dredging in the canals caused temporary, construction-related impacts to the water quality due to excavation of dredged and fill material in aquatic habitat and construction site runoff (IERS #5.a). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Use of a mechanical dredge and turbidity curtains during excavation and dredging minimized and confined water quality impacts. An additional 1.49 and 2.68 acres of waterbottoms was permanently filled in the Orleans and London Avenue Canals, respectively, by project features such as pump stations, riprap, and bypass gates.

New Orleans East - Construction of the New Orleans East Citrus Lakefront levee, floodwall reaches, foreshore protection, and gates caused temporary, construction-related impacts to water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (IER #6, IERS #6). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Placement of riprap for foreshore protection converted approximately 68 acres of open water to upland habitat.

Construction of the New Orleans East Lakefront to Michoud Canal levee and associated floodwall reaches, four drainage structures, ramps, pump stations caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #7, IERS #7). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Placement of materials converted approximately 119 acres of freshwater and intermediate marsh, 126 acres of brackish marsh, 202 acres of bottomland hardwood forest-wet to upland habitat. Placement of riprap for foreshore protection was converted approximately 119 acres of open water to upland habitat.

Construction of the Lake Borgne Surge Barrier; construction and removal of a temporary cofferdam during construction of the Bayou Bienvenue vertical lift gate; and

associated structures caused temporary, construction-related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff (IER #11, IER #11 Tier 2 Borgne, IERS #11c Tier 2 Borgne). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. In addition, the cofferdam installed for construction of the Bayou Bienvenue gate indirectly impacted water quality by impacting local hydrology while in place. Four 4-foot diameter culverts were used to maintain flows through the bayou while the cofferdam was in place, to allow for reduced (10% of the maximum flow capacity without the cofferdam in place) water exchange. Construction of the surge barrier partially enclosed approximately 403 acres of brackish and saline marsh within the Golden Triangle marsh area, and in combination with other structures constructed along the MRGO and IHNC has modified hydrology, water circulation, and water quality within and adjacent to the IHNC basin (the reaches of the IHNC, GIWW, and MRGO confined by the IHNC Lock, Seabrook structure, and Lake Borgne Surge Barrier), including the tidal influence of the MRGO, GIWW, and IHNC on southeastern Lake Pontchartrain. Excavation and placement of materials converted approximately 122 acres of marsh and 15 acres of bottomland hardwood forest-wet, and 45 acres of open water to upland habitat and surge barrier footprint.

Construction of the Seabrook gate structure caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #11, IER #11 Tier 2 Pontchartrain). The primary water quality impacts from sector gate construction were from changes to hydrology during and following construction. For a period of approximately 14 months, the cofferdam prevented water exchange between the IHNC and Lake Pontchartrain. Water quality modeling of the IHNC, GIWW, and MRGO suggested that closure of the IHNC for construction would reduce salinities and dissolved oxygen levels to the north of the closure, while increasing dissolved oxygen levels south of the closure. Excavation and placement of materials converted approximately 7 acres of open water to upland habitat (the gate structure footprint).

Mize and Swarzenski (2014) report titled “Effects of Hydrologic Modifications on Salinity and Formation of Hypoxia in the Mississippi River-Gulf Outlet and Adjacent Waterways, Southeastern Louisiana, 2008 to 2012”, is included in Appendix G and contains the monitoring results for all structures on the IHNC, GIWW, and MRGO. Figure 4-6, from this publication, includes the depiction of continuous salinity data for the IHNC at I-10 station, located south of the Seabrook structure. Overall, the data suggests that the MRGO closure significantly impacted salinity; following completion of the closure, salinities generally decreased to below 5 ppt.

Figure 4-10. IHNC Basin and MRGO salinity monitoring data, from Mize and Swarzenski (2014)

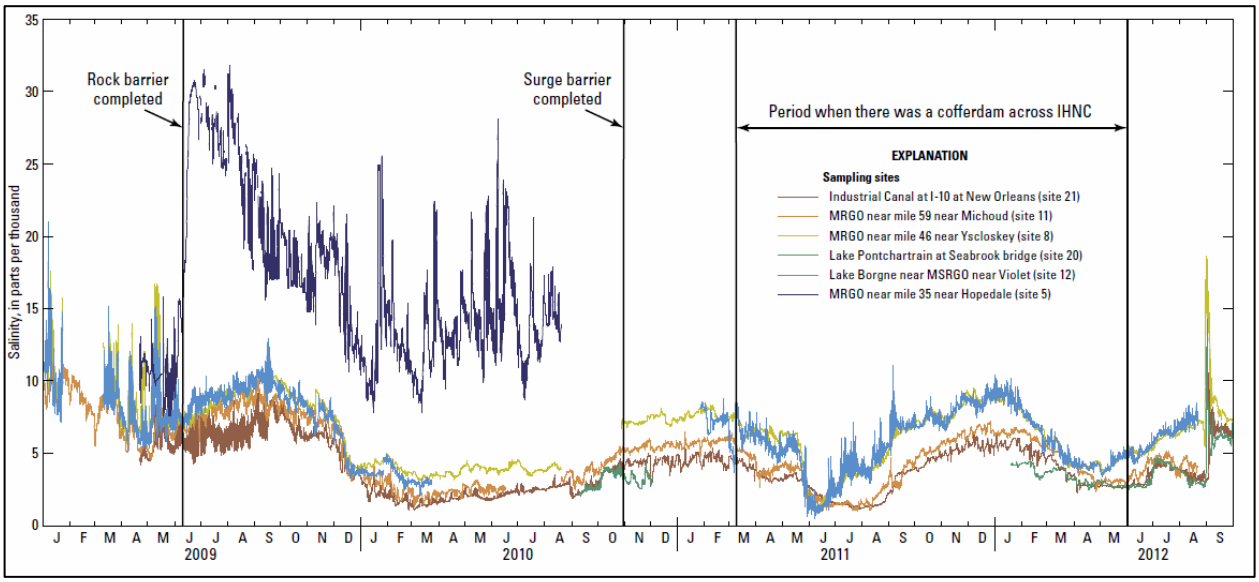


Table 4-10 and Figures 4-7 and 4-8 depict surface, 20-ft, and 40-ft depth interpolations of synoptic water quality monitoring data collected by the USGS in the GIWW west of the Paris Road Bridge, superimposed by vertical lines representing significant construction events within the IHNC basin. The data interpolations suggest there may have been some reductions in dissolved oxygen levels and salinities within the IHNC basin that could be attributed to the MRGO closure, as peaks and troughs in dissolved oxygen concentrations and salinities appear to be slightly lower with the closure in place than prior to construction of the closure. However, there are several additional factors which may account for variations in water quality within the basin during the period the closure was in place, including construction events for basin structures, the diversion of a large volume of Mississippi River water into Lake Pontchartrain through operation of the Bonnet Carré Spillway during the Mississippi River flood of 2011, and less significant local weather events capable of affecting water quality (for example: tropical activity, cold fronts, drought, and heavy rainfall events). Additionally, the time period over which data was collected is limited to approximately two years.

Table 4-3. IHNC Basin construction-related events

Event	Date	Description
1	7/12/2010	Bayou Bienvenue cofferdam and flow-through pipes installed
2	7/19/2010	Barge gate cofferdam on GIWW removed
3	9/13/2010	Pile driving for Borgne Barrier completed
4	9/15/2010	Rock dumping at Seabrook site (sometime in September)
5	10/4/2010	GIWW Sector Gate cofferdam completed
6	11/17/2010	GIWW Barge Gate opened (approximately 18 months prior to closure for repair)
7	2/27/2011	North wall of Seabrook cofferdam completed
8	4/15/2011	South wall of Seabrook cofferdam completed
9	4/29/2011	Seabrook cofferdam dewatered
10	5/9/2011	Bonnet Carre Spillway opened
11	6/7/2011	Bonnet Carre Spillway closed
12	4/8/2012	GIWW Sector Gate opened
13	5/17/2012	GIWW Barge Gate closed for repair
14	6/21/2012	Bayou Bienvenue Gate opened
15	7/2/2012	Seabrook opened

Figure 4-1. Interpolated dissolved oxygen and water temperature in the GIWW West of the Paris Road Bridge, July 2010 – July 2012 (vertical lines represent events included in Table 4-10)

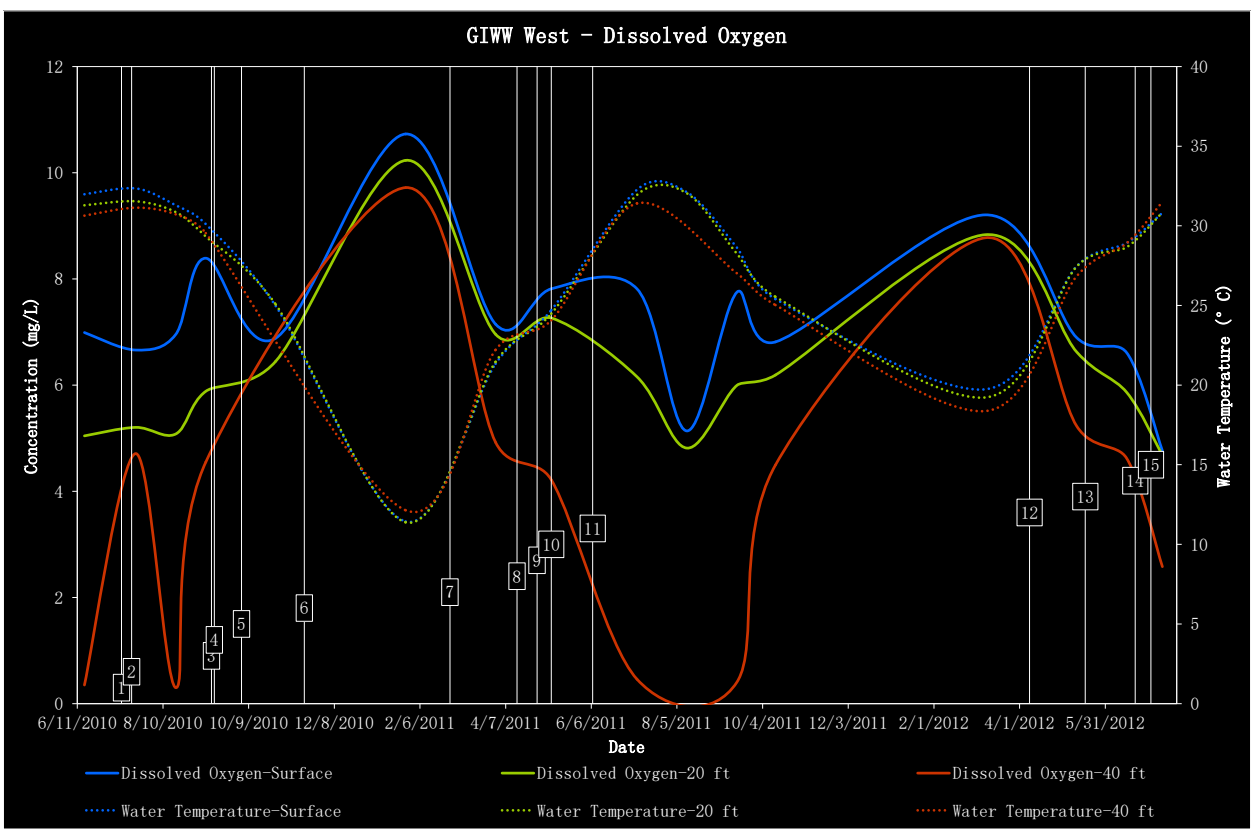
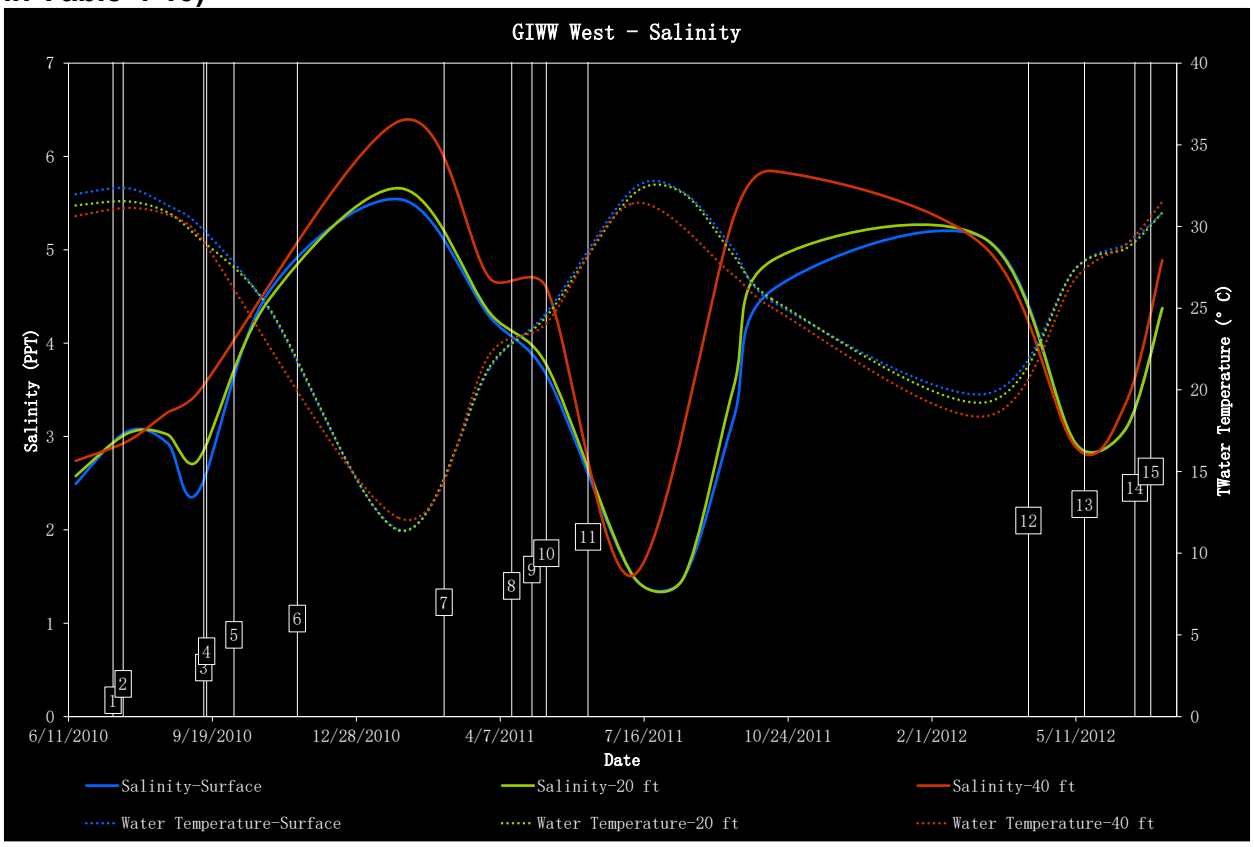


Figure 4-2. Interpolated salinity and water temperature in the GIWW West of the Paris Road Bridge, July 2010 – July 2012 (vertical lines represent events included in Table 4-10)



Improvement of deficient floodwall reaches within the IHNC basin and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of dredged and construction materials in aquatic habitat and construction site runoff (IERS #11.b Tier 2 Borgne, IERS #11.c Tier 2 Borgne). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Access channel expansion converted approximately 22 acres of brackish marsh to open water habitat.

Keeping the cofferdam at Seabrook in place an additional 10 months extended the duration of the expected and observed water quality impacts of Seabrook structure construction during phase I (IERS #11.d Tier 2 Pontchartrain).

Excavation of the Manyard and Eastover borrow areas, as well as drainage of the borrow area using sump pumps, caused local, temporary increases in suspended sediment and turbidity in any adjacent surface waters receiving borrow area runoff (IER #18, IER #19). Borrow area construction locally altered hydrology by creating ponds in previously upland areas and may have modified flooding and drainage patterns of adjacent wetlands. Any impacts to hydrology may have locally affected long-term surface water quality.

Hydraulic dredging of waterbottom sediments from Lake Pontchartrain, mechanical dredging, stockpiling, and backfill of waterbottom sediments for temporary access channel construction, and use of a pipeline access corridor for hydraulic placement of dredged material for construction of the Turtle Bayou Protected-Side Intermediate Marsh project caused temporary, construction-related impacts to water quality due to excavation and placement of dredged material in aquatic habitat (PIER #36, PIER #36 Supplement 1). Construction activities resulted in localized, temporary increases in suspended sediment and turbidity of adjacent waters. Available sediment chemistry data for samples collected in proximity to the borrow area for the project do not suggest the presence of elevated contaminant concentrations relative to NOAA sediment screening benchmarks, and available 10-day sediment toxicity testing results reveal high survival rates for bottom-dwelling organisms exposed to sediment (A. abdita; Buchman 2008), suggesting that placement of material for marsh creation will not result in long-term adverse effects to bottom-dwelling organisms. Water quality impacts would be moderated using retention features during construction of the marsh platform. Following establishment of wetlands habitat, the project would provide localized water quality benefits. Placement of waterbottom sediments would convert 160 acres of open water to marsh habitat.

Chalmette Loop - Construction of the Bayou Dupre sector gate and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #8). The cofferdam indirectly impacted water quality by impacting local hydrology while in place. Space was left between the cofferdam and the bank which connected the bayou to the MRGO while the cofferdam was in place, to allow for reduced (10-20% of flow capacity without the cofferdam in place) water exchange between Bayou Dupre and the MRGO. Placement of materials converted approximately 0.3 acre of open water to upland habitat.

Construction of the Caernarvon floodwall and sector gate, Railroad floodgates, and a gravity drain connecting the area protected by the floodwall to the Jourda Canal caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #9). The gravity drain is not expected to have a significant effect on water quality within the canal and connected waterbodies when water levels allow gravity drainage. Water quality in the area protected by the floodwall when water levels allow gravity drainage is expected to be highly diluted with rainwater but reflect land cover and use within the area, which includes marine industrial facilities and grass cover. The size of the area protected by the floodwall that drains into the Jourda Canal is small in comparison to the overall area of the canal's watershed, and is not expected to have a significant impact on water quality within the canal unless flooding within the area protected by the floodwall inundates infrastructure and/or coincides with a significant spill (for the latter, low-probability case, closing the drain during cleanup activities would prevent the spread of spill-related contaminants into the Jourda Canal and hydraulically connected aquatic habitat). Placement of materials and clearing activities converted

approximately 1.9 acres of marsh, 1.2 acres of bottomland hardwood forest-wet, and 0.3 acre of open water to upland habitat.

Construction of the Chalmette Loop floodwall, fronting protection for the St. Mary's pump station and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #10). Placement of materials and clearing activities converted approximately 430 acres of marsh, 74 bottomland hardwood forest, and 50 acres of open water to upland habitat.

Construction of a permanent access road on the protected side of the Chalmette Loop floodwall and a swing span bridge on Bayou Bienvenue caused temporary, construction-related impacts to water quality due to placement of construction materials in aquatic habitat and construction site runoff (IERS #8, 9, 10.a). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters.

Replacement of discharge pipes, placement of riprap in discharge basins, T-wall construction, and road improvement in association with the Guichard and Bayou Villere pump stations caused temporary, construction-related impacts to the water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (EA #526). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters.

Belle Chasse - Construction of the Hero Canal and Eastern Tie-In levees, a closure structure crossing Hero Canal, a pump station, and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff (IER #13). Placement of materials and clearing activities converted approximately 39 acres of swamp and 19 acres of bottomland hardwood forest-wet to upland habitat.

For the WBV and Mississippi River Co-Located Levees, the clearing, grubbing, and preparation of stabilized soils; replacement of concrete slope pavement; levee re-grading; and construction and use of access roads and staging areas caused temporary, construction-related impacts to the water quality due to construction site runoff (IER #33, IERS #33.a). Approximately 101 acres of freshwater marsh were temporarily impacted by construction activities. Placement of materials converted approximately 82 acres of forested wetlands to upland habitat.

Installation of the segment of the waterline to the Western Closure Complex crossing the WPA Canal generated localized, temporary increases in suspended sediment and turbidity within the canal (IERS #12/13 Waterline). Approximately 0.4 acres of bottomland hardwood forest-wet and 0.02 acres of freshwater marsh were temporarily impacted by construction activities.

Gretna Algiers - Construction of the Western Closure Complex, a flow control structure on the Estelle Outfall Canal, floodwalls and gates surrounding the Belle Chasse Tunnel; improvement and construction of levees and floodwalls bordering the Bayou Aux Carpes 404(c) area; mechanical dredging and beneficial use of Algiers Canal waterbottom sediments for marsh creation in the Jean Lafitte National Historic Park and Preserve (JLNHPP) along the eastern shoreline of Lake Salvador; and associated features caused temporary, construction-related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff (IER #12). The water quality input to the IERS #12/13 Waterline 404(b)(1) evaluation (Eric Glisch, memorandum to file) includes review and evaluation of chemistry data for Algiers Canal sediments for dredging and beneficial use in the JLNHPP, and that placement of material for marsh platform construction would not result in adverse impacts to water column or bottom-dwelling organisms. Also, the Western Closure Complex and adjacent risk reduction features may be indirectly impacting water quality by modifying local hydrology. Placement of materials and clearing activities converted approximately 75 acres of swamp and 2.4 acres of bottomland hardwood forest-wet to upland habitat, and approximately 55 acres of open water to marsh habitat.

Harvey Westwego - Construction of the Harvey to Westwego levee and floodwall, the Highway 45 swing gate, and the Westminster, Ames, and Mount Kennedy pump stations; utility relocations ans associated features caused temporary, construction-related impacts to water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (IER #14, IERS 14.a). Placement of materials and clearing activities converted approximately 72 acres of swamp and 91 acres of bottomland hardwood forest-wet to upland habitat. In addition, the infilling of several flood side borrow pits and 1 acre of Millaudon Canal waterbottoms converted approximately 72 acres of open water habitat to upland habitat.

The existing V-Line Levee Canal did not require re-alignment thus avoiding filling in the canal and dredging a new canal, thereby reducing water quality impacts (IER #12.a). Access road construction alongside the JPDD Canal-C drainage canal and riprap placement along the east bankline of Reach 3B of the V-Line Levee Canal caused temporary, construction-related impacts to canal water quality due to placement of construction materials in aquatic habitat and construction site runoff. Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters.

Installation of permanent pumps at the Harvey Canal Sector Gate resulted in temporary, construction-related impacts to canal water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (SEA #306c). Construction activities generated localized, temporary increases in suspended sediment and turbidity of adjacent waters.

Lake Cataouatche - Construction of the Western Tie-In levee and floodwall, Bayou Verret closure structure and associated feastures caused temporary, construction-

related impacts to water quality due to excavation and placement of dredged, fill, and construction materials in aquatic habitat and construction site runoff (IER #16, IERS #16.a). Construction of the Western Tie-In levee and floodwall may have further hydrologically modified an approximately 2,000-acre area of wetlands to the north of the project. Placement of materials and clearing activities converted approximately 148 acres of marsh and 158 acres of bottomland hardwood forest-wet to upland habitat, and the excavation of a new drainage canal created approximately 55 acres of open water.

Construction of the Company Canal floodwall, modifications to pump stations and other associated features caused temporary, construction-related impacts to water quality due to excavation and placement of fill and construction materials in aquatic habitat and construction site runoff (IER #17). Placement of materials and clearing activities converted approximately 19 acres of swamp and 6 acres of bottomland hardwood forest-wet to upland habitat.

Approximately 14.5 acres of semi-buoyant freshwater marsh, 8 acres of forested wetlands, and 12.9 acres of waterbottoms were mechanically dredged for relocation of the Chevron pipeline that crosses the Lake Cataouatche Levee (IERS #15.a). Dredged material was stockpiled for backfilling dredged features following pipeline relocation. Dredging, stockpiling, and backfilling generated localized, temporary increases in suspended sediment and turbidity of adjacent waters. Post-project monitoring indicated that while stockpiled material was used to backfill dredged and excavated features to the maximum extent practicable, a net increase in open water area within the Chevron pipeline relocation project area attributable to the project was observed (Dusty Pate, NSPS, personal communication). In addition, resurfacing of an existing access road and construction of a temporary board road for access to the drill entrance point caused temporary, construction-related impacts to water quality due to excavation and placement of construction materials in aquatic habitat and construction site runoff. There is a possibility that directional drilling impacted water quality through accidental drilling fluid spillage during pipeline relocation; however, ring levees around drill entry and exit points constructed to provide secondary containment for drilling fluid spills minimized this impact. Construction of a temporary access road, staging area, and pontoon bridges for accessing a reach of the Lake Cataouatche Levee (WBV 15a.2) caused temporary, construction-related impacts to water quality due to construction site runoff (IERS #15.a). Placement of fill material and riprap into the Outer Cataouatche Canal and along its northern shoreline for expansion of a reach of the Lake Cataouatche Levee (WBV 15a.2 Reach 2) caused temporary, construction-related impacts to canal water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff. Placement of material generated a mud wave of organic material by displacing high organic content waterbottom sediments, which generated localized, temporary increases in suspended sediment, turbidity, and biochemical oxygen demand, and temporary decreases in dissolved oxygen levels. Placement of materials converted approximately 32 acres of freshwater marsh and 11 acres of open water to upland habitat.

Construction of an earthen ramp for the Highway 18 crossing and bank stabilization

across Outer Cataouatche Canal closures; and other associated features caused temporary, construction-related impacts to water quality due to placement of fill and construction materials in aquatic habitat and construction site runoff (IERS #16.a). The reach of the Davis Pond East Guide Levee previously proposed for removal was not degraded, so temporary water quality impacts associated with this action did not occur. However, not degrading the levee reinforced hydrology-induced water quality changes associated with partial enclosure of wetlands between the guide levee and Outer Cataouatche Canal western closure.

Construction of a bypass channel narrower than what was proposed in IER #16 during construction of the Bayou Verret structure had minor impacts on water exchange between Bayou Verret and the wetlands and open water north of the structure for the duration of structure construction. In order to minimize impacts to hydrology, a pump was used to aid in the drainage of the area north of the structure during construction of the structure. Two culverts were installed adjacent to the structure to allow for adequate water exchange during future, temporary closures of the Bayou Verret structure (e.g., for maintenance). Un-authorized actions related to IER 16 that are expected to have affected the water quality of adjacent surface waters included the temporary infilling of 0.78 acres of swamp, the permanent infilling of 0.6 acres of wetlands by the land owner, and permanent infilling of 0.34 acres of wetlands for construction of a staging area.

Borrow Areas
Excavation of the Westbank N borrow area, as well as drainage of the borrow area using sump pumps, caused local, temporary increases in suspended sediment and turbidity in any adjacent surface waters receiving borrow area runoff (IER #18, #19, #22 #25, #26, #30 #31). Borrow area construction locally altered hydrology by creating ponds in previously upland areas and may have modified flooding and drainage patterns of adjacent wetlands. Any impacts to hydrology may have locally affected long-term surface water quality.

Areas Outside of the HSDRRS Project Area

Jefferson Parish - Excavation and placement of dredged and/or fill material for construction of the Jean Lafitte Flood-Side Freshwater Marsh, Bottomland Hardwoods-Wet, and Swamp Restoration projects is expected to cause temporary, construction-related impacts to water quality due to excavation and placement of dredged and/or fill material in aquatic habitat and construction site runoff (PIER #37, to be constructed). Excavation and placement of dredged and/or fill material is expected to generate localized, temporary increases in suspended sediment and turbidity of adjacent waters. Material to be used for wetlands platform construction would be derived from Lake Salvador. Previous testing of waterbottom sediments in Lake Salvador was either not conducted or was not accounted for in the project 404(b)(1) evaluation. Following establishment of wetlands habitat, the constructed projects are expected to provide localized water quality benefits. Approximately 53 acres of wetland habitat would be created as a result of these projects. Placement of waterbottom sediments would convert 53 acres of open water and fragmented marsh to 20.4 acres of marsh, 20.5

acres of swamp, and 12.2 acres of bottomland hardwood forest-wet habitat.

Lafourche Parish - Excavation of dredged material and soil for construction of the Lake Boeuf Flood-Side Bottomland Hardwoods-Wet and Swamp Restoration projects are expected to cause temporary, construction-related impacts to the water quality of adjacent waterbodies due excavation of dredged material and soil in aquatic habitat and construction site runoff (PIER #37, to be constructed). For these projects, large land areas would be degraded to elevations suitable for establishment of bottomland hardwood-wet and swamp habitat. In addition, land areas will require preparations such as clearing and grubbing, grading and tiling, and limited application of herbicides to eradicate invasive and nuisance plant species. The swamp restoration project would require construction of several roadways. Construction activities are expected to generate local, temporary increases in suspended sediment and turbidity of adjacent waters. Herbicide application for site preparation is expected to result in temporary increases in herbicide concentrations of adjacent waterbodies (the types of herbicides to be used are not mentioned in PIER #37). Following establishment of wetlands habitat, the constructed projects are expected to provide localized water quality benefits. Placement of waterbottom sediments would convert 542 acres of upland to 320 acres of swamp and 222 acres of bottomland hardwood forest-wet habitat. However, MVN is currently reformulating project alternatives for the BLH-Wet and Swamp habitat types since the real estate instrument needed to obtain the right of way required for these projects is not supported within the USACE at this time.

Orleans Parish - Hydraulic dredging of waterbottom sediments from Lake Pontchartrain, temporary flotation access channel construction, and use of a pipeline access corridor for hydraulic placement of dredged material for construction of the Bayou Sauvage Flood-Side Brackish Marsh and Turtle Bayou Protected-Side Intermediate Marsh projects are expected to cause temporary, construction-related impact to water quality due to excavation and placement of dredged material in aquatic habitat (PIER #36, PIER #36 Supplement 1, to be constructed). Construction activities generate localized, temporary increases in suspended sediment and turbidity of adjacent waters. Available sediment chemistry data for samples collected in proximity to the borrow area for the projects do not suggest the presence of elevated contaminant concentrations relative to NOAA sediment screening benchmarks, and available 10-day sediment toxicity testing results reveal high survival rates for bottom-dwelling organisms exposed to sediment (*A. abdita*; Buchman 2008), suggesting that placement of material for marsh creation will not result in long-term adverse effects to bottom-dwelling organisms. Water quality impacts would be moderated using retention features during construction of the marsh platform. Following establishment of wetlands habitat, the constructed projects are expected to provide localized water quality benefits. Placement of waterbottom sediments would convert 325 acres of open water and fragmented marsh to marsh habitat.

Hydraulic dredging of waterbottom sediments from Lake Pontchartrain, temporary access channel construction, use of a staging area, and use of pipeline access corridor for hydraulic placement of dredged material for construction of the New Zydeco Ridge Bottomland Hardwoods-Wet and Brackish Marsh, and Milton Island Intermediate Marsh

projects are expected to cause temporary, construction-related impacts to water quality due to excavation and placement of dredged material in aquatic habitat and construction site runoff (PIER #36, PIER #36 Supplement 1, PIER #36 Tier 1, to be constructed). Available sediment chemistry data for samples collected in proximity to the borrow area for the projects do not suggest the presence of elevated contaminant concentrations relative to NOAA sediment screening benchmarks, and available 10-day sediment toxicity testing results reveal high survival rates for bottom-dwelling organisms exposed to sediment (*A. abdita*; Buchman 2008), suggesting that placement of material for marsh creation will not result in long-term adverse effects to bottom-dwelling organisms. Water quality impacts would be moderated using retention features during construction of the marsh platforms. Following establishment of wetlands habitat, the constructed projects are expected to provide localized water quality benefits. Placement of waterbottom sediments would convert 270 acres of open water and fragmented marsh to 118 acres of marsh and 152 acres of bottomland hardwood forest-wet habitat.

Borrow Areas (Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptish, St. Tammany Parishes, LA and Hancock County, MS) - Excavation of borrow areas, as well as drainage of the borrow areas using sump pumps, caused local, temporary increases in suspended sediment and turbidity in any adjacent surface waters receiving borrow area runoff. Borrow area construction locally altered hydrology by creating ponds in previously upland areas and deepening drainage canals and may have modified flooding and drainage patterns of any adjacent wetlands. Any impacts to hydrology may have locally affected long-term surface water quality. Reference table 2-1 for a list of borrow sites and their associated parishes/county.

1.1.1.2.2 HSDRRS 2057 Impacts

Impacts to water quality from future maintenance and improvement of the HSDRRS are expected to be similar to those described for HSDRRS construction impacts and would be minimized by adopting BMPs and SWPPPs. One factor which may influence differences between recent and future water quality impacts is that there would likely be less wetland habitat and more open water adjacent to the HSDRRS in 2057. As a result, proportionally less wetland habitat and more open water habitat are expected to be eliminated during future maintenance and improvements. In addition, there would be less habitat present capable of ameliorating water quality impacts of HSDRRS 2057 construction activities.

Many structures constructed during HSDRRS 2011 were designed to HSDRRS 2057 100-year hurricane storm damage risk reduction elevations and an additional 2 ft for structural superiority, and are not expected to require replacement or major improvements until beyond 2057, so there would be no construction-related impacts associated with structures for improvements to the HSDRRS in 2057.

1.1.1.3 CUMULATIVE IMPACTS

Cumulative impacts would in general consist of the recurrence of impacts described for HSDRRS construction impacts, with the exception that many structures constructed during HSDRRS 2011 would not require major improvements or replacement until beyond 2057.

Collectively, other present and future projects would have cumulative short-term moderate adverse impacts on water quality in the region due to stormwater runoff from construction sites, excavation and placement of dredged, fill, and construction materials in aquatic habitat, and hydromodification. Cumulative long-term moderate adverse impacts on water quality would occur due to an increase in impermeable surfaces. Impacts of other ongoing and future regional actions are similar in many of the sub-basins and parishes affected by the HSDRRS.

Storm Damage Reconstruction - Where storm damage reconstruction projects are constructed within the current structural project footprint on previously disturbed upland areas, they would disturb very little soil and would have minor direct impacts on water quality. There is the potential for spills of materials and waste during construction activities that could adversely impact water quality; however, most spills during reconstruction activities would be confined to upland environments restricted by a forced drainage system. Water quality would return to pre-construction conditions when reconstruction activities have been completed. However, reconstruction projects that occur in water bodies, such as rebuilding of bridges and reconstruction of marinas and harbors, have the potential to directly impact water quality from stormwater runoff and from spills during construction activities. These projects would result in cumulative adverse impacts on water quality. Sewage and drainage treatment infrastructure enhancement would improve water quality by capturing, controlling, and filtering tertiary runoff.

Redevelopment - Agricultural and urban land use in the watersheds of the Mississippi River and Pontchartrain and Barataria Estuaries is expected to continue, along with industrial activities affecting the study area.

The quality of Mississippi River water inflows to estuaries, which is heavily influenced by basin agricultural practices, will continue to vary depending on factors mentioned in Section 4.2.2.1. Recent analysis of long-term (1980-2010) data suggests that the trend of increasing nitrate concentrations and loads in the river may continue at a decreasing rate (Murphy et al. 2013). Atrazine application in the continental U.S. decreased between 1992 and 2009 (Thelin and Stone 2013); riverine atrazine concentrations may decrease as a result of decreasing atrazine use. Suspended sediment concentration data show relatively stable annual average concentration from 1967-2007; this trend may continue. In general, it appears that river water quality as impacted by agriculture in the basin will not change significantly.

Improvement of the HSDRRS is expected to encourage an increase in development within the HSDRRS. Development activities may influence the quality of drainage waters discharged to adjacent estuaries, introducing elevated levels of sediments and contaminants. Development activities encroaching rural or more natural and

undisturbed environments could result in direct water quality impacts, as open water and wetlands are filled and converted into industrial, residential, or commercial land use, eliminating habitat capable of providing water quality benefits or associated with good water quality. Clearing bottomland hardwood forest, dredging pipeline canals, rebuilding camps and boat houses, replacing pilings, repairing sewer lines, and constructing bridges and roads would have long-term cumulative impacts on water quality through increased impermeable surfaces and a higher probability of spills of contaminants.

Industrial activities, including accidental spills, would continue to affect study area water quality. Although unanticipated, environmental catastrophes such as the 2011 BP oil spill can have widespread impacts on study area water quality. The high density of industrial activities in the study area vicinity and previous events suggests the possibility of future major spills, especially considering the vulnerability of the area to tropical activity.

Coastal and Wetlands Restoration - The water quality management programs described in this assessment are expected to generate future improvements in study area water quality. For example, improved regulation of point sources of pollution may help reduce the magnitude of water quality issues such as elevated fecal coliform densities in the Pontchartrain Estuary. However, many of the water quality problems in the study area are due to either natural conditions or nonpoint source pollution which is not adequately regulated or managed and are expected to continue. This includes elevated salinities and low pH in the study area due to episodic droughts, low dissolved oxygen levels and non-native aquatic plants in the Barataria Estuary north of the GIWW due to natural conditions and agricultural runoff, runoff from mixed land use areas affecting water quality in Lakes Pontchartrain and Borgne, and low dissolved oxygen levels and elevated mercury concentrations in nearshore Gulf of Mexico waters. In addition, comprehensive management plans specifically addressing Pontchartrain and Barataria Estuary water quality have been developed and may aid in the improvement of study area water quality (LPBF 2014, BTNEP 2013).

Programs such as the EPA's Mississippi River Gulf of Mexico Watershed Nutrient Task Force would continue efforts to reduce nutrient loading from the Mississippi River watershed to the Gulf of Mexico and the study area (USEPA 2014). However, inadequate nonpoint source pollution management and regulation in the watershed continues to prevent nutrient load reductions (COMRACWA 2008). There are currently no anticipated changes in nonpoint source pollution management and regulation that would significantly reduce associated chemical loadings in the river, including loadings of agricultural pollutants such as nutrients. As a result, the formation of annual Gulf of Mexico hypoxic zone is expected to continue, while river water inflows to study area estuaries would continue to generate water quality impacts.

Operation of existing freshwater diversions in both the Pontchartrain and Barataria Estuaries is expected to continue, affecting estuary water quality, salinity, aquatic vegetation and phytoplankton community dynamics, and bioaccumulation rates.

Because higher salinity waters promote improvements in estuary water quality, continued diversion inflows may reinforce reduced water quality in areas where salinities are suppressed by river water. Conversely, during episodic droughts in the study area, it may be possible to use the diversions to locally reduce salinity and increase pH, which may locally reduce the severity of brown marsh and forested wetland tree mortality (LDNR 2015, Hoeppner et al. 2008). Diversion operation is limited to time periods where river stages are higher than estuary stages, which may limit their utility for this purpose. Also, brown marsh has previously occurred in the lower estuary, which is generally removed from the areas influenced by diversions.

In addition, long-term river water inflows may negatively affect the biogeochemistry of estuary wetlands. Chronic inflows of alkaline river water containing sulfate, pesticides, and elevated nitrate concentrations may contribute to the decomposition of wetlands belowground matter, leading to wetlands loss during events which generate significant wave energy, such as tropical storms and hurricanes (Swarzenski et al. 2005). Changes in wetlands biogeochemistry and subsequent wetlands loss from long-term river water inflows may have already occurred in the Breton Estuary, where wetlands losses of approximately 40 square miles have occurred in the area hydrologically influenced by the CFD since 2004 (Figure 4-9; Kearny et al. 2012, Couvillion et al. 2011).

Figure 4-3. Land loss in the Breton Estuary, from Couvillion et al. (2011) (purple areas represent land loss since 2004; the CFD is just north of Big Mar)

Other coastal environmental project types that would affect these estuaries include wetlands creation and nourishment, ridge rehabilitation, shoreline protection, oyster reef creation, and other types of hydrologic modification. Projects of these types within the Pontchartrain and Barataria Estuaries are described in section 3.2. These projects share a common goal of improving the natural environment within the estuaries, which would be expected to improve water quality conditions. For example, wetlands creation

and nourishment will result in additional or improved habitat capable of serving as a water quality filter for constituents. Shoreline protection would be expected to aid in minimizing the loss of adjacent wetlands through erosion. New oyster reef habitat would also serve as a natural water quality filter. Other types of hydromodification for environmentally beneficial purposes would ideally create hydrologic conditions supportive of healthy wetlands vegetation and promote water circulation. A majority of the major coastal environmental projects studied to-date have not been implemented, and this trend is expected to continue.

Flood Risk Reduction Projects - Flood protection projects adjacent to the HSDRRS are also expected to affect project area water quality, through impacts similar to those described for HSDRRS construction activities. In addition, the diversion of Mississippi River water into Lake Pontchartrain during river floods would continue, temporarily altering Pontchartrain estuary and Mississippi Sound water quality, salinity, and phytoplankton community dynamics.

Transportation - Repairs to highway and road infrastructure and new road and highway alignments would have little to no cumulative effects on water quality since most of the projects are being constructed in previously disturbed areas and are short-term construction activities. Even for those projects that could be constructed along undeveloped corridors, impacts on water quality are expected to be short-term and localized, and reduced through the implementation of BMPs. Most of the impacts would be from construction site runoff and typical roadway pollutant runoff. Implementation of mitigation measures and BMPs are expected to minimize water quality impacts from transportation infrastructure and related construction activities.

Other Regional Actions - Future climate change could have a myriad of impacts on study area water quality. Increasing surface water temperatures could affect water quality by increasing primary productivity, rates of waterborne disease, and frequency of harmful algal blooms, and decreasing dissolved oxygen levels (Milello et al. 2014). Increasing sea-level and severity of hurricanes could aid in accelerating wetland loss rates, as well as increases in the flooding of study area infrastructure, impacting water quality by removing habitat capable of ameliorating water quality and increasing the frequency of introduction of infrastructure floodwaters into study area estuaries. Increasing severity of droughts in the study area may impact water quality by facilitating stagnation of estuary waters during the warm summer months, leading to changes in phytoplankton community, decreases in pH and dissolved oxygen levels, and elevated water temperatures. Increasing severity of droughts may also foster dieback of some marsh communities and saltwater intrusion of upper estuary swamps, with both temporary and permanent impacts to these wetland communities. More severe rainfall events in both the study area and Mississippi River watersheds could affect water quality by altering the transport of runoff constituents, particularly nutrients. Changes in Mississippi River discharge in response to climate change could alter the timing and extent of the Gulf of Mexico dead zone.

The area would continue to be impacted by coastal deltaic processes associated with a transgressive delta, such as subsidence, erosion, and land loss. The continued

subsidence and erosion of estuary wetlands would reduce their water quality benefits. An increase in the abundance of open water habitat, and the resulting increase in the fetch of waterbodies, may lead to increases in turbidity and suspended particulates in waterbodies, which could further affect water quality, for example through changes in phytoplankton community and abundance, bioaccumulation rates, and changes to ambient levels of other physical parameters such as pH.

Changes in barrier island morphology may lead to increased tidal prism volumes (the daily volume of water exchanged between the estuary and Gulf of Mexico). This may be especially true for the Barataria estuary, which has a near-continuous barrier island chain. An increase in tidal prism may increase the flushing rates as well as salinity variability and magnitude for some portions of the estuary (similar to what may have already occurred in the Barataria Waterway and lower estuary; Van Sickle et al. 1976). This may provide some water quality benefits in regions of the study area where salinities would increase, such as decreased harmful algal bloom taxa abundances and removal of inorganic and organic materials.

Additional foreseeable changes in water quality may occur due to redistribution of river discharge between the Mississippi and Atchafalaya rivers. Although there are no current plans to change the flow distribution between these rivers, the Atchafalaya River may eventually carry a higher proportion of Mississippi River discharge (McPhee 1987). This could lead to increases in estuary salinities and changes in water quality (e.g., reduced water quality impacts associated with Mississippi River influence on the lower estuaries and diversions, and reduced severity and extent of hypoxia in study area nearshore waters).

Summary of Cumlative Impacts - HSDRRS construction and 2057 impacts combined with other present and future regional actions and natural conditions are overall expected to lead to decreasing water quality in the project area. Despite some possible water quality improvements from state and federal water quality management programs and coastal environmental projects that are implemented, the trends of increasing wetland loss and development in the project area and its watersheds suggest the continued introduction of pollutants into aquatic habitat and a decrease in habitat capable of mitigating pollution of surface waters.