

Deer Island Aquatic Ecosystem Restoration Project

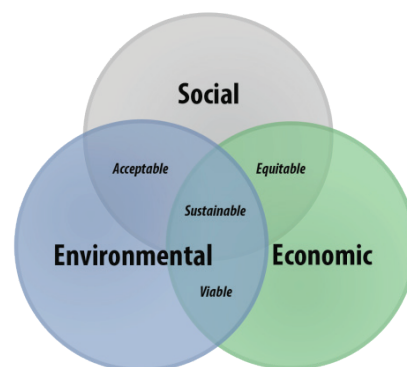
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PURPOSE: Implementation of Engineering With Nature (EWN) practices and principles across the U.S. Army Corps of Engineers (USACE) requires that a broad base of EWN understanding and support be built. The Deer Island Aquatic Ecosystem Restoration Project (Deer Island AERP) has been identified as a case study for EWN, based on its “triple-win” benefits, operational efficiency achievements, use of natural processes, and high degree of stakeholder collaboration. The purpose of this technical note is to showcase the Deer Island AERP from an EWN perspective. Summary case studies such as this, which document the objectives, methods, and outcomes of projects with EWN features, provide useful information for others with like missions and goals. This case study was conducted as an activity of the EWN Initiative and sponsored by the U.S. Army Engineer Research and Development Center (ERDC) Navigation Research, Development, and Technology portfolio, Dredging Operations Environmental Research Program, USACE Mobile District, and the State of Mississippi.

INTRODUCTION: The Engineering With Nature initiative is focused on the sustainable, systems-approach delivery of multiple project benefits across USACE mission areas. EWN is defined as “the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes” (USACE EWN 2014). EWN includes the following practices:

- Use science and engineering to produce operational efficiencies supporting sustainable infrastructure.
- Use natural processes to maximum benefit, thereby reducing demands on limited resources and enhancing the quality of project benefits.
- Broaden and extend the base of benefits provided by projects to include substantiated economic, social, and environmental benefits (“triple-win” benefits).
- Use science-based collaborative processes to organize and focus interests, stakeholders, and partners to reduce social friction, resistance, and project delays while producing more broadly acceptable projects.



The achievement of EWN practices is guided by several principles. The approach should endeavor to be holistic, systematic, sustainable, science-based, collaborative, time efficient, cost effective, socially responsive, innovative, and adaptive (USACE EWN 2014).



The Deer Island AERP is a joint effort by the USACE Mobile District, Mississippi Department of Marine Resources (MDMR), and local stakeholders. The project is multi-phased and includes the restoration of features on the island that — by utilizing several EWN principles and practices — has already resulted in the achievement of “triple-win” benefits. A summary of the project background, objectives, outcomes, and its alignment with EWN follows.

PROJECT BACKGROUND: Deer Island, located in the Mississippi Sound near the mouth of Biloxi Bay and the City of Biloxi, Mississippi (Figure 1), is a spindle-shaped, 4.5-mile-long island originating from late Pleistocene beach ridges (Schmid and Otvos 2003).

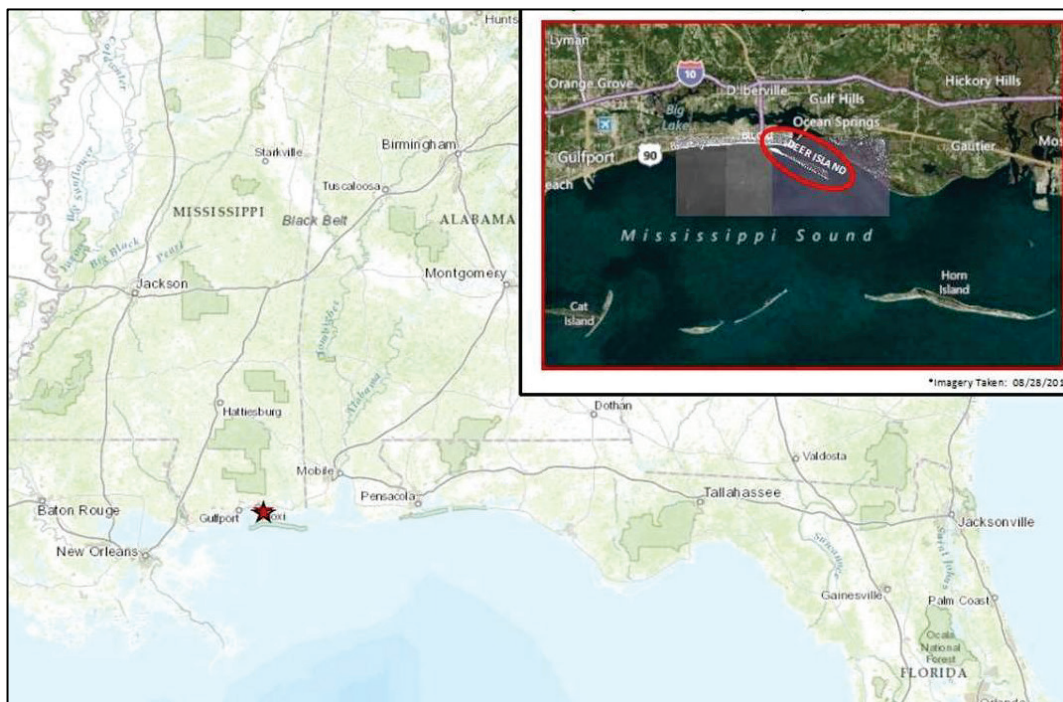


Figure 1. Location of Deer Island.

Deer Island is not a true barrier island, but is a remnant of the mainland. It has long provided a diverse habitat for native flora and fauna. In addition, the island’s location and orientation along the coastline has provided the City of Biloxi with long-term erosion protection by reducing the energy of wind and waves moving onshore. Deer Island’s location has also afforded Biloxi critical, periodic storm damage reduction by absorbing some of the energy from extreme storm events. Historical records indicate that Deer Island has incurred near continuous erosion since the 1850s, resulting in an accumulative loss of approximately 300 acres (USACE SAM 2013). Hurricanes Camille (1969), Ivan (2004), Dennis (2005), Katrina (2005), Gustav (2008), and Ike (2008) are noted to have had significant adverse impacts to Deer Island’s structural integrity and ecological diversity (USACE SAM 2007; USACE SAM 2010). In the last 25 years, the strong storms significantly eroded beaches, breached an entire section of the island, reduced island elevations, and severely damaged the forested areas (Coastal Management News (CMN) 2010) (Figures 2 and 3). USACE was recently engaged in another environmental activity on Deer Island, a Section 204 (Water Resources Development Act of 1992 - Beneficial Uses of Dredged Material (in connection

with dredging of a federally authorized navigation project)) marsh restoration project on the northeastern side of the island. That project area also suffered damage from several strong storms but was not targeted for restoration in the Deer Island AERP. Prior to the Deer Island AERP, Deer Island had lost an estimated one-third of its 1850 footprint.

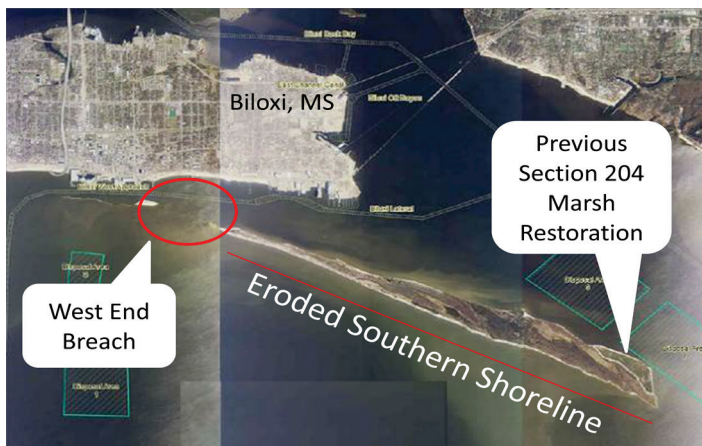


Figure 2. Deer Island condition prior to Deer Island AERP.



Figure 3. Shoreline erosion.

These losses resulted in a weakened capability for Deer Island to provide erosion reduction and storm protection for the mainland; reduced diverse ecological habitat features for native and migratory species (including fish, deer, raptors, and shorebirds); and diminished recreational opportunities for locals and tourists (USACE SAM 2007).

The island is owned by the State of Mississippi and is part of the MDMR Coastal Preserves Program. The aim of the Coastal Preserves Program (established in 1992) is to “effectively preserve, conserve, restore, and manage Mississippi’s coastal ecosystems to perpetuate their natural characteristics, features, ecological integrity, social, economic and aesthetic values for future benefit” (MDMR 2013a).

As “one of the most important properties on the MS Coastal Preserves system,” restoration efforts for Deer Island have received multiple lines of support from the federal, state, and local levels (CMN 2010). Authorization for the Deer Island AERP originated from Section 528 of the Water Resources Development Act of 2000 (Coastal Mississippi Wetlands Restoration Projects). The project received additional funding through several public laws in response to hurricane damages (USACE SAM 2010). The original project authorization included (1) repairing a breach in the west end of the island and (2) restoring the southern shoreline. Construction of the project was slated to begin in 2008; however, the contract had to be terminated due to hurricane impacts that required relocation of the dredge. This delay, and the receipt of additional funds and authorizations, provided the opportunity to expand the project to mitigate the more recent damages as well. Project construction restarted in 2010, with the repair of the west end breach, followed by restoration of the southern shoreline and strategic vegetation plantings. Figure 4 provides a timeline of the Deer Island AERP.

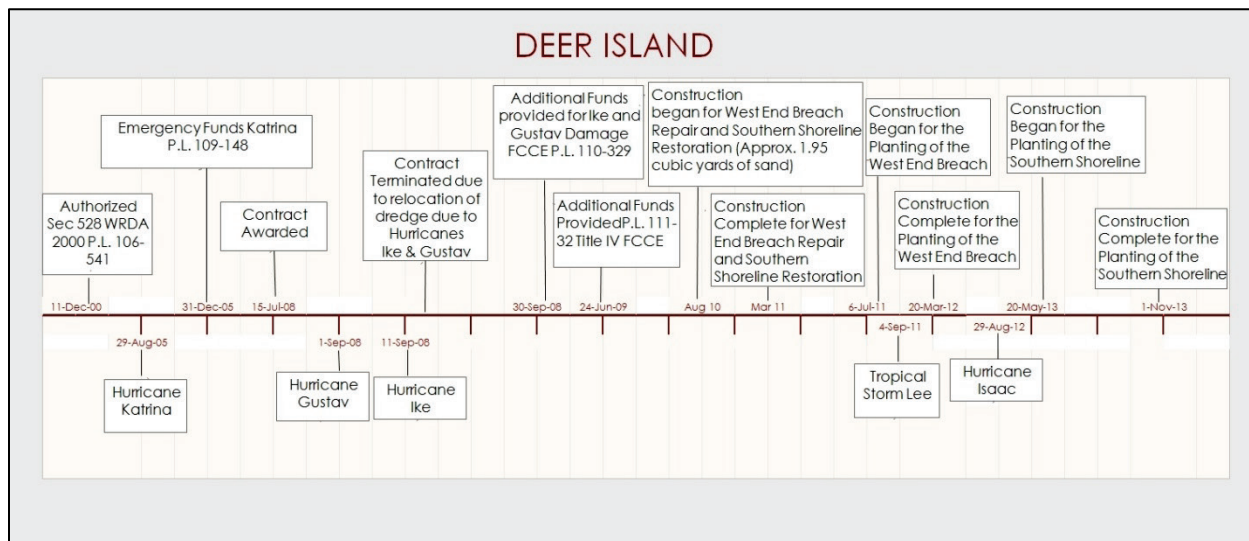


Figure 4. Deer Island AERP project milestones and major storm events.

PROJECT DESCRIPTION: As a Section 528 project, the initial objectives of the Deer Island AERP included protection of the aquatic ecosystem and restoration of the natural shoreline protection function to reestablish marsh and maritime forests on the island for the primary benefit of species diversity. Additional interests, opportunities, and objectives emerged during communications among USACE colleagues, regulatory agencies, elected officials, non-governmental organizations, and local stakeholders. Through this collaboration, and after consideration of the diverse needs of the community, the breadth of the objectives increased. While the Deer Island AERP team remained committed to providing environmental benefits through the closure of the west end breach and the restoration of the southern shoreline, the team also implemented strategic design concepts and used innovative engineering and natural processes to achieve additional benefits.

Closure of the West End Breach. The west end breach had not only occurred and widened over time due to prior storm events, it had also significantly deepened as a result of scour. To fill the 4,300-foot west end breach and restore the southern shoreline, a total of 1.95 million cubic yards of sand was needed. As originally planned, the sand was locally sourced and hydraulically dredged from a nearby borrow site, visible in Figure 5. However, a new plan for stabilizing the breach emerged through utilization of essential ingredients of EWN. Instead of stabilizing the west end breach with an emergent rip-rap dike as originally planned, the project team placed two large geotubes in the breach template below surface level (Figure 6) and utilized a robust, strategic native planting effort involving over 300,000 plants (USACE SAM 2007). This change, widely supported by stakeholders, allowed the project to minimize the overall boundary footprint, and maintained natural shoreline egress and ingress activities for faunal species and recreators. The innovative effort also reduced the need for — and associated cost of — rock resources and the construction and maintenance of over-dike access points.



Figure 5. Left, west end breach filling, showing borrow site.



Figure 6. Right, subaerial geotube filling.

An unanticipated challenge was encountered during repair of the west end breach. The weight of the sand used to close the breach exceeded the load-carrying capability of the underlying soil. This led to displacement of the underlying material, which resulted in the formation of a mud wave along a portion of the north side of the west end breach fill. To address this issue without constructing a hard structure that would prohibit access, dense native grass plantings were planted on top and in front of the mud wave to discourage vessel and pedestrian traffic in that area.

Restoration of the Southern Shoreline. In addition to closing the length of the west end breach, the Deer Island AERP restored approximately two miles of shoreline along the southern portion of the island. Sand was hydraulically pumped via pipeline to the shoreline and contoured using mechanical equipment. After initial beach consolidation, approximately 325,000 native plants were placed along the southern shoreline. The initial project design would have restored the beach to its 1850s configuration by building directly adjacent to the existing shoreline in a seaward direction. However, the Deer Island AERP team developed a new design to address regional challenges and maximize project benefits.

The beneficial placement or disposal of fine-grained sediments is an environmental challenge for the USACE's Navigation Program and Mississippi's navigation and environmental health stakeholders, due to concerns regarding the potential impacts associated with turbidity and sediment migration during discharge. To address these challenges, the implemented design constructed the shoreline in a manner that left a long gap, resulting in a peninsula-like sub-aerial feature with an open-water area (i.e., a lagoon) that is connected with the Mississippi Sound. This open-water area, approximately 100 acres in size and 19,000 ft in length, created an ideal beneficial use site for fine-grained material due to the area's proximity to the Biloxi Lateral and East Access Navigation Channels and its long, slender configuration. Owing to the lagoon's location and configuration, dredged material from the nearby channels can be managed regionally and beneficially, and can be easily contained during placement without the use of traditional containment features such as large dikes and weir boxes. Instead, more cost-effective features that require less effort to construct, such as small spur dikes, natural weirs, and turbidity curtains, could be



Figure 7. View of the restored shoreline and constructed lagoon with spur dike and sand weir.

utilized. These features, shown in Figure 7, also allow the site to have continual connectivity with the Mississippi Sound, which facilitates the development of tidal channels and natural sediment segregation with minimal environmental impact. The connectivity also provides access to larval and juvenile forms of commercially and recreationally important species of shellfish and finfish. Through time, the strategic seaward native plantings, and natural processes, the placed dredged material will provide substrate — and potentially a seed bank — for the evolution of a diverse marsh and maritime forest complex (Lang 2012).

PROJECT DELIVERY AND EWN ALIGNMENT: The Deer Island AERP was identified as an ideal EWN case study because it satisfies all four criteria for determining alignment with EWN principles and practices. Each of these EWN alignment criteria complement the four “essential ingredients” of EWN. The ways in which the Deer Island AERP meets these criteria are presented below (USACE EWN 2014).

Criteria 1. Extent to which the project produces and makes use of efficiencies to contribute to sustainable delivery of project benefits, including how the project function is sustainable in the broader systematic context (e.g., in the watershed or sediment system).

- The engineering methods used, in conjunction with the local sourcing of the fill material, resulted in cost efficiencies that enabled expansion of the planting effort for improving long-term island resiliency.
- The lagoon provides an environmentally acceptable, proximal placement site for material from recurring navigation channel maintenance. This allows the dredged sediment to be managed regionally, at lower cost, and in a beneficial manner that keeps local sediment in the littoral system.
- Utilization of small spur dikes and natural weirs provides an efficient and cost-effective means of reducing turbidity and sediment migration out of the lagoon.
- Closure of the west end breach provides a natural barrier, which reduces sedimentation of the navigation channels and the aquatic habitat on the leeward side of the island. The reduction of sedimentation results in improved substrate and species diversity, improved channel reliability, and cost savings through a reduction in dredging demand.
- The plantings were executed in a strategic manner to encourage natural dune formations for improving island stability; additionally, only native species were incorporated for long-term vegetative community survivability.

Criteria 2. Extent to which natural processes are used to produce benefits and outcomes.

- Wave wash was used to slope the intertidal zone, naturally providing a profile conducive to small fish and avian foraging and reptile and mammal haul-out. This method, along with the soft-shore design (see below), made possible a loggerhead sea turtle nesting (2012) on a restored portion of the island (see Figure 8). This event was one of the first recorded nestings on a Mississippi mainland beach in over 15 years.
- Soft-shore design (in lieu of rip-rap or other hard structures) permitted the expansion of recreation benefits to the entire site and improved aesthetics.
- Natural propagation and recruitment from the strategic native plantings already completed and an anticipated seed bank in the dredged material are expected to vegetate the lagoon and contribute to the development of the marsh/forest habitat complex.

- Filling of the breach and shoreline restoration improved the island's natural capability to reduce the power of erosive forces and the magnitude of periodic storm damage on the mainland coast near the city of Biloxi.

Criteria 3. Extent to which the project and its configuration broaden the base of benefits provided (economic, social, and environmental).

- The project expanded the environmental benefits achieved through use of soft-design concepts, construction of the lagoon, and the expanded planting effort. Greater habitat and species diversity and life-history utilization for a variety of species are expected to result.
- Utilization of buried geotubes, in lieu of rip-rap, for stabilization provided added social benefits through improved island aesthetics and increased accessibility and safety, and reduced long-term maintenance costs.
- The final project created social and economic benefits by providing a multitude of recreation opportunities (e.g., beach-going, bird watching, and angling) for users and related business opportunities for the local community. In 2012, a large festival with several thousand attendees was held on the restored portions of the island. The borrow area for the fill material has become a popular angling site.
- The final project contributes to community resiliency through the joint economic, environmental, and social benefit of reducing severe storm damage to the mainland.
- Through an initial design capacity of approximately one million cubic yards, the lagoon provides a beneficial use and regional sediment management location for material dredged from the Biloxi Lateral and East Access Navigation Channels. As a cost-effective dredged material management alternative, 170,000 cubic yards of fine-grained dredged material from the Biloxi Lateral Channel were placed in the lagoon in October 2011, with subsequent placements planned.
- Restoration of the southern shoreline provides partial erosion protection from onshore wind and waves for the pre-existing Section 204 (beneficial use of dredged material) "Deer Island Marsh Creation Project."

Criteria 4. Extent to which the project makes use of collaborative processes to organize and focus interests, stakeholders, and partners.

- The Deer Island AERP opportunity was initially identified through proactive collaboration with the State of Mississippi.
- During project planning, USACE environmental planning and engineering staff worked in close collaboration with the MDMR Coastal Preserves Program, USACE navigation project managers, resource agencies, and local leaders and other stakeholders to identify needs, opportunities, and innovative alternatives to maximize project benefits.
- The project purposes and progress were communicated often throughout the project by various means, including through local media, for increasing support and awareness and for furthering interest and generating partnering opportunities for future efforts.
- Collaboration with the State of Mississippi is on-going, with recent discussions focusing on suitable locations for boardwalks, trails, and piers to facilitate recreational use, as well as a ferry service for increased ecotourism activities.

PROJECT SUMMARY: Through application of EWN principles and practices, the Deer Island AERP provides multiple services and contributes to the attainment of coastal community resiliency and national sustainability objectives. The Mobile District adeptly leveraged prior project achievements and lessons, Section 528 and public law funding authorities, and partnerships with the MDMR (including The Long-Term Comprehensive Master Plan for Beneficial Uses of Dredged Material) and additional stakeholders to develop an integrated project plan (CMN 2010). The project utilized primarily local resources and “soft engineering” approaches, which effectively saved costs and allowed a broadening of the project scope and subsequent expansion of the realized benefits.



Figure 8. Deer Island AERP main features contributing to “triple-win” benefits.

Through dedicated collaborative and socially responsive processes, holistic thinking, and innovative design concepts (Figure 8), the Deer Island AERP continues to produce “triple-win benefits.” The project has created over 200 acres of restored habitat that benefit several life history stages of migratory and resident avian species, and that provide nursery habitat for several fish species, while simultaneously providing recreational opportunities for people. The project has already served as a cost-effective site for beneficial use of fine-grained dredged material from nearby federal navigation channels. Future use of dredged material as a resource for environmental improvements, by the USACE and others, will be aided by the innovative design and collaborative approach taken by the USACE Mobile District and by the satisfaction of project stakeholders with the project outcomes (CMN 2010). The Deer Island AERP project team was officially recognized for its achievements through receipt of the 2013 Western Dredging Association Environmental Excellence Award and a World Association for Waterborne Transport Infrastructure (PIANC) Working with Nature Certificate of Recognition. Figure 9, below, identifies the primary members of the project delivery team.

USACE	Dr. Susan Rees, Program Manager	
	Jennifer Jacobson, Environmental Mike Malsom, Environmental	Thomas Smith, Project Manager
	Justin McDonald, Contract Manager	Nathan Lovelace, Beneficial Use Manager
MDMR	Jamie Miller, Director	
	Jeff Clark, Project Manager	George Ramseur, BU Manager
Contractors	Mike Hooks Incorporated, Dredging	
	Fish Tec Incorporated, Geotubes	
	RCG-Quality Enterprises USA Joint Venture, Vegetation	
	Tropical World Construction, Landscaping & Irrigation, Vegetation	

Figure 9. Deer Island AERP Project Delivery Team primary members.

The success of the Deer Island AERP has already inspired additional restoration activities in partnership with the National Oceanic and Atmospheric Administration Restoration Center and the Gulf of Mexico community-based Restoration Partnership through the District's Mississippi Coastal Improvements Program (MDMR 2013b). The Deer Island AERP is a credit to the Mobile District and its partners and serves as an excellent example of what can be achieved by Engineering With Nature.

ADDITIONAL INFORMATION: This technical note was prepared by Jennifer Gerhardt Smith, Research Biologist, of the ERDC Environmental Laboratory; Justin McDonald, P.E., Lead Project Engineer for Civil Works; Dr. Susan Ivester Rees, Mississippi Coastal Improvements Program Manager; and Nathan Lovelace, P.E., Dredge Material Project Manager, all of the USACE Mobile District. The study was conducted as an activity of the USACE EWN Initiative within the ERDC Navigation Research, Development, and Technology portfolio and the USACE Mobile District. For information about EWN, please consult www.engineeringwithnature.org. You may also contact the USACE EWN lead, Dr. Todd Bridges, at Todd.S.Bridges@usace.army.mil.

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REFERENCES

- Coastal Management News (CMN). 2010. Mississippi Restoration Focuses on Deer Island and Beneficial Use. *Coastal Management News* 5(2):1-2.
- Lang, M. J. 2012. Post-construction assessment of saltmarsh habitat on Deer Island, Biloxi, Mississippi. MS thesis, University of South Alabama.
- Mississippi Department of Marine Resources, Coastal Preserves Program Website (MDMR). 2013a. <http://www.dmr.state.ms.us/coastal-ecology/coastal-preserves/60-coastal-preserves-mission-vision-and-goals>. Accessed 10 February 2013.
- Mississippi Department of Marine Resources, Coastal Preserves Program Website (MDMR). 2013b. <http://www.dmr.state.ms.us/index.php/wildlife-a-plants/coastal-preserves/134-deer-island-restoration-project>. Accessed 15 October 2013.

- Schmid, K. and E. O. Otvos. 2003. Deer Island, Coastal Mississippi – A Geological and Historical Story, Abstract; Presentation: Mississippi Academy of Sciences, v. 48(1):45. http://geology.deq.state.ms.us/coastal/NOAA_DATA/Publications/Presentations/Harrison/MAS_DeerIslandGeology_Pres.pdf. Accessed 2 February 2013.
- U.S. Army Corps of Engineers (USACE); Engineering With Nature Website (USACE EWN). 2014. Website: <http://el.erd.c.usace.army.mil/ewn/About.html>. Accessed multiple dates 2013-2014.
- USACE, Mobile District (USACE SAM). 2007. Project Information Report – Aquatic Ecosystem Restoration, Deer Island, Harrison County, Mississippi.
- USACE, Mobile District (USACE SAM). 2010. Post-Authorization Change Report - Aquatic Ecosystem Restoration, Deer Island, Harrison County, Mississippi.
- USACE, Mobile District (USACE SAM). 2013. Design Documentation Report – Deer Island Breach Repair and Planting, Harrison County, Mississippi.