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CREATING HORSESHOE BEND ISLAND, ATCHAFALAYA RIVER, LOUISIANA

ABSTRACT

The capacity for the placement of shoal material dredged from Horseshoe Bend at eight wetland development sites located along the river's bank lines adjacent to the channel was nearly exhausted in 1999. To meet the anticipated disposal requirements for future channel maintenance, several alternatives were examined. The choice was made for strategic placement of dredged sediment mid-river and beginning in 2002, strategic placement of the sediment dredged from Horseshoe Bend occurred at the mid-river open water placement area. This contributed to the development of an approximately 35 ha island mid-river. This practice of strategically placing dredged sediments upriver of a naturally occurring island aided the island's growth and produced greater environmental benefits than otherwise would be present using more conventional placement practices.

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INTRODUCTION

During the 1990s, placement of shoal material dredged from Horseshoe Bend occurred at eight wetland development sites located along the river's banklines adjacent to the channel. Capacity of these placement sites was nearly exhausted by 1999. Thus, to meet the anticipated disposal requirements for future channel maintenance, the US Army Corps of Engineers New Orleans District evaluated three placement alternatives:

1. convert the wetland development sites into upland disposal areas;
2. open water placement of dredged material via a long-distance pipeline into the open waters of Atchafalaya Bay; and
3. mounding of material at mid-river open water placement sites within a 350-acre (142 ha) area immediately adjacent to the navigation channel and upriver of a small naturally forming island.

The third alternative was selected on a demonstration basis to investigate the impacts

Above: The river island at Horseshoe Bend on the lower Atchafalaya River, Louisiana is being self-designed by dredged sediment strategically placed upriver (lower right), allowing the river's energy to disperse the sediment, which contributes to the natural growth of the island (Photography by Wings of Anglers).

of mid-river placement on shoaling trends downriver of the site. Beginning in 2002, strategic placement of the sediment dredged from Horseshoe Bend occurred at the mid-river open water placement area. Placement of between 0.5 to 1.8 million cubic yards of sediment was conducted every 1 to 3 years which influenced and contributed to the development of an approximately 35 ha island mid-river. The practice of strategically placing dredged sediments upriver of a naturally occurring island was conducted to aid the island's growth to produce greater environmental benefits than otherwise would be present using more conventional placement practices.

GOALS AND OBJECTIVES

To help understand how and why the island was formed over the last 12 years, the USACE conducted studies to better understand the hydrology of the river used to transfer the mounded material onto the island. Information regarding ecosystem classification and mapping and floral and faunal composition of the island were conducted to document environmental and other benefits being realised. In addition, multiple moderate and high resolution aerial photographs available from prior to 2002 to the present clearly documented the growth of the island. In Figure 1 the changes from 2010, 2011 and 2012 can be seen.

The project objective was to demonstrate how dredged material can be used beneficially to nourish a naturally forming river island.

Biology, ecology, geomorphology and hydrodynamics were examined to catalog the island's maturation for determining the effectiveness of this individual project in terms of restoring, creating, enhancing, and protecting the coastal Louisiana landscape.

STUDY RESULTS

A multi-factor ecological assessment of dredged material supported wetlands located within the Atchafalaya River, Louisiana was conducted. Sample locations included:

- Island E – a traditional dredged material supported wetland island,
- Horseshoe Bend Island – a dredged material supported wetland island created based upon Engineering With Nature (EWN) principles, and
- Middle Island – a mature, naturally formed wetland island.

Within each of the three wetlands, multiple ecological assessment factors were evaluated including:

- geomorphic evolution,
- ecosystem classification and distribution,
- floral communities,
- avian communities,
- aquatic invertebrates,

- soils and biogeochemical activity, and
- hydrodynamic and sediment transport processes.

The multi-factor approach provided a comprehensive assessment of each wetland island and facilitated identification of differences between the three study areas. For example, Horseshoe Bend Island and Island E contained forested, scrub-shrub, emergent, and aquatic bed wetland classes; while Middle Island contained only forested and emergent wetlands. Horseshoe Bend Island contained the highest plant species richness (82 species; 85% native vegetation). Surveys of bird populations on Horseshoe Bend Island yielded a high number of breeding wading birds in dense, mixed-species nesting colonies including 79% juveniles, indicating that the island supports a productive nesting colony. Island E and Middle Island did not support wading bird nesting colonies.

Examining invertebrate communities, the creation of islands using dredged materials supports the formation of emergent aquatic bed habitats that contain significantly higher amounts of fine particles and organic matter than river shoreline sediments, resulting in significantly higher infaunal abundance.

As a result, Horseshoe Bend Island and Island

E displayed significantly higher infaunal species richness than Middle Island. Soils at Horseshoe Bend Island and Island E both displayed evidence of frequent inundation (average period of inundation 316-365 days); while Middle Island exhibited fewer indicators of frequent overbank flooding.

Both dredged-material-supported islands provide nutrient cycling functions including estimated nitrogen removal rates of 2,000-3,800 kg NO₃-/year, indicating the ability to improve water quality. However, denitrification rates for these recently formed wetland features remain lower than values reported in other published studies from the region.

The strategic placement of dredged materials at Horseshoe Bend has the potential to provide improved navigation benefits, yet no known studies had examined the impact of open water dredged material placement in this riverine setting. To address this data gap, two modelling efforts were undertaken examining the hydrodynamics and sediment transport characteristics occurring at Horseshoe Bend Island. The Lower Atchafalaya River, Louisiana represents an important navigable waterway linking the Gulf of Mexico and inland communities and waterways. The range of hydrological cycles



Figure 1. Landsat imagery displaying island location of dredged material (DM) placement and subsequent formation, establishment, and growth from strategic dredged material placement from December 2010, 2011, 2012 (imagery provided by USACE MVN).

and tidal conditions of Atchafalaya Bay provides a typical river-lake-estuary-bay system hydrodynamics response.

The system is thus controlled by hydrology, meteorology and astronomical tides with varying time scales. Upstream, river

hydrodynamics near Morgan City, Louisiana remain dominated by hydrological influence and tidal flows that modulate the strong river inflows, especially during the spring and summer wet season. Downstream areas are dominated by micro-tidal circulation patterns influenced by weather patterns.

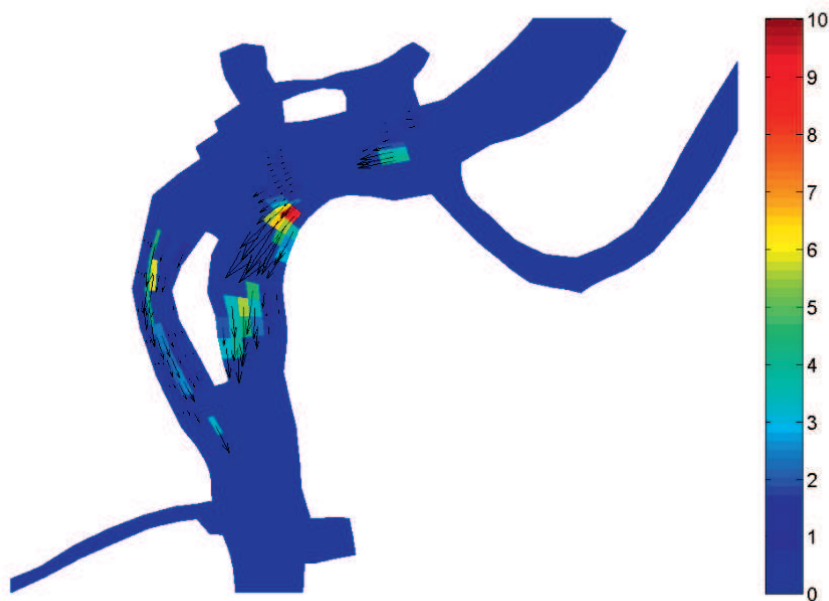


Figure 2. Mean suspended sediment transport rate from January through March, 2012.



Figure 3. Mean bedload transport rate from January through March, 2012.



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Figure 4. The island's cut bank bordering the Atchafalaya River reveals a nearly 2-foot layer of sediment deposited during the 2011 spring flood. Dredged material feeder mounds placed upstream are contributing to the deposition of this material. Decaying vegetation is visible below the newly deposited sediments.

HORSESHOE BEND ISLAND

As part of the Dredged Material Management Plan (DMMP) in force, relocation of the authorised Federal channel through Horseshoe Bend was studied. The proposed relocation of the channel to the east at Crewboat Cut can reduce maintenance dredging over 0.76 million cubic metres (1 million cubic yards) per year. A three-dimensional hydrodynamic model, CH3D, was applied to the Lower Atchafalaya River and adjacent Atchafalaya Bay to assess the formation of the Horseshoe Bend Island in the Atchafalaya River to gain a more complete understanding how the island footprint is being created. A two-dimensional model, RMA-2, was developed to simulate Atchafalaya River flow conditions.

The changes in velocities were analysed to determine potential impacts of relocating the channel. Sediment transport was also simulated to study erosion and deposition. The RMA-2 model utilised the model's grid and bathymetry data for defining boundary conditions in the area. To assess the formation of the Horseshoe Bend Island, the CH3D hydrodynamic model was developed to gain an understanding about how the island footprint is growing and to serve as input into models determining the transport of sediments from dredged material seed

mounds placed upstream of the island. The model analysed the hydrodynamics around the island and determined sediment transport characteristics. The hydrodynamic model will also help identify the processes associated with hydrodynamics and sediment transport of the island's creation and growth.

The results of the CH3D model proved strongly related to hydrological forcings. When linked with a transport model, GTRAN, sediment transport rates indicated possible deposition toward the northern shore and erosion from the southern shore of Horseshoe Bend Island. Sedimentation rates remained elevated during the wet season with an estimated maximum volume transport rate of 9.66 m³/m/s (Figure 2) and 0.71 m³/m/s (Figure 3) as suspended and bedload sediments respectively.

The hydrodynamic and sediment transport results indicated that the innovative use of dredged materials in this riverine environment supports wetland formation and expansion while providing habitat, hydrologic and biogeochemical functions.

The multi-factor assessment can be used in future studies examining the ecological, societal, and economic value of the strategic placement of dredged material applied in this

manner. The study demonstrated that each of the factors examined at Horseshoe Bend Island proved comparable or exceeded the other wetland study areas examined, including the naturally formed riverine island and a traditionally created dredged material supported island (Figure 4). This innovative beneficial use of dredged material for creating Horseshoe Bend Island can be applied in other riverine project scenarios to demonstrate the success and potential benefits of this application of the Engineering With Nature practice of utilising natural process for improving wetland creation and restoration outcomes.

Engineering With Nature (EWN)

EWN is a USACE initiative that seeks to support more sustainable practices, projects, and outcomes. The four key elements of EWN include:

1. use science and engineering to produce operational efficiencies supporting sustainable delivery of project benefits,
2. use natural processes to maximum benefit thereby reducing demands on limited resources, minimising the environmental footprint of projects, and enhancing the quality of project benefits,
3. broaden and extend the base of benefits provided by projects to include substantiated economic, social, and environmental benefits, and
4. use science-based collaborative processes to organise and focus interests, stakeholders and partners to produce more broadly acceptable projects.

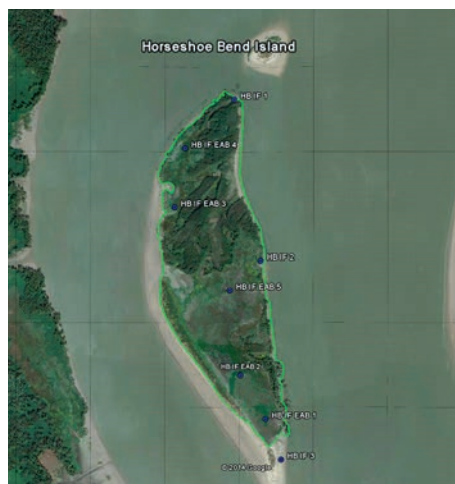


Figure 5. Left, The infaunal community sampling locations at Horseshoe Bend Island. Right, Infaunal sampling utilised a 7.5 cm coring device.



ENVIRONMENTAL BENEFITS

Previous studies only provided qualitative documentation of the fauna, flora and geomorphology of the island. Recently quantitative surveys of the plant communities that have developed on the island (Figure 5) have been completed. The results of these surveys indicated that Horseshoe Bend Island provides habitat and biogeochemical functions at rates comparable or exceeding observations made at a traditional dredged material supported island and a natural reference island in the area.

Wetland classification and analysis of geomorphic features demonstrated that Horseshoe Bend Island provides a variety of habitat types supporting complex communities

of vegetation, invertebrates, soil microbes and higher organisms (i.e., avian species; Figure 6). The distribution of forested, shrub-scrub, emergent, and emergent aquatic bed habitat types corresponds to the natural distribution reported throughout the study area. Horseshoe Bend Island contains a wide variety of vegetation including >85% native species, with species richness values exceeding observations from both traditional dredged material supported and natural reference areas (Figure 7).

The Engineering With Nature design utilised at Horseshoe Bend Island resulted in landscape and landform characteristics (e.g., distance from shore, flooding regime) that support a large, successful wading bird rookery.



Figure 6. A diverse assemblage of native plant and animal life has colonised the island. Left to right, A juvenile tricolored heron, a juvenile snowy egret and an ibis chick were observed in nests on the island during nesting season (July 2014).



Figure 7. Variation in surface elevation of the island supports a mixture of habitats, including ponded areas, emergent wetlands, and forested wetlands that are all influenced to some degree by river stage and duration of flooding. Far left, American lotus (*Nelumbo lutea*) flowering in one of the island's low-lying pools.

Horseshoe Bend Island also supports more invertebrate abundance and diversity than natural islands in the region that lack the emergent aquatic bed landforms resulting from the strategic placement of dredged materials. Finally, the soils at the Horseshoe Bend Island display a capacity to sequester nutrients and other compounds and perform water quality functions at levels comparable to natural wetlands in the region.

ECONOMIC BENEFITS

The project uses natural processes to maximum benefits, thereby reducing demands on limited resources, minimising the environmental footprint of the project and enhancing the quality of project benefits. Economic benefits are being realised as the enlarging island has reduced the overall cross sectional area of the river, increasing the river's flow through the navigation channel to velocities that were sufficient to reduce shoaling and maintenance dredging requirements.

Costs were lower than the conventional approach because all other placement alternatives required additional equipment and land-rights to convey dredged material over long distances. Signs of human activity were also noted on the island, as the presence of shotgun shells signified that the island was being used for hunting. Intentionally aligning natural processes in the river with engineering processes via strategically mounding dredged material is realising tangible environmental, social and economic benefits.

CONCLUSIONS

The Atchafalaya River island project exemplifies what can be achieved through the application of EWN concepts and practices. Current EWN activities include documenting current USACE projects exemplifying the approach and communicating across the technical community and with USACE partners and stakeholders. Sediment dredged from the adjacent Federal navigation channel during routine maintenance was strategically placed in mounds upriver of the island over a period of 12 years. The mounded

material was dispersed by the river's currents to self-design the island over time.

The transferability of these developments has been established. These investigations further quantifying the multiple benefits of using dredged material to create such riverine islands will provide a more complete understanding of the formation of the island so this concept can be integrated into other dredging projects in coastal Louisiana and elsewhere, thereby providing substantial environmental, social and economic benefits as part of ongoing USACE maintenance dredging activities.

REFERENCES

- Berkowitz, J.F., Beane, N.R., Evans, D.E., Suedel, B.C. and Corbino, J.M. (2014). "Preliminary Use of strategic placement of dredged sediment to support Horseshoe Island in the Atchafalaya River, Louisiana: A preliminary ecological survey." EWN Technical Notes Collection ERDC TN-EWN-14-4. Vicksburg, MS: US Army, Engineer Research and Development Center. <http://el.ercd.usace.army.mil>.
- Berkowitz, J.F., Beane, N.R., Evans, D.E., Suedel, B.C. and Corbino, J.M. (2015). "Ecological Survey of a Dredged Material-supported Wetland in the Atchafalaya River, Louisiana: An Engineering with Nature Case Study". *Wetland Science and Practice*. 32(1):14-18.
- Kim, S. and Suedel, B.C. (2015). "Hydrodynamic and sediment transport modeling for Horseshoe Bend Island creation in the lower Atchafalaya River Louisiana". *Proceedings of the Western Dredging Association and Texas A&M University Center for Dredging Studies' "Dredging Summit and Expo 2015"*, Houston, Texas, USA, June 22-25.
- Suedel, B.C., Fredette, T.J. and J.M. Corbino. (2014). "Island Building in the Atchafalaya River, Louisiana USA: An Engineering with Nature Demonstration Project". *World Dredging*. 48(9/10):14-16.