Sustainability and Operational Design of Sediment Delivering River Diversions

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Abstract

Sea level rise presents an urgent threat to the occupants of river deltas. However, while low lying deltaic landscapes are at risk of significant drowning, the ability to harness a river's sediment delivery system offers deltaic populations a mechanism to control the location and extent of land loss via land building sediment diversions. Despite their well-recognized importance there are few examples of diversions that have been intensively monitored throughout their development to the extent necessary to support engineering decisions.

In order to guide the operational design of two planned diversions in the Lower Mississippi River, we apply Delft3D to simulate diversion discharge through time as a function of the sediment erodibility in the receiving basin, hydraulic connectivity of the receiving basin, and diversion invert elevation. In all cases the conveyance channel connecting the river to the basin is prevented from eroding. We find that diversions in basins that offer many outlets for flow are more likely to maintain their discharge over a ten-year time horizon. We also find that diversion performance is not significantly affected by substrate erodibilities in well connected environments, but that poorly connected receiving basins are more sensitive to substrate erodibility.

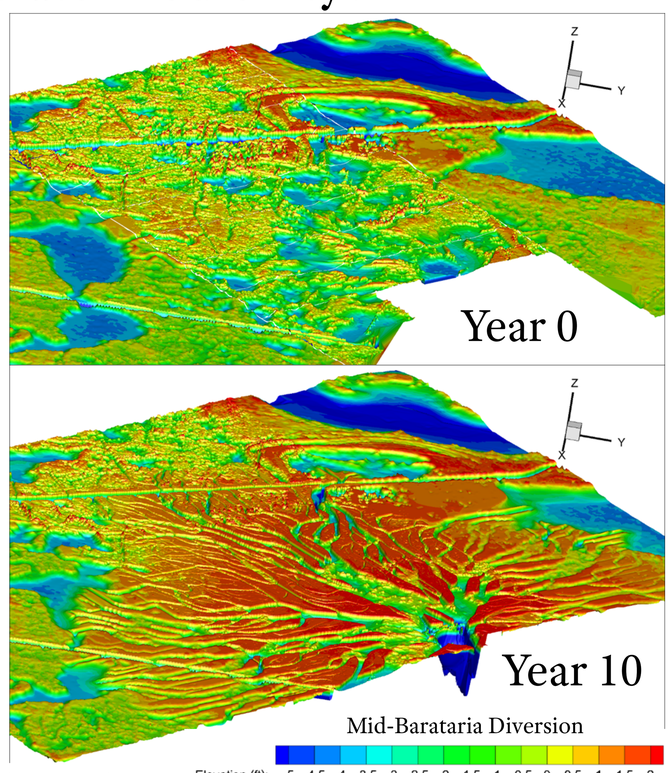
Our work also sheds light on the spatial pattern of erosion near a diversion. We find that very little erosion into the substrate occurs away from the immediate vicinity of the outfall channel, but that the evolution of the proximal scour is a critical control on the sustainability of the diversion. We examine diversion performance for a range of differnt entrance configurations to examine this effect.

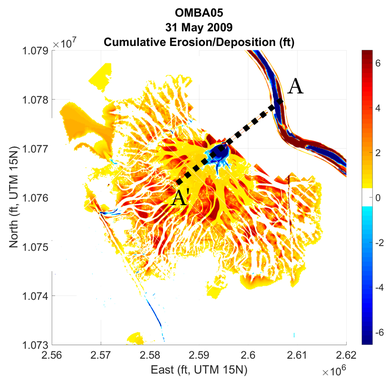
Are Diversions Sensitive to Substrate Erodibility?

We varied the critical shear stress for erosion in the basin substrate to examine the influence of basin substrate erodibility on diversion performance.

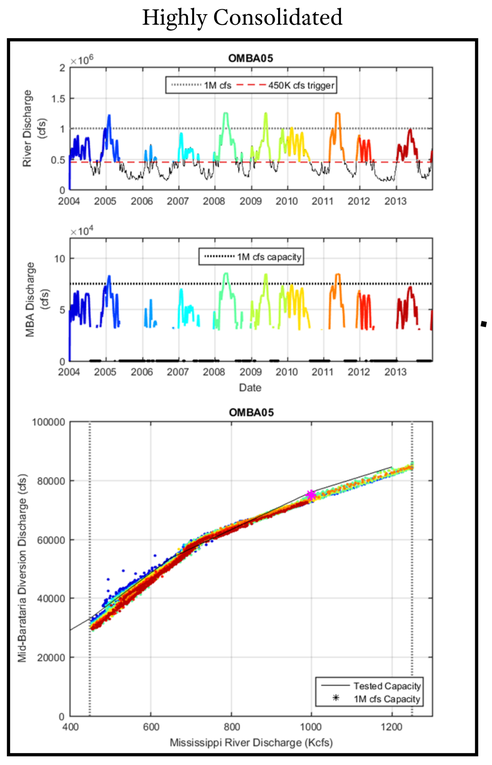
The initial stratigraphy in the Mid-Barataria Outfall Management Model (OMBA) consists of a layer of marsh on top of a layer of consolidated clay. The contact between the two layers is set to -3.3 ft NAVD88 throughout the basin. We ran the model for for two values of critical shear stress for erosion in the consolidated clay layer. Both values are in the range of measurements in the Mississippi River Delta, though the VHC value is an extreme high..

	τcr, marsh (Pa)	τcr, compact clay (Pa)
OMBA04 Very Highly Consolidated	1.5	2.5
OMBA05 Highly Consolidated	1.5	1



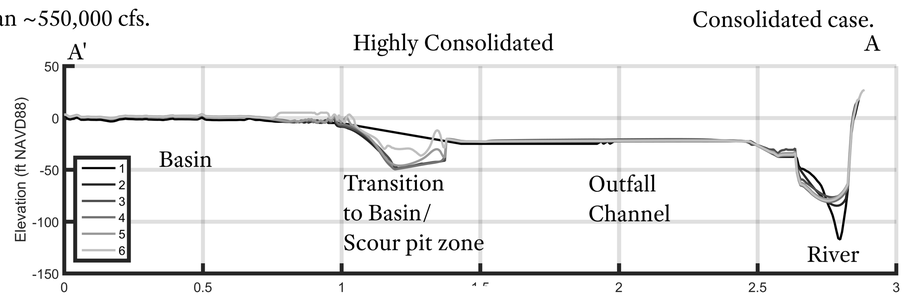


Highly Consolidated

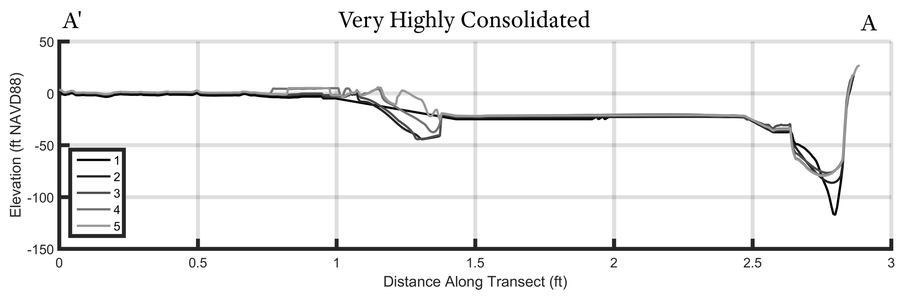


The Highly Consolidated case loses very little performance over the 10 year model interval. The ony decrease in performance is seen at river discharges less than ~550,000 cfs.

Highly Consolidated

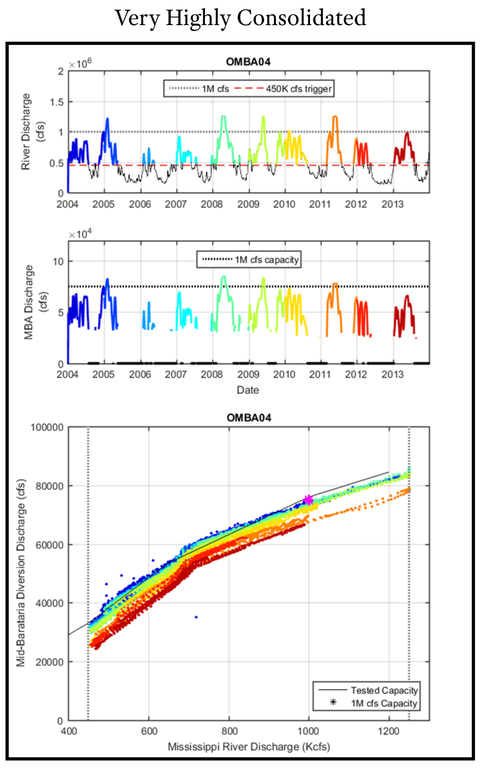


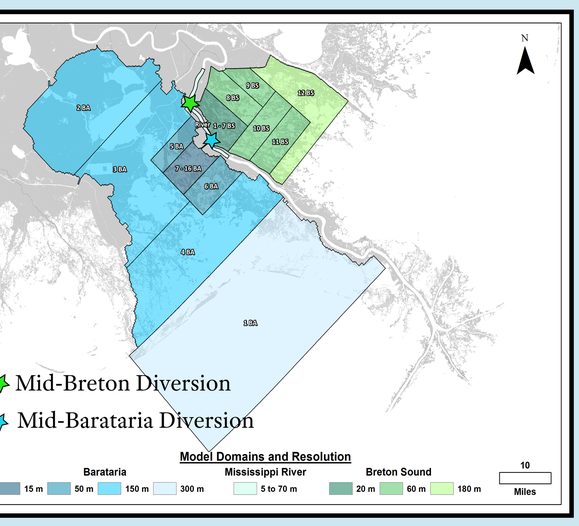
Very Highly Consolidated



The Very Highly Consolidated case loses at least 10% of its performance at all discharges, and more at lower discharges. The decrease in performance is associated with scour pit dimensions that are smaller than those of the Highly Consolidated case.

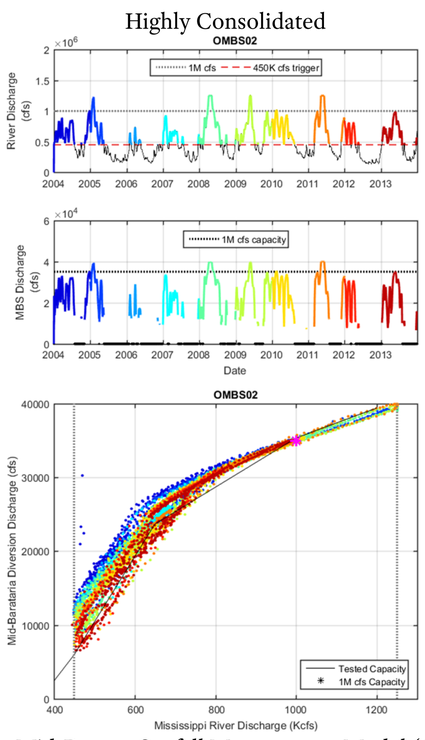
Very Highly Consolidated



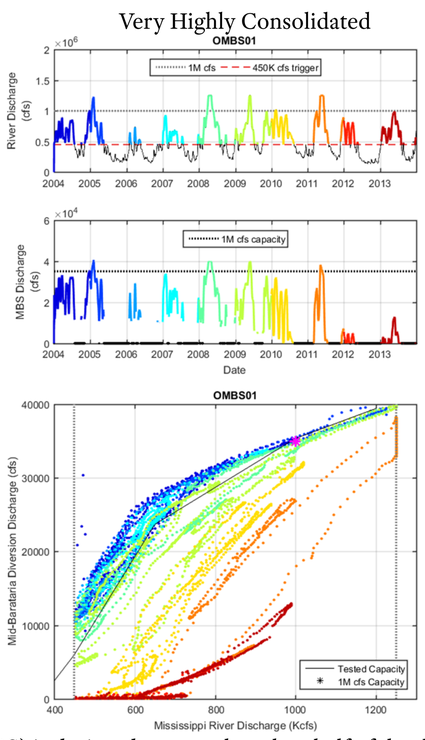


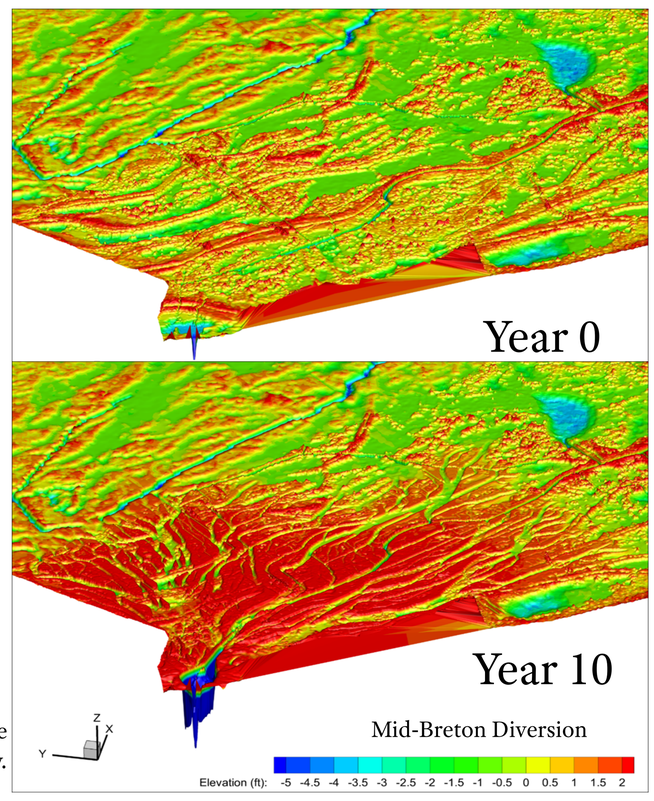
Does Diversion Size and Basin Connectivity Matter?

Highly Consolidated



Very Highly Consolidated





The Mid-Breton Outfall Management Model (OMBS) is desitned to carry less than half of the discharge of the Mid-Breton Diversion, and is situated in a receiving basin that has fewer outlets for diverted flow. Both cases shown here perform more poorly than their Mid-Barataria counterpart. It is notable here that the Very Highly Consolidated case here has almost completely ceased to function after 10 years.

Modeling Overview

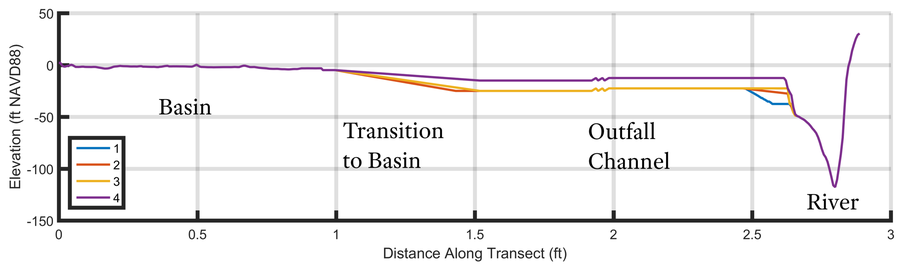
The outfall management models simulate morphological change in the basin and in the river, but do not include vegetation, salinity, sea level rise, or water quality components. Further, the simulations discussed in this report do not include the subsidence that would be induced by sediment loading. This process would introduce enhanced head differential between the river and the basin, therefore potentially allowing water to flow through with less resistance. In this respect our current model setup represents a conservative view of the diversions' performance.

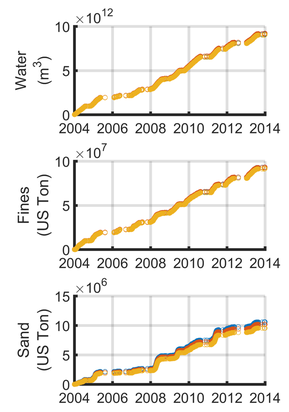
Conclusions

1. Substrate erodibility plays an important role in determining the long term performance of sediment diversions. High sediment strengths are associated with declining performance, particularly in basins that are poorly connected to outflow paths. Smaller diversions are also more susceptible to this effect.

2. These diversions, which are fed mostly by suspended load, are not sensitive to the inlet configuration.

Is Inlet Configuration Important?





We tested four different inlet configurations with highly consolidated s, and found that ubstrate in the Mid-Barataria model. Because sediment discharge to the diversion is dominated by suspended load, we find very little difference in sediment output as a function of inlet configuration.

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