

BRAZOS RIVER FLOOD GATE PROJECT: UNDERSTANDING HYDRODYNAMICS AND SEDIMENTATION USING NUMERICAL AND PHYSICAL MODELS

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INTRODUCTION

Brazos River Floodgates (BRFG) are located where the Gulf Intracoastal Waterway (GIWW) intersects with the Brazos River southwest of the city of Freeport in Brazoria County, Texas (Figure 1). The gates were initially installed in the early 1940s to prevent heavy sediment loads in the Brazos River from entering the GIWW. The structures were installed at a time when most tugboats pulled barges behind them, rather than using the modern pushing method. The gate openings are 75 feet wide, which is narrower than the 125 feet wide and 12 feet deep GIWW navigation channel. Although regulations restrict the width of tows to 55 feet, oversize tow permits are routinely granted for tows as wide as 108 feet, particularly along the upper Texas coast. To move these wider tows through the BRFG, vessel operators must park the tows, break the barges apart, move them through the gates in smaller sets or individually, and reconnect the tows on the other side. This process, known as “tripping,” is inefficient and causes delays that result in substantial costs to the towing industry each year. Difficulty in navigation through the BRFG results in temporary navigation restrictions and/or closures imposed by the USACE and U.S. Coast Guard. These restrictions and closures result in additional delays and economic impact to the towing industry.

To mitigate this, the United States Army Corps of Engineers, Galveston District (USACE-SWG), in cooperation with the Texas Department of Transportation (TxDOT) Maritime Division, has conducted a feasibility study (USACE, 2019) to investigate improvements to the BRFG facility that would reduce navigational difficulties, delays, and accidents occurring as tow operators transit the BRFG structures and across the Brazos Rivers. The recommended design included removal of the existing gates on both sides of the Brazos River crossing, the construction of a 125 feet wide channel on the west side, and a new 125 feet wide sector gate structure on the east side. The new sector gate on the east side would be set back approximately 700 feet from the existing east gate structure. It was found that the new gate design and channel alignment would provide increased safety and efficient vessel operations through the system, reducing allisions. However, the feasibility study concluded that the open channel on the west side would increase sediment deposition in the west GIWW channel between the Brazos River and the San Bernard River resulting increased operation and maintenance (O&M) triggering further

investigation in the final design phase. As part of the current study in the final design phase, SWG utilized numerical and physical models to investigate hydrodynamics, salinity, and sedimentation at and near the project site due to the modifications of the channel and existing gate structures.



Figure 1 - Project Area Location

METHODOLOGY

In this study, SWG utilized ADH, and Delft3D as the numerical model tools to resolve hydrodynamic and sediment transport at and near the project site. In addition to the numerical models, a 1:60 Reynold’s scale physical model was developed to investigate eddies and currents at the junction and further validate the numerical model findings. The primary intent of the numerical and physical modeling was to investigate how the recommended design may influence current, sediment movement, deposition (shoaling), and O&M in and around the project area.

RESULTS

A set of conditions was run to calibrated and validate the numerical models to ensure the models accurately replicated the observed hydrodynamics and morpho dynamics of the area. This involved validating water level signals for both background conditions and storm conditions, as well as validating channel shoaling rates against the Corps Shoaling Analysis Tool (CSAT) results. Four storm events (Harvey 2017, September 2020, January 2020 and October/November 2021) were chosen to calibrate and validate the models. Figure 2 shows an example of the water level comparison at the east gate location with USGS observed data during January 2020.

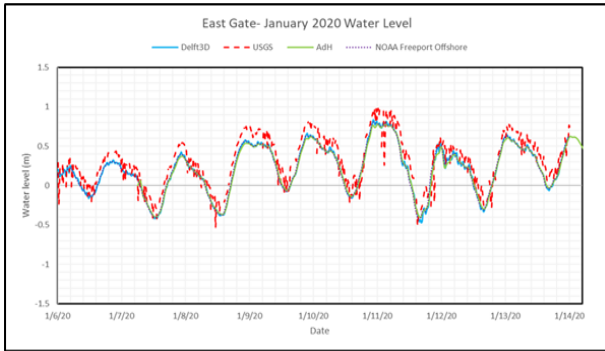


Figure 2 - Water Level Comparison at East Gate Location with USGS Observed Data During January (2020) Event

Numerical models were then used to evaluate changes in currents and sedimentations between existing and proposed project conditions. It was observed that the proposed modification would increase depositional area along east forebay due to setback of the gate (Figure 3). Nominal changes in sedimentation pattern were observed along the east and west GIWW section. As expected, both AdH and Delft3D produced similar results (Figure 3).

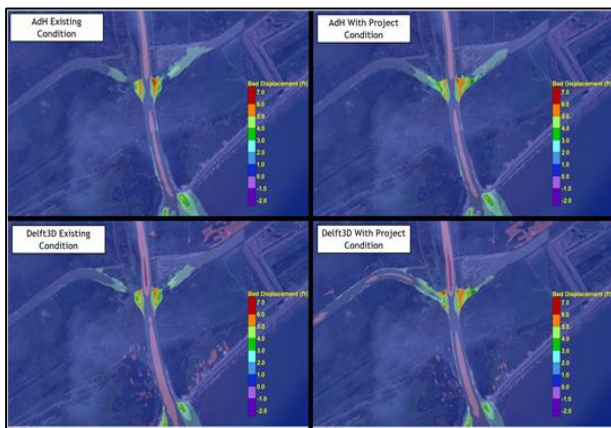


Figure 3 - With and Without Project Sediment Deposition (Top Panel - AdH Model, Bottom Panel - DELFT 3D Model, Left Panel - Existing Condition, Right Panel - Proposed Project Condition)

The physical model was run in steady state conditions, where flow and water surface elevation did not change with respect to time. The steady state simplification eliminated the need for continuous water level and flow control, but still allowed for comparisons in flow patterns between existing and proposed conditions. Relevant forcing functions for the model could occur outside the physical model domain, therefore, the physical model was used in conjunction with the numerical models which provided physical model boundary conditions. In the physical model, seven proposed condition tests were completed, including three with the same operating conditions as the existing condition tests. Shoaling impacts were evaluated by observing and measuring changes in flow patterns between the existing and proposed conditions in the fixed bed model using dye. In addition to velocity measurements and flow visualization,

small amounts of lightweight tracer sediment were added to the model for both the existing and proposed condition models.

The physical model provided insight into the complex flow patterns such as eddies that would occur at the confluence of the Brazos River and the GIWW sections. Observation of the existing and proposed flow patterns provided insight on the expected change in sedimentation characteristics. It was observed that sediments tend to deposit along the east and west forebay (Figure 4) similar to the one observed during the numerical model tests.



Figure 4 - Sediment Tracer in Physical Model (Looking Downstream of Brazos River)

CONCLUSIONS

The key conclusion on the hydrodynamics was that there was no evidence that tows would experience more challenging conditions due to an increase in velocity along either the west GIWW channel or the east GIWW channel due to the proposed gate modifications. The higher velocity conditions that occur regularly at the gates will be reduced by about a factor of six in the open channel that replaces the west gate and will be reduced by about a factor of two at the proposed east gate location. Irrespective of the far field impact, such as San Bernard outlet condition, the modification of the gates will not have any significant impacts in the typical velocity along the east and west GIWW channel.

The GIWW crossing will experience an increase in deposition (shoaling) due to the project, in large part due to the new east gate being set farther away from the Brazos River. This increase in shoaling will likely not result in a similar increase in O&M dredging because of navigation traffic, but there certainly will be some increase in dredging in the crossing area. Sedimentation along the east and west GIWW channel will not have any noticeable changes due to the project primarily because of nominal changes in currents as stated above.

REFERENCE

U. S. Army Corps of Engineers. (2019). Gulf Intracoastal Waterway, Brazos River Floodgates and Colorado River Locks, Texas. Final Integrated Feasibility Report and Environmental Impact Statement.