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Jacksonville Harbor Deepening Project: St. Johns River Circulation and Salinity Modeling

JACKSONVILLE HARBOR DEEPENING PROJECT: ST. JOHNS RIVER CIRCULATION AND SALINITY MODELING

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The U.S. Army Corps of Engineers, Jacksonville District (USACE-SAJ) is conducting a General Re-evaluation Study for improving Jacksonville Harbor navigation and assessing the effects of channel modifications on the general circulation and salinity in the St. Johns River in Duval County, Florida. In anticipation of larger vessel navigation due to improvements in the Panama Canal, the USACE-SAJ is considering deepening Jacksonville Harbor beyond the current 40-ft depth. This paper presents the calibration and verification of a modified Environmental Fluid Dynamics Code (EFDC) model from the St. Johns River Water Management District (SJRWMD) to evaluate the effect on river hydraulics and salinity of (1) channel deepening, channel widening at select locations, and construction of new turning basins; and (2) cumulative impacts of other projects including the Mayport Deepening Project for the U.S. Navy and Freshwater Withdrawals in the St. Johns River.

The St. Johns River, the longest river in Florida, spans 310 miles. Its drainage basin encompasses over 8,840 square miles spread across 16 counties. Located in the Lower St. Johns River (LSJR), the study area includes the lower (northern) 100 miles of the St. Johns River from the mouth near Mayport to upstream of Astor and includes the Jacksonville Harbor Deepening Project (JHDP) area — from the mouth of the St Johns River to mile-marker 20. The St. Johns River is a slow-moving river with very mild slope. The river drops, on average, 0.1-ft per mile and this very mild slope allows tidal effects to extend at least 106 miles from the river mouth in Duval County to Lake George in Volusia County. The main shipping channel, a 20-mile stretch of the river, extends from the river mouth to the Jacksonville Port Authority (JAXPORT) Talleyrand Marine Terminal just north of downtown Jacksonville (Figure 1).

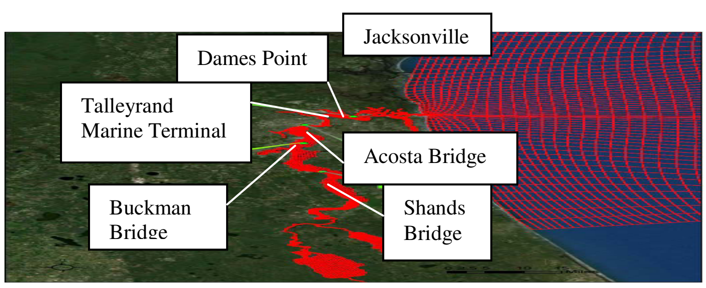

Figure 1 Model Mesh and Locations of Calibration Salinity Stations

In the lower St. Johns River, three major factors govern the upstream extent of salinity: net freshwater discharge entering the upper estuary through Astor, subtidal variability of ocean water levels, and wind. The SJRWMD's EFDC model calibration and verification (covering 1996 – 2001 and 1996 – 2005), showed the salinity front reached an area between Buckman Bridge (river

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mile 35) and Shands Bridge (river mile 47). Moderate levels of salinity intrusion rarely reached Shands Bridge. Although a water quality monitoring station located about 4.3 mi upstream of Shands Bridge recorded salinity at 5 practical salinity units (psu, approximately equal to 5 ppt) during May 1994, neither a theoretical maximum nor probability of the extent of upstream salinity intrusion has been determined. Simulating effects of the proposed channel deepening template was not possible in the SJRWMD version of the model due to limited model mesh resolution in the navigation channel. Prior to the model application, Taylor Engineering in consultation with the USACE-SAJ and the SJRWMD refined the EFDC model mesh in the navigation channel, re-calibrated, and re-verified the model to improve its simulation of salinity within the project area. Figure 2 Comparison of Modeled and Measured Surface Salinity during Model Calibration (Dry Period)

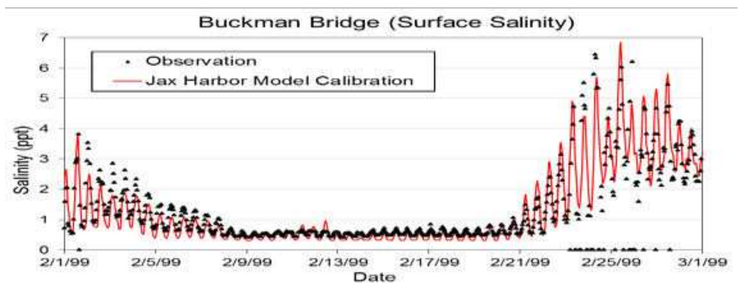

Figure 2 Comparison of modeled/measured surface salinity during model calibration (dry period)

Model re-calibration and re-verification consist of model simulations to reflect three hydraulic conditions: wet period, dry period, and wind condition period. The refined, re-calibrated, re-verified model provides the means to evaluate changes to hydrodynamics and salinity caused by the JHDP. This study presents results of the model sensitivity analyses, model calibration, and model verification. Comparison of model computed water level with measurements show very good agreement during model calibration and verification.

Comparisons of observed and simulated hourly salinity at four stations (Dames Point, Acosta Bridge, Buckman Bridge and Shands Bridge) along the lower St. Johns River provide the means to evaluate model performance during the salinity calibration and verification periods. Model root mean square error (RMSE) at Acosta Bridge to Shands Bridge ranged 0.1 – 2.3 ppt (dry period calibration), 0.9 – 2.0 ppt (dry period verification), 0.0 – 0.5 ppt (wet period calibration), and 0.4 – 2.7 ppt (wet period verification). At Dames Point, model RMSE ranged 2.3 – 3.0 ppt (dry period calibration), 2.4 – 2.6 ppt (dry period verification), 3.8 – 4.1 ppt (wet period calibration), and 6.0 – 6.2 ppt (wet period verification). Notably, model performance at Dames Point is affected by the complex hydraulics due to multiple connections to the ocean. Figure 2 show the comparison plot of the dry period surface salinity at Buckman Bridge. Visual observation of figures and examination of the statistical results show generally good agreement between the measured and simulated salinity. The overall good agreement between simulated and observed water levels and salinity demonstrates the capability of the model to reasonably simulate these processes in the lower St. Johns River. Based on the calibration and verification results, the model is suitable for predicting hydrodynamic and salinity changes in the lower St. Johns River from the potential channel deepening project.