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Design Considerations for Beneficial Use Sites along the Channel to Victoria, Calhoun County, Texas

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PURPOSE: This U.S. Army Corps of Engineers (USACE) Regional Sediment Management (RSM) investigation considered implementation of new or historically underutilized beneficial use (BU) sites for the Channel to Victoria (CTV) in Calhoun County, Texas (Figure 1). The utilization of alternative placement areas is justified on two main grounds: (1) there is cost savings associated with the shorter pump distance compared to the existing upland confined placement areas and (2) shoaling reduction relative to a *without project* condition. Additional benefits realized by utilizing the proposed sites include (1) increased safety for vessels navigating CTV due to the reduction/elimination of open fetch and currents, (2) additional placement options available in times of emergency dredging, and (3) increased bird habitat, particularly for the endangered whooping crane. These sites have received National Environmental Policy Act (NEPA) clearance in previous project documents, and it is anticipated minimal or no additional NEPA coordination will be required to construct/restore these sites.

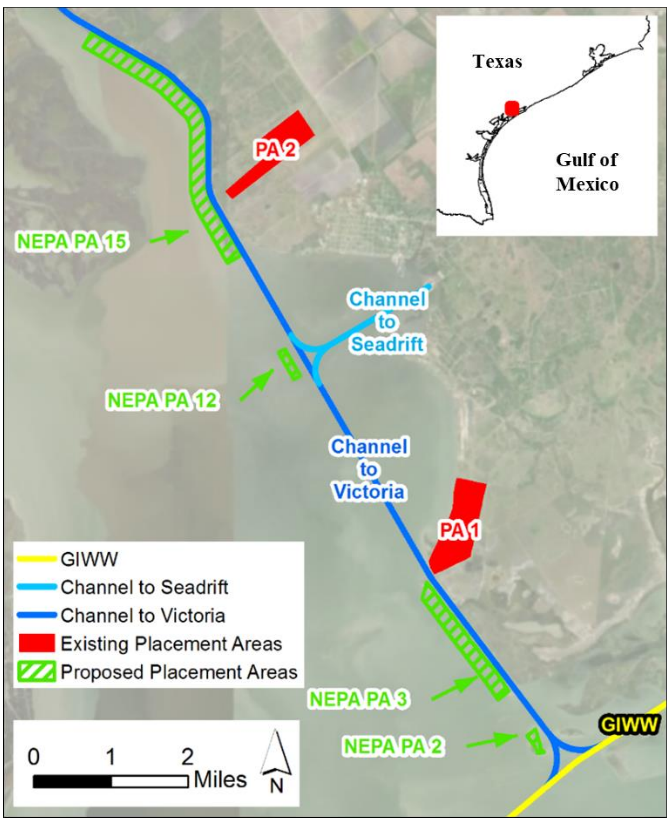

Figure 1. Study area in San Antonio Bay, Texas, including the CTV, the Channel to Seadrift, and the associated placement areas.

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PROJECT AREA: The CTV is a shallow-draft navigation channel, authorized to -14 feet (ft) Mean Lower-Low Water (-14.19 ft Mean Tide Level [MTL]) and is a tributary to the Gulf Intracoastal Waterway (GIWW) (Figure 1). The CTV runs along the eastern side of San Antonio Bay before transitioning to a dedicated land-cut northward to the Port of Victoria that has approximately 5,700 barge calls per year. The Port of Victoria is ranked 74th in the nation with over 5 million short tons of commerce moved through the Port in 2016 (Bureau of Transportation Statistics 2016). The channel has a single tributary, the Channel to Seadrift, which provides access to dock facilities largely comprised of commercial fishing vessels in Seadrift, TX, approximately midway through San Antonio Bay. The focus of this RSM study is the lower reach of the CTV, specifically up to approximately station 700+00 from the GIWW (Figure 2).

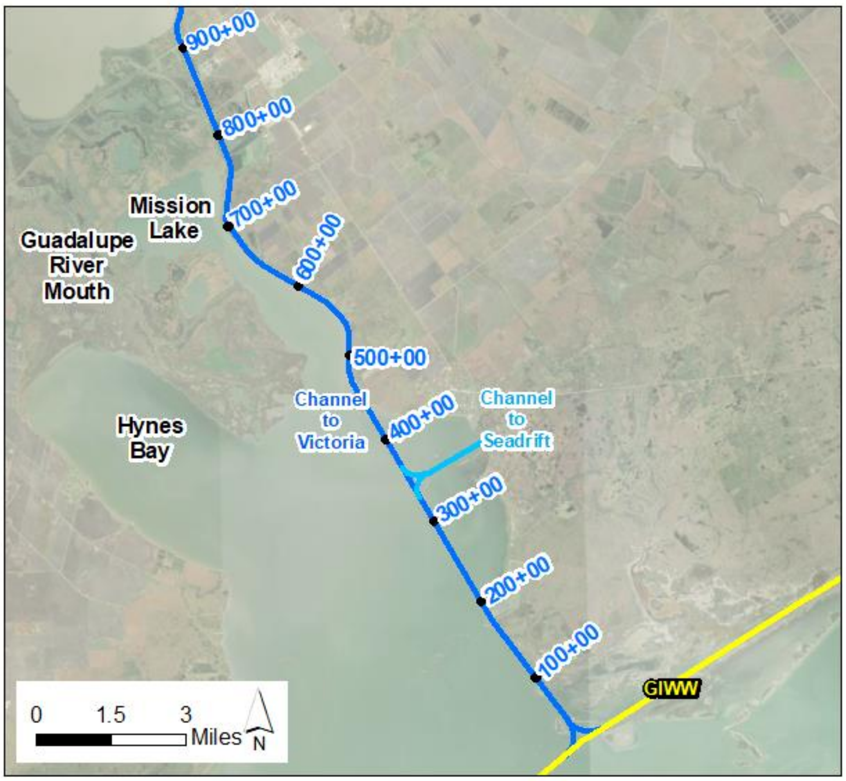

Figure 2. CTV, TX, channel and stationing (blue).

BACKGROUND AND DATA

Historical Dredging and Placement Data. Dredged material from the lower reach of the CTV and the entirety of the Channel to Seadrift is placed in one of two upland confined placement areas (PA), PA 1 and PA 2 (Figure 1). Historical dredging records, and associated shoaling rates, for the period 2007-2017 for the CTV are listed by cubic yards in Table 1. Material from the Channel to Seadrift and from the CTV between the GIWW and station 350+00 is placed in PA 1. PA 2 accommodates the CTV material between stations 350+00 and 650+00. The CTV is the primary maintenance dredging challenge in the area. The Channel to Seadrift is dredged infrequently, with maintenance dredging occurring on an approximate 7-year cycle at an average annualized rate of approximately 65,000 cubic yards (CY) per year.

Table 1. Dredging history for the period 2007-2017 for the CTV.

From Station	To Station	Total Dredged 2007-2017 [CY]	Percent of Total Material Dredged	Average Annual Shoaling [CY]
-0+32(W)	42+56(W)	435,000	8.2%	43,500
-0+32(E)	42+56(E)	293,000	5.5%	29,300
42+56	100+00	135,000	2.5%	13,500
100+00	150+00	169,000	3.2%	16,900
150+00	200+00	204,000	3.8%	20,400
200+00	250+00	465,000	8.7%	46,500
250+00	300+00	394,000	7.4%	39,400
300+00	350+00	384,000	7.2%	38,400
350+00	400+00	470,000	8.8%	47,000
400+00	450+00	485,000	9.1%	48,500
450+00	500+00	343,000	6.4%	34,300
500+00	550+00	354,280	6.7%	35,428
550+00	600+00	319,080	6.0%	31,908
600+00	650+00	281,640	5.3%	28,164
650+00	700+00	179,000	3.4%	17,900
700+00	750+00	122,000	2.3%	12,200
750+00	800+00	99,000	1.9%	9,900
800+00	850+00	94,000	1.8%	9,400
850+00	900+00	95,000	1.8%	9,500
	Totals	**5,321,000**	**100%**	**532,100**

Tides and Tidal Datum Information. Tidal datum information as reflected at the National Oceanic and Atmospheric Administration (NOAA) station at Seadrift (#8773037) is listed in Table 2. San Antonio Bay is a micro-tidal environment with a mean tidal range of 0.36 ft.

Table 2. Datum information at the NOAA station at Seadrift (#8773037).

Datum	Description	Value [ft]
MHHW	Mean Higher-High Water	0.38
MHW	Mean High Water	0.37
MSL	Mean Sea Level	0.20
MTL	Mean Tide Level	0.19
MLW	Mean Low Water	0.01
MLLW	Mean Lower-Low Water	0.00
NAVD88	North American Vertical Datum of 1988	-0.88

Grain Size Data. Grain size data are available from the Texas Coastal Sediments Geodatabase Project (TxSed), a statewide database managed by the Texas General Land Office (GLO 2018) that compiles sediment data from multiple sources, as well as from the U. S. Army Engineer Research and Development Center (ERDC) Sediment Analysis and GeoApp (SAGA) database and Web-application (http://navigation.usace.army.mil/SEM/Analysis). SAGA is a database for borings, grab samples, wells, monitoring areas, river gages, and any associated information to the sampling activity. Figure 3 shows the grain size characteristics in and around the study area as a function of sand (0.0625 – 2.0 millimeter [mm]) content. San Antonio Bay consists of predominately fine-grained material (silt and clay) at the surface.

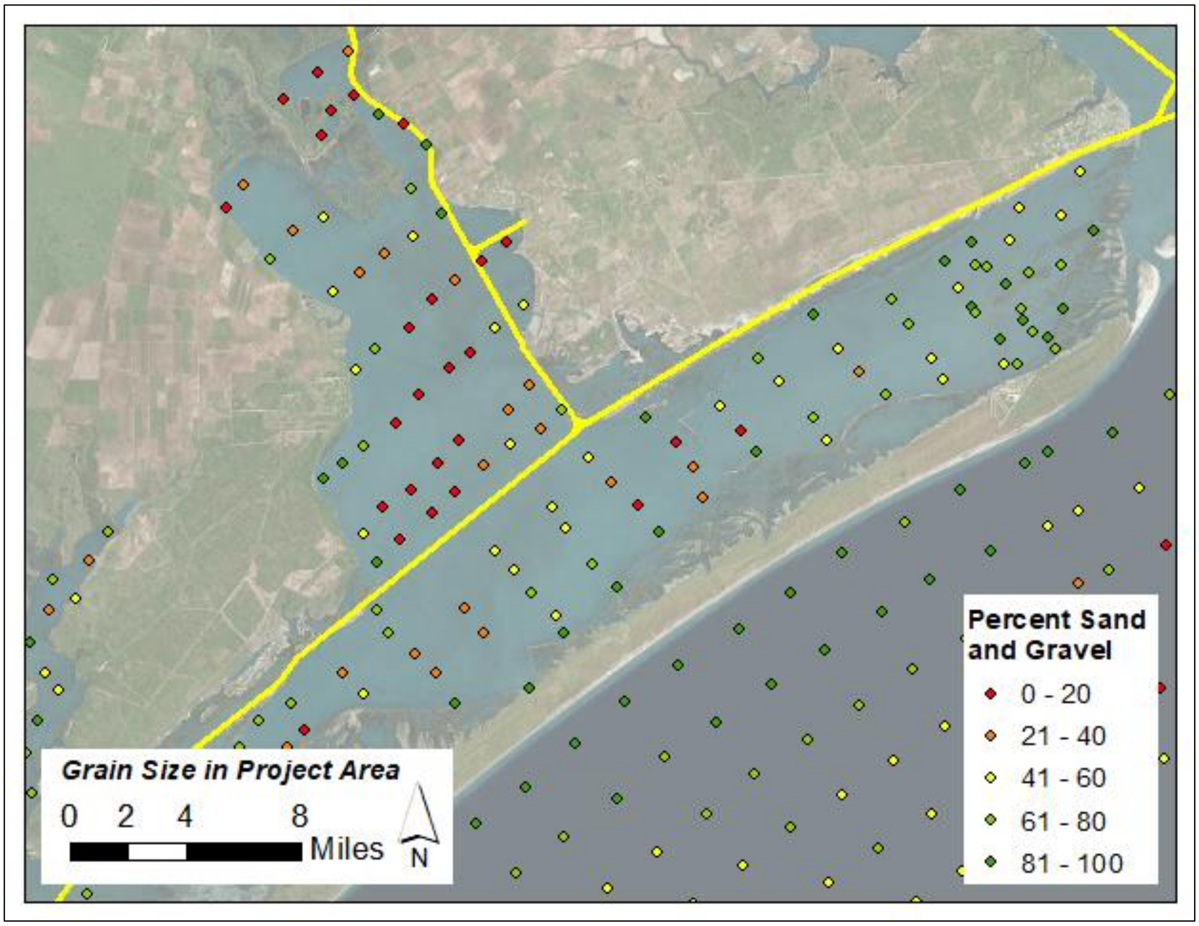

Figure 3. Grain size data in the project area (source: TexSed, Texas GLO, channels shown in yellow).

Meteorological and Oceanographic Data. Figure 4 shows the NOAA stations in the project area used as a part of this study. Figure 5 shows the wind rose for meteorological data during 2017 at the Seadrift and Aransas Wildlife Refuge NOAA stations (#8773037 and #8774230, respectively). Wind is predominately from the south-southeast. The available data are not a long-term continuous dataset but nevertheless, based on comparisons with other nearby stations, appear to be a reasonable representation of wind speed and direction even though it was impacted by Hurricane Harvey (August 2017) and sustained several days of high southeastern winds.

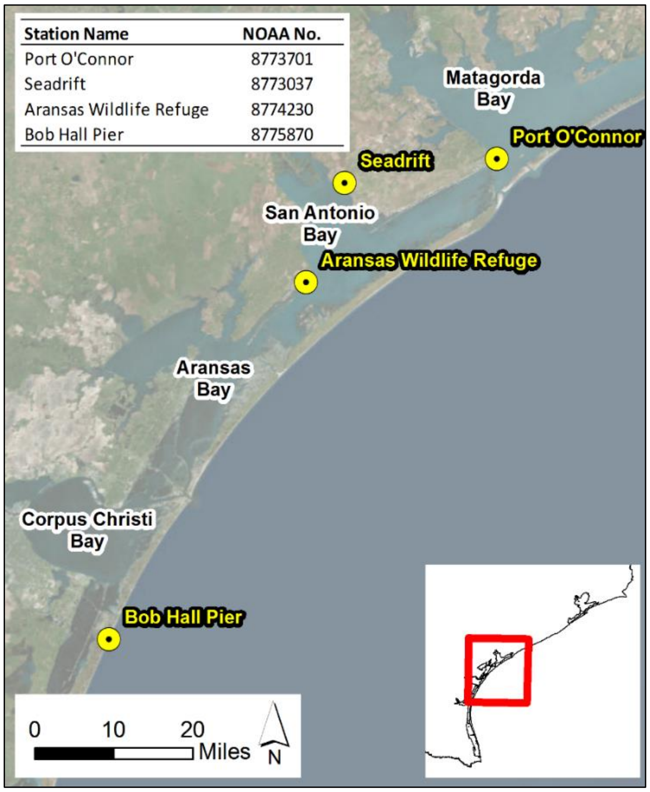

Figure 4. NOAA water-level stations used for this study.

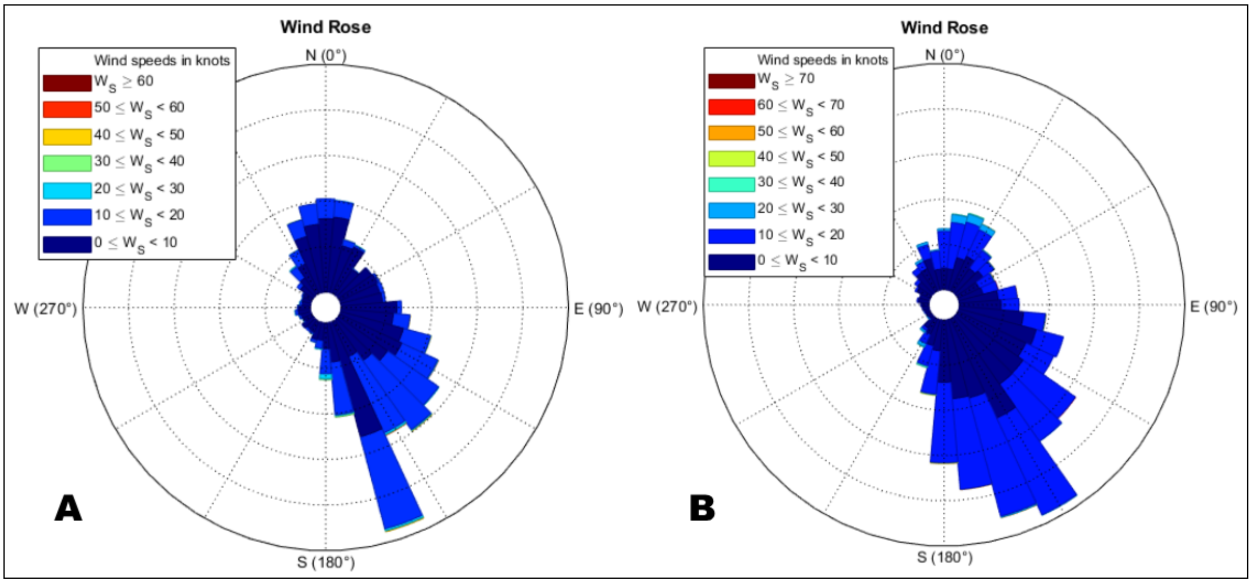

Figure 5. Wind roses based on 2017 wind data at the (A) Seadrift NOAA station (#8773037) and (B) Aransas Wildlife Refuge NOAA station (#8774230).

METHODS

Numerical Modeling. The existing conditions and proposed amendments to the RSM strategy were simulated using the ERDC Coastal Modeling System (CMS). The CMS is a depth-average, two-dimensional hydrodynamic and wave model suited for the coastal embayment environment considered as a part of this project. In association with the simulation, the CMS calculates sediment transport and morphologic change (Demirbilek and Rosati 2011).

Figure 6 shows the model domain, covering the entire San Antonio Bay in a rectangular area of 38 miles × 34 miles, for this study. Environmental boundary forcing for the simulations is provided by (1) the Port O'Connor NOAA Station (#8773701) from the east, (2) the Aransas Wildlife Refuge NOAA Station #8773037 from the west, and (3) the Bob Hall Pier NOAA Station (#8775870) from the Gulf of Mexico. The Seadrift NOAA Station (#8773037) was used to calibrate the model from a hydrodynamic perspective, and historical shoaling rates were used to calibrate the sediment transport and morphology. Figure 7 shows the model calibration based on water level data with respect to MTL collected at the Seadrift station for November and December 2016. Figure 8 shows the model validation with water level data (MTL) from the Seadrift station for January to April 2017. The correlation coefficients between model water levels and data are equal to 0.95 in both model calibration and validation.

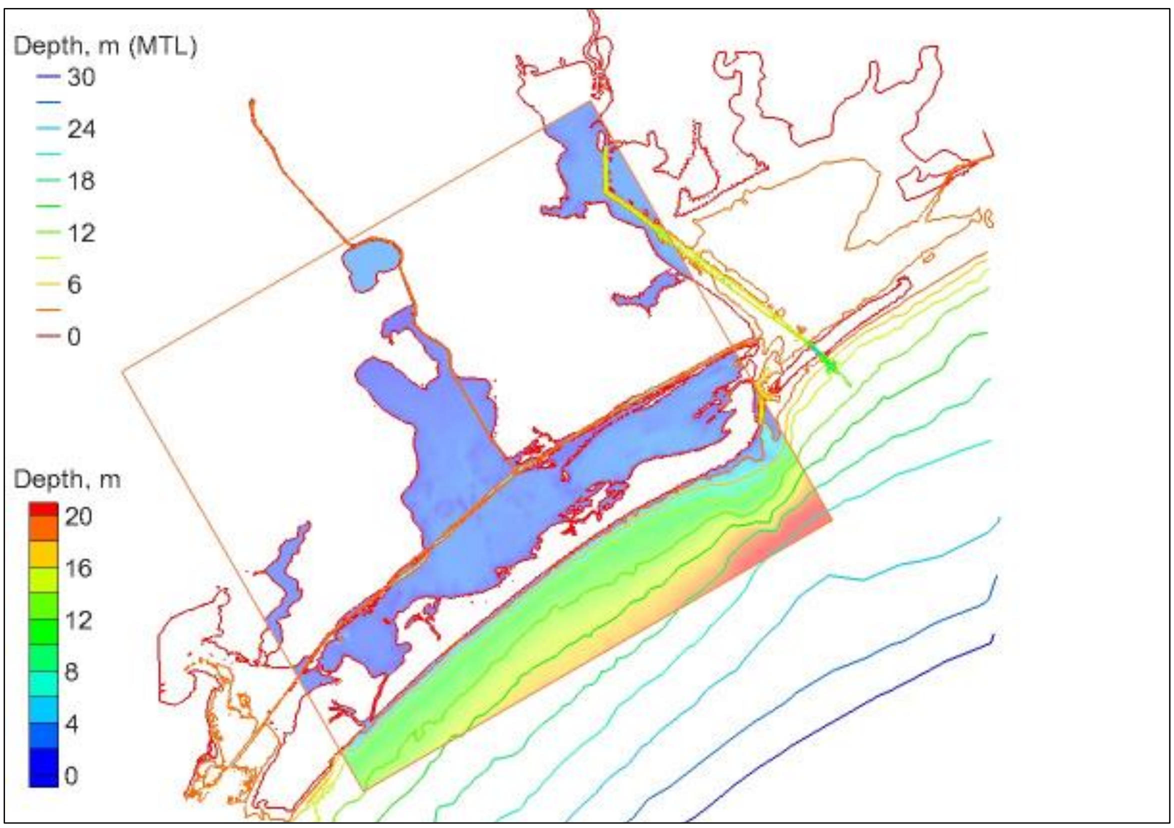

Figure 6. The CMS modeling domain used for this study.

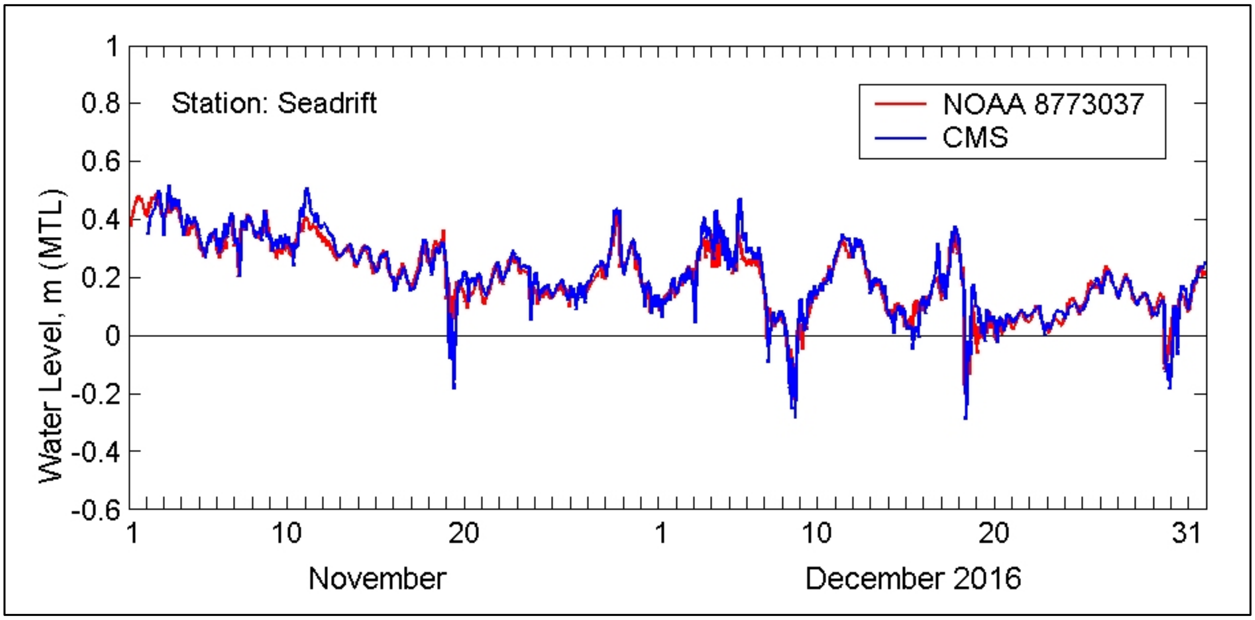

Figure 7. Model calibration based on water level data at the Seadrift NOAA station (#8773037) for November-December 2016.

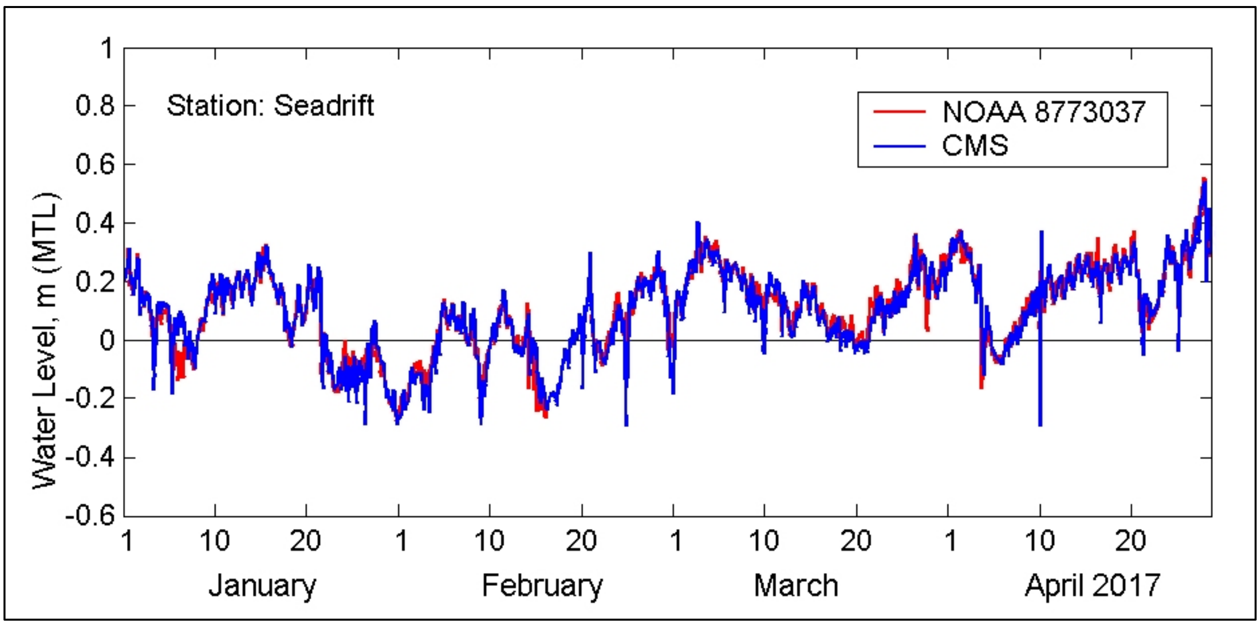

Figure 8. Model validation based on water level data at the Seadrift NOAA station (#8774230) for January-April 2017.

Sediment Budget Analysis. The sediment budget analysis reviewed various sediment sources and sinks in the study area in the manner of Rosati and Kraus (2001) and Dopsovic et al. (2002). The Guadalupe River is the primary fluvial sediment source. The river delta is within San Antonio Bay itself, with Mission Lake primarily a tidal water body and Hynes Bay likely receiving sediment at higher flows.

A secondary sediment source to the San Antonio Bay system is lateral input from shoreline erosion. The shoreline change along the perimeter of San Antonio Bay was documented by Paine et al. (2016). The long-term rates generally show relatively aggressive erosion; however, the more recent trend (i.e., 1970s-2010) shows the eastern shoreline in San Antonio Bay to be approximately stable (Figure 9). Therefore, shoreline erosion from the mainland is not thought to be a substantial sediment source to the CTV.

Figure 9. Shoreline change rate near PA 3 (after Paine et al. 2016).

Maintenance dredging of the CTV moves considerable sediment out of the system to upland confined placement areas. With the Bay shoreline relatively stable along the eastern side of the navigation channel, the predominant sediment source to the CTV is material from the Bay.

PROPOSED CONCEPTS: The proposed action at this site includes establishing one or more new BU sites for the CTV (Figure 1): (1) NEPA PA 2, (2) NEPA PA 3, (3) NEPA PA 12, and/or (4) NEPA PA 15. All sites need not be constructed for some benefit to be realized.

NEPA PA 2, at the west wye (Figure 1) near the intersection with the GIWW, is intended to be nesting bird habitat (Figure 10). There is no upper limit on the elevation of this placement area but for the sediment angle of repose. The island has been relatively stable over the past 20 years based on a review of historical aerials (1996-2016), experiencing only minor erosion compared to other upland areas along the CTV (Figure 10). Therefore, it is anticipated material placed at NEPA PA 2 would reside within PA 2, and the benefit of upland bird habitat restoration could be realized without the need for additional stabilization of the island as a part of the revised placement plan. The maintenance dredging material would be placed on the island within the NEPA-cleared polygon away from the CTV, up to an approximate elevation of +6 ft North American Vertical Datum 1988 (NAVD88) (+4.93 ft MTL). Assuming that the island exists at an average elevation of +3 ft NAVD88 (+1.93 ft MTL) today, approximately 70,000 CY of dredged material could be placed on the island's upland area. A significant amount of additional material would be placed to restore eroded shorelines to maintain its historical footprint. This site would be used for placement during each maintenance dredging cycle of the adjacent channel reach in coordination with the

U.S. Fish and Wildlife Service. There is an endangered species window between 15 October and 15 April due to the presence of the whooping cranes (*Grus americana*) when no dredging is permitted to occur.

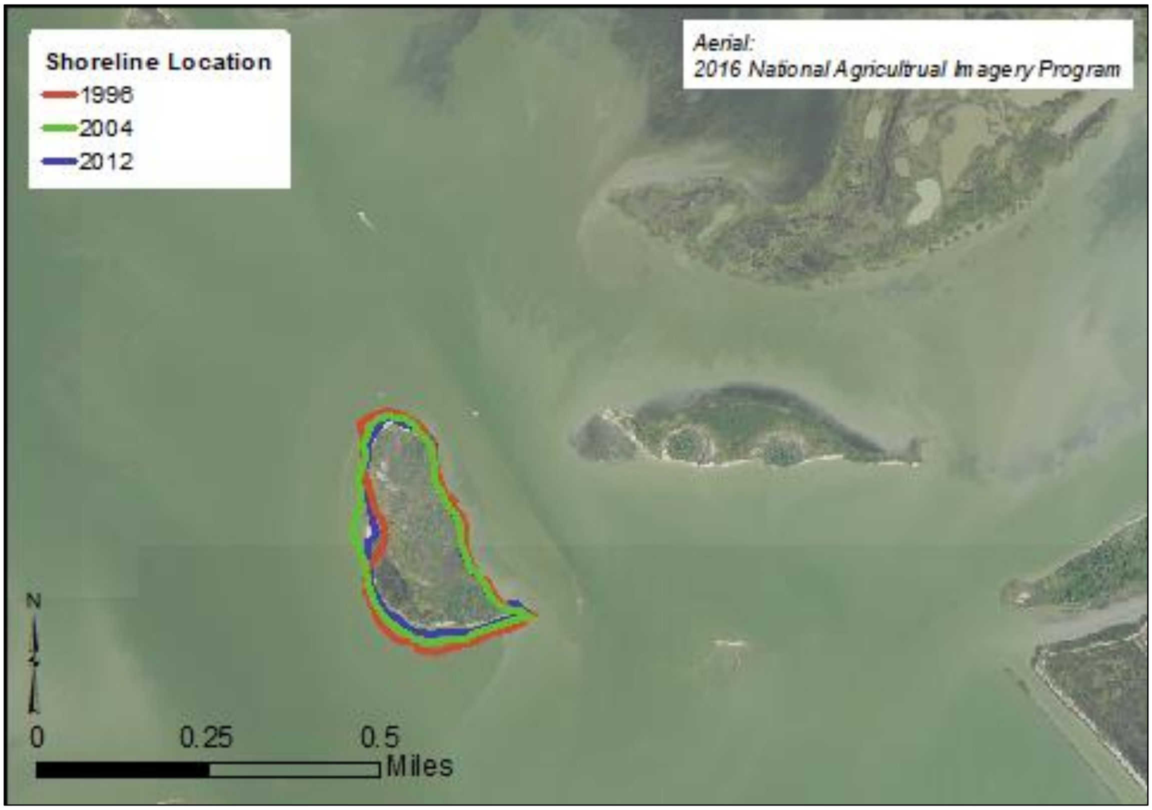

Figure 10. NEPA PA 2 shoreline data from 1996, 2004, and 2012 overlaid on a 2016 aerial.

NEPA PA 12 (Figure 1), near the intersection of the CTV and the Channel to Seadrift, would mimic the approach of NEPA PA 2 by providing upland nesting bird habitat. Assuming the existing elevation in the area averages -4 ft NAVD88 (-5.07 ft MTL) and assuming that the habitat could be constructed up to +6 ft NAVD88 (+4.93 ft MTL), approximately 743,000 CY could be placed in the area. This PA would need to be armored with a stone revetment facing the channel, and with additional erosion protection features on its north and south ends, to ensure the material is not transported back to the navigation channels. This site would either be constructed incrementally through placement during future maintenance cycles or by utilizing material in one of the upland confined sites to establish this BU site. After establishment of this site, material from future maintenance cycles would be placed to restore habitat that has been eroded or to enhance existing habitat.

NEPA PA 3 (Figure 11) and NEPA PA 15 (Figure 12) are slightly different situations. The BU purpose in these locations would be to restore islands that have been eroded over time. These areas would need to be armored along the eastern side to dissipate ship-induced waves. The wave energy along the western side of the island would be minimal given the prevailing wind direction, and any erosion along the western side would be unlikely to be re-shoaled into the CTV channel. The unlikeliness of the placed material being re-shoaled is predicated on these PAs being continuous along the proposed extents and connecting with the existing islands.

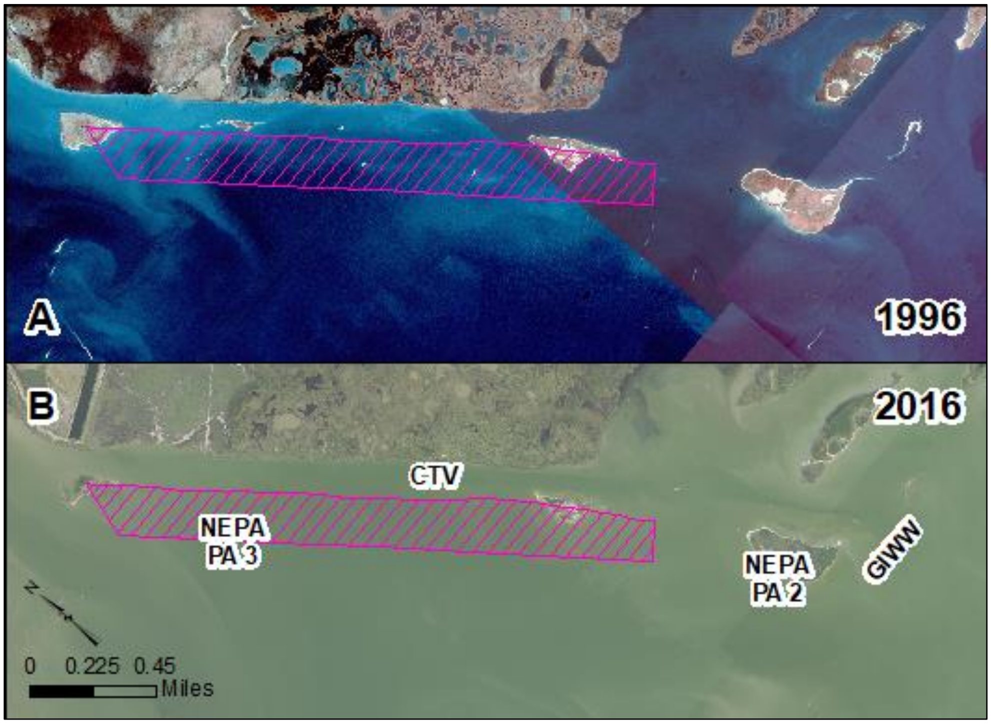

Figure 11. Aerial imagery of the NEPA PA 3 site in (A) 1996 and (B) 2016.

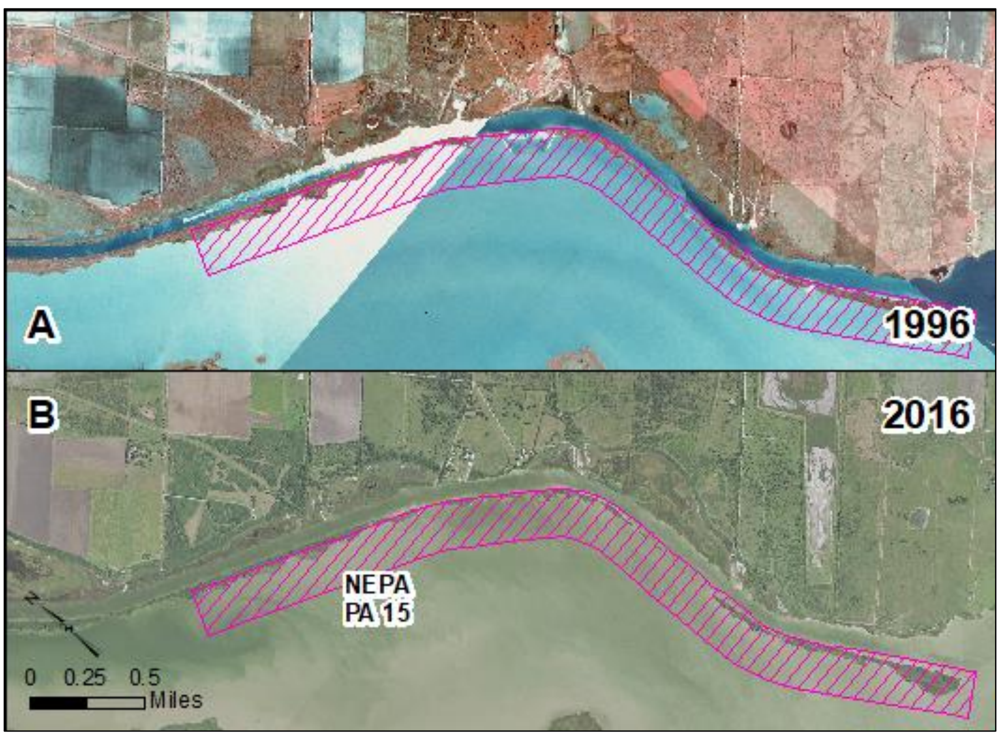

Figure 12. Aerial imagery of the NEPA PA 15 site in (A) 1996 and (B) 2016.

A key aspect in constructing these islands will be adequate containment of the material required for restoring the islands. Constructed concrete Reef Balls® (*http://www.reefball.org/brochure.html*) could be used for wave dissipation for the constructed islands but would not be adequate for containment. Innovative ways of providing containment such as hay bales have been successfully tested in Mobile Bay (Lovelace 2016). That study looked at biodegradable turbidity curtains, which could work well at the CTV site. Assuming the existing elevation in the area averages -4 ft NAVD88 (-5.07 ft MTL), and assuming that the habitat could be constructed up to +3 ft NAVD88 (+1.93 ft MTL), approximately 2.1 million cubic yards (MCY) could be placed in PA 3 and 4.9 MCY in PA 15. Additional material would be placed during future maintenance cycles to restore eroded areas or to enhance existing areas. An oyster survey partially funded through this RSM study was conducted in September 2019 to determine if oysters are present and to map their extent in NEPA PA 3. The presence of oysters within these sites may require additional coordination and mitigation to utilize the site and/or may require a smaller area within the current site delineation be utilized for placement to avoid impacts to oysters.

ALTERNATIVES ANALYSIS: The exiting conditions and proposed use of BU at the discussed NEPA permitted sites were simulated for the same period using the CMS. This was an effort to estimate the shoaling reduction associated with the construction, given the majority of shoal material comes from the open bay, riverine, and local runoff. The proposed placement plan was also evaluated based on the potential cost savings associated with a shorter distance between the channel and the placement site.

Modeling Results. Figures 13 and 14 show the simulated morphology change in the project area for the existing and proposed conditions, respectively. The proposed conditions include construction of the new BU sites NEPA PA 3, NEPA PA 12, and NEPA PA 15 as non-interacting cells in the computational mesh. NEPA PA 2 is not a truly new physical feature since it presently exists. These effectively make the PAs barriers to sediment transport, although it also assumes the placement areas are non-eroding. All three cells were included in the proposed condition model. The PAs and their effects on channel sedimentation were considered to operate sufficiently independently. Table 3 lists the shoaling reduction associated with the proposed condition over the existing condition for three channel segments. The overall shoaling reduction was estimated at 18% and was considered to be 15% across the project as a conservative approximation.

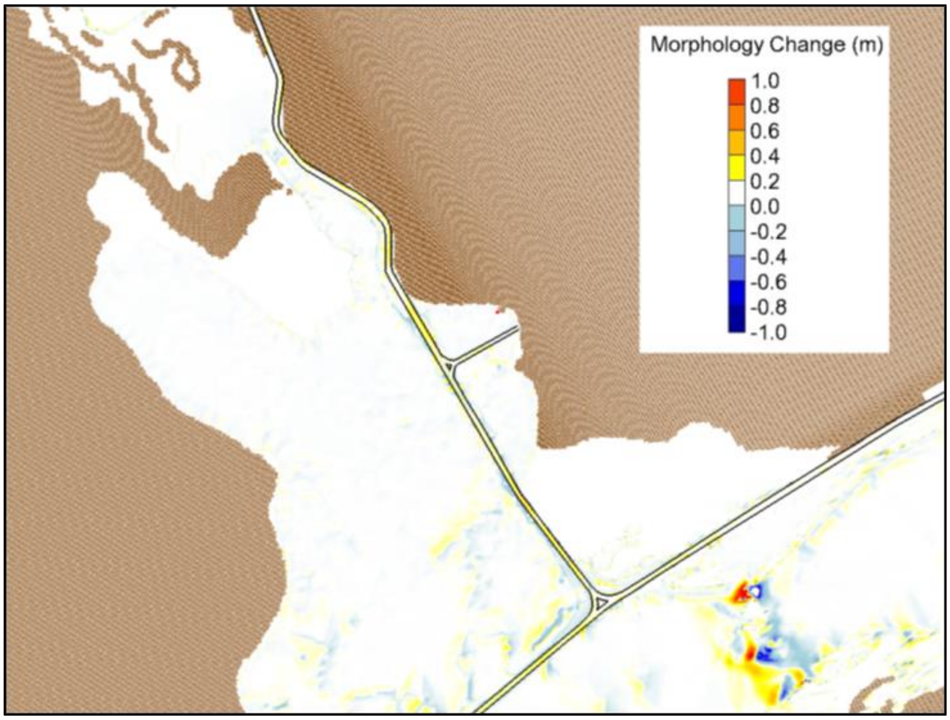

Figure 13. Simulated morphology change under existing conditions (November 2016 - July 2017). Blue indicates erosion, and red indicates deposition.

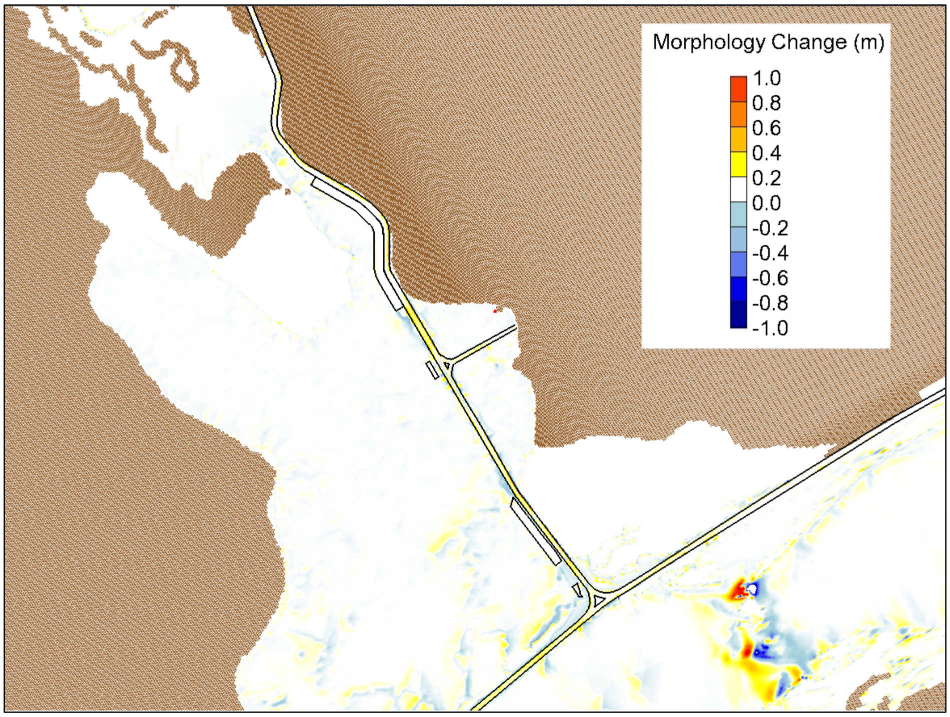

Figure 14. Simulated morphology change under proposed conditions (November 2016 - July 2017). Blue indicates erosion, and red indicates deposition.

Table 3. Simulated difference in shoaling within the CTV channel between proposed and existing conditions (November 2016 - July 2017).

Section	Station Range	Modeled Channel Shoaling [CY]		Shoaling Change
		Existing	Proposed	[%]
1	0+00 – 200+00	157,600	111,100	-30
2	200+00 – 400+00	162,100	147,100	-9
3	400+00 – 650+00	199,400	169,100	-15
Total	0+00 – 650+00	519,100	427,300	-18

Cost Estimates. Order-of-magnitude cost estimates were developed for the existing dredging and placement plan, the proposed plan including the construction with use of all new BU sites, and the permutations of partial construction of BU sites with use of existing PAs. These cost estimates take into consideration the benefits of reduced maintenance of the upland confined PAs. The estimates assume a 15% reduction in dredging volume across the project area in all of the with project conditions. That is not precisely the case; the financial benefits associated with reduced dredging are likely overstated in certain scenarios and understated in other scenarios. The mobilization/demobilization costs for new BU site construction are assumed the same across scenarios under the assumption that BU sites are constructed at the beginning of the 50-year cost horizon. There would be additional mobilization/demobilization costs if the sites were built in the future, though that would be a rather small fraction of the overall cost.

Table 4 lists the order-of-magnitude costs associated with construction of the proposed BU sites. Table 5 lists the costs associated with the various permutations of construction and placement scenarios over 50 years. These costs take into consideration the construction costs of the proposed BU sites, the cost of maintenance dredging using the associated placement strategy (the current and proposed sites, or appropriate combination), and the costs associated with operation and maintenance (O&M) of the current and proposed placement sites. With the caveat that these are order-of-magnitude estimates, construction and usage of the proposed BU sites could save approximately $42 M over the next 50 years.

Table 4. Order-of-magnitude estimates for BU site construction.

BU Site	ROM Construction Cost	
NEPA PA 2	$	2,742,000
NEPA PA 3	$	5,921,000
NEPA PA 12	$	3,373,000
NEPA PA 15	$	4,453,000

Table 5. Order-of-magnitude estimates for the various construction and placement scenarios over 50 years (a check mark indicates the construction and utilization of the indicated proposed BU site). The first row is the base condition wherein no BU sites are constructed and the current O&M dredging and placement strategy continues.

NEPA PA 2	NEPA PA 3	NEPA PA 12	NEPA PA 15	50-yr Cost
				$ 148,424,000
✓	✓	✓	✓	$ 107,026,000
✓	✓	✓		$ 130,445,000
✓	✓			$ 135,347,000
✓	✓		✓	$ 120,495,000
✓				$ 142,327,000
✓		✓		$ 137,499,000
✓			✓	$ 127,150,000
✓		✓	✓	$ 114,105,000
	✓			$ 150,158,000
		✓		$ 143,553,000
			✓	$ 137,254,000
	✓	✓		$ 147,080,000
	✓		✓	$ 137,106,000
		✓	✓	$ 121,359,000
	✓	✓	✓	$ 123,661,000

SUMMARY AND CONCLUSIONS: The construction of the proposed BU sites would create cost savings from two sources: (1) a reduction in shoaling and therefore a reduction in maintenance dredging (an approximately 15% reduction, see Table 3) and (2) a reduction in pump distance between the channel and placement location. Additional benefits include (1) increased safety for vessels navigating CTV due to the reduction/elimination of open fetch and currents, (2) additional placement options available in times of emergency dredging, and (3) increased bird habitat, particularly for the endangered whooping crane.

ADDITIONAL INFORMATION: This USACE RSM Technical Note (RSM-TN) was prepared by Paul Hamilton, Steve Howard, Ashton Burgin, and Brandon Crawford, USACE Galveston District (SWG); and Lihwa Lin, ERDC, Coastal and Hydraulics Laboratory (CHL). This study was conducted as an activity of the USACE National RSM Program, a Navigation Research, Development, and Technology portfolio program administered by Headquarters, USACE. Additional information pertaining to this RSM-TN, or to the SWG RSM investigations, can be obtained from Paul Hamilton (Paul.B.Hamilton@usace.army.mil). For information pertaining to the USACE National RSM Program, please consult the RSM website (http://rsm.usace.army.mil) or contact the USACE National RSM Program Manager, Katherine Brutsché (Katherine.E.Brutsche@usace.army.mil).

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REFERENCES

Bureau of Transportation Statistics. 2016. *U.S. Port Ranking by Cargo Volume: Port Performance Freight Statistics Program; Annual Report to Congress 2016*. Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics. https://rosap.ntl.bts.gov/view/dot/32796

Demirbilek, Z., and J. Rosati. 2011. *Verification and Validation of the Coastal Modeling System: Executive Summary*. ERDC/CHL-TR-11-10. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://hdl.handle.net/11681/7660

Dopsovic, R., L. Hardegree, and J. D. Rosati. 2002 (rev. 2003). *Sediment Budget Analysis System-A: SBAS-A for Arcview© Application*. ERDC/CHL CHETN-XIV-7. Vicksburg, MS: U.S. Army Research and Development Center. http://hdl.handle.net/11681/4979

GLO (Texas General Land Office). 2018. TxSed Database. http://gisweb.glo.texas.gov/txsed/index.html

Lovelace, N. D. 2016. *Gaillard Island Bio-Degradable Geotube Test Project, Mobile Bay, Alabama.* ERDC/CHL CHETN-XIV-56. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://hdl.handle.net/11681/20506

Paine, J. G., T. Caudle, and J. Andrews. 2016. *Shoreline Movement in the Copano, San Antonio, and Matagorda Bay Systems, Central Texas Coast, 1930s to 2010s*. Bureau of Economic Geology report prepared for Texas General Land Office. http://www.beg.utexas.edu/research/programs/coastal/measurement-and-characterization-of-bay-shoreline-change

Rosati, J. D., and N. C. Kraus. 2001 (rev. 2003). *Sediment Budget Analysis System (SBAS): Upgrade for Regional Applications*. ERDC/CHL CHETN-XIV-3. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://hdl.handle.net/11681/5013

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