TAYLOR ENGINEERING, INC.

Long-Range Dredged Material Management Plan Update for the Intracoastal Waterway

Nassau County, Florida

December 2016

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Long-Range Dredged Material Management Plan Update for the Intracoastal Waterway
Nassau County, Florida

Prepared for

FLORIDA INLAND NAVIGATION DISTRICT

by

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LONG-RANGE DREDGED MATERIAL MANAGEMENT PLAN UPDATE FOR THE INTRACOASTAL WATERWAY NASSAU COUNTY, FLORIDA

EXECUTIVE SUMMARY

The Nassau County project area — comprising three reaches (N-FHP, I and II) and 38 cuts — extends from Cumberland Sound southward 15.65 miles to the south side of Nassau Sound. Reach N-FHP, designated during this DMMP update and approved by the FIND Board in July 2015, is coincident with the deep-water channel of the Fernandina Harbor Project (FHP). The two dredged material placement sites for Nassau County — established through a detailed evaluation and selection of a dredged material management concept, consistent evaluation criteria, and public involvement — comprise one upland Dredged Material Management Area (DMMA NA-1) and one beach placement area (located at the southern end of Amelia Island State Park). Together, these sites provide sufficient storage capacity (with periodic offloading) to manage the amount of material dredged from the two defined reaches over a 50-year period.

A review of the historical maintenance dredging records and recent shoaling data provided the 50-year dredged material storage requirements for the Nassau County reaches. The resulting countywide 50-year dredging and storage requirement equates to approximately 853,600 cy and 1,835,300 cy, respectively. Previous physical and chemical analyses of sediments revealed that Reach I sediments (designated for disposal in the DMMA NA-1 site) are likely ineligible for beach placement under Florida permitting criteria; however, chemical analyses indicated that special dredging and handling procedures would be unnecessary. Reach II sediments, designated for beach placement at the Amelia Island State Park, are beach compatible and meet the requirements as set forth in Florida Administrative Code 62B-41.007(2)(k). Because the USACE has maintained Reach N-FHP at depths greater than the AIWW project depth as part of the FHP, past channel maintenance does not provide information suitable for calculation of long-term AIWW maintenance requirements in this reach. Maintenance dredging occurred in Reach I at a median frequency of 4.5 years from 1942 through 1982; no maintenance dredging has occurred in this reach since 1982. Maintenance dredging occurred in Reach II at a median frequency of 6 years from 1942 through the last maintenance operation in 2013.

The 35.5-acre DMMA NA-1 — located east of the AIWW, west of the Fernandina Municipal Airport, and on the north end of Crane Island — will receive, dewater, and temporarily store sediments dredged from the AIWW Nassau County Reach N-FHP and Reach I. The FIND acquired the DMMA NA-1 site in 1988, obtained construction permits in 2011, and completed site construction in 2013. Due to FIND's commitment to environmental and socioeconomic criteria, the DMMA NA-1 site, despite best efforts, was unable to meet the projected 50-year dredged material storage (481,572 cy) requirement. Shielding the site from view of Nassau County residents (both from the SR-A1A bridge and future residential development to the south), limiting wetland impacts, and limiting dike height due to Federal Aviation Administration (FAA) requirement reduced the overall DMMA capacity to 186,754 cy. Thus, this site may require offloading after each maintenance operation or prior to subsequent use. Further, the USACE recently approved a channel realignment that should substantially reduce future maintenance dredging volumes.

The USACE has routinely used the beach placement site immediately north of Nassau Sound on Amelia Island State Park since 1982 for sediment dredged from Reach II. This reach, where shoals form primarily by wave- and tide-driven sand movement, provides beach-compatible sediments for beneficial use. The beach placement site has received a total of ±812,600 cy of material since 1982, with placement about every 7 years. The most recent dredged material placement in the park occurred in 2013. The limits of construction generally extend approximately 2,400 ft from FDEP Range Monument AP-23 to R-78; however, future operations may consider extending the project area north of the state park boundary. Though placement operations have varied depending on beach conditions at the time of maintenance operations, typical beach design features have included a maximum 600-ft berm width, maximum berm elevation of +5.5 ft NAVD, and a 20H:1V toe of fill slope. A ±3,400-ft pipeline access corridor lies seaward of the vegetation line. For each beach placement operation, the FIND coordinates associated sea turtle and migratory bird monitoring requirements with regulatory and local interest groups.

Immediate dredged material storage needs of the Nassau County DMMP have largely been addressed. FIND's bathymetric condition survey of the AIWW, completed in 2015, found shoals requiring maintenance dredging in Reach I. Design and permitting for Reach I dredging is underway and is expected to be completed by 2017. USACE completed the maintenance dredging of Reach II in vicinity of Nassau Sound in late 2013; therefore, Reach II will not likely require maintenance until around 2020. To advance the DMMP, FIND should move forward with the development of a market analysis for the DMMA NA-1 sediment.

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1.0 INTRODUCTION

Since its formation in 1927, the Florida Inland Navigation District (FIND) has served as the local sponsor for the ±410-mile long federal Atlantic Intracoastal Waterway (AIWW) and Intracoastal Waterway (ICWW) channels. Collectively known as the “Waterway”, the federal channels extend along Florida’s east coast from the Florida-Georgia state line south to Biscayne Bay in Miami-Dade County. The 125-ft wide Waterway comprises two authorized project depths: (1) 12-ft below mean lower low water (MLLW) from the state line to the Ft. Pierce Harbor Project (FPHP) and (2) 10-ft below MLLW from the FPHP southward to the Miami Harbor Project (MHP) in Biscayne Bay. An additional 75-ft wide segment of the Waterway, authorized and constructed to seven feet below MLLW from the MHP to Cross Bank, Florida Bay is also considered part of the ICWW[1]. The ±26-mile Florida section of the AIWW comprises that portion of the federal navigation project that extends northward from the Jacksonville Harbor Project (JHP) at the St. Johns River to the state line, while the ±384-mile IWW extends southward from the JHP to the MHP. Together, the AIWW and ICWW intersect each of Florida’s 12 east coast counties. As the projects’ local sponsor, FIND provides the U.S. Army Corps of Engineers (USACE) with sites suitable for placing material dredged from the authorized navigation channels.

1.1 Background

Before the increased environmental awareness of the 1970s and the recognition by various federal and state regulatory agencies of the value of estuarine wetlands, a short-term economic approach guided management of dredged material. *Engineering/operational* and *cost* considerations determined the design and execution of channel maintenance projects. To this end, the Trustees of the Internal Improvement Trust Fund granted to FIND perpetual easements — typically named and identified by an MSA (maintenance spoil area) and number designation — of significant acreage along the Waterway. A majority of these easements, located entirely within the sovereign waters of the state, included open water areas as well as expanses of pristine salt marsh in the more northern counties and mangrove wetlands in the more southern counties. Additionally, many landowners with holdings adjoining the Waterway sought to improve the development potential of wetlands by granting disposal easements and allowing the unconfined placement of maintenance material. This approach, combined with the desire of dredging contractors to maximize operational efficiency, resulted in open-water and wetland placement of channel construction and maintenance material. These activities resulted in a loss of wetlands and the proliferation of numerous small spoil mounds and islands lining the Waterway.

Because of society’s increased environmental awareness and scientific knowledge, the unconfined placement of dredged material within wetland areas no longer represents a responsible approach to the long-term and continued maintenance of the Waterway. Present-day legislation and regulatory constraints have also rendered this approach unrealistic. Dredging and dredged material management must comply with state and federal legislation dealing with water quality, wetland filling, habitat protection, and threatened and endangered species. In addition, county and municipal governments typically address dredge-and-fill issues in local comprehensive planning documents within state-established guidelines. The long-range limitations

[1] Rivers and Harbors Act of 1945 authorized an expansion of this southern segment that would have widened the channel from 75 ft to 90 ft from Miami to Cross Bank and extended the 90-ft wide channel to Key West, FL; however, construction funds were never received and the channel remains unconstructed.

on dredged material management imposed by these constraints have become more apparent as existing dredged material sites reach capacity and as the identification and permitting of new dredged material management sites become increasingly difficult. Moreover, the intensive development pressure currently experienced throughout coastal Florida has made the acquisition of additional dredged material management sites an increasingly expensive proposition.

To secure its ability to maintain the Waterway within the existing framework of engineering/operational and added *environmental* and *socioeconomic/cultural* considerations, FIND initiated preparation of a long-range Dredged Material Management Plan (DMMP). Beginning in 1986, the two-phased plan implemented, on a county by county basis, planning and site acquisition activities to accommodate all maintenance material dredged from the Waterway for the next 50 years. Phase I focused on the development of basic plan concepts, the definition of long-term dredging requirements, and the identification of suitable management alternatives which satisfy, to the extent practicable, the identified considerations. Phase I resulted in the identification of a bank of primary and secondary sites potentially suitable for long-term dredged material management. Phase II focused on obtaining and documenting detailed site-specific information required for the preparation and submission of permit applications for the primary sites identified in Phase I. In addition, Phase II addressed site acquisition, design of site facilities, and the construction and continuing operation and maintenance of these sites as permanent dredged material management facilities.

1.2 Project Overview

1.2.1 Phase I and Phase II DMMP Development

In general accordance with the USACE Engineer Regulation 1105-2-100 guidance document, FIND originally completed the *Long-Range Dredged Material Management Plan for the Intracoastal Waterway in Northeast Florida* — inclusive of both Nassau and Duval Counties — in September 1986. In October 2006, FIND completed the *Re-evaluation of Reach I Dredged Material Management Alternatives for the Atlantic Intracoastal Waterway (AIWW)* in Nassau County. The development of both the original and updated Nassau County Phase I reports consisted of six primary components:

(1) Establishment of the 50-year material storage requirement based on historic maintenance dredging volumes and subsequent examination surveys;
(2) Evaluation of remaining or potential storage capacity of existing easements and the FIND-owned tracts within the project area;
(3) Development of a management concept or strategy appropriate to specific engineering/operational, environmental, and socioeconomic/cultural considerations;
(4) Identification of additional candidate sites consistent with the management concept;
(5) Evaluation of all candidate sites based on a standard set of criteria that reflects specific engineering/operational, environmental, and socioeconomic/cultural considerations; and
(6) Selection of a set of primary (first-choice) and secondary (second-choice) dredged material management sites that best meet projected requirements consistent with the established management concept.

With the completion of the Phase I report(s), FIND moved into Phase II of the DMMP, which included three primary components:

(1) Collection of public record information (e.g., land use, zoning restrictions, taxes and assessed values, easements, and property ownership) to assist in the further development (and final site selection) of the primary and secondary sites;
(2) Collection of site-specific information for primary sites (and secondary sites if the primary sites were deemed unfit)
    a. Boundary survey
    b. Topographic survey
    c. Subsurface and soils survey
    d. Environmental resource survey; and
(3) Preliminary design and analysis of dredged material management facilities.

As a result of the preceding efforts, FIND developed four site-specific reports (i.e., Environmental Site Documentation, Management Plan, Engineering Narrative, and Cost Report) for each primary site. Combined, these collective Phase I and II documents, authored between 1986 and 2010, comprise the original DMMP for Nassau County. This document updates the DMMP, succinctly incorporating recently collected data with previously published information, to guide immediate and future planning efforts in Nassau County. Executed in close cooperation with FIND and USACE Jacksonville District, this document will

(1) Summarize the key and established foundation of the DMMP;
(2) Establish, define, and update the Nassau County channel reaches and associated 50-year maintenance dredging and storage requirements;
(3) Provide the current status and evaluate the remaining or potential storage capacities of the FIND-owned and designated dredged material management areas (DMMAs); and
(4) Recommend a long-range dredging and DMMA construction schedule.

This report makes no attempt to recount all the information previously developed for Nassau County during the original DMMP's two-phased plan implementation. Rather, the report summarizes relevant portions of this information and presents additional information developed to support the update of the long-range DMMP for Nassau County.

1.2.2 Project Area Extension

A FIND bathymetric survey of the Nassau County AIWW completed in 2015 found shoals north of the previously defined Nassau County Reach I. The shoals, which reduced depths to as little as -5 ft MLLW, occurred in the southern part of the Fernandina Harbor Project (FHP) channel. The USACE is unlikely, however, to remove these shoals as part of FHP maintenance. Therefore, this Nassau County DMMP update — via approval by the FIND Board in July 2015 — includes a 3.89-mile extension of the project area (identified as “N-FHP”) north through the FHP to Cumberland Sound.

1.3 Established and Updated DMMP Features

As summarized above and detailed in the previously developed Phase I and II reports, the Nassau County DMMP included the establishment of permanent dredged material management sites to receive, dewater, and temporarily store materials dredged from an adjacent segment (i.e., reach) of the Waterway. Previously defined reach delineation reflects the detailed review and consideration of historic shoaling patterns, sediment quality, projected material transfer and storage requirements, area demographics, and site availability. Each reach comprises several straight-line segments (i.e., cuts). A change in orientation (i.e., direction) of the Waterway provides the end of one cut and the beginning of the next.

Thus, the Nassau County project area — comprising three reaches (N-FHP, Reach I and II) and 38 cuts (N-FHP-10 – 27A), as updated in this report — extends from the Cumberland Sound southward 15.65 miles to a point near the south side of Nassau Sound. The south end of Cut 27A extends a short distance into Duval County, but is nonetheless included in the Nassau County DMMP. The selected dredged material placement sites for Nassau County include one upland DMMA (NA-1) and one beach placement area (located at the southern end of Amelia Island State Park). Together, the two sites provide sufficient storage (with periodic offloading) and beach placement capacity to manage the amount of material dredged from the identified reaches over a 50-year period. The area in vicinity of Reach II, Cuts 27B and 27C, also includes two Advanced Maintenance Areas (i.e., AMA-A and AMA-B), and a settling basin (SB), that, when dredged to the depth of the AIWW, assist in decreasing the frequency of dredging in this area.

Table 1.1, **Figure 1.1**, and **Figure 1.2** present the reach delineation and accompanying dredged material management sites. Description of the channel geometry, specifically the detailed longitudinal stationing information included with the more recent dredging plans, was used to establish a system for cross-referencing a particular location along the Waterway to both cut and station, and channel mileage.

Table 1.1 Reach Limits and Designated Dredged Material Management Sites

<table>
<tr><th colspan="2">REACH</th><th>CUT</th><th>END STATION (FT)</th><th>LENGTH (MI)</th><th>AIWW MILEAGE[1]</th><th>MANAGEMENT SITE[2]</th></tr>
<tr><td rowspan="5">N-FHP</td><td rowspan="5">Cumberland Sound to South End of Fernandina Harbor</td><td>N-FHP-10</td><td>27+87.55</td><td>0.53</td><td>0.53</td><td rowspan="5">DMMA NA-1</td></tr>
<tr><td>N-FHP-9</td><td>35+47.30</td><td>0.67</td><td>1.20</td></tr>
<tr><td>N-FHP-8</td><td>13+07.28</td><td>0.25</td><td>1.45</td></tr>
<tr><td>N-FHP-7</td><td>30+80.35</td><td>0.58</td><td>2.03</td></tr>
<tr><td>N-FHP-6</td><td>23+51.95</td><td>0.45</td><td>2.48</td></tr>
</table>

Table 1.1 Reach Limits and Designated Dredged Material Management Sites Continued

Reach		Cut	End Station (ft)	Length (mi)	AIWW Mileage[1]	Management Site
N-FHP	Cumberland Sound to South End of Fernandina Harbor	N-FHP-5	6+78.85	0.13	2.60	DMMA NA-1
		N-FHP-4	20+72.16	0.39	3.00	
		N-FHP-3	10+19.16	0.19	3.19	
		N-FHP-2	5+23.38	0.10	3.29	
		N-FHP-1	24+00.04	0.45	3.74	
I	South End of Fernandina Harbor to Nassau Sound	C	10+31.51	0.20	3.94	
		B	34+59.20	0.66	4.59	
		A	29+15.50	0.55	5.15	
		34	22+63.33	0.43	5.58	
		33	2+96.87	0.06	5.63	
		32	20+25.97	0.38	6.02	
		31	15+49.92	0.29	6.31	
		30	26+15.42	0.50	6.80	
		29	9+43.17	0.18	6.98	
		28	82+53.98	1.56	8.55	
		27T	21+27.41	0.40	8.95	
		27S	9+23.50	0.17	9.12	
		27R	8+34.12	0.16	9.28	
		27Q	35+78.34	0.68	9.96	
		27P	22+89.87	0.43	10.39	
		27N	24+70.20	0.47	10.86	
		27M	10+90.83	0.21	11.07	
		27L	12+82.97	0.24	11.31	
		27K	28+89.88	0.55	11.86	
		27J	6+42.76	0.12	11.98	
		27H	6+88.86	0.13	12.11	
		27G	18+59.09	0.35	12.46	
		27F	23+50.72	0.45	12.91	
		27E	25+35.25	0.48	13.39	
		27D	31+96.62	0.61	13.99	
II	Nassau Sound	27C	26+95.94	0.51	14.50	Amelia Island State Park
		27B	34+93.60	0.66	15.17	
		27A	25+35.05	0.48	15.65	

[1]AIWW Mile zero occurs at Cut N-FHP-10, Station 00+00 (coincident with Cut 2, Station 00 + 00.00 of the FHP). Column value is the southerly end mileage for the cut.; [2]In the event that DMMA NA-1 is unavailable, DMMA DU-2, located approximately 9.5 miles south of DMMA NA-1 could also be considered.

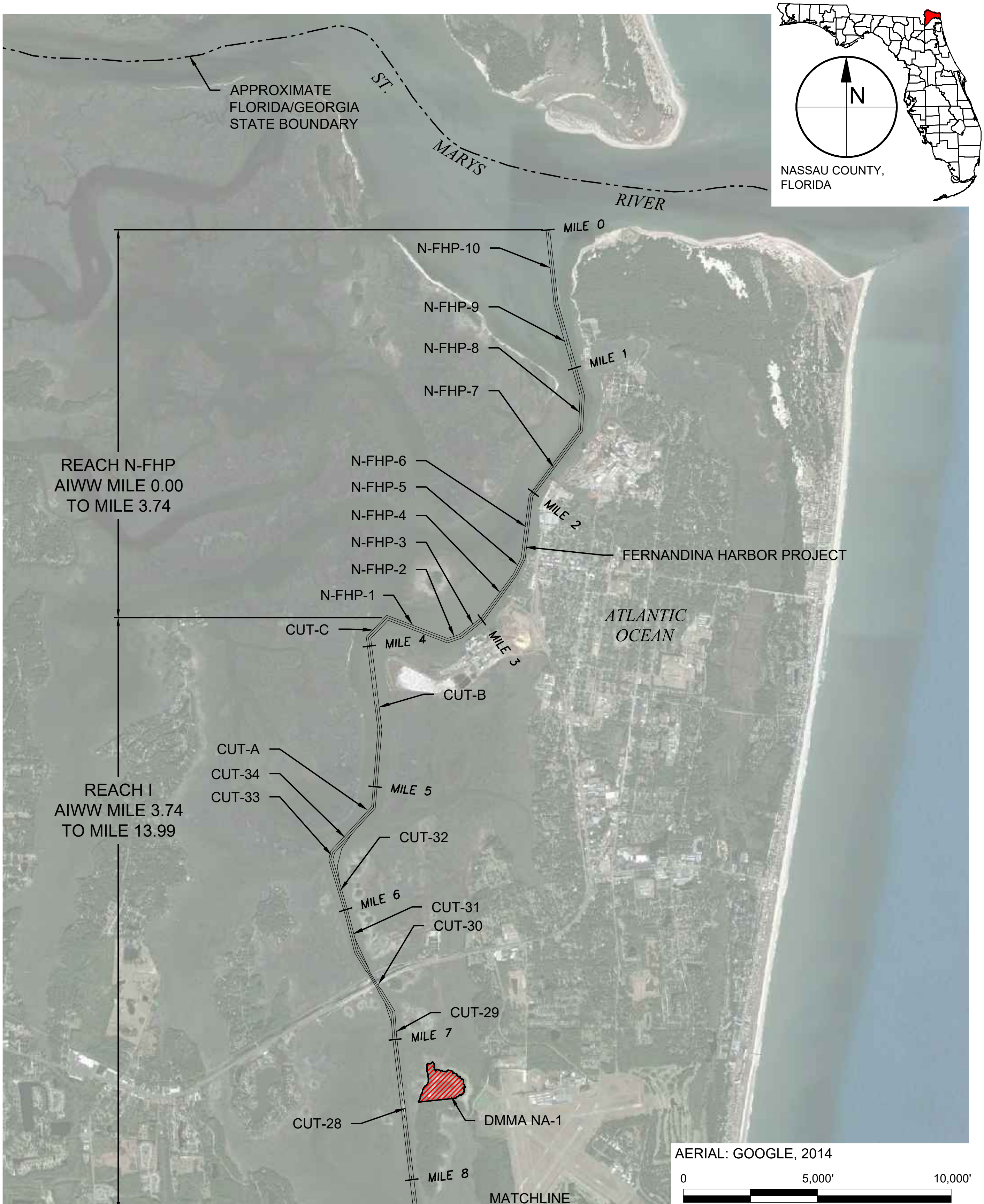

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FIGURE 1.1
REACH LIMITS AND DESIGNATED DREDGED MATERIAL MANAGEMENT SITES, REACHES N-FHP AND I
ATLANTIC INTRACOASTAL WATERWAY
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
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SHEET	1 of 9
DATE	DEC 2016

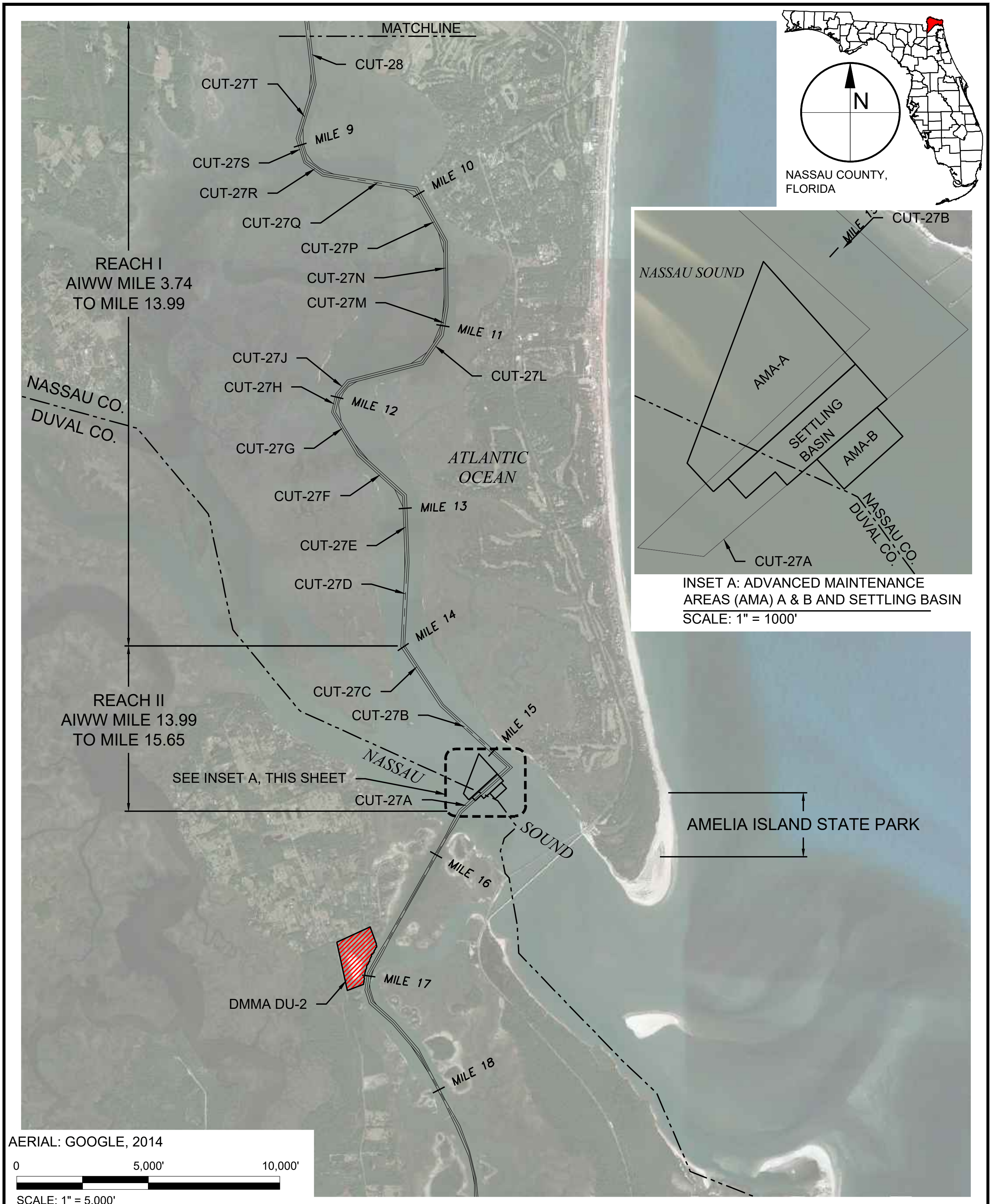

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FIGURE 1.2
REACH LIMITS AND DESIGNATED DREDGED MATERIAL
MANAGEMENT SITES, REACHES I AND II
ATLANTIC INTRACOASTAL WATERWAY
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
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DATE	DEC 2016

Within this segment of the study area, channel mileage was measured from the northern boundary of Reach N-FHP (AIWW mile 0.0). Due to the addition of Reach N-FHP and resolution of inconsistencies in the older plan documents (stemming from modifications in the channel geometry over the project lifetime), the channel mileages applied in this updated report vary from those in the original DMMP.

1.4 Report Organization

The methods reported herein closely follow the method of the original Phase I and subsequent Phase II DMMP reports. The organization of this report generally reflects those methods. **Chapter 2.0**, *DMMP Development*, summarizes the primary components of the original DMMP development including the selected dredged material management concept(s) and summarizes the evaluation criteria for selection of the upland DMMA sites. This chapter also discusses the addition of Reach I-FHP to the Nassau County DMMP. **Chapter 3.0**, *50-Year Dredged Material Storage Requirement*, provides a revised projection of the 50-year dredged material management requirements based on an update of the historic channel maintenance records and evaluation of the most recent bathymetric surveys and channel sediment data, and discusses the implications of the revised projections. **Chapter 4.0**, *DMMA Design and Construction*, addresses the overall dredged material management strategy for Nassau County along with the current status, design, operation, management, and mitigation, as applicable, of the selected dredged material placement areas. **Chapter 5.0**, *DMMA Operational Considerations*, provides a summary of the three phases (pre-, during-, and post-dredging) of DMMA operations. **Chapter 6.0**, *Beach Placement Site*, details the Amelia Island State Park beach placement area. Finally, **Chapter 7.0**, *Conclusions and Recommendations*, summarizes the updated findings.

2.0 DMMP DEVELOPMENT

The underlying foundation for the reach delineation and ultimate dredged material placement site selection — summarized herein and extensively detailed in the original DMMP reports — included selection of a dredged material management concept(s) and identification, evaluation, and eventual selection of DMMA NA-1 and Amelia Island State Park for the management of dredged material from the AIWW. The following paragraphs summarize the development of the Nassau County DMMP.

2.1 Dredged Material Management Concept

The central issue guiding the development of a management concept — i.e., a guiding set of principles that reflects the attitudes and considerations of the project's local sponsor — for the AIWW in Nassau County was the selection of the most appropriate material management strategy. Based on previous experience and DMMP reports, four basic alternatives are available for consideration: (1) ocean disposal, (2) open water placement, (3) beach placement, and (4) centralized upland storage. The following paragraphs discuss each of these alternatives with respect to its applicability to Nassau County management requirements.

(1) *Ocean Disposal.* While considered a favorable management strategy typically reserved for large volume areas (e.g., entrance channels, inlets, deepening projects) — ocean disposal requires the transport of dredged material from the dredging site to an authorized offshore disposal area. For the Nassau County project area, this condition would result in a very inefficient and thus costly operation for the following reasons. The dredge (hydraulic or mechanical) must first load the material into a hopper barge capable of transiting the relatively shallow depths of the AIWW. Within Nassau County, the channel's -12 ft MLLW controlling depth would place severe limits on the barge's draft and thereby on its capacity. Regulatory restriction on overflowing the barge during filling would likely limit its effective capacity even further. Once a barge is filled to its draft-limited capacity, the barge must then transit to an appropriate point at which to transfer the material to a deep-draft seagoing barge for transport to an authorized offshore placement site. A review of offshore disposal areas currently authorized by the U.S. Environmental Protection Agency (EPA) to receive dredged material identified an approved offshore placement site (identified as the Fernandina Beach Ocean Dredged Material Disposal Site [ODMDS]), historically used by the federal government to receive material dredged from the Kings Bay Entrance Channel, 7.1 nautical miles offshore and 11.8 nautical miles from the entrance to St. Mary's River. Thus, given the concentration of shoaling in the northernmost section of Reach I (located closest to St. Mary's entrance channel), material transfer to the Fernandina ODMDS would require hauling each partially-filled, shallow-draft barge an average one-way distance of ±1.1 channel miles to the Fernandina Harbor entrance channel, then transferring the material to a deep-draft barge for the final 11.8 nautical miles to the offshore placement site. The relatively small volume projected for this portion of Reach I cannot justify the inefficiency and expected resulting cost for this type of operation.

(2) *Open Water Placement.* This particular method, as noted in **Chapter 1.0**, was perhaps the most widely used approach before the growth of today's environmental regulatory programs that address wetland and benthic habitat protection. Today, under the guise of wetland or habitat creation, open water placement has found favor in areas (e.g., coastal Louisiana, Chesapeake Bay) that have experienced severe losses of similar wetland habitats. However, in Florida, open water placement as a dredged material management strategy has generally not gained regulatory support. Discussions with representatives of the relevant regulatory agencies have repeatedly confirmed that they consider open water placement within Florida's estuaries to carry unacceptable environmental impacts in terms of the destruction or degradation of shallow-water or benthic habitat. *Open water placement or island creation also remains inconsistent with a basic principle of FIND's dredged material management program: to provide permanent infrastructure of material management facilities that can support the long-term maintenance of the Waterway without relying on changeable regulatory attitudes.* Even if the initial placement operation would receive the necessary permits, the creation or expansion of open water placement represents an unacceptable and short-term dredged material management strategy for Nassau County.

(3) *Beach Placement.* Both the State of Florida and the USACE (via its Regional Sediment Management program) encourages placement of beach-quality dredged material on the beach as a beneficial use of dredged material. FIND also includes this approach as an essential part of the dredged material management for channel reaches which, based on the historic data, are likely to contain beach quality sediments. These conditions are most typically encountered in the immediate area of tidal inlets where Waterway shoals are formed primarily by sand driven through the inlet by waves and tides. Within Nassau County, such conditions are present within the Waterway channel in the vicinity of Nassau Sound. Feasibility of beach disposal is influenced by other considerations such as material quality (**Section 3.4**), regulatory requirements, cooperation of beachfront property owners, the need for additional material on the beach, and seasonal operational restrictions due to sea turtle nesting.

(4) *Centralized Upland Storage*. A needed complement to beach disposal is the use of a diked containment area with appropriate outlet flow control structures. The dredged material is pumped in a sediment-slurry to one end of the containment basin opposite the outlet structure. Sediment settles in the basin while the residual water returns to the Waterway via the basin outlet structure and return pipeline. Upland storage sites offer a number of significant advantages over other available methods: (1) they provide an efficient means of dredged material management without excessive costs of transportation and material re-handling involved with the use of ocean disposal; (2) given identification of suitable sites, they avoid most wetland impact issues inherent in the use of open water disposal; (3) they are conducive to reconfiguration and reconditioning for subsequent disposal events; and (4) unlike beach disposal, they do not demand particular physical characteristics of dredged material.

The use of a limited number of centralized upland storage sites has additional economic, operational, and environmental advantages over the use of a greater number of smaller sites: (1) fewer, larger sites reduce the total acreage required and thereby reduce the total cost of site acquisition; (2)

developing and constructing fewer, larger sites is more cost effective than developing and constructing a number of small sites; (3) the use of centralized sites allows for improved site security and requires the allocation of fewer operating personnel; and (4) the use of fewer, larger sites reduces the total impact to upland habitat and allows for improved effluent and stormwater control, as well more efficient and comprehensive monitoring procedures. Thus, the Nassau County DMMP relies on (1) beach placement and (2) centralized upland storage.

2.2 Evaluation Criteria

With the management concepts in-hand and beach-placement considerations defined, the final site evaluation and selection process for the overall site bank, specifically the "Centralized Upland Storage" sites, employed a standard set of criteria. Developed as part of the original 1986 Phase I report, these criteria remain consistent with the dredged material management strategy designated most appropriate for future Nassau County requirements. Taylor Engineering evaluated each centralized upland storage candidate site based on its ability to satisfy criteria in three broad areas:

(1) *Engineering/Operational.* Engineering/operational considerations take into account the mechanics behind the construction of an upland DMMA and maintenance dredging of the Waterway. Selection of the optimal site will have a long-term and compounding economic impact on the construction, operation, and maintenance of a particular site. Specific considerations within this broad-based criterion include ability of the site to meet the required storage capacity, adequate and appropriate dike material for site construction, minimization of pumping distance, and availability of pipeline and upland access.

(2) *Environmental.* By minimizing adverse impacts to sensitive habitats, the environmental site evaluation criteria guided the selection of sites that carried minimal environmental permitting constraints. Reflecting FIND's established principle of restricting the placement and storage of dredged material to upland areas, the resulting criteria fell under two categories: (1) criteria for the avoidance of wetland areas to the greatest extent possible and (2) criteria for minimizing unavoidable impacts to sensitive upland habitats. Other environmental considerations included maximization of buffer area (to limit view and lessen sound intrusion of the DMMA from adjacent properties), identification of potential archeological sites, and protection of groundwater.

(3) *Socioeconomic/Cultural.* The third major category of site evaluation criteria considers the socioeconomic issues of on-site or adjacent land use, current comprehensive plan and zoning designations, local governmental jurisdictions, and site ownership. Typically, the initial site selection process seeks areas of suitable existing on-site land use with areas of minimal development receiving preference. Given their reduced environmental value, areas previously disturbed by clearing, excavation, timber harvesting, or drainage also received preference. To the maximum extent possible, a buffer zone was considered to reduce potential conflicts by separating the site's active storage from adjacent residential or commercial development.

2.3 Site Identification

Given the established dredged material management concept strategy of centralized upland storage in Reach I and beach placement for Reach II, FIND limited the search for permanent facilities to the Reach I segment of the Nassau County AIWW. For both the 1986 and 2006 Phase I reports, the site identification process began with an office review of LABINS (Land Boundary Information System, Florida Department of Environmental Protection [FDEP] Bureau of Survey and Mapping) visible/infrared aerial photography, supplemented with aerial photography and other information from the Nassau County Property Appraiser's office. Other resource materials included U.S. Geological Survey 7.5-minute topographic quadrangle maps, Nassau County Comprehensive Plan Future Land Use and zoning maps, U.S. Fish and Wildlife Service (USFWS) Wetland Inventory maps, and U.S. Soil Conservation Service maps. Through this review, Taylor Engineering identified potentially suitable sites for development as DMMAs. Consistent with FIND's established program standards, the selection of the identified sites reflects each site's potential to satisfy a range of engineering/operational, environmental, and socioeconomic/cultural criteria.

Through the general process outlined above, the FIND 1986 report originally identified a primary (Pine Island) and secondary (Crane Island) site — narrowed down from the preliminary selection of four alternative sites, two of which were FIND's perpetual easements (i.e., S/A No. 43-44 and S/A-32) — to serve the projected future dredged material management requirements of Reach I. As it happened, the concurrent approval of a Planned Unit Development (PUD) order on the study's first recommended site (since developed as the Pine Island subdivision) prompted FIND to turn its focus to the study's second choice — Crane Island (now known as DMMA NA-1). The DMMA NA-1 site, reaffirmed as the primary choice in the 2006 report, provides the upland site for Reach I within the Nassau County DMMP. The beach placement site, Amelia Island State Park — predominantly chosen because of the compatibility of beach sediments with Reach II material characteristics and previous placement operations — has received Reach II maintenance material approximately every 6 years from 1982 to 2013. As an erosion protection measure for the residential area north of the state park boundary, FIND could consider expanding the beach placement area north of the existing template. Should DMMA NA-1 be unavailable (due to capacity related issues), DMMA DU-2, located on the north end of Black Hammock Island and approximately 9.5 miles south of DMMA NA-1 could also be considered as an upland containment area for the finer-grained fraction of material that is not considered beach compatible.

2.4 Public Involvement

Lastly, the implementation of the DMMP, by design, included a four-tiered involvement of outside reviewers and interested members of the public who commented on the long-range DMMP as it developed. These four sources of input consisted of (1) a technical advisory committee comprising representatives from FIND staff, USACE Jacksonville District, the Florida Department of Environmental Regulation (DER) and the Florida Department of Natural Resources (now combined as the FDEP), and the Florida Department of Community Affairs; (2) a citizens advisory committee comprising community representatives appointed by the Nassau County Commission; (3) the FIND Board of Commissioners; and (4) the general public. Outreach activities included initial telephone and letter contacts followed by short presentations in the Tallahassee DER office and presentations within the local community. The constructive and valuable input received from each of the above-described sources contributed greatly to the successful completion of the original long-range DMMP for Nassau County.

3.0 50-YEAR DREDGED MATERIAL STORAGE REQUIREMENT

The first step in reestablishing, defining, and updating the 50-year maintenance dredging and material storage requirement requires updating and reassessing the projected future dredging and material storage requirements of the project area. These projected requirements will determine the volume of dredged material that each established placement area must accommodate. The projected dredging and dredged material storage requirements, in turn, reflect two quantities:

(1) the estimated volume of material removed from the Waterway channel in all maintenance dredging operations since construction of the channel to its present project depth, and
(2) the estimated volume of shoaling presently within the authorized channel based on recent surveys of the project area.

The latter quantity represents the volume of shoaling since the last maintenance operation or, in non-maintained areas, the volume of shoaling since the channel's original construction to its present dimensions. By accounting for channel maintenance operations performed within the project area since the original 1986 study as well as more accurate and comprehensive survey data unavailable at the time of the original study, this reassessment will provide a more accurate, updated projection for the volume of dredged material that the DMMA (and beach placement area) must accommodate. The following sections provide a breakdown of both the historical maintenance and recent shoaling volumes, the resulting projection of the 50-year dredging and material storage requirements, and a review of the material quality (physical and sediment chemistry characteristics) of previously collected geotechnical borings.

3.1 Historic Channel Maintenance

The volume of historic maintenance dredging derived from an analysis of the USACE Jacksonville District archival records — specifically, analysis of all engineering plans and supporting documents for channel maintenance performed in the Nassau County segment of the AIWW since the USACE deepened the channel to its authorized project depth of 12 ft below MLW[2] in 1941 – 1942. To ensure accuracy, consistency, and completeness, the original 1986 review (as well as the records since received for this updated report) included all available sources of dredging information held by the USACE Jacksonville District. Relevant sources included the annual Office of the Chief of Engineers (OCE) Reports, previous USACE summaries of maintenance dredging within the project area, and interviews with USACE personnel. The primary sources of information, however, remained USACE archival maintenance plan documents and examination surveys.

The archival records express the estimated volume of material dredged in previous channel maintenance operations in two forms. The first estimate — the pre-dredging estimate, or the design volume of required dredging — reflects the comparison of the results of a detailed pre-dredging examination survey of the authorized channel to the project design depth, plus the required advanced maintenance or overdepth dredging. The plan for the dredging operation and the bids of the dredging contractors reflect this estimate. The second estimate represents the pay volume. This estimate determines the dollar amount the dredging

[2]The current design depth is defined as 12 ft below MLLW. Prior to 2008, the USACE referenced the design depth to MLW.

contractor receives for the work and reflects the comparison of detailed pre- and post-dredging examination surveys. Therefore, the pay volume closely corresponds to the actual volume of material removed from the channel. Because of past contracting and recording procedures, pay volumes do not always link dredging quantities to specific dredging locations. In those maintenance operations for which the pay volume was unavailable, multiplying the design volume by a correction factor provides an estimate of the pay volume. Derived from all dredging records evaluated thus far in FIND's long-range program (and consistent with all other Waterway DMMP efforts), the correction factor of 1.19 represents the ratio of pay volume to design volume in those channel maintenance operations for which both quantities are known. The original 1986 analysis of historical dredging records established that USACE performed four separate channel maintenance operations within Nassau County Reaches I and II between 1942 and 1986 — 1943, 1945, 1952, and 1982 (**Table 3.1**).

The three earliest operations removed relatively small quantities — roughly 11,000, 19,000 and 13,000 cubic yards (cy) from Reach I and roughly 6,500 and 11,500 cy from Reach II. Available records for these operations documented the specific locations for only the 1952 operations as north of the A1A Bridge within Cut 28. A 30-year gap in channel maintenance then followed. However, as discussed later in this section, the lack of maintenance dredging between 1952 and 1982 does not necessarily prove the absence of shoaling. Other factors unrelated to shoaling often postpone required channel maintenance. These factors include contracting procedures, the availability of funding and equipment, and availability of material management sites. Before the 1986 study's designation of the Crane Island site and its later acquisition and eventual construction by FIND for dredged material management, Nassau County suffered from a lack of placement sites appropriate to receive dredged material under increasingly strict regulatory criteria.

Table 3.1 Summary of Historic Maintenance Dredging, 1943 – 2015

Reach	**AIWW Mileage**		**Cut**		**Length (ft)**	**Year**	**Design Volume (ft)**	**Pay Volume (cy)[1]**
	From	**To**	**From**	**To**				
N-FHP	No historical maintenance dredging relative to AIWW project depth							
						N-FHP Total	**0**	**0**
I	--	--	--	--	--	1943	***9,179***	10,923
	--	--	--	--	--	1945	***16,116***	19,178
	7.17	7.54	28/72+50	28/53+00	1,954	1952	11,000	***13,096***
	6.61	6.89	30/10+00	29/5+00	1,478	1982	10,500	***12,500***
	8.47	9.79	28/4+00	27Q/9+00	6,970	1982	51,500	***61,311***
	11.46	12.20	27K/21+00	27G/14+00	3,854	1982	68,500	***81,549***
						Reach I Total	**166,795**	**198,557**
II	15.11	15.42	27B/3+00	27A/12+00	900	1943	5,480	***6,521***
	15.11	15.42	27B/3+00	27A/12+00	900	1945	9,621	***11,449***
	15.11	15.42	27B/3+00	27A/12+00	900	1982	71,000	***84,490***
	14.16	14.50	27C/18+00	27C/0+00	1,800	1997	39,882	47,459

Table 3.1 Summary of Historic Maintenance Dredging, 1943 – 2015 Continued

Reach	AIWW Mileage		Cut		Length (ft)	Year	Design Volume (ft)	Pay Volume (cy)[A]
	From	To	From	To				
II	14.16	14.50	27C/18+00	27C/0+00	1,800	2001	19,033	22,649
	15.27	15.49	27A/20+00	27A/8+00	1,200	2006	238,413	231,728
	14.02	14.50	27C/25+50	27C/0+00	2,550	2013	111,173	96,616
	15.44	15.16	AMA-A[2]/ 5+50	AMA-A/20+00	1,450		237,779	228,977
	15.27	15.02	SB[3], AMA-B/ 7+00	SB, AMA-B/20+00	1,300		90,254	82,699
	15.46	15.27	27A/10+00	27A/20+00	1,000			
	Reach II Total						**822,635**	**812,588**
Reach FHP, I and II Total							**989,430**	**1,011,145**

[1]Numbers in ***bold italic*** are based on the relationship: pay volume = 1.19 x design volume; [2]AMA = Advanced maintenance areas A and B, constructed by the USACE in 2000, northwest and southeast of the channel bend at Cuts 27A and 27B; [3]SB = Settling basin, constructed by the USACE likely between 1982 and 2001, located between AMA-A, AMA-B and the AIWW channel

The 1982 channel maintenance operation within Reaches I and II represented only a portion of a significantly larger operation that extended from near the northern limits of Reach I to well south of the Ft. George Inlet in Duval County, AIWW Reach IV. Within Reach I, this operation removed over 155,000 cy of shoal material. However, federal and state environmental regulations in place by the 1970s had rendered all of FIND's easements within Nassau County unacceptable for dredged material placement (Taylor and McFetridge, 1986). [Note: One of these easements, designated S/A 43 – 44, although unusable on its own, would later form part of DMMA NA-1, the Crane Island site, and had received material from the 1945 and 1952 dredging operations.] Combined with the critical need to dredge within the Nassau County segment of the AIWW, this lack of suitable existing placement sites dictated that the FIND seek an alternative placement site specifically to support the 1982 channel maintenance operation. By December 1980, FIND had secured a temporary 25-acre easement (designated Tract T-200) located near the western shoreline of Alligator Creek near the end of Frank Ward Road and about one mile west of the AIWW channel. USACE then constructed a temporary ±15-acre containment basin on this easement to receive the material dredged from Reach I. Following the completion of dredging, USACE then partially dismantled the containment dikes and distributed the dewatered material within the property. FIND then released the easement in November 1983. The 1982 operation also removed about 84,500 cy of shoal material from Reach II (Cuts 27A and 27B) and placed this material on the beach at south Amelia Island immediately north of Nassau Sound.

USACE has also performed four additional channel maintenance operations — 1997, 2001, 2006, and 2013 — within the Nassau County project area since the 1986 study. In 1997, USACE dredged over 418,000 cy of shoal material from Cut 27C in Reach II (Nassau County) southward through Cut 22 in Reach III (Duval County). An estimated 47,500 cy of this total represents material dredged from Cut 27C. USACE placed this volume, as well as the material from Cuts 27B and 27A (that is, the remainder of Reach II) totaling approximately 150,000 cy, on the beaches of southern Amelia Island with the remaining 268,000 cy (from Duval County, Reach III) going to DMMA DU-2 located on northeastern Black Hammock Island adjacent to Cut 27 (also known as Sawpit Cutoff). The 1986 Nassau/Duval Phase I study identified DMMA DU-2 as one of nine dredged material management sites to serve the seven reaches of the Waterway within the Nassau and Duval County project area. The FIND's subsequent acquisition of this property (between 1988 and 1990) and the USACE's 2004 construction of the containment facility came as a direct result of the 1986 Phase I study. The Duval County DMMP report (Brownell et al., 2014) contains additional detail on the DMMA DU-2 facility.

The 2001 USACE operation removed approximately 308,500 cy from essentially the same channel segment — Cut 27C in Reach II southward through Cut 21 in Reach III — maintained in 1997. (Note: this volume also includes advanced maintenance of the Nassau Sound flood shoals adjacent to Cut 27A in Reach II. Although this section lies outside the authorized AIWW channel, the 2001 maintenance operation included this section for the first time to extend the period before these shoals would once again impinge on the Waterway channel.) An estimated 22,600 cy of this total represents material dredged from Cut 27C. Similar to the 1997 operation, in 2001 the dredged material was apportioned between two sites, with the beach-quality material from Reach II going to south Amelia Island beaches and the remaining material from Reach III (that is, from Cut 27 southward) going to DMMA DU-2.

The 2006 USACE operation removed approximately 429,000 cy of material between Cut 27A (southern end of Reach II in Nassau County) southward through Cut 11 (Reach IV in Duval County). The USACE deposited approximately 129,100 cy in the upland DMMA DU-2 in Duval County. The DMMA DU-2 material originated from Cut 27 (STA 5+00 – 14+00) and Cut 20 – Cut 11. The USACE deposited the remaining 299,900 cy of material — originating from Cut 27 [STA 8+00 – 20+00, 61+00 – 67+00] and Cut 26A – Cut 22 — onto the southern beaches of Amelia Island. Cut 27A, the sole cut of the 2006 USACE project that lies within Nassau County, comprised a pre-dredge survey volume of 238,413 cy and an after-dredge survey payment volume of 231,728 cy. Due to the beach-quality material of Cut 27A, the USACE was able to place the entire pay volume onto the beaches of Amelia Island.

Finally, in 2013, the USACE operation removed approximately 519,500 cy of material between Cut 27C (southern end of Reach II) southward through Cut 24 (Reach III in Duval County). As a result of this maintenance operation, the USACE deposited 508,187 cy of beach-quality material to the southern Amelia Island beaches and the remaining material (11,368 cy) to DMMA DU-2. The DMMA DU-2 deposited material originating from Duval County Reach III, Cut 27 STA 59+00 – STA 67+00. Cut 27A, inclusive of the settling basin and Advanced Maintenance Area (AMA) B, comprised a pre-dredge survey volume of 90,254 cy and an after-dredge survey payment volume of 88,699 cy. Similarly, AMA-A included a pre-dredge survey volume of 237,779 cy and an after-dredge survey payment volume of 228,977 cy. Finally, Cut 27C comprised a pre-dredge survey volume of 111,173 cy and an after-dredge survey payment volume of 96,616 cy.

In summary, four dredging operations have removed a total of 198,557 cy from Reach I since construction of the Nassau County segment of the AIWW channel to its authorized depth in 1942; seven operations removed a total of 812,588 cy from Reach II over the same period. USACE's FHP maintenance has generally kept Reach N-FHP at depths in excess of the AIWW -12 ft MLLW project depth. Therefore, maintenance dredging records for the FHP do not provide any useful information about shoaling relative to the AIWW project depth.

3.2 Recent Shoaling

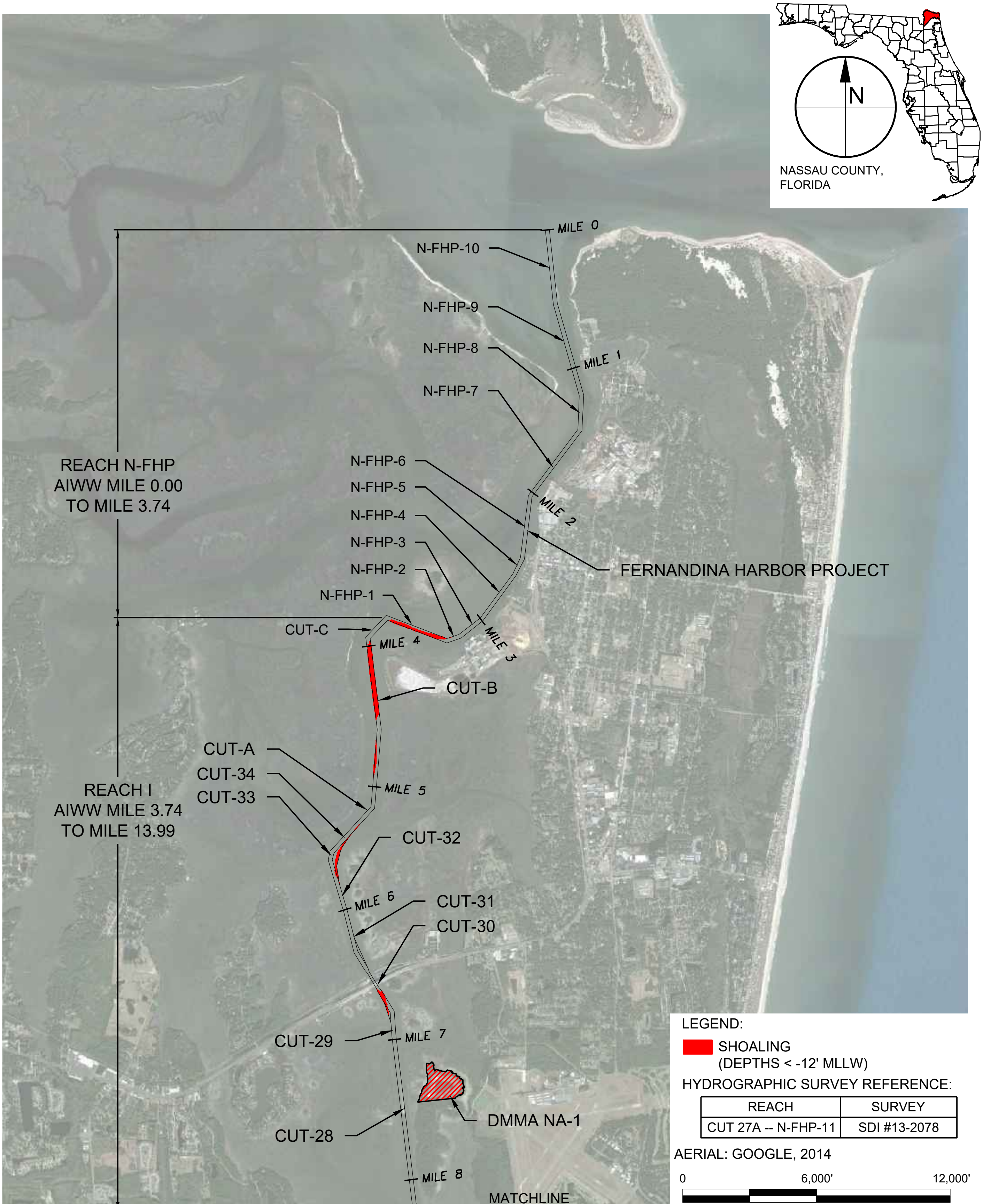
As discussed in the introduction paragraph of **Section 3.0**, the volume of recent shoaling represents the second component that determines the projected future dredging and dredged material storage requirements for the Nassau County segment of the AIWW. In late 2014 and early 2015, FIND obtained a hydrographic survey of the entire Nassau County Waterway (Sea Diversified, Inc., 2015). From the survey data, Taylor Engineering calculated shoal volumes based on excavation to project depth. The resulting volumes correspond to the design volume (the pre-dredging estimate). The application of the correction factor (i.e., 1.19) as described in the previous section then derived a corresponding pay volume. **Table 3.2** provides the locations (referenced by AIWW mileage and channel cut and station) and shoal volumes.

Table 3.2 Summary of Recent Shoals, 2014 - 2015

Reach	**AIWW Mileage**		**Cut**		**Length (ft)**	**Year**	**Design Volume (cy)**	**Pay Volume (cy)** [1]
	From	**To**	**From**	**To**				
N-FHP	3.25	3.72	AIWW 9/1+89	AIWW 10/1+33	2,456	2015	24,997	29,746
						N-FHP Total	**24,997**	**29,746**
I	3.96	4.53	B/33+39	B/3+65	2,973	2015	44,562	53,029
	4.67	4.94	A/25+22	A/11+02	1,420		4,842	5,763
	5.29	5.81	34/14+96	32/10+75	2,743		6,798	8,089
	6.60	6.82	30/10+61	29/8+37	1,167		7,549	8,983
	8.86	9.8	27T/4+62	27Q/8+43	4,955		35,284	41,988
	11.03	12.73	27M/1+96	27F/9+32	8,979		71,374	84,935
						Reach I Total	**170,409**	**202,786**
II	14.11	14.52	27C/20+84	27B/34+20	2,157	2015	685	816
	15.30	15.49	27A/18+29	27A/8+22	1,007		1,515	1,803
						Reach II Total	**2,200**	**2,619**
						Reaches N-FHP – II Total	**197,606**	**235,151**

[1]Pay Volume = 1.19 x Design Volume

As summarized, the estimated design and pay volumes of shoals within Reaches N-FHP, I and II of the Nassau County project area total 197,606 cy and 235,151 cy, respectively. **Figure 3.1** and **Figure 3.2** depict the shoal locations listed in **Table 3.2**.



REACH	SURVEY
CUT 27A -- N-FHP-11	SDI #13-2078

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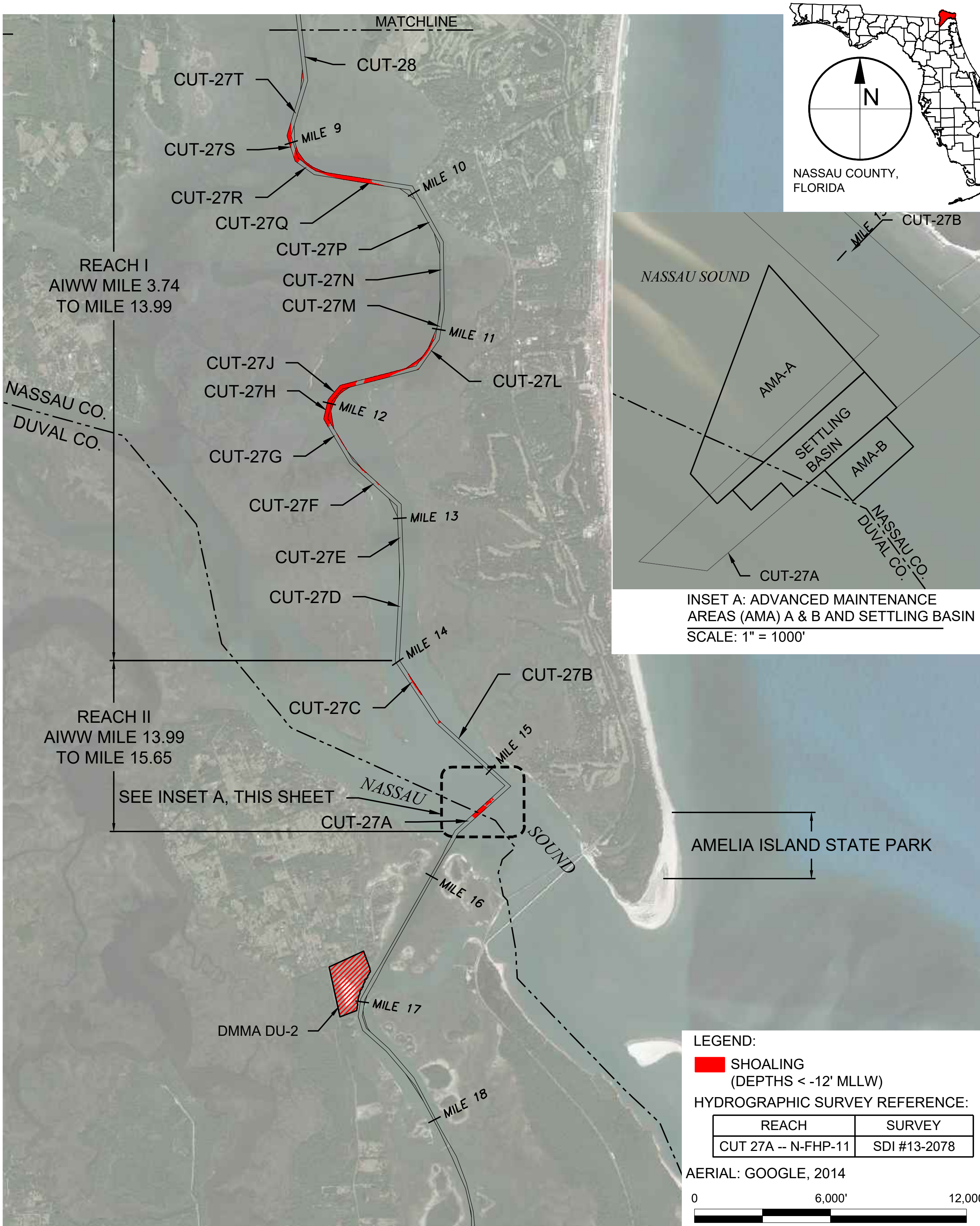
TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 3.1
RECENT SHOALS, REACHES N-FHP AND I
ATLANTIC INTRACOASTAL WATERWAY
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	3 of 9
DATE	DEC 2016



TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 3.2
RECENT SHOALS, REACHES I AND II
ATLANTIC INTRACOASTAL WATERWAY
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	4 of 9
DATE	DEC 2016

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3.3 Projected 50-Year Dredging and Material Storage Requirements

Sections 3.1 and **3.2** provide information to develop the projected 50-year dredging and material storage requirements for Nassau County Reaches N-FHP, I and II (**Table 3.3**). These projections were derived as follows. To project the corresponding 50-year maintenance requirement for the Nassau County project area, the shoal volumes (that is, the in situ pay volume of historic maintenance dredging and recently documented shoaling) over the 72-year period of record (1943 – 2015) were summed, converted to an annual shoaling rate, and then interpolated to 50 years. The resulting project dredging volumes of 20,657 cy, 278,711 cy and 566,116 cy for Reaches N-FHP, I and II correspond to the in situ or unbulked volume of dredging anticipated within each reach over the next 50 years. Translating the projected 50-year in situ volume into the volume of storage required to handle the dredged material requires application of a bulking factor.

Table 3.3 Projected 50-Year Dredging and Material Storage Requirements

REACH	LENGTH (MILES)	HISTORICAL MAINTENANCE PAY VOLUME (CY)	2015 SHOAL VOLUME (CY)	TOTAL VOLUME (CY)	VOLUME (CY/ YEAR) 1943-2015	VOLUME (CY/ YEAR/ MILE)	50-YEAR DREDGING REQUIRE-MENT (CY)	50-YEAR STORAGE REQUIRE-MENT (CY)
N-FHP	3.74	--	29,746	29,746	407	109	20,374	43,804
I	10.26	198,557	202,786	401,343	5,498	536	274,893	591,019
II	1.65	812,588	2,619	815,207	11,167	6,768	558,361	1,200,475
TOTAL	**15.65**	**1,011,145**	**235,151**	**1,246,296**	**--**	**--**	**853,627**	**1,835,299**

Bulking refers to the expansion of consolidated sediment that occurs as a result of dredging. Hydraulic dredging leads to material bulking by increasing the water content of the dredged material compared to its in situ consolidated state. After dredging and placement for long-term storage, the dredged material will begin to consolidate under its own weight. Given the appropriate conditions and sufficient time, the material may approach its original pre-dredging volume. The degree to which the material expands (bulks) depends on the physical characteristics of the sediment, as well as its relative consolidation before dredging. The present study (as well as the original 1986 report) applies a conservative factor of 2.0 to account for the increase in volume of the dredged material compared to its in situ volume. Consistent with USACE Jacksonville District experience and recommendations, an additional allowance of 15% of the original in situ volume accounts for non-pay volume (i.e., unauthorized) overdredging. Thus, multiplying the projected 50-year volume of required dredging by the effective bulking factor of 2.15 yields a projected 50-year material storage requirement of 43,804 cy, 591,019 cy, and 1,200,475 cy for Reaches N-FHP, I and II. **Table 3.4** compares these volumes to the volumes estimated from previous surveys and reports.

As summarized in **Section 3.2**, the projected 50-year material storage requirements for Reach I and II are based, in part, on the 2014 and 2015 survey data. Because the Reach I and II boundaries were adjusted in 2006 (i.e., Cut 27C moved from Reach I to Reach II) and the shoaling volumes from the N-FHP, AMA or SB were not included in previous analyses, the updated material storage requirements for each individual reach (**Table 3.3**) are not directly comparable to reach values prior to 2006 given in **Table 3.4**.

Table 3.4 Previously Reported 50-Year Material Storage Requirements

REACH	LENGTH[1] (MI)	50-YEAR STORAGE REQUIREMENT (CY)				
		2014/15	2004	2000	1996	1986
N-FHP	3.74	44,413[1]	--	--	--	--
I	10.26	599,228	796,003	653,228	819,399	429,003
II	1.65	1,217,149	464,717	612,976	266,957	215,215
TOTAL	**15.65**	**1,860,789**	**1,260,720**	**1,266,204**	**1,086,356**	**644,218**

[1]USACE recently approved a channel realignment at the southern end of Reach N-FHP will substantially reduce the dredging volume in this reach.

As shown, the projected 50-year storage requirement for Reach I in 2015 (i.e., 591,019 cy) is greater than that originally estimated in 1986, but less than the estimates made from 1996 – 2004. The reassignment of Cut 27 from Reach I to Reach II (Taylor et al., 2006) and the inclusion of the AMA and settling basin in the 2014 projections resulted in a lower volume in Reach I and greater volume in Reach II. Removal of the AMA-A, AMA-B, and SB material from the Reach II calculation would result in a nearly 300,000 cy reduction in the amount of Reach II historic maintenance material (**Table 3.1**). The total Nassau County AIWW projected 50-year storage requirement would fall to about 1,400,000 cy, a value similar to the values determined in 2004 and 2000.

3.4 Material Quality

In addition to projected material quantities, the long-range DMMP must also consider the physical and chemical properties of channel sediments. Techniques employed to maintain water quality during dredging and dewatering operations depend on the material's physical (i.e., particle site, specific gravity, etc.) and chemical characteristics. In addition, physical and chemical properties determine the dredged material's potential for reuse (e.g., beach placement, construction fill, landfill cover) and therefore, influence a dredged material management site's effective service life.

3.4.1 Sediment Physical Characteristics

Historically, USACE Jacksonville District only obtained channel sediment data as part of the planning process for scheduled channel maintenance operations, and then only within the proposed dredging template as required to obtain the state Water Quality Certification. The following paragraphs detail four known geotechnical sampling events — occurring in 1982, 1995, 2006, and 2009 — within Nassau County. **Table 3.5** summarizes the relevant physical sediment data derived from the three latter geotechnical investigations and **Figure 3.3** shows the location of the sampling locations data as they relate to the shoals identified in the recent surveys. In July 2016 the USACE collected geotechnical borings in Reach N-FHP; the results, unavailable at the time of this report, are expected in late 2016.

At the time of the 1986 Phase I *Long-Range Dredged Material Management Plan for the Intracoastal Waterway in Northeast Florida* study, sediment data for AIWW channel sediments within Nassau County were limited to qualitative drilling log descriptions of cores obtained by the USACE in anticipation of a planned 1982 channel maintenance operation. These qualitative data adequately characterized channel sediments within Nassau Sound (Reach II, Cuts 27A and 27B) as suitable for beach placement, while sediments well north of Nassau Sound (Reach I, Cuts 27G – 27K and Cuts 27Q – 28) contained excessive amounts of fine-grained material rendering them unsuitable for beach placement.

Table 3.5 Sediment Sampling Locations and Physical Characteristics

REACH	AIWW MILEAGE	YEAR	BORING ID	NORTHING	EASTING	DATUM	BORING ELEVATION (FT)		SOIL DESCRIPTION
				NAD83 FL STATE PLANE, EAST ZONE (FT)			TOP	BOTTOM	(DEPTH (FT): DESCRIPTION)[1]
I	4.02	2006	AIWW-NA05-CB-10	2,301,119	503,881	MLW	-8.6	-14.68	8.60 – 9.8: Gray fine grained sand (SP): 9.8 – 14.7: Mottled muddy sand
	4.18	2006	VB-AIWWNC06M-1	2,300,267	503,875	MLW	-6.3	-13.1	6.3 – 11.8: Sand, poorly-graded, mostly fine-grained sand-sized quarts, dry (SP); 11.8 – 12.1: Silt, inorganic-H, medium plasticity, firm, mostly silt, some fine-grained sand-sized quartz, moist (MH); 12.1 – 13.1: Clay, fat medium plasticity, firm, mostly clay, little fine-grained sand-sized quartz, moist (CH)
	4.74	2006	AIWW-NA05-CB-9	2,297,379	503,913	MLW	-9	-14	9.0 – 13.1: Gray fine grained sand with occasional mud lens (SP); 13.1 – 14.5: Gray muddy sand (SC)
	4.82	2006	VB-AIWWNC06M-2	2,296,940	503,873	MLW	-5.1	-12.8	5.1 – 12.8: Sand, poorly-graded, mostly fine to medium-grained sand-sized quart, trace shell, moist (SP)
	6.69	2006	AIWW-NA05-CB-8	2,288,082	504,304	MLW	-8.65	-14.15	8.7 – 12.8: Gray fine grained sand with occasional mud lens (SP); 12.8 – 14.2: Gray muddy sand (SC)
	6.7	2006	VB-AIWWNC06M-3	2,288,047	504,370	MLW	-4.5	-12.3	4.5 – 6.6: Sand, poorly-graded, mostly fine-graded sand-sized quartz, moist (SP); 6.6 – 7.7: Sand, silt, most fine-graded sand-sized quartz, little silt (SM); 7.7 – 8.6: Sand, poorly-graded, mostly fine-graded sand-sized quartz, moist (SP); 8.6 – 8.8: Sand, silt, most fine-graded sand-sized quartz, little silt (SM); 8.8 – 10.2: Silt, organic-L, medium plasticity, soft, mostly silt, some fine-grained sand-sized quartz, moist (OL); 10.2 – 12.0: Sand, poorly-graded, mostly fine-graded sand-sized quartz, moist (SP); 12.0 – 12.3: Silt, organic-L, low plasticity, soft, mostly silt, some fine-grained sand-sized quartz, moist (OL)
	8.93	2006	VB-AIWWNC06M-4	2,276,462	505,117	MLW	-5.4	-11.8	5.4 – 8.2: Sand, poorly-graded, mostly fine-graded sand-sized quartz, trace silt, moist (SP);8.2 – 11.8: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz, few silt, moist (SP-SM)
	9.09	2006	VB-AIWWNC06M-5	2,275,677	505,307	MLW	-8.9	-16.1	8.9 – 10.4: Sand, poorly-graded, mostly fine-grained sand-sized quart, trace silt, moist (SP); 10.4 – 11.4: Silt, organic-L, low plasticity, soft, mostly silt, little fine-grained sand-size quart, most (OL); 11.4 – 12.9: Sand, poorly-graded, mostly fine-grained san-sized quartz, trace silt, moist (SP); 12.9 – 15.6: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz, few silt, moist (SP-SM); 15.6 – 16.1: Shell, mostly sand to gravel-sized shell, little fine-grained sand-sized quartz, little silt, moist
	9.1	2006	AIWW-NA05-CB-7	2,275,622	505,301	MLW	-9.2	-14.7	9.2 – 9.9: Black muddy sand with minor shell (SC); 9.9 – 14.7: Gray fine grained sand with occasional mud lenses (SP)

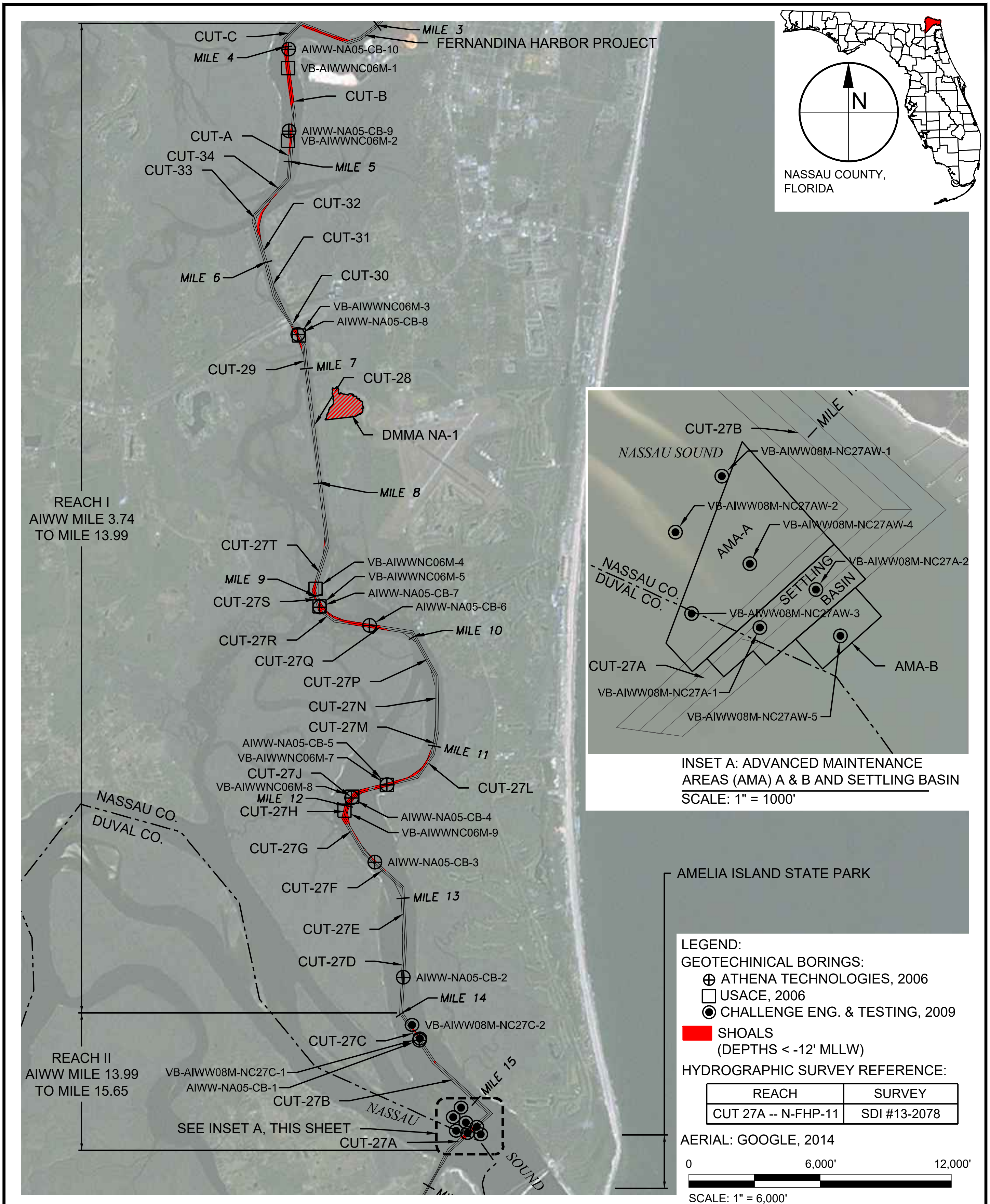
Table 3.5 Sediment Sampling Locations and Physical Characteristics Continued

REACH	AIWW MILEAGE	YEAR	BORING ID	NORTHING	EASTING	DATUM	BORING ELEVATION (FT)		SOIL DESCRIPTION
				NAD83 FL STATE PLANE, EAST ZONE (FT)			TOP	BOTTOM	(DEPTH (FT): DESCRIPTION)[1]
I	9.58	2006	AIWW-NA05-CB-6	2,274,780	507,588	MLW	-11.3	-17.58	11.33 – 15.5: Dark gray mud (CH).; 15.5 – 17.6: Dark gray mixed sand, mud and shell fragments (SC)
	11.58	2006	AIWW-NA05-CB-5	2,267,521	508,393	MLW	-9.6	-16.68	9.6 – 11.52: Dark gray muddy sand. Mud decreasing downcore (SC); 11.52 – 13.3: Medium gray fine sand with minor shell. Muddy. (SP). 13.3 – 16.7: Interbedded sand and mud (SC).
	11.58	2006	VB-AIWWNC06M-7	2,267,512	508,386	MLW	-10.3	-17.3	10.3 – 12.0: Silt, organic-L, low plasticity, soft, mostly silt, some fine-grained sand-sized quart, moist (OL), 12.0 – 15.1: Sand, silt, mostly fine-grained sand-sized quart, little silt, moist (SM) [from 12.2 – 14.6, most fine-grained sand-sized quart, some silt, moist]; 15.1 – 16.0: Clay, fat high plasticity, firm, mostly clay, little fine-grained sand-sized quart (CH); 16.0 – 16.4: Shell, mostly fine gravel-sized shell, few silt; 16.4 – 17.3: Clay, fat, high plasticity, firm, mostly clay (CH)
	11.9	2006	VB-AIWWNC06M-8	2,266,979	506,810	MLW	-7.7	-14.1	7.7 – 9.5: Sand, poorly-graded, mostly fine-grained sand-sized quart, trace silt, trace shell, moist (SP); 9.5 – 13.1: Sand, poorly-graded with silt, mostly fine-grained sand-sized quart, few silt, moist (SP-SM); 13.1 – 13.3: Sand, poorly-graded, mostly fine-grained sand-sized quartz, trace shell, moist (SP), 13.3 – 14.1: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz, few silt, moist (SPM-SM)
	11.92	2006	AIWW-NA05-CB-4	2,266,909	506,763	MLW	-8.95	-19.45	8.9 – 18.5: Olive gray, fine to very fine grained sand with mud lens increasing downcore (SC); 18.5 – 19.5: Gray sand and shell mix
	12.05	2006	VB-AIWWNC06M-9	2,266,328	506,455	MLS	-9.9	-15.7	9.9 – 11.9: Sand, poorly-graded, mostly fine-grained sand-sized quartz, trace silt, moist (SP); 11.9 – 14.0: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz, few silt, moist (SP-SM); 14.0 – 14.6: Sand, silt, mostly fine-grained sand-sized quart, some silt, moist (SM); 14.6 – 15.5: Silt, inorganic-L, low plasticity, very soft, mostly silt, little fine-grained sand-sized quartz, moist (ML); 15.5 – 15.7: Sand, silt, mostly fine-grained sand-sized quart, some silt, moist (SM)
	12.58	2006	AIWW-NA05-CB-3	2,263,974	507,822	MLW	-14.1	-22.6	14.1 – 15.4: Dark gray fine to very fine gained sand. Muddy at top (SC); 15.4 – 17.6: Olive gray fine to very fine grained sand with shell and mud lenses (SC); 17.6 – 20.7: Olive gray sand and shell mix. Muddy. 20.687 – 22.6: Gray, fine sand with occasional mud lenses.

Table 3.5 Sediment Sampling Locations and Physical Characteristics Continued

Reach	AIWW Mileage	Year	Boring ID	Northing	Easting	Datum	Boring Elevation (ft)		Soil Description
				NAD83 FL State Plane, East Zone (ft)			Top	Bottom	(Depth (ft): Description)[1]
II	13.69	2006	AIWW-NA05-CB-2	2,258,715	509,120	MLW	-14.9	-21.07	14.9 – 18.4: Olive gray, interbedded sand and mud (SC); 18.4 – 24.7: Tan/gray, clean, fine grained sand (SP)
	14.13	2009	VB-AIWW08M-NC27C-2	2,256,541	509,528	MLLW	-8.8	-18.8	8.8 – 14.2: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP); 14.2 – 15.5: Sand, silty, most fine-grained sand-sized quart (SM); Sand, poorly-graded with silt, mostly fine-grained san-sized quart, trace sub angular sand to gravel-sized shell up to ¼" (SP-SM)
	14.27	2009	VB-AIWW08M-NC27C-1	2,255,915	509,882	MLLW	-7.3	-17.3	7.3 – 15.4: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)
	14.28	2006	AIWW-NA05-CB-1	2,255,840	509,864	MLW	-10.6	-15.35	10.6 – 15.4: Tan/gray, clean, fine grained sand (SP)
	14.95	2009	VB-AIWW08M-NC27AW-1	2,252,750	511,768	MLLW	-6.6	-16.6	6.6 – 16.6: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)
	15.33	2009	VB-AIWW08M-NC27A-2	2,251,886	512,484	MLLW	-10.6	-20.6	10.6 – 18: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)
	15.35	2009	VB-AIWW08M-NC27AW-5	2,251,533	512,671	MLLW	-12.7	-22.7	12.7 – 17.6: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP); 17.6 – 19.1: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz (SP-SM); 19.1 – 20.1: Sand, poorly-graded, mostly fine-grained sand-sized quartz
	15.38	2009	VB-AIWW08M-NC27AW-4	2,252,082	511,981	MLLW	-10	-20	10 – 17.4: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)
	15.43	2009	VB-AIWW08M-NC27AW-2	2,252,321	511,415	MLLW	-1	-11	1.0 – 8.7: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP); 8.7 – 9.2: Sand, poorly-graded with silt, mostly fine-grained sand-sized quartz, moist (SP-SM)
	15.43	2009	VB-AIWW08M-NC27A-1	2,251,597	512,057	MLLW	-10.6	-20.6	10.6 – 18.3: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)
	15.49	2009	VB-AIWW08M-NC27AW-3	2,251,702	511,538	MLLW	-8.3	-18.3	8.3 – 15.9: Sand, poorly-graded, mostly fine-grained sand-sized quartz (SP)

[1]Refer to the referenced geotechnical report(s) for complete description of the borings.



ANTON X:\SYS\PROJECTS\C2013-031 NA-DU DMMP\FIGURES\C2013-031-F-NASSAU SAMPLING.DWG 12/16/2016 4:01:23 PM

TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 3.3
GEOTECHNICAL BORING LOCATIONS
ATLANTIC INTRACOASTAL WATERWAY
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	5 of 9
DATE	DEC 2016

In 1995, USACE obtained more extensive, quantitative physical data in anticipation of 1997 channel maintenance. In addition to drilling logs, this data set included grain-size distributions and suspended sediment settling curves. Like the earlier data, these data only characterized the shoal material targeted for removal and, as a result, only covered from Cut 27C southward in Reach II. However, in contrast to the 1982 data, these data identified the material within Cuts 27C – 27A as uniformly fine to medium sand, with mean grain-size diameters ranging from 0.12 mm to 0.20 mm. The fine-grained silt and clay sized component of each sample (that is, the portion of each sample passing a #200 sieve or with a diameter <0.074 mm) remained ≤3% with one exception. One sample from Cut 27A recorded a fine-grained component of 7%. Thus, these data indicate that the sediments throughout Reach II appear suitable for beach placement.

As part of the 2006 Reach I reinvestigation, both FIND, through its geotechnical subcontractor (Athena Technologies, Inc.), and USACE collected a series of 17 vibracores to supplement limited existing USACE sediment data in Nassau County. In addition to documenting sediment conditions within Reach I, the sediment sampling and analyses program investigated the northward extent of channel sediments suitable for beach placement. Under the Unified Soil Classification System (USCS), the silt- and clay-sized component of each sample ranged from 1.5 to upwards of 90%. With exception of boring AIWW-NA05-CB-01 within Cut 27C, each core within Reach I contained at least one stratum with a fine-grained component exceeding 10%. The presence of these fine-grained strata likely renders sediment north of Cut 27C (i.e., Reach I) ineligible for beach placement. FDEP typically requires less than 10% fines suitable for beach placement material; however, depending on the site-specific conditions, the agency may allow material with additional silt content.

Finally, in 2009, in conjunction with the aforementioned bathymetric survey and in anticipation of 2013 channel maintenance, USACE, through its subcontractor (Challenge Engineering & Testing, Inc.), obtained nine vibracores in Nassau County. As a result of this sampling effort, nearly all of the maintenance material dredged in 2013 was deemed beach compatible.

3.4.2 Sediment Chemistry

This section focuses on the chemical characteristics of Nassau County AIWW sediments. Chemical contaminants enter Nassau County coastal waters from non-point (agricultural and urban storm water runoff, atmospheric pollutant deposition, marine craft operations, etc.) and point (industrial and municipal wastewater effluent, etc.) sources. Contaminants, over time, may accumulate in the underlying sediments. Sediment-associated contaminants prevalent in urbanized areas include metals (e.g., arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury), pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). Some natural sediment constituents, such as metals, should only qualify as contaminants when their concentrations exceed natural levels. PAHs may have natural or human origins. Other constituents, such as pesticides and PCBs that do not occur naturally, may qualify as contaminants when present at any concentration. However, the presence of a contaminant does not necessarily indicate that it will cause adverse effects during dredging or dredged material placement. Expression of contaminant effects depends on a variety of factors including the contaminant concentration and chemical properties and other sediment characteristics (e.g., type of sediment, grain size, and organic content). In particular, fine-grained sediments tend to adsorb hydrophobic contaminants and therefore may likely contain potentially toxic concentrations. As an initial screening, Taylor et al. (2006) evaluated sediment quality information with interpretive tools developed by FDEP. Given that Reach II has been established as having beach-quality sediments, the objective of the 2006 screening was to determine whether AIWW sediments within Nassau County Reach I contain contaminants at levels that would require additional investigation or might necessitate special dredging and sediment handling procedures. Thus, one sample from the finest-grained stratum (from the 2006 sediment collection effort) from the six boring locations was sent to a certified laboratory for chemical analysis.

3.4.2.1 Sediment Analytical Results

Metals

Severn-Trent Laboratories, Inc. (now known as TestAmerica Laboratories, Inc.), under contract to Taylor Engineering, Inc., analyzed the six submitted samples for nine sediment metals by atomic adsorption or inductively coupled plasma spectroscopy following hydrofluoric acid sediment digestion. One of these metals (aluminum) is considered a major element naturally abundant in most geologic formations. Human activities may enrich concentrations of the other eight metals, considered trace elements and potential contaminants. Only metal concentrations that exceed natural levels qualify as pollutants. The natural occurrence of metals at variable concentrations complicates the evaluation of metal values. However, FDEP has described a method for determining natural ranges of metal concentration based on statistical relationships between metals and a common reference element, aluminum (Schropp and Windom, 1988). These relationships permit the calculation of metal enrichment ratios (i.e., the ratio of measured metal concentration to maximum predicted natural concentration), where enrichment ratios greater than one indicate that a metal exceeds the natural range. **Table 3.6** lists metal enrichment ratios for the six samples submitted for chemical analyses. Enrichment ratios (less than one) for all metals in all samples indicate these metals fall within natural ranges.

Table 3.6 Metal Enrichment Ratios of Sediment Samples

BORING ID	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	NICKEL	ZINC	MERCURY
CB-05	0.17	0.48	0.28	0.15	0.44	0.18	0.54	0.05
CB-06	0.19	<0.38[1]	0.35	0.22	0.50	0.26	0.68	0.12
CB-07	0.07	<0.25	0.19	0.11	0.34	0.10	0.52	0.05
CB-08	0.15	0.36	0.23	0.20	0.41	0.14	0.55	0.06
CB-09	0.14	<0.28	0.17	0.15	0.41	0.09	0.56	0.05
CB-10	0.15	0.35	0.22	0.12	0.40	0.14	0.49	0.43

[1]Metal enrichment ratios were calculated with detection limit values.

Another approach to interpreting contaminant concentrations in coastal sediments is based on the likelihood of a contaminant causing adverse effects on aquatic organisms. To evaluate the potential for biological impact, FDEP prepared biological effects-based sediment quality guidelines for several metals, pesticides, PAHs, and other compounds (MacDonald, 1994). The Threshold Effects Level (TEL) indicates a contaminant concentration below which adverse effects appear unlikely. The Probable Effects Level (PEL) represents a concentration above which adverse effects usually occur. **Table 3.7** lists the PEL, TEL, and measured metal concentrations in the Nassau County ICWW samples. Metal concentrations in all six samples fell below the TEL.

Table 3.7 Metal Concentrations of Sediment Samples [ppm]

BORING ID	ALUMINUM	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	NICKEL	ZINC	MERCURY
CB-05	3,700	3.0V[1]	***0.18***[2]	9.3	***1.9***	3.0	***2.2V***	9.4	<0.011
CB-06	9,900	6.5V	<0.19	20.0	***4.4***	7.0	***4.7V***	24.0	***0.026***
CB-07	1,500	***0.76V***	<0.073	3.8	***0.88***	1.2	***0.83V***	4.8	***0.011***
CB-08	2,500	2.1V	***0.12***	6.0	***2.1***	2.1	***1.5V***	7.3	***0.012***
CB-09	1,000	***1.1V***	<0.074	2.7	***1.0***	1.1	***0.69V***	3.9	<0.0099
CB-10	3,500	2.7V	***0.13***	7.2	***1.4***	2.6	***1.7V***	8.2	<0.0098
TEL[3]	--	7.24	0.676	52.3	18.7	30.2	15.9	124.0	0.130
PEL[4]	--	41.60	4.210	160.0	108.0	112.0	42.8	271.0	0.696

[1]"V" indicates that the analyte was detected in both the sample and the associated method blank.; [2]Numbers in ***bold italic*** indicate values between the method detection limit and the practical quantitation limit; [3]TEL – Threshold effects level from MacDonald (1994); [4]PEL – Probable effects level from MacDonald (1994)

Pesticides, PAHs, and PCBs

Severn-Trent labs also analyzed the 6 submitted samples for 26 individual chlorinated compounds (20 organochlorine pesticides and 7 PCB analytes) and 18 aromatic compounds (PAHs) by EPA Methods 3550B/8081A, 3550B/8082, and 3550B/8270C. Chlorinated pesticides and PCBs were below detectable limits in all six of the sediment samples. No pesticides or PCBs were detected above the TEL. Trace amounts of PAHs were detected in all six of the samples. **Table 3.8** summarizes the concentration of PAHs and the associated TEL and PEL. Sediment sample concentrations of PAHs at all six sampling locations fell below the TEL.

Table 3.8 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations of Sediment Samples [ppm]

ANALYTE	CB-05	CB-06	CB-07	CB-08	CB-09	CB-10	TEL/PEL[3]
1-Methlnaphthalene	<0.48	<0.58	<0.43	<0.47	<0.45	<0.44	NG[4]
2-Methylnaphthalene	<0.42	<0.51	<0.38	<0.41	<0.39	<0.39	20.2/201
Acenaphthene	<0.32	<0.39	<0.29	<0.32	<0.30	<0.30	6.7/88.9
Acenaphthylene	<0.42	<0.51	<0.38	<0.41	<0.39	<0.39	5.9/128
Anthracene	<0.61	<0.74	<0.54	<0.59	<0.56	<0.56	46.9/245
Benzo(a)anthracene	<0.42	<0.51	<0.38	<0.41	<0.39	<0.39	74.8/693
Benzo(a)pyrene	<0.52	<0.63	<0.47	<0.51	<0.48	<0.48	88.8/763
Benzo(b)fluoranthene	<0.51	8.0V[2]	<0.46	<0.50	<0.47	<0.47	NG
Benzo(g,h,i)perylene	<0.20	<0.24	<0.18	<0.19	<0.18	<0.18	NG
Benzo(k)fluoranthene	<0.45	<0.55	<0.40	<0.44	<0.42	<0.42	NG
Chrysene	<0.30	*5.4*V	<0.27	<0.29	<0.28	<0.27	108/846
Dibenz(a,h)anthracene	<0.34	<0.41	<0.30	<0.33	<0.31	<0.31	6.2/135
Fluoranthene	*3.6*[1]	15V	*4.3*V	*5.0*V	*1.1*V	<0.39	113/1490
Fluorene	<0.34	<0.41	<0.30	<0.33	<0.31	<0.31	NG
Indeno(1,2,3-cd)pyrene	<0.42	<0.51	<0.38	<0.41	<0.39	<0.39	NG
Naphthalene	<0.44	<0.53	<0.39	<0.43	<0.41	<0.40	34.6/391
Phenanthrene	<0.59	<0.72	<0.53	<0.58	<0.55	<0.55	86.7/544
Pyrene	*3.5*	17V	*4.7*V	14V	*1.9*V	*0.80*V	153/1400

[1]Numbers in *ITALICS* indicate values between the method detection limit and the practical quantitation limit; [2] "V" indicates detected analyte in both the sample and the associated method blank; [3]TEL – Threshold effects level; PEL – Probable effects level from MacDonald (1994); [4] NG = FDEP has not established TEL & PEL sediment quality assessment guidelines.

Total Recoverable Petroleum Hydrocarbons

In addition to the chemicals discussed above, analysis of total recoverable petroleum hydrocarbons (TRPH) (EPA Method 3550B/FL-PRO) indicated whether the Waterway sediments in Nassau County contain atypical concentrations of these chemicals. Two samples contained detectible TRPH concentrations (12 and 14 ppm). Currently no interpretive tools exist for TRPH. However, the detected values fall well below the FDEP's soil cleanup guidelines for TRPH (340 ppm residential, 2,500 ppm industrial).

3.4.2.2 Summary

The results of this initial sediment quality screening show that the AIWW channel within Nassau County generally contains uncontaminated sediments. Based on these results, dredging and dredged material placement operations within AIWW Reach I in Nassau County should not require additional sediment chemistry investigation or necessitate special dredging and sediment handling procedures. The coarser, beach quality, Reach II sediments are unlikely to contain contaminants and should not require chemical testing.

4.0 DMMA DESIGN AND CONSTRUCTION

With the foundation of the DMMP established (**Chapter 2.0**) and the update of the 50-year maintenance dredging and storage requirements complete (**Chapter 3.0**), this section of the report focuses on providing a design and operational overview of the selected upland dredged material placement site — DMMA NA-1.

The selection of DMMA NA-1 was based on the site's capability to best satisfy three primary categories of consideration — engineering/operational, environmental, and socioeconomic/cultural. The following section details these considerations and how they factored into the design life cycle —preliminary design, permitting, and final design and construction — of the DMMA. This section also includes a location map, plan view, and representative cross-sectional drawings depicting the as-built site condition and a tabular summary of primary site characteristics (i.e., location, reach, DMMA design, and access).

4.1 DMMA NA-1

The 35.5-acre DMMA NA-1 — located east of the AIWW, west of the Fernandina Beach Municipal Airport, and on the north end of Crane Island — will receive, dewater, and temporarily store sediments dredged from the AIWW Nassau County Reach I. FIND acquired the DMMA NA-1 site in 1988, permitted the DMMA construction in 2011, and constructed the site in 2013. As of April 2014, the FIND has acquired an operational permit necessary to receive and dewater dredged sediment at DMMA NA-1.

4.1.1 Preliminary Design

Engineering/Operational. Due to FIND's commitment to the environmental and socioeconomic criteria, the 35.5-acre DMMA NA-1 site, despite best efforts, was unable to meet the projected 50-year dredged material handling (223,987 cy) and storage (481,572 cy) requirements. As outlined below, shielding the site from view of Nassau County residents (both from the SR-A1A bridge and future residential development to the south), limiting wetland impacts, and limiting dike height due to Federal Aviation Administration (FAA) requirement reduced the overall DMMA capacity to 186,754 cy (approximately 38% of the desired 50-year storage requirement). Thus, the site must be offloaded more frequently than once every 50 years. Given the historical maintenance and in situ volumes, the site may require offloading after each maintenance operation or prior to subsequent use. Further, in May 2016 the USACE approved a "best water" channel adjustment that resulted in a net shoal volume reduction of ±100,000 cy for the Reach I maintenance event (expected to occur in early 2017) and that should substantially reduce future maintenance dredging volumes.

With respect to other engineering/operational issues of pumping distance and road and pipeline access issues, DMMA NA-1 site at AIWW Mile 7.4 lies in the northern one-third of the 10.26-mile reach; thus, the maximum pumping distance expected (to the southern end of the reach) is approximately 6.5 miles. FIND was able to resolve road access to the site through a November 2008 easement with the owners of the adjacent residential development. Via this agreement, the owners of the Crane Island Development will construct and maintain permanent access roads and bridges from Bailey Road to DMMA NA-1. As the site lies immediately on the Waterway, a pipeline easement was not necessary.

Environmental. While meeting minimum engineering/operational requirements, the basin was configured to minimize environmental impacts. The pre-construction condition of the site comprised a natural maritime hammock on the west and a remnant dredged material placement site (placed between 1943 and 1960) on the east. A 3.21-acre saltmarsh community rims the north, west, and east boundaries of the site; an undeveloped property (designated for future residential development) borders the south and immediate east boundary of the site. Additional wetland features included a north-south oriented 0.63-acre inland pond and slough, created between the natural island and remnant dredged material placement site, and a surrounding 5.92-acre mixed wetland hardwood community. The resulting basin configuration produced the fewest wetland impacts and thus, was successfully positioned above the surveyed Mean High Water (MHW) line. To offset the 1.87 acres of wetland impacts to inland pond and slough and mixed wetland hardwood, FIND purchased 1.27 mitigation bank credits at the Longleaf Mitigation Bank.

Socioeconomic/Cultural. Finally, the containment basin's placement within the site had to provide adequate separation from adjacent properties. The minimum required 100-ft buffers between NA-1, the proposed Crane Island Development to the south, and the AIWW reduced the total site construction area from its original 35.5 acres to 19.5 acres. In addition, because DMMA NA-1 lies near the Fernandina Beach Municipal Airport, the FAA — via a January 2004 Aeronautical Study No. 2003-ASO-6038-OE — restricted the dike height to a maximum of 16 ft above existing grade. Finally, inquiry to the Florida Department of State, Division of Historical resources confirmed that the Florida Master File records did not show any archaeological sites within the project area on the northern end of Crane Island (letter from George W. Percy, Historical Resources Director and State Historic Preservation Officer, dated March 9, 1995). The Division of Historical Resources further stated that an archaeological survey should precede clearing or excavating activities. Between September and October 1995, the USACE performed an archaeological survey of the DMMA NA-1 site and found no archaeological or historic sites within the project area.

In summary, these cumulative restrictions, along with reducing the environmental impacts to the greatest extent possible, reduced the available capacity, including the 2-ft freeboard and 2-ft ponding depth[3], to 186,754 cy.

4.1.2 Easements and Permits

FIND's acquisition of easements and permits for the site included coordination with the adjacent landowners for site access, FDEP, USACE, and USFWS. The road access easement agreement with the adjacent landowners includes several conditions that will require FIND's action pre-, during, and post-dredging operations. Per the easement agreement, FIND must monitor and model the groundwater and surface water system for the "probable extent of contaminant and saltwater migration into the groundwater lens of Crane Island'; however, due to previously identified on-site saline water, a June 2016 memorandum (from The Range at Crane Island, "TRCI") removed the requirements as listed in Section 4.5 Contaminant and Salt Water Intrusion." The easement also outlines restrictions on time of access, noise abatement, and material hauling. The easement conditions must be included in any future dredging or offloading contracts

[3] Freeboard, in this instance, refers to the depth between the water surface and the top of dike. Ponding depth refers to the height of the water column (with its suspended sediment load) which is maintained above the depositional surface during dredging and disposal operations.

involving this site. Additionally, the agreement allows the use of the DMMA by the adjacent landowners to dewater material from planned boat basin dredging.

FIND acquired the construction permits for the DMMA NA-1 facility in 2011. While this section is not intended to be all encompassing, the following paragraphs summarize, by regulatory agency, unique permit conditions of the DMMA NA-1. As of April 2014, an operational permit was active for this facility.

FDEP Permit No. 45-291060-002-EI
DMMA Operation Condition No. 21. "The permittee shall operate the weirs to meet the following water level control requirements: a. Minimum freeboard of 4 ft; b. Minimum ponding depth of 2 ft."

Note: Due to an updated seepage and slope stability analysis (November 2012) and revised DMMA design during construction, FIND has requested a permit modification to revise this condition to a minimum freeboard of 2 ft. With this revision, the capacity of DMMA NA-1 will increase from 132,857 cy to 186,754 cy.

DMMA Operation Condition No. 22. "To ensure the dam safety and the disposal area is functioning as designed and permitted, the permittee shall provide for P.E inspections during each calendar year (January 1 – December 31) of the followings but not limited to:

a. The condition of the weir structure, the outflow and inflow pipeline.
b. Evidence of erosion and seepage.
c. Adequate vegetative cover on the exposed surface of the dam."

DMMA Operation Condition No. 23. "The permittee shall submit the inspection report to the Department within 30 days from the date of inspection certifying that the disposal area is operating as designed. In addition, the permittee shall state in the report what operational maintenance has been performed during the previous year. The inspection is not required if the site did not operate during the calendar year, however, the permittee shall notify the Department that the site was inactive for the calendar year. If the site has not been operating for 2 years or more, the permittee shall provide the Department a P.E. inspection report prior to resuming operation."

USACE Permit No. SAJ-2008-03402 (SP-BAL)
No unique features were identified in this permit.

Lastly, FIND also acquired a USFWS permit (No. MB37624A-0) on July 2011. This permit provided FIND the authorization to disturb a pair of bald eagles (nest number NA911) during non-nesting season (May 15 – September 30). The permit did not authorize take or injury of the bald eagles or eggs and it required eagle monitoring during site construction. Any future use of this site may require coordination with USFWS.

4.1.3 Final Design and Construction

Carrying forward the preliminary design and permitting features that inherently include the original engineering/operational, environmental, and socioeconomic/cultural criteria, the final design and construction phase of the DMMA NA-1 facility included design analysis of earthwork (i.e., dike, ramps, perimeter road, perimeter ditch), stormwater control, dike erosion and vegetation, weir design, and site security. Included in the earthwork analysis were a geotechnical investigation, DMMA seepage and slope stability analysis, and a consolidation analysis. While the rationale behind each engineering decision is not detailed herein, all safety factors met the minimum requirements specified in the USACE Engineering Manual (EM 1110-2-1901). The following sections detail the subsurface geotechnical investigation, earthwork design, weir design, environmental considerations, and site security features.

Geotechnical Investigation

A March 2010 geotechnical investigation revealed that the eastern half of the site contained previously deposited dredged material comprising very soft clayey sand to sandy clay layers of variable thickness and extending to an elevation of -5 to -10 ft NAVD. The western portion of the site consisted of predominantly natural, clean sandy soils to elevations of +36 to -20 ft NAVD. The western-side borings also revealed varying thickness layers of dark brown cemented sand, clayey sand to sandy clay, and cemented shell or limestone.

Earthwork

Considering the subsurface conditions and the maximum basin footprint, the final dike specifications included a minimum crest elevation of +18.5 ft NAVD, or 12.5 ft above the existing mean site elevation of +6 ft NAVD, a dike crest width of 15 ft, 3H:1V side slopes, and a bottom basin elevation of 0 feet NAVD. Due to the sub-surface presence of thick clay layers, particularly on the east side of the site, the final site design included 40-ft wide interior toe berms and a perimeter interior toe drain to meet the minimum required slope stability safety criteria. Excavating the basin interior to a mean elevation of 0 ft NAVD — 6 ft below the existing mean grade elevation of the basin footprint — provided the majority of the material for dike and ramp construction. Remaining material needed for dike construction originated from the partial offloading of DMMA DU-2. With the containment basin filled to capacity, the surface of the deposition layer will lie a minimum 4 ft below the dike crest (i.e., 14.5 ft NAVD), allowing a minimum 2 ft of freeboard and 2 ft of ponding. A 12-ft wide stabilized road, lying on the inside of an 8-ft wide perimeter ditch, designed to collect and treat stormwater runoff, provides access to the DMMA's perimeter features. An additional feature of the containment dike is a ramp to provide ingress and egress to and from the interior of the containment area. The outside slope of the ramp and the slope of the supporting toe maintain the same 3H:1V slope as the main dike. The ascending/descending grade is 20H:1V. These ramps allow the removal of the dewatered dredged material from the DMMA without disturbing the overall structural integrity of the system.

To accelerate the time rate of consolidation for the clay-laden soils beneath the dike, final design and construction included the installation of wick drains at a maximum 3-ft triangular spacing. Finally, to account for the post-construction settlement of the underlying foundation soils, the eastern side of the dike was overbuilt by 2 ft (i.e., 20.5 ft NAVD top elevation). With the wick drains in place, the minimum 80% level of consolidation required before use of the DMMA was expected to occur about 6 – 8 months post-construction. The actual magnitude and time rate of settlement of the dike site was monitored (via the use of settlement plates, Sondex casing, and pore water pressure transducers) by Dunkelberger Engineering & Testing, Inc. (DET) between 2013 and 2016. As of the date of this report, DET completed post-construction monitoring of the site in July 2016 when the site met the consolidation requirements to function as a fully-operational DMMA. Over the long-term site operation and maintenance of the site, periodic monitoring of site consolidation is recommended.

Weir

Several aspects of weir design strongly influence the efficiency of solids retention and quality of effluent released from the DMMA NA-1. These include weir type, weir crest length, and the location of the weirs within the containment area.

The type of weir structure employed at the DMMA NA-1 site represents a compromise between considerations of performance, adjustability, maintenance, and economy. The weir structure consists of two 4-ft by 4-ft sharp-crested box-weirs and a high-density polyethylene (HDPE) discharge pipe penetrating through the perimeter dike at the site's southwest corner. Each box weir will provide for the release of effluent over the sharp-crested 16-ft weir section, for a total minimum crest length of 32 ft. The 14.5-ft NAVD weir crest elevation (located 4 ft below the top of the dike crest) is adjustable by means of removable boards. Composite boards, stored in a secure on-site container and inserted into the weir structure during operation, provide the ability to control the ponding depth and thus, the retention time within the containment basin. A 24-in diameter manifold connects the two weirs, each containing a 24-in diameter culvert, with a single outlet pipe passing under the dike in the southwest corner of the containment basin.

The specification of a minimum weir crest length of 32 ft is based on USACE guidelines related to the dredging equipment. Weir crest length, and all project calculations, assume the use of a 24-in outside diameter (O.D.) dredge (discharge velocity of 16 ft/sec, volumetric discharge of 6,430 cy/hr, and a 20/80 solids/liquid slurry mix) for future channel maintenance. However, the physical constraints of the channel will most likely dictate the use of a 15 – 18-in O.D. dredge. Therefore, the assumption of a 24-inch dredge ensured a conservative disposal site design. Analysis of weir performance based on nomograms (or alignment charts) developed at the USACE Waterways Experiment Station (WES) under the Dredged Material Research Program (DMPR) (Walski and Schroeder, 1978) indicated that the weir design parameters described above will produce an effluent suspended sediment concentration of 0.4 g/L, assuming an average ponding depth of 2 ft. Relating suspended solids concentration to the State of Florida turbidity-based effluent water quality standard is problematic because turbidity depends highly on the physical characteristics and concentration of the suspended material. However, WES guidelines (Palermo, 1978) indicate that 0.4 g/l should result in turbidity values well below the Florida standard.

The final weir design parameter considered was the location of the weirs within the DMMA to maximize the distance from the dredge pipe inlet and minimize the return distance to the AIWW. The latter requirement allows the effluent to discharge from the containment area by gravity flow. As designed, distance between the weir and the inlet provides for a maximum ±800-ft separation. Based on the weir location, an analysis of the containment area and its efficiency was performed. Assuming a 57% basin efficiency (length to width ratio – Gallagher and Company, 1978), a 2-ft mean ponding depth provides a basin retention time of 8.2 hours. For a settling time of 3.43 in/hr and a 2-ft ponding depth, fine sediments in the DMMA will settle to acceptable levels within 7 hours. If effluent quality deteriorates below the ambient conditions of receiving waters, steps shall be taken to decrease effluent turbidity. These include intermittent dredge operation, increased ponding depth, or the use of turbidity curtains surrounding the site outlet weirs.

Environmental

After clearing and grubbing activities and approximately two years before construction, an eagle pair constructed a nest in a wetland area on the site. The following year, a strong storm knocked the nest down after FIND had acquired a take permit through USFWS. The eagles subsequently reconstructed their nest in the buffer area at the southwest site corner. Eagle protection precautions (i.e., buffer maintenance and monitoring by qualified staff) during construction allowed the nest to remain undisturbed in the southwest site corner. Future eagle monitoring may become necessary once Reach I maintenance activities are underway.

Site Security

Site security measures will restrict access, prevent vandalism and damage to site facilities, and ensure public safety. As shown in **Figure 4.2**, permanent security fencing erected around the site's perimeter and locked gates will control access to the DMMA. FIND has authorized access to the site and is the only agency able to grant temporary access to authorized parties on an as-needed basis. Notably, site security is most critical during dredging and decanting operations. Therefore, a qualified facility operator must remain at the site at all times during dredging and decanting operations following a dredging event.

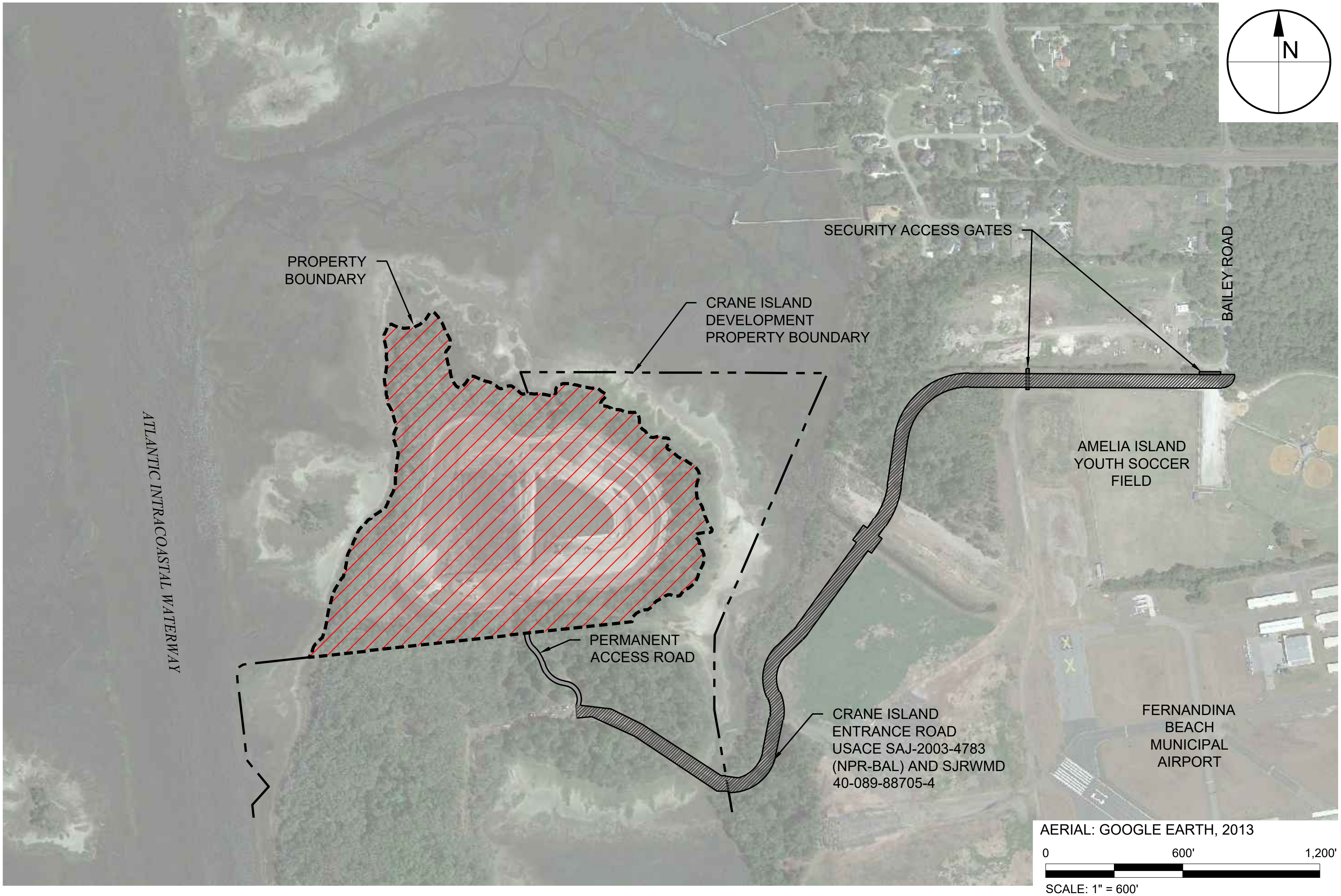
The primary goal of the upland DMMA is to provide sufficient capacity to receive, dewater and temporarily store sediments dredged from an adjacent reach; **Table 4.1** provides a quantitative summary of the design and current storage capacity of DMMA NA-1. As outlined above, DMMA NA-1 has a 50-year storage capacity deficit of ±295,000 cy. This table also provides a summary of the location, reach, and DMMA features along with a narrative of unique site features. **Figures 4.1 – 4.3** provide a location map, an as-built plan, and cross-sectional detail of the DMMA NA-1 facility.

Table 4.1 DMMA NA-1 Site Data Summary Sheet

LOCATION			
Also Known As	**Crane Island (S/A 43 – 44)**		
Section/Township/Range	**19 / 2N / 28E**	East/West of Waterway	**East**
County	**Nassau**	Municipality	**Fernandina Beach**
REACH			
Designation	**I**	Projected Dredging Frequency	**15 years**
Length (mi)	**10.26**	50-Year Dredging Requirement (cy)	**223,987**
Mileage	**3.74 to 13.99**	50-Year Storage Requirement (cy)	**481,572**
Cut/Station	**Cut C / 0+0.00 to 27D / 31+96.62**		
Geographic	**Southern End of the Fernandina Harbor Project to Nassau Sound**		
DREDGED MATERIAL MANAGEMENT AREA			
Property Area (ac)	**35.5**	Design Basin Capacity (cy)	**186,754**
Basin Area (ac)	**16.1**	Available Basin Capacity (cy)	**186,754**
Buffer Width (ft)	**N = 100**	Dike Slope	**3H:1V**
	S = 100	Crest Width (ft)	**15**
	E = 100	Natural Grade Elevation (ft NAVD)	**6**
	W = 100	Depth of Excavation (ft NAVD)	**6**
AIWW Mileage	**7.3**	Dike Height above Natural Grade (ft)	**12.5**
Max. Pumping Distance (mi)	**±6.5**	Required Ponding & Freeboard (ft)	**4**
Distance from Waterway (ft)	**Adjacent**	Type of Weir System	**2 4-ft Box Weirs**
Impacted Wetlands (ac)	**1.87**	Weir Crest Length (ft)	**32**
Mitigation	**Longleaf Mitigation Bank**	Entity and Year Constructed	**FIND 2013**
Regulatory Permits	**Construction: FDEP 45-291060-002-EI; USACE SAJ-2008-03402 (SP-BAL)**		
	Operation: FDEP 45-291060-002-EI		
ACCESS			
Public Access	**Bailey Road**	Pipeline Easement	**Not Required**
Road Easement	**Yes**	Deep Draft Access	**No**
NARRATIVE			

FIND acquired DMMA NA-1 — locally known as Crane Island — in 1988, permitted the DMMA construction in 2011, and constructed the site in 2013. FIND has an active operational permit.

Operational issues include, but are not limited to: (1) periodic monitoring of consolidation, (2) P.E. inspections of dike annually or prior to construction with reports submitted to FDEP, (3) on-site and active eagles nest located in the buffer of the site’s southwest corner, (4) stringent road access easement agreement conditions, and (5) site offloading after each maintenance event.



TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

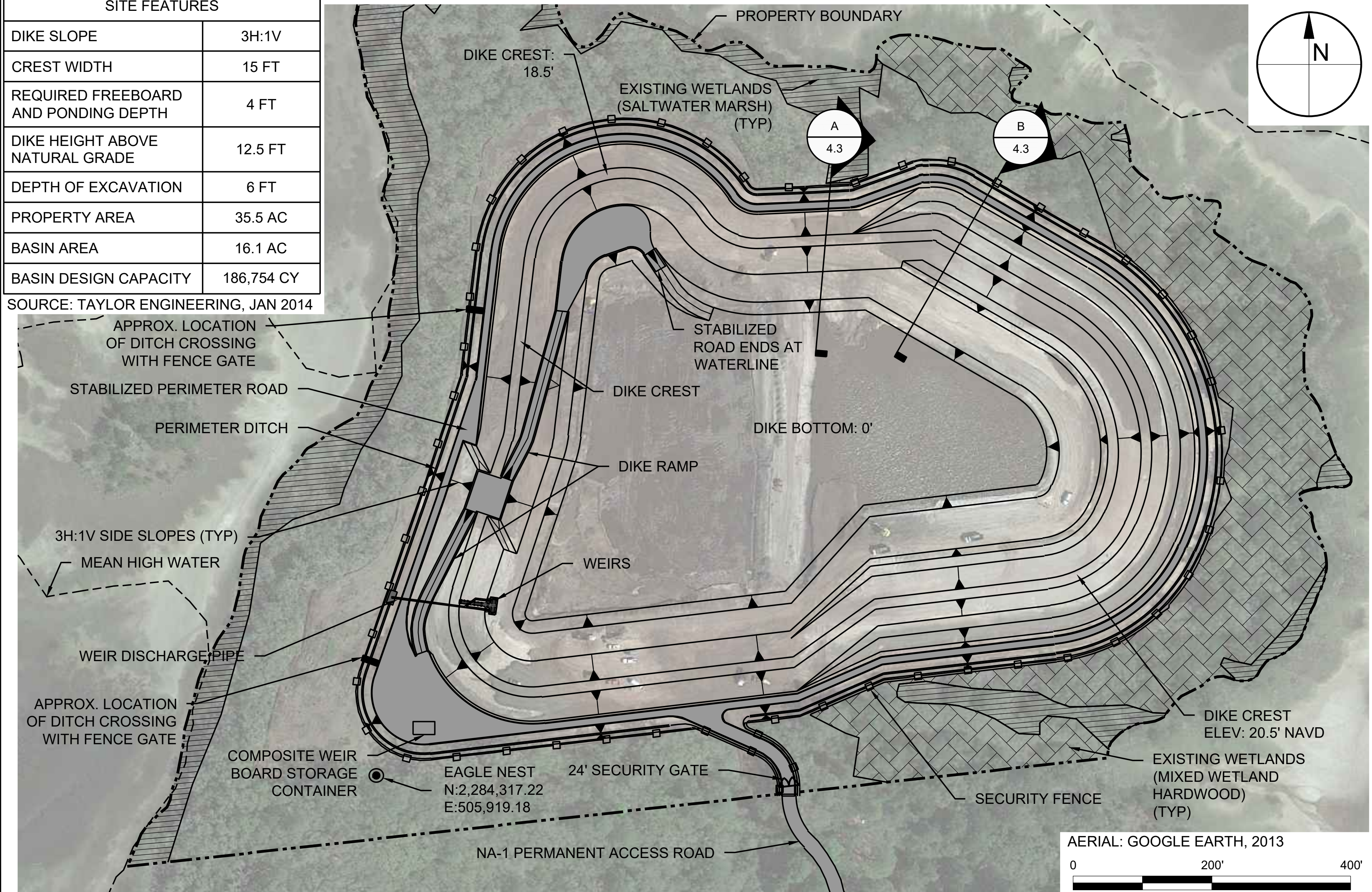
FIGURE 4.1
DMMA NA-1 LOCATION
ATLANTIC INTRACOASTAL WATERWAY DMMA
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	6 of 9
DATE	DEC 2016

ANTON X:\SYSPROJECTS\C2013-031 NA-DU DMMP\FIGURES\C2013-031-F-NA1 LOCATIONMAP.DWG 12/16/2016 4:01:30 PM

SITE FEATURES	
DIKE SLOPE	3H:1V
CREST WIDTH	15 FT
REQUIRED FREEBOARD AND PONDING DEPTH	4 FT
DIKE HEIGHT ABOVE NATURAL GRADE	12.5 FT
DEPTH OF EXCAVATION	6 FT
PROPERTY AREA	35.5 AC
BASIN AREA	16.1 AC
BASIN DESIGN CAPACITY	186,754 CY

SOURCE: TAYLOR ENGINEERING, JAN 2014



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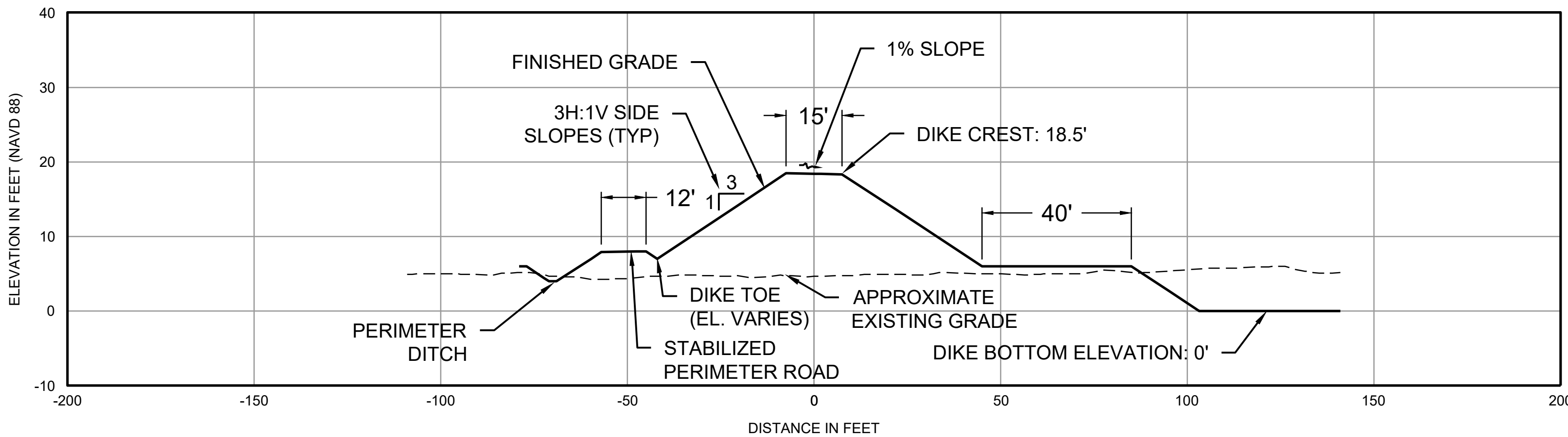
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 4.2
DMMA NA-1 PLAN VIEW
ATLANTIC INTRACOASTAL WATERWAY DMMA
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	7 of 9
DATE	DEC 2016

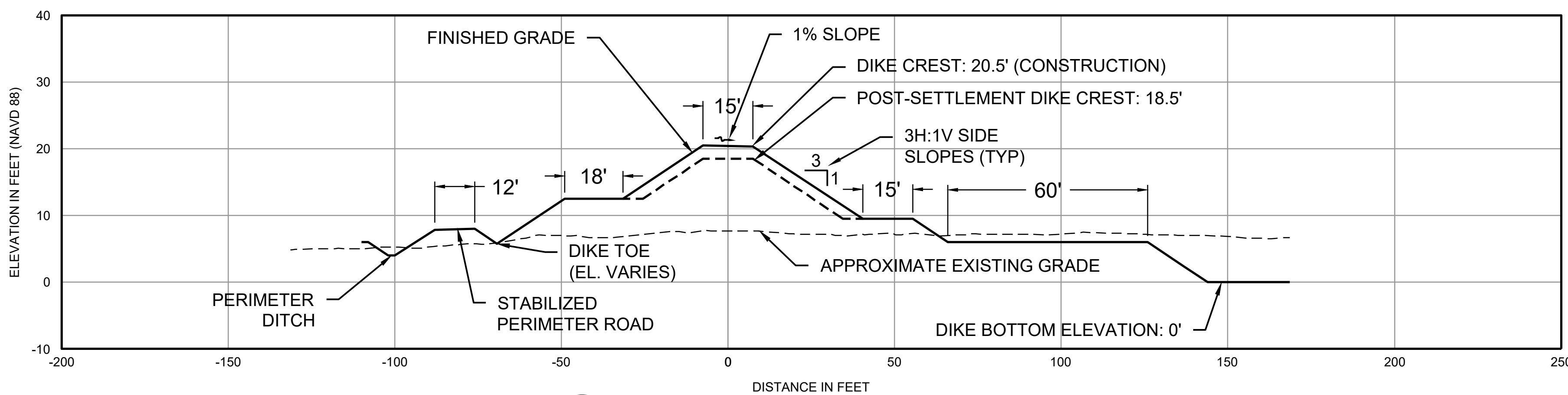


A
4.2

NA-1 CROSS-SECTION A

SCALE: 1" = 50'
2X VERTICAL EXAGGERATION

0 50'



B
4.2

NA-1 CROSS-SECTION B

SCALE: 1" = 50'
2X VERTICAL EXAGGERATION

0 50'

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TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 4.3
DMMA NA-1 SECTION VIEW
ATLANTIC INTRACOASTAL WATERWAY DMMA
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
DRAWN BY	AF
SHEET	8 of 9
DATE	DEC 2016

PRELIMINARY DRAWINGS: THESE DRAWINGS ARE NOT IN FINAL FORM, BUT ARE BEING TRANSMITTED FOR AGENCY REVIEW.

5.0 DMMA OPERATIONAL CONSIDERATIONS

This section provides guidance for the operation of the DMMA to achieve optimum efficiency in both effluent quality and disposal area service life. This section addresses site-specific design and operational elements, as well as those facets of design and operation that directly influence site efficiency or reduce off-site conflicts. The three phases of operational considerations include (1) elements of site preparation prior to the initial dredging and disposal of dredged material; (2) techniques of decanting and dewatering the dredged material during and immediately following a disposal event; and (3) criteria for post-dredging site operation and maintenance. Throughout the operations, each aspect of site management seeks to assure that the site not only achieves its minimum design service life, but also serves as a permanent operating facility for the intermediate storage and re-handling of maintenance material dredged from the AIWW.

Both state and federal regulatory requirements are subject to change. Currently, maintenance dredging events with upland disposal qualifies for a state permit exemption and federal authorization under a regional general permit. If FIND acts as the permittee for a dredging project, FIND may request that FDEP approve a maintenance dredging exemption from state permitting and that USACE verify federal authorization under the Department of the Army Regional General Permit SAJ-93 for Waterway maintenance dredging.

5.1 Pre-Dredging Site Preparation

5.1.1 Earthwork

Site preparation will include clearing and grubbing vegetation that has grown since site construction and/or last use of the facility and altering existing topography within the DMMA. Historically, containment area construction has often been accomplished without any interior site preparation. Documentation (Haliburton, 1978; Gallagher, 1978) has established that a limited amount of herbaceous vegetation or native grasses can improve sedimentation by filtration. However, large woody vegetation (brush, trees) can constrict or channelize the flow through the containment area, resulting in short-circuiting of flow, reduced retention times, resuspension of sediment, and the deterioration of effluent quality. Additionally, failure to clear existing vegetation will increase the organic content of the fill, rendering it less suitable for removal and re-use as construction material; therefore, the containment area may need to be cleared and grubbed prior to each use.

Similarly, the existing topography (resulting from previous dredging events) within the containment area, if allowed to remain undulating and non-uniform, may cause the flow from the inlet to the weir to channelize, thereby reducing the effective sedimentation area, increasing flow velocities, and again, decreasing the efficiency of solids removal. Moreover, irregular topography will produce irregular deposition, which in turn will result in the ponding of surface water, thereby inhibiting the drying of the deposition layer and making initial attempts at surface trenching more difficult. Therefore, providing a uniform grade with a slope on the order of 0.2% from the inlet to the weir becomes very important. In addition, given an initially level surface, differential settling of varying grain size fractions will quickly establish a deposition surface sloping downward from the inlet to the weir as coarse sediments deposit near the inflow and fine sediments deposit near the weirs.

Finally, per the requirements of FDEP Permit Operation Condition No. 22 and 23, FIND must submit a Professional Engineer's inspection of the DMMA — including, but not limited to, the condition of the weir structure, evidence of erosion and seepage, and adequate vegetation cover — prior to site operation.

5.1.2 Migratory Bird Protection

Should construction activities at DMMA NA-1 take place during the migratory bird-nesting season (March 15 – September 1), FIND or USACE should coordinate with the USFWS to establish site-specific migratory bird protection activities. Due to the presence of an active on-site eagle nest, future coordination with USFWS should occur prior to initiating dredging activities.

5.1.3 Gopher Tortoise Protection

Gopher tortoises may be present on DMMA NA-1. Where permits require ongoing tortoise management practices, FIND must ensure compliance with the permit requirements. Prior to each site use, FIND or USACE should survey the containment basin, dikes, and any ground areas potentially impacted by the project for tortoises. If the surveys find tortoises or burrows potentially affected by site operation, consultation with FWC should occur.

5.1.4 Groundwater Monitoring and Soil Sample Collection

Crane Island is an upland area surrounded mostly by salt marsh. Subsurface surveys have documented a high water table, typically less than 2.5 ft beneath the undisturbed soil surface. Although the DMMA NA-1 will impound brackish water pumped from the AIWW in connection with dredging operations only for relatively short periods once every 10 – 15 years, the possibility exists for chloride intrusion into the shallow aquifer. The planned residential development on the southern portion of the island will most likely connect to the Fernandina Beach municipal water supply, and therefore will require no potable or sanitary water from wells. However, water for lawn irrigation may be drawn from the deeper, Floridan aquifer if it proves suitable.

In accord with the FDEP permit, FIND installed a shallow test well within the on-site buffer region that separates the containment area from the remainder of the island. Pre-operation monitoring — with the initial sampling occurring in June 2014 — will determine a baseline chloride concentration, and a regular monitoring program should be established to document any deviations from the baseline concentrations after site use.

FIND (as part of the FDEP permit requirements specific to the DMMA NA-1 facility) will collect pre-construction soil samples (in the vicinity of the planned monitoring well installation) to analyze the baseline Sodium Adsorption Ratio (SAR). Future SAR monitoring will only occur on an as-needed basis upon FDEP request.

5.2 Operational Considerations During Dredging

The primary objectives of site management during dredging operations are to maintain acceptable effluent quality during the decanting process, and by controlling the pattern of deposition, maximizing the potential for dewatering the deposited material subsequent to the completion of dredging operations. To these ends, the following paragraphs discuss eight unique aspects of site management:

(1) Placement and handling of the supply and return water pipelines
(2) Operation and monitoring of the dredged slurry inlet
(3) Operation and adjustment of the weirs
(4) Monitoring of the released effluent
(5) Inspection of the dike
(6) Continued monitoring of local groundwater and soil conditions
(7) Migratory bird protection
(8) Gopher tortoise protection

5.2.1 Pipeline Placement

Each maintenance and disposal operation over the design life of DMMA NA-1 will require the temporary placement of both supply and return pipelines. Given the historical 15- to 20-year dredging frequency, allowing either the supply or return pipelines to remain permanently in place is not economically feasible. Supply and return pipeline access is available directly from the AIWW to the site with no additional easement required. The supply pipeline would traverse the unvegetated sand flats west of the DMMA and enter the site near the southwest corner of the containment basin. From MHW, the pipeline will be routed along the outside toe of the dike along the west and north sides of the containment dike, entering the basin from its northeast corner by passing over the dike crest. The dredging contractor will install a single return pipeline, via a water-tight connection to the weir discharge pipe, such that the decanted water returns to the AIWW via the most direct and least environmentally impactful route. Following completion of dredging, the dredging contractor will remove the supply pipeline. The return pipeline will remain in place until all ponded water is removed and the decanting process is completed.

Stormwater runoff, expected to collect in the containment area, will be treated and decanted via the weir system such that the system will retain any suspended sediment from deposited material and minor dike erosion. The runoff will route, via the manifold system, to the exterior perimeter ditch and either evaporate or seep into the ground. Also, due to the relatively high water table and presence of underlying clay, operation/use of the DMMA could result in the perimeter ditch overflowing during dredging operations. Under this scenario, the dredging contractor must pump the water from the ditch back into the DMMA to provide adequate stormwater and seepage storage capacity and ensure compliance with water quality discharge criteria.

5.2.2 Inlet Operation

The quality of the dredged sediment, specifically, the settling characteristics of the different grain-size fractions, govern the operation of the inlet (i.e., the point at which the supply pipe discharges the dredged material slurry into the containment basin). The coarsest fraction of material will settle out of suspension very rapidly and form a mound near the inlet. Successively finer fractions, characterized by lower settling velocities, will deposit closer to the outlet weir. Absent an inlet operation strategy, the dominant grain-size fraction will determine the distribution of sediment within the basin. For example, if fine-grained sediments dominate, a relatively large volume of material will concentrate near the weirs. As discussed below, an extensive concentration of fine-grained sediment may require specialized dewatering procedures to speed drying.

As discussed in **Section 3.4** and **Table 3.5**, samples taken within Reach I indicate predominant sediments as mainly fine sand with occasional mud lenses. The silt and clay-sized component of each sample ranged from 1.1 to upwards of 90%. In addition, each core boring contained at least one stratum with fine-grained components that exceeded 10%. Although these samples may generally indicate the quality of sediment within Reach I of the AIWW, FIND will likely acquire additional data characterizing specific channel shoal sediments prior to future maintenance operations. This information will document the results of core borings taken within the shoal areas to be dredged, and will include, at a minimum, boring logs and qualitative categorization of each sediment strata, gradation curves and/or Atterberg limits, and suspended sediment-settling time curves for the aggregate from each boring location.

Subject to this event-specific information, which characterizes the quality of sediment to be dredged, two basic strategies of inlet operation and control of sediment deposition within the containment area could occur. Based on historic sediment information, DMMA NA-1 will likely receive sediments characterized primarily as fine to medium sand, with minor silt and clay components. The primary strategy makes no attempt to segregate material grain size fractions; however, the position of the inlet will move during disposal operations to minimize mounding of the coarser fraction of sediment and to achieve more uniform deposition. For the DMMA NA-1 facility, this will entail a progressive extension of the supply pipe from the point where it enters the containment area in the northeast corner of the basin southward, parallel, and interior to the eastern containment dike, resting each extension on the mound formed by the previous inlet position. A minimum distance of 100 ft must be maintained between the inlet and the inside toe of the dike to prevent erosion or undercutting the interior dike slope. The resulting deposition pattern should maintain a consistent slope from inlet to weir and should minimize dead zones and channelization.

An additional, although secondary, advantage gained through extending the inlet pipeline results from shutting down the dredge plant to allow the addition of each extension. These operational intermissions, together with temporary shutdowns to move the dredge, effectively increase the retention time of the containment area, thereby increasing the solids retention efficiency of the basin. However, preliminary analysis of containment area performance indicates that attaining adequate effluent quality will not require intermittent dredge operation.

The documented presence of discrete shoals or significant depositional strata characterized as predominantly fine-grained materials, such as organic silts or clays, could require an alternate strategy of inlet operation to segregate fine sediments. Segregation of the fine-grained fraction to optimize the engineering properties of the remaining sediment can occur by moving the inlet pipe to deposit silts and clays nearer the weirs, thereby keeping the fine material spatially concentrated. The coarser fraction of material dredged during the same operation can then be deposited along the eastern portion of the containment area. This alternate strategy would necessitate additional operating precautions. Given the reduced distance between the area of fine material deposition and the weirs, retention times adequate to allow precipitation of the fine sediment and maintain acceptable effluent quality must occur via additional ponding depth, intermittent dredge operation, or the use of turbidity control devices. Preliminary analysis of the channel sediment core borings indicated that approximately 7 hours of retention time would provide adequate solids retention. Combined with the expected shutdowns in pumping operations to relocate the dredge plant and inlet pipe, this strategy would allow for the maintenance of acceptable effluent quality. However, to achieve the desired segregation of fine-grained material, this strategy must also include removal of a substantial portion, if not all, of the segregated material following dewatering and prior to succeeding placement operations. The DMMA NA-1 design specifically excludes interior dikes and compartmentalization for segregation of fine sediments.

5.2.2.1 Monitoring Related to Inlet Operation

Dredging operations will require several monitoring procedures related to inlet operations. Ponding depth remains a critical parameter for maintaining acceptable containment basin performance. Increased ponding depth improves solids retention performance of the basin by increasing retention time. However, under saturated foundation conditions, daily dike monitoring will be necessary to determine whether modification of allowable freeboard and ponding depths should occur. Indications of impending dike instability include foundation saturation at the outer dike toe and excessive seepage through the dike's outer slope, followed by piping and small-scale slumping. Obviously, such conditions must not occur. Therefore, the ponded water surface should be allowed to rise above the 2-ft minimum depth only under close monitoring by visual inspection of dike integrity. If no effluent is released at the weir, the output of a 16-in. dredge (i.e., 2,800 cy/hr slurry at a 20/80 solids/liquid mix, or 2,240 cy/hr liquid) will produce an increase in ponding depth of approximately 0.67 ft/hr and a rise in the water surface (i.e., deposition layer plus ponding) of approximately 0.83 ft/hr. These rates are slow enough to allow close continual monitoring of the entire dike perimeter. Dike stability should be monitored continuously during periods if ponding depth is maintained above the 2-ft minimum. Experience has shown that as the ponded water percolates into the interior dike slope, the coarser dike material filters the fine suspended sediment. This filtering reduces the dike permeability and thus decreases the dike's susceptibility to excessive saturation and seepage.

Optimal operating efficiency requires that flow through the containment basin approaches plug flow (i.e., flow without any mixing) to the greatest degree possible. Uneven flow distribution — evidenced by irregular sediment deposition, channelization, and short-circuiting — increases flow velocities, reduces retention time, and promotes sediment resuspension. If inspection reveals an irregular deposition pattern, the inlet pipe should be repositioned to produce a more uniform depositional surface.

Lastly, the incoming slurry should be periodically monitored at the containment basin inlet to confirm or refine dredge output specifications, including volumetric output and slurry solids content. These parameters, in combination with the actual duration of dredging, can serve as an independent measure of deposition volume to determine remaining site capacity. Additionally, the computed deposition volume can be used with pre- and post-dredging bathymetric surveys of the channel and, following placement and dewatering of the deposition layer, topographic surveys within the containment basin to refine the bulking factor employed to translate in situ dredging volumes to required storage volumes. Also, within the same monitoring program, the quality of dredged sediment should be established by laboratory analysis of grain size distributions, settling velocities, specific gravity, and Atterberg limits, if appropriate. The results of this monitoring and analysis will provide a basis for the operational management of containment area performance and efficiency.

5.2.3 Weir Operation

Weir operation — that is, controlling the ponding depth and flow rate over the weirs by adjusting the weir crest elevation — is the procedure most critical to maintaining effluent quality during dredging and decanting operations. Operational requirements begin during containment basin construction and continue thereafter. Prior to dredging commencement, the weir crest elevation should be set as high as possible to prevent the early release of effluent. The minimum initial elevation above the mean interior site grade should be equal to the maximum anticipated ponding depth of 5 ft. For the DMMA NA-1 site, this will result in an initial weir crest elevation of +5.0 ft NAVD. As the deposited material reaches the base of the weirs, the weir crest elevation should be increased at approximately the same rate as the growth of the depositional layer.

Once dredging begins, the weir crest elevation should be maintained at its initial elevation until the ponded water surface approaches the weir crest. As ponding depth increases above the 2-ft minimum design depth, the decision must be made to initiate release of the supernatant. Notably, a flow control structure such as a weir cannot improve effluent quality beyond that of the surface water immediately interior to the weir crests. The decision to release effluent over the weirs should be based on the results of turbidity testing or suspended concentration analysis conducted on surface waters inside the weirs. These tests must reflect conditions at the maximum withdrawal depth. For DMMA NA-1, recommended WES procedures determined this depth to be 1.5 ft, based on the design dredge discharge of 2,800 cy/hr and a design weir loading of 0.53 cfs/ft. If adequate water quality is not achieved prior to the ponded water surface reaching the initial weir crest elevation, the dredge plant must shut down until the surface water turbidity reaches acceptable limits, or until alternative measures such as the installation of turbidity screens or floating baffles are implemented. If the desired water quality is achieved at a ponding depth less than the initial weir crest elevation, the water surface should still be permitted to rise to the weir crest if dike integrity is not threatened.

Once flow over the weirs has begun and effluent of acceptable quality is being produced, as indicated by the effluent sample analysis, the hydraulic head over the weir becomes the most readily used criterion for weir operation. For the design weir loading, the operational static head has been calculated to be 0.29 ft (3.5 in), based on an empirical relationship (Walski and Schroeder, 1978) developed for sharp-crested weirs. Actual operating head over the weir can be measured on site by two methods. First, it can be determined by using a stage gage, located in the basin where velocities caused by the weir are small (at least 10 – 20 ft from the weir), to read the elevation of water surface and subtracting from it the elevation of the weir crest. The static head can also be determined indirectly by measuring the depth of flow over the weir. The ratio of depth of flow over the weirs to static head, estimated as 0.85 for sharp-crested weirs, yields a design flow depth for the NA-1 facility of 0.25 ft or 3.0 in. If the head over the weir, as measured by either method, falls below these design values because of unsteady dredge output or intermittent operation, effluent quality should increase. However, if the head exceeds these values, the ponding depth should be increased by adding flashboards or temporarily halting dredging to prevent a decrease in effluent quality.

At all times, all four sides of each of the two box weirs must be maintained at the same elevation to prevent flow concentration and a decrease in effluent quality related to an increase in weir loading. Preventing floating debris from collecting in front of the weir sections is also important. An accumulation of debris at the weirs will reduce the effective weir crest length and thereby increase the withdrawal depth. This may increase the effluent suspended solids concentration.

With dredging completed, decanting — the slow release of all remaining ponded water within the basin by gradually removing flashboards — begins. Flow over the weirs should drop essentially to zero before the next flashboard is removed. Effluent monitoring must continue during the decanting process. If at any time during this process effluent turbidity violates water quality standards, the effluent must be retained until analysis of the interior surface waters shows the suspended solids concentration within acceptable limits. Decanting then continues in this manner until all ponded water is released over the weir.

Should an event dictate the need to eliminate discharge from the weir, the DMMA NA-1 site also has two emergency flap gates (one for each discharge pipe) that can be engaged from the top of the weir deck platform. The flap gates consist of a hinged, gravity-operated aluminum flap and seat. The approximate 100-lb flap is suspended in the open position via an overhead stainless steel cable; the cable is secured to a steel support at the level of the weir walkway. To close the gate, the workman pulls the pin that is inserted through a loop in the cable. The flap, no longer supported by the cable, falls down into the closed position under its own weight. Hydrostatic pressure holds the flap firmly in the closed position.

5.2.4 Effluent Monitoring

As discussed in the preceding section, effluent monitoring is an integral part of facility operation. DMMA NA-1 is designed to produce effluent that meets or exceeds water quality standards for Class III waters as set forth in Chapter 62-302 of the Florida Administrative Code. The monitoring program must therefore continue throughout dredging and decanting operations. Effluent samples should be taken and analyzed as often as practical. The minimum recommended sampling frequency is twice per 8-hour daylight shift. Notably, due to safety reasons, no nighttime monitoring of turbidity will occur at the weir discharge pipe. However, the current DMMA NA-1 environmental permits require the dredging contractor to install a temporary light at the discharge location to visually monitor (on an hourly basis) the effluent water quality.

5.2.5 Dike Inspection Requirements

Throughout all phases of dredging and dewatering, the contractor shall be responsible for additional inspections of the containment facility related to ensuring the integrity and stability of the containment dikes and related structures. The following paragraphs summarize the required critical and supplemental inspections required to monitor dike condition and comply with the permit requirements noted in **Section 4.1.2**.

5.2.5.1 Critical Inspections

The contractor shall perform periodic inspections of the containment dikes to check for certain critical conditions that may require implementation of remedial measures. A qualified geotechnical engineer or engineering technician with specific training and experience in performing inspections of earthen dams, earthen reservoirs, or earthen dredged material containment facilities will conduct all inspections. As part of the required preconstruction submittals, the contractor must submit the qualifications of the designated dike inspector for review and approval of FIND or its authorized representative.

The contractor shall conduct inspections for the items listed below during each day of operation. Any of these conditions could indicate a critical condition that requires immediate investigation and may require emergency remedial action. Immediately upon confirming the existence of a critical condition, the contractor must inform FIND and its authorized representative and increase the inspection frequency. FIND will then immediately notify FDEP. Within 24 hours of confirming a critical condition, the contractor must submit to FIND documentation of the inspections and implemented remedial actions. FIND will then submit to FDEP a written report detailing the condition and the implemented remedial actions within 7 days of the confirmation of the critical condition. The following items could indicate a critical condition.

(1) Seepage with boils, sand cones, or deltas on outer face of the dike or downstream from the dike’s outer toe
(2) Silt accumulations, boils, deltas, or cones in the drainage ditches at the dike’s base
(3) Cracking of soil surface on the dike’s crest or on either face of the dike
(4) Bulging of the downstream face of the dike
(5) Seepage, damp area, or boils in vicinity of or erosion around a conduit through the dike
(6) Any subsidence of the crest or faces
(7) Any failure of the weir structure or its operation
(8) Any leaks or seepage of the supply and return pipelines

5.2.5.2 Supplemental Inspections

During the critical inspections described above, the items listed below could indicate potential areas of concern that the contractor must then continue to monitor closely during subsequent inspections and perform repairs as necessary. Within 24 hours of confirming the presence of an indicator of a potential area of concern, the contractor must also inform FIND and its authorized representative of the item and any required repairs undertaken. Indicators of potential areas of concern include the following.

(1) Overgrown patches of vegetation on the inside and outside portions of the dike
(2) Surface erosion, gullying, or wave erosion on the inside portion of the dike
(3) Surface erosion, gullying, or damp areas on the outside face of the dike, including the berm and the area immediately adjacent to the outside toe

(4) Erosion below any conduit exiting the dike
(5) Wet areas or soggy soil on the outside face of the dike or in the natural soil below dike
(6) Failure of the weir boards, their containing structure, or any blockage or interference of weir operations

5.2.6 Groundwater Monitoring and Soil Sample Collection

Per the requirements of the easement and regulatory permits (**Section 4.1.2**), required groundwater monitoring and soil sample collection shall continue throughout the duration of the DMMA operation.

5.2.7 Migratory Bird Protection

Should dredging become necessary during the migratory bird-nesting season (March 15 – September 1), FIND or USACE should coordinate with USFWS to establish site-specific migratory bird protection activities. Expected activities include education of contractor personnel, daily monitoring for nesting activity, steps to deter nesting activity within the active construction area, avoidance of nests and, if necessary, to protect nesting birds, modification of construction activities. Alternatives that may be considered to prevent impacts to nesting birds include creation of undesirable habitat (e.g., flagging construction area, placement of ground cover, seeding or sodding exposed areas), dissuasion through noise or activity, or creation of alternative nesting sites. A final, undesirable alternative — incidental take — should only be considered during a documented emergency.

In addition to the height restrictions placed on the DMMA (**Section 4.1**), the FAA aeronautical study also recommended consultation with a professional wildlife management biologist should the site attract wildlife that would be considered a hazard to aviation. Prompt remedial actions —including coordination with the airport owner and managing site operations to minimize the site attractiveness as a foraging area — are key to protection of aviation safety.

5.2.8 Gopher Tortoise Protection

Prior to construction, gopher tortoises should be relocated from work areas in accordance with any FWC relocation permit. Relocation permits or the results of consultation with FWC could require protective measures such as marking buffers (generally 25-ft diameter) around tortoise burrows remaining near the work area or erecting barriers (e.g., silt fence) to exclude tortoises from the work area. Observations of gopher tortoise in the work area during construction will trigger consultation with FWC to determine protective actions.

5.3 Post-Dredging Site Management

Following the completion of each dredging event, the post-dredging phase of disposal site operation occurs. This phase continues until the next maintenance-dredging event begins. During the post-dredging phase, dredged material deposited within the containment area is managed to maximize the rate at which its moisture content is reduced. In so doing, the material is made suitable for handling and removal from the site, the primary objective of the DMMA management plan. However, given the permanent nature of the DMMA NA-1, other management procedures between active dredging operations must occur. These include a comprehensive monitoring and data collection effort to guide the efficient use and environmental compliance of the disposal area, the handling of stormwater runoff, vegetation control and maintenance, the monitoring and maintenance of site habitat, mosquito control measures, and the provision for adequate ongoing site security. These are discussed in the following sections.

5.3.1 Dewatering Operations

Following the completion of dredging operations, the contractor must continue to operate the weir system and slowly release the clarified surface water that remains ponded within the basin over the weir crest by incrementally removing weir boards. The process, known as decanting, continues until all residual ponded water within the basin at the completion of dredging is released over the weirs. To maintain effluent quality throughout the decanting process, the contractor should allow the flow over the weir to drop essentially to zero before removing another set of weir boards. If at any time during the decanting process monitoring shows effluent turbidity to exceed permitted standards, the contractor must again add weir boards until testing of the ponded water that remains within the basin confirms that turbidity has returned to acceptable limits.

The fine sediment predominant in Reach I is unlikely to dry through natural evaporation and percolation alone. Therefore, the dredging contractor will likely employ supplementary dewatering techniques. The most appropriate dewatering techniques for this purpose include surface water removal, progressive trenching to promote continued drainage, and progressive reworking or removal of the dried surface layer. The following paragraphs discuss each technique and its specific application to the present situation.

Decanting all ponded surface water is necessary before significant evaporative drying of the deposited material can occur. Simply continuing to lower the weir crest will remove most of the ponded water following the completion of dredging operations. However, the anticipated topography of the deposition layer makes draining all ponded water in this manner unlikely. As discussed, differential settling of the various size fractions of the sediment results in partial segregation of the dredged material within the containment basin. Coarser sand- and gravel-sized particles settle nearer the inlet, while finer particles concentrate nearer the weir. The sand-sized fraction should experience relatively little consolidation because of its low initial water content. However, the fine material's greater consolidation will likely form one or more depressions near the weirs. To remove the ponded water that remains in these areas, a drainage trench may be needed to connect each depression to a sump excavated adjacent to one or more weirs. During this phase of operations, the weir crests may be raised to prevent the premature release of the ponded water which, as a result of the excavation, will likely contain a high concentration of suspended solids. Clarified water can then be released over the weirs as soon as effluent turbidity standards are met.

Following the removal of all remaining ponded water, evaporative drying will eventually form a crust over the deposition layer. This crust will trap water beneath its surface and retard continued evaporation. In addition, the desiccation cracks that quickly form in the crust will hold rainwater and limit further drying. Therefore, complete drying may require additional trenching. Initially, a dragline or clamshell operating from the crest of the containment dike can excavate a perimeter trench. More intensive trenching must wait until a crust of significant thickness (greater than 1 – 2 in.) has developed on the deposition surface. The crusted surface will eventually allow the use of conventional low ground pressure equipment. A network of radial or parallel trenches should then be constructed throughout the area of fine sediment deposition. The slumping resistance of the semiliquid layer beneath the crust will determine the appropriate depth of each trenching operation. The thickness of the fine-grained deposition layer will dictate the number of trenching operations required. After initial construction of the trenches, the DMMA NA-1 should require grading no more than once to provide sufficient drainage for the relatively thin fine sediment deposition layer. Given a sufficient volume of coarser sediments, the dried surface crust can also be transferred to a more well-drained area of sandier material nearer the inlet. This would expose the wetter under layers and restore a relatively high rate of evaporative drying.

The dewatering process will continue until the moisture content of the deposition layer has lowered to a level necessary for efficient handling and removal. The time required to complete this phase of site operation will depend on the physical characteristics of the sediment, as well as climatic conditions (e.g., rainfall, relative humidity, season, etc.). During the entire dewatering phase, the weirs must be operated to control the release of residual water and impounded stormwater. The clarified effluent will be routed to the perimeter ditch and drained off site.

5.3.2 Grading the Deposition Material

In preparation for the next dredging operation, grading the dried sediment will follow dewatering. Grading will distribute the mounded sand, shell, and gravel over the remainder of the containment area and serve a number of necessary functions. These functions include reestablishing the initial uniform slope from the inlet down to the weirs, restoring the effective plan area of the containment basin, and improving subsequent dewatering of the fine-grained material by separating successive deposition layers with a free-draining substrate. As discussed in the next section, grading also provides for stormwater runoff control. Finally, a series of post-grading topographic surveys will assess material consolidation and refine estimates of remaining storage capacity.

5.3.2.1 Control of Stormwater Runoff

Grading the dewatered deposition layer provides the additional benefit of allowing the control and release of stormwater that drains from the interior slopes of the containment dike as well as the dewatered sediment. In compliance with regulatory policy, a sump or retention area of adequate capacity should be constructed adjacent to the weirs (with the weir flashboards in place) to retain the runoff from the first 1 in. of rainfall. A site operator would then gradually release the ponded runoff at intervals determined by local weather conditions. Before the dredging contractor demobilizes from the site, FIND and its authorized representative will determine the weir crest height required to ensure that no uncontrolled release of stormwater occurs following project close-out. This determination will reflect information specific to each placement operation at the DMMA NA-1 site including the bulked volume of the dredged material, the geometry of the deposition, and the specific permit requirements imposed to govern the control and release of stormwater from the NA-1 facility. The contractor must then reinstall the weir boards in all weirs at or above this elevation.

After the dredging contractor completes demobilization from the DMMA NA-1 site, responsibility for continued management of stormwater within the basin, as well as all other continuing site maintenance activities between successive dredging operations, resides with FIND. To this end, FIND's designated site operator will periodically return to the site to release stormwater as well as the accumulated drainage from the dredged material as it continues to consolidate under its own weight. To release this water, the site operator will remove one or more weir boards from a single stack as necessary to release the surface layer of the ponded water. To minimize the work required, the operator need only open one side of a single weir stack and only to the level to start water flowing over the lowered weir crest. Only when the flow over the lowered weir crest approaches zero should the operator remove another board. This process should continue one board at a time, until all ponded water drains from the site. The operator should then replace the weir boards to the required elevation to prevent uncontrolled stormwater releases.

5.3.2.2 Topographic Surveys

As mentioned in **Section 4.1.3**, initial dike construction included installation of settlement plates, Sondex casing, and pore water pressure piezometer transducers for dike settlement monitoring during and after construction. Before each dredging event, FIND must verify dike integrity through a topographic survey and settlement monitoring data to restore the minimum DMMA design crest elevation of 18.5 ft NAVD.

5.3.3 Material Rehandling/Reuse

Although DMMA NA-1 has been designed for a specific service life, it must also operate as a permanent facility for the intermediate storage and rehandling of dredged material. To fulfill this intended use, and given the smaller capacity basin and quantity of material dredged sediment expected within Reach I, the dewatered material will require removal after each maintenance event (or prior to the next use) from DMMA NA-1. The following paragraphs discuss the ultimate use of this material.

Based on a comprehensive analysis of dredging records and recent survey data, the bulked material volume projected for placement and temporary storage over the 50-year design service life of the DMMA NA-1 facility is nearly 600,000 cy (**Table 3.3**). Even if the possible return on the sale of this material were disregarded, the cost savings of permanent storage alone would justify an effort to determine, through a formal market analysis, the potential demand for dewatered dredged material. If such a determination shows that material resale and/or reuse is practical, the properties of the dredged material must satisfy the requirements of commercial interests. The coarsest fraction of material (sand and gravel) can likely be used as fill or construction material. However, the fine-grained material in Reach I, containing large percentages of organic silt or clay, may prove suitable for municipal composting or agricultural amendments once rainfall and percolation have reduced its chloride content. Elevated concentrations of contaminants that remain below the threshold for environmental hazard would further limit the material to ornamental horticulture (e.g., sod farms) or landfill capping. Fine-grained material might also be mixed with coarse-grained material to render some of the fine material useful for fill or construction.

A determination by FIND that resale, or reuse is unfeasible will dictate locating and developing one or more permanent storage site(s). The appropriate location for such sites would appear to be inland where lower real estate values and development potential make permanent storage more economically feasible. The optimal distance from the initial containment area(s) to the permanent storage site would represent a compromise between lower land costs and higher transportation costs.

5.3.4 Maintenance of Vegetative Cover

Following construction of the containment facility, and again following each use of the facility to receive and dewater dredged material, FIND will remain responsible for establishing and maintaining a vegetative cover on all exposed surfaces of the dike. To prevent the establishment of shrubs, trees, or other woody vegetation, the dike's slopes and crest will be regularly mowed. Mowing will maintain vegetation sufficiently short to allow visual inspection of the soil surfaces in critical areas such as:

(1) The condition of vegetation and soil surface on the dike and in areas up to 50 ft from the outside toe;
(2) The condition of drainage ditches in the area of the base of the dike;
(3) The freeboard surface above liquid surface elevation; and
(4) The condition of spillways and water level control structures, including all conduits exiting the dikes.

FIND should conduct periodic inspections of both the interior and exterior of the dike berm for herbaceous vegetation potentially damaging to the berm integrity. Removal of this vegetation, by hand or mechanically, shall occur regularly and in a manner that maintains berm integrity. Regular spot treatment (with proper herbicides) for herbaceous vegetation should occur as needed.

5.3.5 Additional Environmental Considerations

5.3.5.1 Migratory Bird Protection

Available sediment data suggest that the deposition layer will present very little sandy substrate, and thus should prove poorly suited for migratory bird nesting. However, given sufficient sandy material, migratory birds may nest in portions of the containment basin following dewatering and grading as well as on the containment dike. Should post-dredging site management activities be required during the March 15 – September 1 nesting season and, in particular, to minimize wildlife in the area due to the adjacent Fernandina Beach Municipal Airport (**Section 5.2.7**), they will be carried out in accordance with site-specific migratory bird protection activities developed in consultation with USFWS.

5.3.5.2 Gopher Tortoise Protection

Gopher tortoise management will continue as a post-construction activity in accordance with any tortoise relocation permit conditions.

5.3.5.3 Groundwater Monitoring

Per the requirements of the easement and regulatory permits, required groundwater monitoring and soil sample collection shall continue throughout the post-construction DMMA operation.

5.3.5.4 Mosquito Control

The basic approach of the mosquito control program for DMMA NA-1 will emphasize physical rather than chemical control. The time during which standing water remains inside the containment area will be kept to a minimum to reduce the potential for mosquito breeding. The operational phase most favorable for mosquito breeding follows decanting when desiccation cracks form in the crust. Trenching procedures will accelerate the dewatering process. However, given the anticipated thickness of the deposition layer and the nature of the dredged material, the dewatering phase could extend long enough to result in mosquito breeding within the desiccation cracks and residual ponds. This situation could require a short-term spray program coordinated through the Nassau County Mosquito Control Board.

5.3.5.5 Site Security

Providing adequate security will remain a key element in the proper management of DMMA NA-1. Unsecured sites typically host a variety of unauthorized activities including illegal dumping, vandalism, hunting, and dike destruction by off-road vehicles. Permanent security fencing erected around the site's perimeter and locked gates control site access to DMMA NA-1.

Authorized access to the DMMA is restricted to agents and representatives of FIND and, when required, USACE Jacksonville District and contractor personnel. Access gates will remain locked at all times except during dredging and maintenance operations. The presence of an on-site operator during such operations should further discourage unauthorized entry to the site and the occurrence of unsanctioned activities. Between dredging operations, the site operator will be responsible for carrying out regularly scheduled security inspections. These inspections, which may occur in conjunction with routine operational functions, intend to ensure that facility security is maintained. Breaches in site security will be identified and appropriate actions will be taken as quickly as possible to restore the security measures.

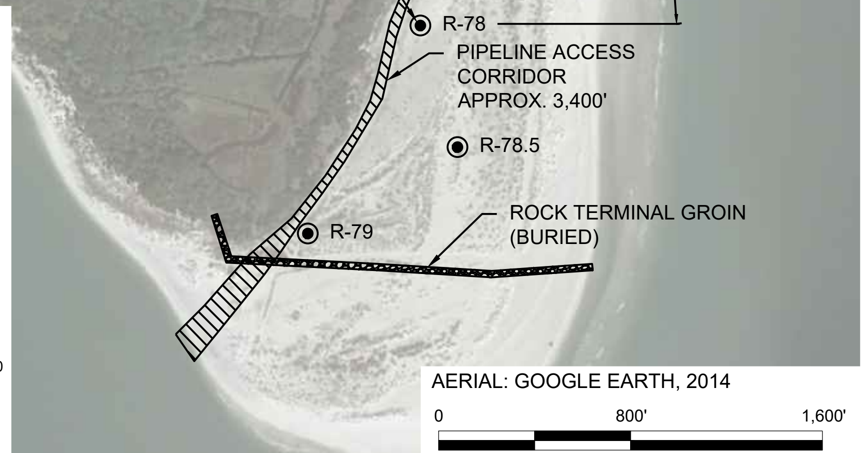
6.0 BEACH PLACEMENT SITE

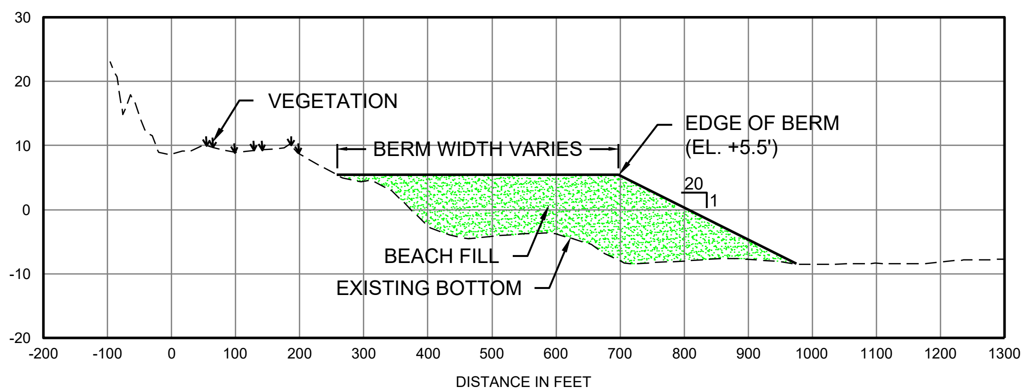
This section summarizes previous beach placement operations (e.g., beach design template, pipeline placement) that should assist future beach permitting and design efforts. Amelia Island State Park, immediately north of Nassau Sound, is the designated beach placement area for Reach II maintenance material. This area has received a total ±812,600 cy of material since 1982 with placement every ±7 years. The most recent dredged material placement in the park occurred in 2013. Reach II, where shoals form primarily by wave- and tide-driven sand, provides beach-compatible sediments for beneficial use. The following FDEP permits authorize Reach II maintenance dredging, historically performed under direction of the USACE.

(1) Florida Department of Environmental Protection Permit No.0307923-001-JC and Variance No. 0307923-002-BV Effective Date: July 23, 2012; Expiration Date: July 23, 2022.
(2) Florida Department of Environmental Protection Permit Modification No. 0307923-003-JN; Effective Date: December 12, 2012; Expiration Date: July 23, 2022.
(3) Florida Department of Environmental Protection Exemption Acknowledgment No. 16-167820-002-EE; Effective Date: December 4, 2012.

In accordance with specific conditions outlined in the above-noted permits, FIND will coordinate required monitoring of the beach placement area for nesting turtles and migratory shorebirds (during nesting season) with the appropriate regulatory agencies, Nassau County, and the Amelia Island Plantation Community Association (or its successor).

Figure 6.1 provides the plan and cross-sectional view of the 2013 placement template. The limits of construction extended approximately 2,400 ft from FDEP Range Monument AP-23 to R-78. Though placement operations have varied depending on beach conditions at the time of maintenance operations, typical beach design features have included a maximum 600-ft berm width, maximum berm elevation of +5.5 ft NAVD, and a 20H:1V toe of fill slope. A ±3,400-ft pipeline access corridor lies seaward of the vegetation line.





TYPICAL BEACH CROSS-SECTION
HORIZONTAL SCALE: 1" = 300'
VERICAL SCALE: 1" = 30'

TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256
CERTIFICATE OF AUTHORIZATION # 4815

FIGURE 6.1
AMELIA ISLAND STATE PARK BEACH PLAN AND SECTION VIEW
ATLANTIC INTRACOASTAL WATERWAY BEACH PLACEMENT AREA
NASSAU COUNTY, FLORIDA

PROJECT	C2013-031
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DATE	DEC 2016

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7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The Nassau County project area — comprising three reaches (N-FHP, I and II) and 38 cuts — extends from Cumberland Sound southward 15.65 miles to the south side of Nassau Sound. Reach N-FHP, designated during this DMMP update and approved by the FIND Board in July 2015, is coincident with the deep-water channel of the FHP. The two dredged material placement sites for Nassau County — established through a detailed evaluation and selection of a dredged material management concept, consistent evaluation criteria, and public involvement — comprise one upland DMMA (NA-1) and one beach placement area (located at the southern end of Amelia Island State Park). Together, these sites provide sufficient storage capacity (with periodic offloading) to manage the amount of material dredged from the two defined reaches over a 50-year period.

A review of the historical maintenance dredging records and recent shoaling data provided the 50-year dredged material storage requirements for the Nassau County reaches. The resulting countywide 50-year dredging and storage requirement equates to approximately 853,600 cy and 1,835,300 cy, respectively. Previous physical and chemical analyses of sediments revealed that Reach I sediments (designated for disposal in the DMMA NA-1 site) are ineligible for beach placement under Florida permitting criteria; however, chemical analyses indicated that special dredging and handling procedures were unnecessary. Reach II sediments, designated for beach placement at the Amelia Island State Park, are beach compatible and meet the requirements as set forth in Florida Administrative Code 62B-41.007(2)(k). Because the USACE has maintained Reach N-FHP at depths greater than the AIWW project depth as part of the FHP, past channel maintenance does not provide information suitable for calculation of long-term AIWW maintenance requirements. Maintenance dredging occurred in Reach I at a median frequency of 4.5 years from 1942 through 1982; no maintenance dredging has occurred in this reach since 1982. Maintenance dredging occurred in Reach II at a median frequency of 6 years from 1942 through the last maintenance operation in 2013.

FIND's bathymetric condition survey of the AIWW, completed in 2015, found shoals requiring maintenance dredging in Reach I. Design and permitting for Reach I dredging is underway. USACE completed the maintenance dredging of Reach II in vicinity of Nassau Sound in late 2013; therefore, Reach II will not likely require maintenance dredging until around 2018-2020. Though the addition of Reach N-FHP to the DMMP resulted in modest (c.a., 44,000 cy) projected dredged material storage requirement, that requirement does not warrant identification and acquisition of a DMMA for the reach. The Reach N-FHP dredging requirement stems from shoals present at the southern end of the reach from which dredged material could be pumped to DMMA NA-1.

The design and operation overview of the selected upland and beach placement sites revealed a few considerations for future use of each site. The 35.5-acre DMMA NA-1 site — located east of the AIWW, west of the Fernandina Beach Municipal Airport, and on the north end of Crane Island — will receive, dewater, and temporarily store sediments dredged from the AIWW Nassau County Reach I. Based on the recommendation from the 1986 Phase I report, FIND acquired the DMMA NA-1 site in 1988, permitted the DMMA construction in 2011, and constructed the site in 2013. Both the road access agreement and regulatory permits impose several unique requirements during site operations including: (1) annual submittal of a Professional Engineer's report of the weir structure and DMMA conditions and (2) monitoring and buffer requirements for an active on-site eagle nest.

Secondly, because the site was constructed on relatively thick layers of clay, the site had to meet an 80% consolidation requirement before its first use. Dunkelberger Engineering & Testing, Inc. (DET) monitored consolidation from 2014 through July 2016 when the site met the consolidation requirement. Due to the relatively high water table and presence of underlying clay, operation/use of the DMMA could result in the perimeter ditch overflowing during dredging operations. Under this scenario, the dredging contractor must pump the water from the ditch back into the DMMA to provide adequate stormwater and seepage storage capacity and ensure compliance with water quality discharge criteria.

Lastly, the DMMA NA-1 site, despite best efforts, is unable to meet the 50-year dredged material storage requirement. DMMA NA-1 has a 50-year storage capacity deficit of ±295,000 cy and, based on the 2009 in situ volume estimation, the site may require offloading after each maintenance operation or prior to subsequent use. However, the channel re-alignment recently approved by USACE may substantially reduce future maintenance dredging volumes. Due to the fine-grained nature of the Reach I sediment, finding a final disposal location of the dewatered sediment may prove more difficult than other DMMA sites with medium- to coarse-grained sediment.

USACE has routinely used the beach placement site on Amelia Island State Park since 1982 for the beneficial use of the sediment dredged from Reach II. Three separate FDEP permits authorize AIWW maintenance dredging and placement of the beach-quality sediments onto the State Park. As placement operations will vary depending on beach conditions at the time of maintenance operations, each operation will require a detailed beach design based on updated topographic, bathymetric, and upland vegetation surveys. Any monitoring requirements will require coordination with the regulatory agencies and local interests.

7.2 Recommendations

While the immediate dredged material storage needs of Nassau County have largely been addressed, some outstanding requirements remain to meet the full potential of the outlined plan. To advance the DMMP, FIND should move forward with the development of a market analysis for the DMMA NA-1 sediment.

8.0 REFERENCES

Note: This section includes reference materials that are not necessarily cited in the text; however, were used in the overall development of the updated Nassau County DMMP.

Deeds / Easements

2016. Letter amendment to Road Access Easement Agreement, Section 4.5 Contaminant and Salt Water Intrusion.

2008. Road Access Easement Agreement. Instrument No. 200831012, O.R. Book 1594. Page 1387.

1991. Quit-Claim Deed, Special Warranty Deed. O.R. Book 640. Page 817-821.

1988. Warranty Deed. O.R. Book 539. Page 1059. (Exhibit A, O.R. Book 539. Page 1100)

Environmental Reports

MacDonald, D. D. 1994. *Approach to the assessment of Sediment Quality in Florida Coastal Waters. Volume 1 – Development and Evaluation of Sediment Quality Assessment Guidelines*. MacDonald Environmental Sciences, Ltd. Ladysmith, British Columbia.

Maguire, T. and Hiller, C. 2010. *Dredged Material Management Area; NA-1 (Crane Island); Nassau County, Florida; Wetland Delineation Repor*t. Taylor Engineering, Jacksonville, FL. (Project No. C2008-044).

Mosura, E. L. 1987. *Environmental Site Documentation Report for Proposed Dredged Material Management Areas in Northeast Florida; Volume II – Crane Island.* Water & Air Research, Inc. (WAR). Gainesville, FL.

Schropp, S. J. and Windom, H.L. 1988. *A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments*. Florida Department of Environmental Protection, Tallahassee, FL.

Geotechnical Data / Reports

Ardaman & Associates, Inc. 2009. *Laboratory Testing Services, AIWW Sedimentation Column Tests* (File No. 09-181). Port St. Lucie, FL.

Challenge Engineering & Testing, Inc. 2009. Final Report Vibracore Sampling and Laboratory Testing; Atlantic Intracoastal Waterway Nassau Sound to Sawpit Creek; Jacksonville to Miami, Florida. Contract # W912EP-05-D-0010. Delivery Order # 0018. U.S. Army Corps of Engineers – Jacksonville District, Geotechnical Branch.

Dunkelberger Engineering & Testing, Inc. 2016. *Post-Construction Monitoring Letter; Vane Shear Test Results; NA-1 Dredged Material Management Area, Nassau County, Florida* (Project Number: HB145007).

Dunkelberger Engineering & Testing, Inc. 2012. *Supplemental Geotechnical Engineering Services; NA-1 Dredged Material Management Area, Nassau County, Florida* (Project No. PSL-08-2670, BG 11.3).

Dunkelberger Engineering & Testing, Inc. 2012. *Technical Memorandum (February 16, 2012): Engineering Services, Test Pit Exploration Summary; NA-1 Dredged Material Management Area; Nassau County, Florida* (Project No. WPB-12-8243, BG 21.1)

Dunkelberger Engineering & Testing, Inc. 2012. *Technical Memorandum (March 19, 2012): Geotechnical Engineering Services; NA-1 Dredged Material Management Area; Nassau County, Florida* (Project No. PSL-08-2670, BG 11.3)

Dunkelberger Engineering & Testing, Inc. 2012. *Technical Memorandum (June 6, 2012): Request for Additional Information, Geotechnical Engineering Services; NA-1 Dredged Material Management Area; Nassau County, Florida* (Project No. PSL-08-2670, BG 11.3)

Dunkelberger Engineering & Testing, Inc. 2010. *Geotechnical Design Report; NA-1 Dredged Material Management Area, Nassau County, Florida* (Project No. PSL-08-2670).

Dunkelberger Engineering & Testing, Inc. 2009. *Sediment Testing Report for the NA-1 Dredged Material Management Area; Nassau County, Florida* (Project No. PSL-08-2670). Port St. Lucie, FL.

Regulatory

FIND NA-1 DMMA Florida Department of Environmental Protection Environmental Resource Permit (45-291060-003-EM). Issued 06/28/2016.

Memorandum for Record. Shifting of the Atlantic Intracoastal Waterway (AIWW) in the vicinity of Cut 10 and Cut B to Best Water. CESAJ-PM-W. Issued 05/20/2016.

FIND NA-1 DMMA Florida Department of Environmental Protection Environmental Resource Permit (45-291060-002-EI). Issued 11/09/2011.

FIND NA-1 DMMA Department of the Army Permit (SAJ-2008-03402 (SP-BAL)). Issued 12/08/2011.

FIND NA-1 DMMA Federal Aviation Administration. *Determination of No Hazard to Air Navigation.* (2003-ASO-6038-OE). Issued 01/08/2004.

Owners of Crane Island. Entrance Road (USACE SAJ-2003-4783 [NPR-BAL]) and SJRWMD (40-089-88-705-4).

Planning and Design Documents

Brownell, L. B., Schropp, S. S., Adams, J. A., Taylor, R. B. 2016. *Long Range Dredged Material Plan Update for the Intracoastal Waterway; Duval County, Florida.* Taylor Engineering, Inc. Jacksonville, FL.

Carvalho, A. 2006. SURVEY 2004. Taylor Engineering, Inc. Jacksonville, FL.

Craig, K.R. and Brownell, L.S. 2000. SURVEY 2000. Taylor Engineering, Inc. Jacksonville, FL.

Craig, K.R, Dompe, P.E., and Schropp, S.J. 1996. SURVEY 1996. Taylor Engineering, Inc. Jacksonville, FL.

Gallagher, B. J. and Company. 1978. *Investigation of Containment Area Design to Maximize Hydraulic Efficiency*. Technical Report D-78-12. U. S. Army Engineer Waterways Experiment Station.

Vicksburg, MS.

Haliburton, T. A. 1978. *Guidelines for Dewatering/Densifying Confined Dredged Material.* Technical Report DS-78-11. U. S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Palermo, M. R., Montgomery, R. L. and Poindexter, M. E., 1978. *Guidelines for Designing, Operating, and Managing Dredged Material Containment Areas.* Technical Report DS-78-10. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Taylor, R. B. and McFetridge, W. F. 1987 (Updated 2010). *Management Plan; Crane Island Disposal Area.* Taylor Engineering., Inc., Jacksonville, FL.

Taylor, R. B., McFetridge, W. F., Maguire, A. J. and Ellis, C. B. 2006. *Reevaluation of Dredged Material Management Alternatives; Phase I Reach I Atlantic Intracoastal Waterway; Nassau County, Florida.* Taylor Engineering, Inc., Jacksonville, FL.

Taylor, R. B., and McFetridge. 1986. *Long-Range Dredged Material Management Plan for the Intracoastal Waterway in Northeast Florida.* Taylor Engineering, Inc., Jacksonville, FL.

USACE. 1993. *Engineering and Design Seepage Analysis and Control for Dams.* Engineering Manual 1110-2-1901. Washington, DC.

USACE. 2000. Planning Guidance Notebook. Engineering Regulation 1105-2-100.

Walski, T. M. and Schroeder, P. R. 1978. *Weir Design to Maintain Effluent Quality from Dredged Material Containment Areas.* Technical Report D-78-18. U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

Surveys

Eaton, G., PSM, PLS, CP. 2009. *Final Report of Digital Orthophotography Survey*. Performed for the State of Florida; Division of Emergency Management (Contract No. 07-HS-34-14-00-22-470. Colorado Springs, CO (The Sanborn Map Company) and Tallahassee, FL (Program & Data Solutions). Program & Data Solutions is a joint venture consisting of PBS&J, Dewberry, and URS Corp. Electronic and report data provided by the Nassau County GIS Department.

Privett & Associates, Inc. 2014. Dredged Material Management Area BV-4B As-Built Survey. Jacksonville, FL. (DWG No. T-2-2221(A)-2-13)

R.E. Holland & Associates, Inc. 2009. *Map Showing Specific Purpose Survey (Ground Truthing).* Jacksonville, FL (Work Order No. 211-09, Project No. 13208)

R.E. Holland & Associates, Inc. 2008. *Mean High Water Line Survey*. Jacksonville, FL (Work Order No. 247-08, Project No. 13208)

Sea Diversified, Inc. 2015. *Hydrographic Survey of the Intracoastal Waterway Nassau County, Florida*. Project Number 13-2078. Delray Beach, FL

Sunshine State Surveyors, Inc. 1987. *Map of Specific Purpose Survey for Craney Island.* Jacksonville, FL (File No. 87E-2218).

Thomas & Hutton Engineering Co. 2003. *Crane Island Entrance Road – Phase 1A. Right-of-Way and Easement Exhibit* (Job No. J-11608.01). Mt. Pleasant, SC. Electronic and report data provided by

Mr. William Moore, Amelia Island Plantation.

U.S. Army Corps of Engineers Hydrographic Survey No. 12-117. 2012. Atlantic Intracoastal Waterway Fernandina to St. Johns River, Nassau County, Fla (Cuts 27D thru 34).