APPENDIX A

Historical Shoreline Change

Comparison of historical maps, aerial photographs and survey data indicate a fairly consistent trend in shoreline change along the Kennedy Space Center coastline over the past 140 years, as described below. Approximate mean high water shoreline locations were compared from among the following available data sources:

- 1874-75 (USCGS, from FDEP historical database)
- 1928 (USCGS, from FDEP historical database)
- 1943 (aerial photography, interpreted by R. Schaub (IHA) at 5-m spacing alongshore
- 1948-49 (USCGS, from FDEP historical database)
- 1964 (USCGS, from FDEP historical database)
- 1969-70* (NOS, from FDEP historical database; *not used, as values appear suspect)
- 1969 (aerial photography, interpreted by R. Schaub (IHA) at 5-m spacing alongshore
- 1970* (USGS, from FDEP historical database; *not used, as values appear suspect)
- 1976 (USGS, from FDEP historical database)
- 1999 (Fall) Lidar survey
- 2007 (Fall) Lidar survey
- 2009 (May) USGS Lidar survey
- 2011 (May) Beach profile surveys (UF)
- 2012 (March) Beach profile surveys at FDEP V-monuments (Morgan & Eklund, Inc. (M&E))
- 2014 (Sept.) MHWL and +8' NAVD contour survey, with select beach profile surveys (M&E)

Figure A-1 depicts the long-term historical locations of the high water shoreline along the KSC shoreline relative to the mean high water location in September 2014. The average-annual rate of change in shoreline location, in feet per year, is likewise indicated between the historical shoreline locations and September 2014. The boundaries of KSC are approximately between virtual monument locations V-065.3 and V-098, where each monument is spaced 1000-feet alongshore. These historical data suggest the following, fairly consistent trends:

- V065 – V070/71: Stable to modest accretion
- V070/71 – V086/87: Consistent erosion, particularly severe from V-071 to V-084
- V086/87 – V089: Stable to accretional (immediately north of False Cape)
- V089 – V096: Strongly accretional (immediately along & south of False Cape)
- V096 – V098: Historically accretional tending toward recent stability

By typical standards along Florida's central east coast, the long-term rates of shoreline change over the last century are significant: on the order of -2 to -4 feet per year erosion (V072-V078) and +3 to +5 feet per year accretion (V090-V095).

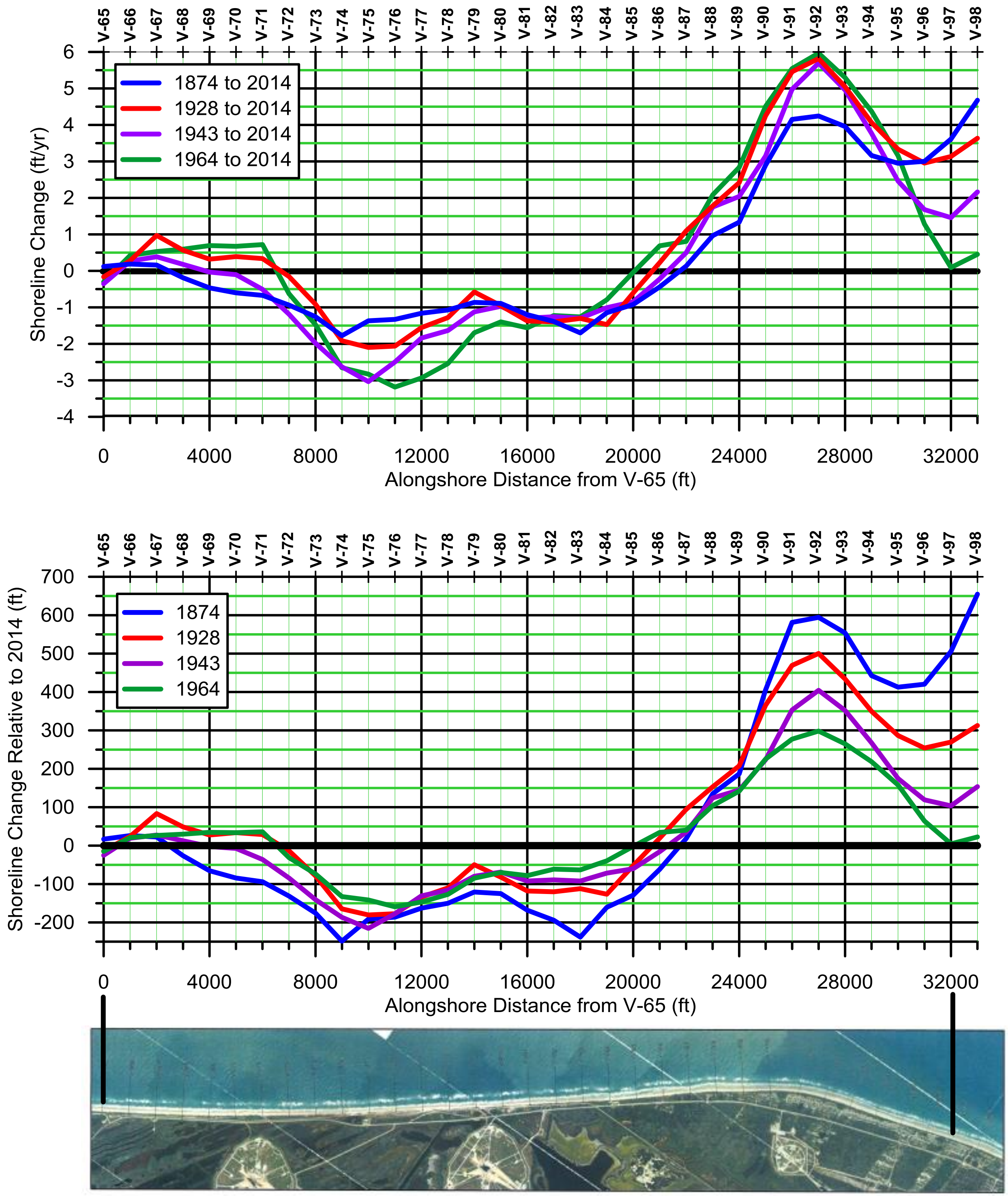


Figure A-1: Historical shoreline locations, and average-annual rates of shoreline change for selected typical intervals, along the KSC coastline from 1874 through September 2014.

Figure A-2 depicts recent locations of the high water shoreline along KSC relative to the 1943 location, specifically including survey data from 1964 through September 2014. The average-annual rates of shoreline change, discerned from these data, are additionally shown for the periods 1943-2014 and 1999-2014. These average-annual rates are based upon regression (linear trend) analysis of the shoreline locations for each year within the given time period, including the years 1943, 1948, 1964, 1969, 1976, 1999, 2007, 2009, 2011, and 2014 as applicable. The shoreline location represents the mean high water shoreline (+0.9 ft NAVD'88) for those recent survey data since 1999. The values were discerned from the data at 1000-ft alongshore spacing; i.e., at the FDEP virtual monuments. Rates of shoreline change using end-point analysis (1943 to 2014, and 1999 to 2014) were also computed. These values are similar to those developed through the regression analysis and are not illustrated.

Figure A-3 similarly depicts the locations of the shoreline and duneline discerned from interpretation of aerial photographs from 1943 through 2009, prepared by R. Schaub (IHA). The results are equivalent to those developed from the survey data as depicted in Figure A-2.

Figure A-4 depicts the change in shoreline location of the mean high water line (MHWL; +0.9 ft NAVD) and toe-of-dune (+8 ft) between May 2011 and September 2014. This includes the effects of Hurricane Sandy in 2012. The lower figure illustrates the change in the MHWL and dune-line over the last 15 years [1999-2014] computed from regression analysis of these contours' locations for the intervening surveys 1999, 2007, 2009, 2011, 2012 and 2014. The computed shoreline change rates of the MHWL and duneline are very similar -- indicating that long-term changes (erosion/accretion) along the dune are similar to those of the MHWL.

The modern shoreline change data depicted in Figures A-2 through A-4 are consistent with the long-term historical shoreline changes described in Figure A-1. This affirms a long-term, chronic response of the KSC shoreline to oceanographic forces, generally consisting of erosion along 3.2 miles north of False Cape (V-070 to V-087) and accretion for 1.7 miles along and south of False Cape (V88 to V-096). Specifically, the prevailing shoreline trends since 1943/1999 include

- moderate stability of the northern 0.9 miles of the KSC shoreline (from V065.3-V070);
- very severe erosion of the north-central 1.9 miles of KSC shoreline between launch pads 39A and 39B (from V070/71 to V080, particularly from V071.5-V078), ranging from at least -2 to -6 ft per year;
- chronic erosion along the central 1.3 miles of KSC shoreline (V080-V087), from Pad 39A to 500-feet north of the Corrosion Test Facility, averaging between -1 and -2 ft/yr;
- mild stability to accretion along 0.2-miles north of False Cape (V087-V088);
- accretion along 1.5-miles at and south of False Cape (V088-V096), extending from False Cape to about 300 feet north of the Beach House; and
- dynamic stability or perhaps developing erosion along the southern 0.4 miles of the KSC shoreline, extending into the north end of CCAFS (V096-V098).

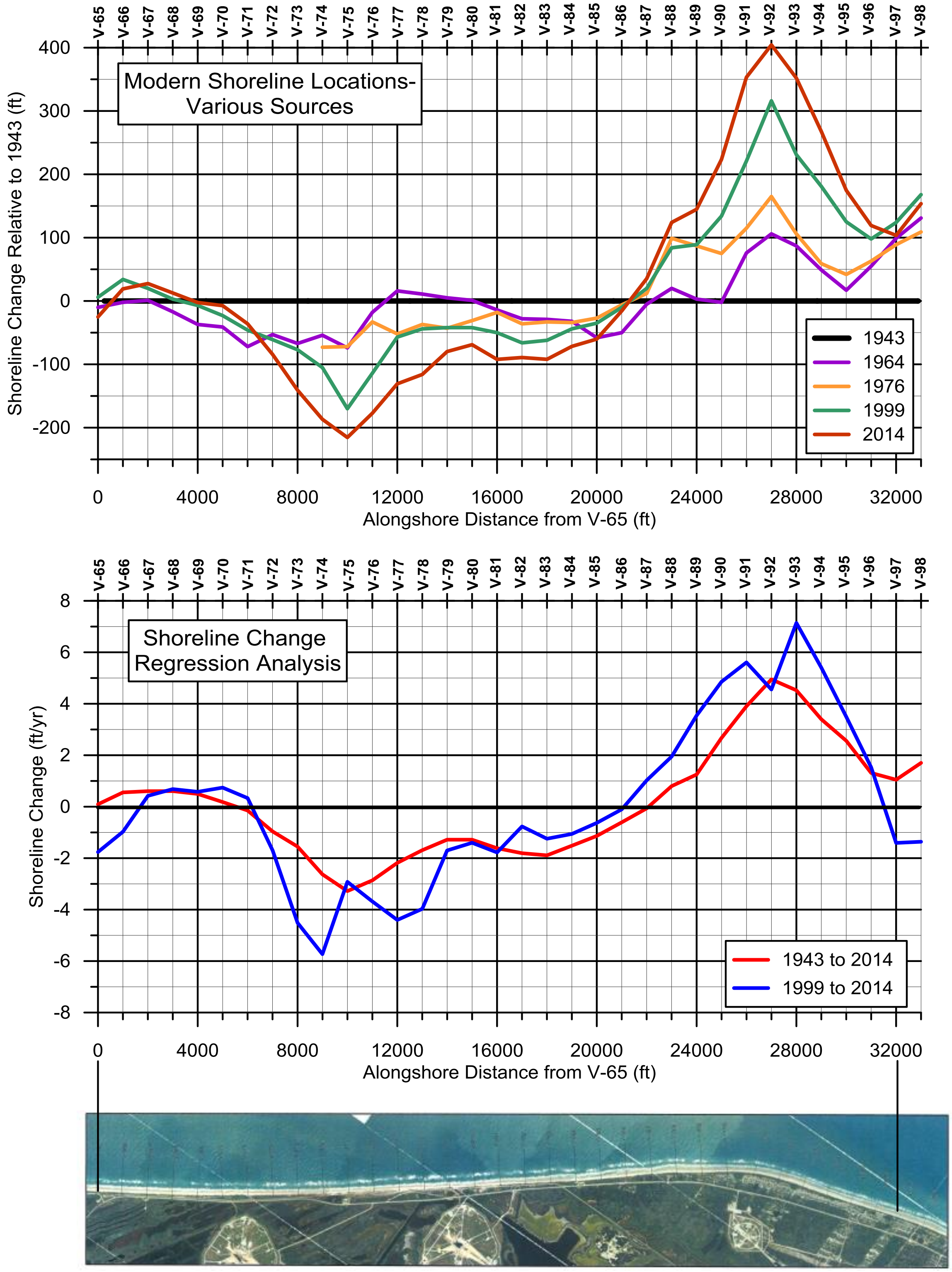


Figure A-2: Recent shoreline locations and average-annual rates of mean high water shoreline change along the KSC coastline from 1943 through September 2014.

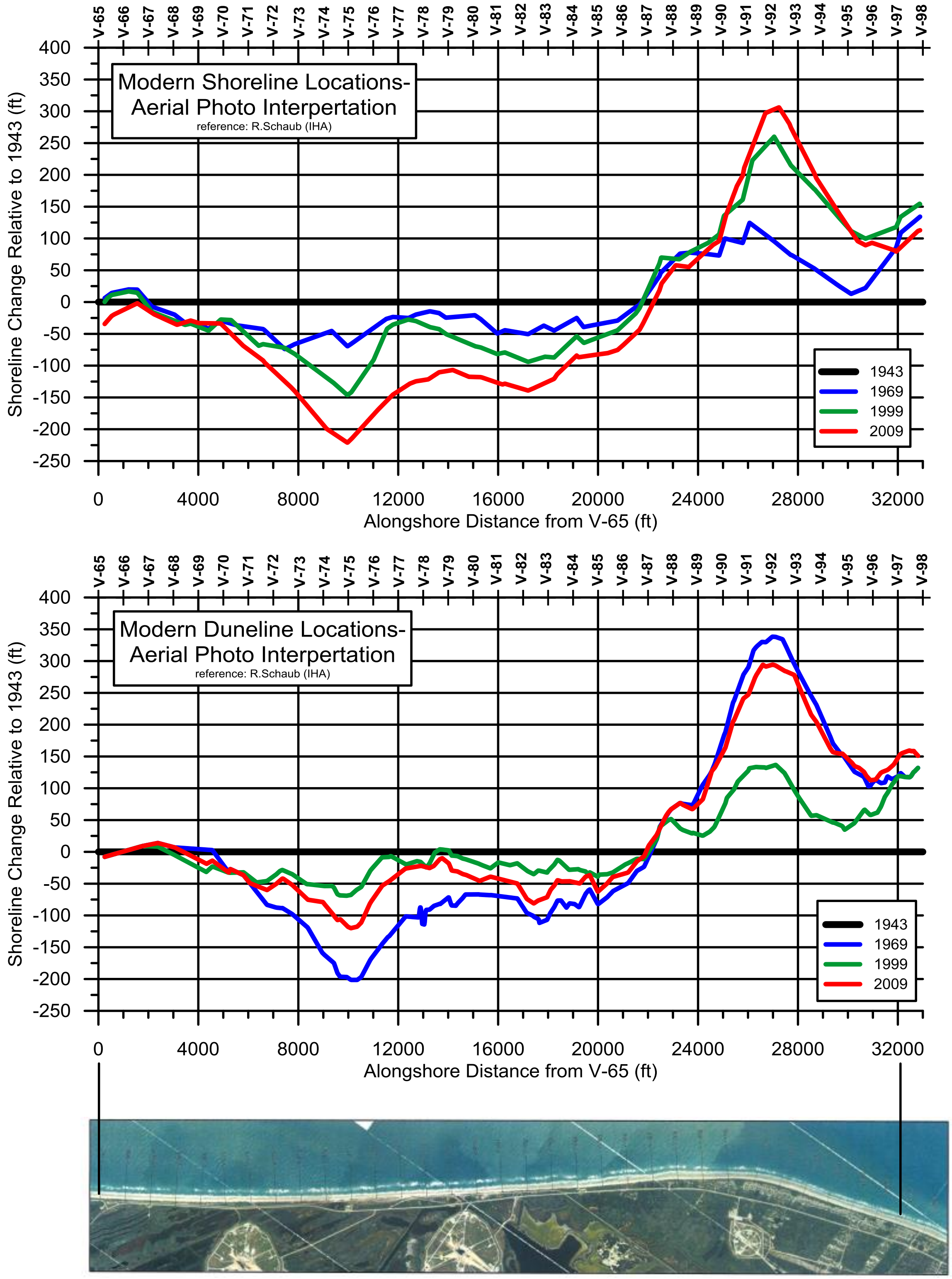


Figure A-3: Recent changes in the shoreline and dune locations interpreted from aerial photography, 1943 to 2011. Adapted from data provided by Ron Schaub (IHA).

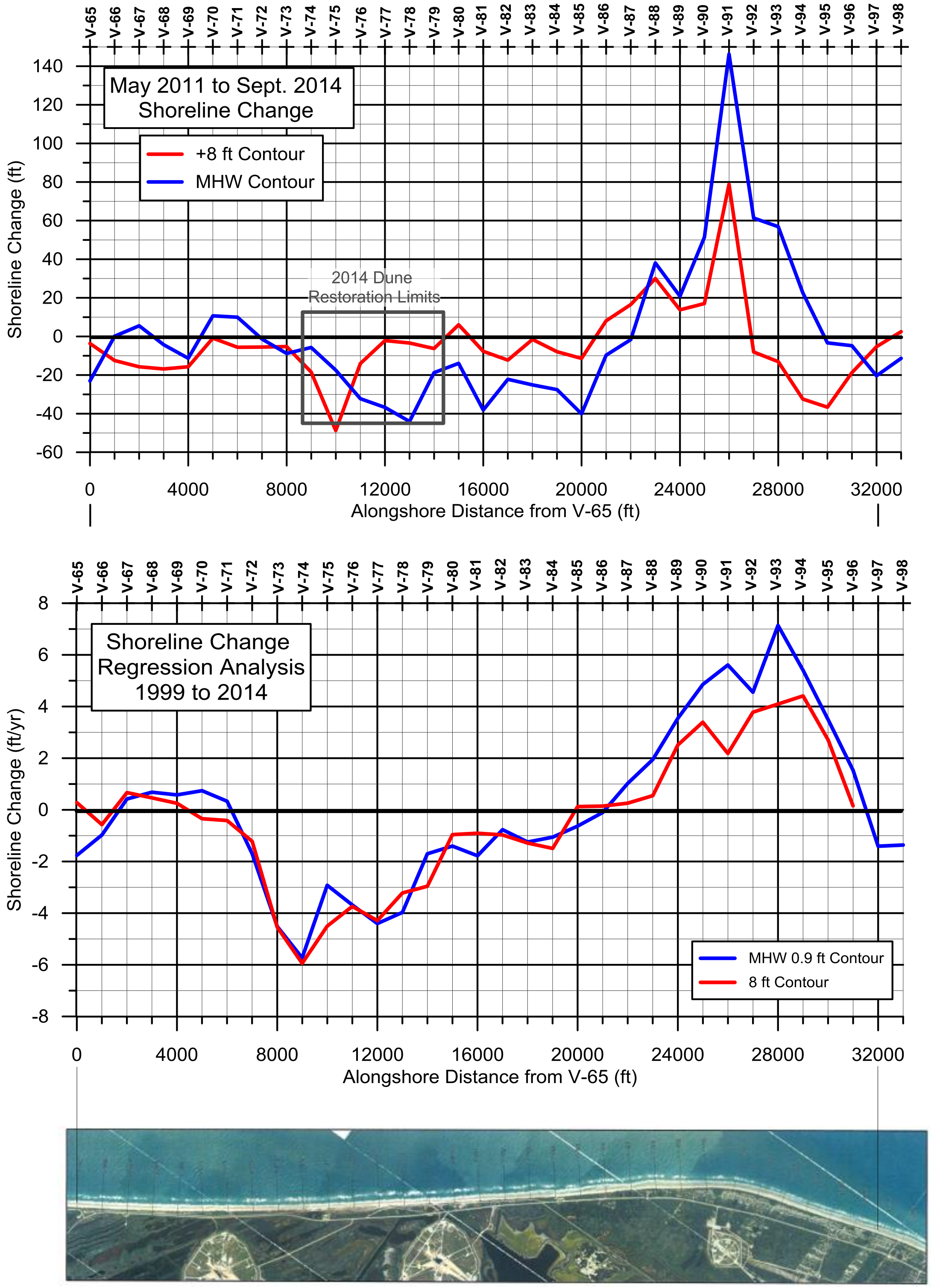


Figure A-4: Change in shoreline location from May 2011 to September 2014 (including Hurricane Sandy impacts in 2012), and average-annual rate of shoreline change computed from Fall 1999 to September 2014, along the mean high water shoreline (+0.9') and toe-of dune (+8', NAVD).

Sufficient beach profile data extending from the dune to depth-of-closure (or at least to -17 ft NAVD) are not known to be available for the purposes of computing, reliable long-term beach volume changes along KSC. **Figure A-5** presents a proxy estimate of beach volume changes along the coastline based upon the historical shoreline changes illustrated in the previous figures. These estimates utilize a Bruun Rule approach that assumes an active vertical beach profile height of 27 feet (from nominal dune elevation of +11 ft to profile toe of -16 ft, NAVD), which suggests a volumetric change of 1 cy/ft per ft alongshore. The figure presents the cumulative alongshore volume change, computed from north to south along the KSC shoreline, using the average-annual shoreline change rates computed for the periods 1874/1928 to 2014 (average value), 1943 to 2014, 1999 to 2011 and 1999 to 2014. Downward-sloping lines indicate erosion; upward-sloping lines indicate accretion.

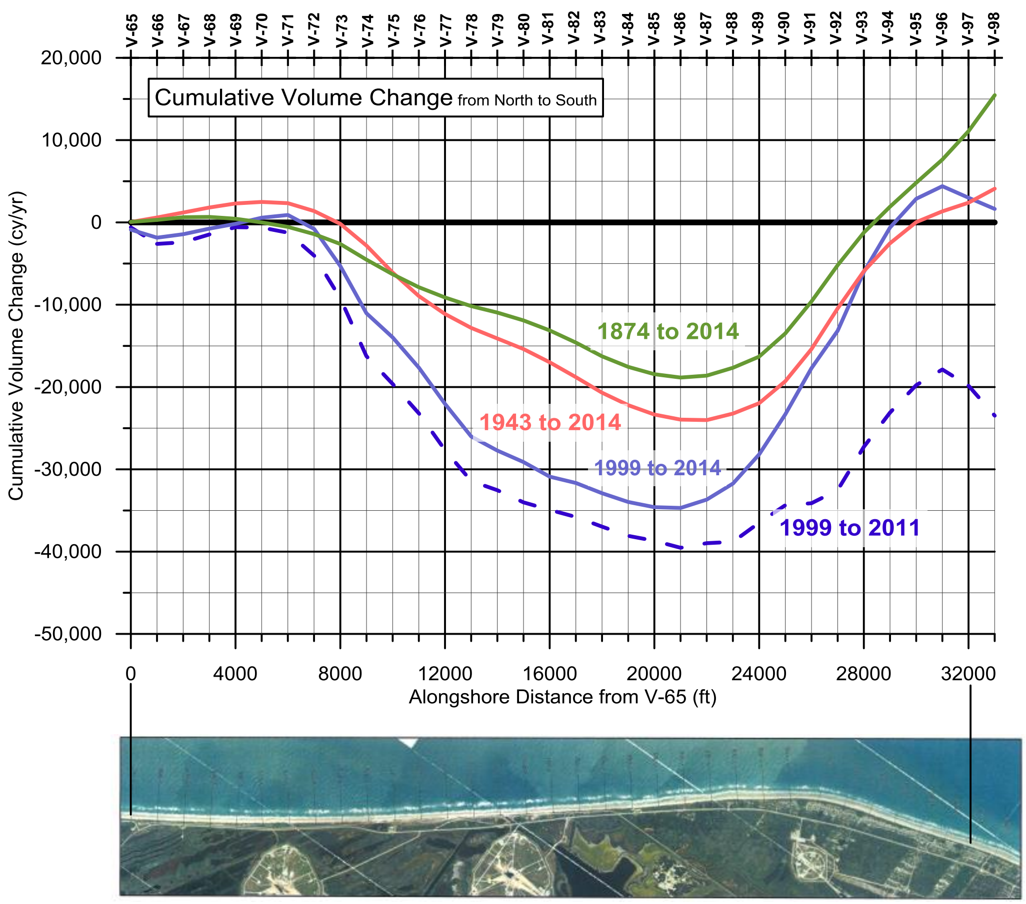


Figure A-5: Cumulative alongshore volume change, computed from north to south along the KSC shoreline, based upon average-annual rates of shoreline change.

From **Figure A-5**, a proxy estimate of the average-annual net rate of beach erosion along the northern 21,000 feet (4 miles) of KSC shoreline, from V-065 to V-086, is -35,000 to -40,000 cubic yards per year since 1999. From 1999-2011, the southern 12,000 feet (2.2 miles) of KSC shoreline, from approximately V-086 to V-098 -- along and south of False Cape – gained about +16,000 cubic yards per year, suggesting a loss of sand along the overall KSC shoreline of on the order of -24,000 cy/yr from 1999-2011. From 1999-2014 (including Hurricane Sandy), the southern 12,000 ft of KSC shoreline may have gained almost 38,000 cy/yr – offsetting the estimated beach profile losses north of False Cape, for an overall apparent net balance.

For the long-term period 1874/1928 to 2014, the estimated volume losses north of False Cape (about -19,000 cy/yr) were more than offset by accretion south of False Cape (about +35,000 cy/yr). For the long-term contemporary periods 1943-2014 and 1999-2014, the estimated net volumetric losses north of False Cape (about -24,000 cy/yr and -35,000 cy/yr, respectively) appear to have been approximately balanced by estimated net volumetric gains south of False Cape. In contrast, for 1999 to 2011, losses north of False Cape (-40,000 cy/yr) exceeded apparent gains south of False Cape (+16,000 cy/yr), for net erosion of about -24,000 cy/yr.

These results suggest that, on temporal average, the rate of beach volume loss along the northern 4 miles of the KSC shoreline has progressively increased over the last century (i.e., from about -19,000 cy/yr in the long-term to between -35,000 and -40,000 cy/yr at present). And, in the present epoch – at least from 1999 to 2011 (excluding Hurricane Sandy), the rate of erosion north of False Cape exceeds the rate of deposition south of False Cape (i.e., by -40,000 cy/yr versus +16,000 cy/yr).

The long-term historical data (from c. 1874/1928 and c. 1943) indicate that False Cape was prograding in the whole toward the south. The recent historical data (c. 1999-2011) suggest that the Cape is continuing to prograde toward the south, however, it is doing so with a slight net loss (erosion) to the overall headland and shoreline. During this period, the northern two-thirds of the KSC shoreline may have eroded at 2.5 times the rate at which the southern one-third of the KSC shoreline accreted. The long-term rate of erosion of the northern two-thirds of the KSC shoreline appears to be accelerating – or, at least, not diminishing – over the last century.

Figure A-5 demonstrates that the most severe shoreline erosion is concentrated between launch pads 39A and 39B (approximately V-071 to V-078), and more broadly from the Corrosion Test Facility to just north of launch pad 39B (approximately V-070 to V-087), or a distance of about 3.2 miles. This latter reach corresponds to that portion of the KSC shoreline that exhibits the lowest and narrowest natural dune ridge that separates the upland from the ocean (i.e., excepting the post-Hurricane Sandy dune repair project constructed in 2013-14). Observation indicates that the dune along parts of this reach is very frequently overwashed by storm tides and waves. These areas (specifically from V-071/072 to V-078) are the areas of highest, long-term shoreline erosion rate. Prior to Hurricane Sandy in 2012, it was anticipated that the minor dune along this area would be eroded, overtopped and breached in the near future – which, indeed, occurred during Hurricane Sandy. Erosion, overtopping, and breaching of the dune in this area can be expected in the future, resulting in significant inundation and/or flooding of the low-elevation uplands that lie immediately landward of the dune ridge.

Figures A-6 and A-7 depict the land elevations of the KSC barrier island complex prior to Hurricane Sandy's impacts in October 2012 and subsequent emergency dune reparations in 2014. Almost all of the inland lies below +5.0 ft NAVD; i.e, the approximate predicted storm water level for a 10-year return period event (USACE 2010, after Dean and Chiu 1986). Much of the complex lies below the normal mean high water elevation, approximately +1 ft NAVD. Along the northern 3.6 miles of the coastline, these low inland areas are separated from the ocean by a narrow dune ridge. Most of this natural ridge is substantially less than +9.6 ft elevation (the predicted 100-yr still water storm level), particularly in the highest chronic erosion areas between launch pads 39A and 39B where the dune is frequently overwashed. A 25-yr return period storm event (such as estimated for Hurricanes Frances or Jeannie, in 2004), with still water surge level of at least +7 ft NAVD -- or a less severe storm – will readily breach the weakest portions of this dune ridge, flood the uplands, and ultimately blow out remaining sections of the dune by flanking and backwash. The potential for this damage will increase annually as the natural beach and dune continues to erode through the chronic erosion stress exhibited by the shoreline history indicated over the last decades and century.

Figure A-8 depicts the maximum dune elevation and the total sediment volume above +7 ft NAVD within 220-ft landward of the mean high water shoreline in existing conditions (Sept. 2014), pursuant to the construction of Post-Hurricane Sandy dune reparations in early 2014. The +7 ft elevation approximately corresponds to the 25-year storm surge level and the natural beach berm elevation; and the 220-ft distance includes the limits of the 2014 dune reparations. Lower dune heights and volumes south of V-089 are associated with the lower-energy, accretional nature of the shoreline area along and south of False Cape, and do not otherwise indicate shoreline vulnerability.

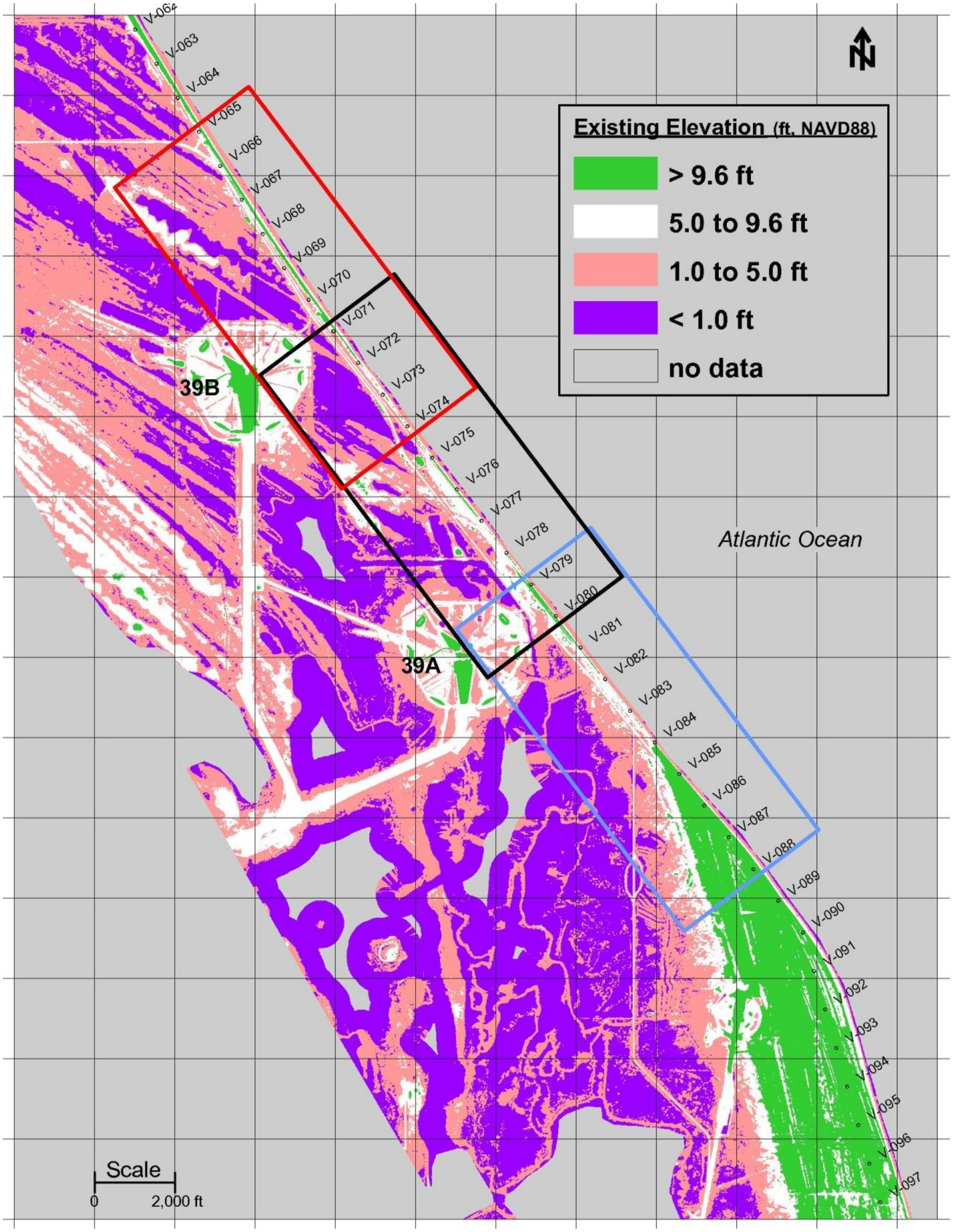


Figure A-6: Upland land elevations along the overall KSC oceanfront (from 2007 Lidar survey). Much of the interior is below Mean High Water elevation, approximately +1 ft (pink), and below +5 ft elevation (purple), separated from the ocean by a narrow ridge above +5 ft (white). Lands higher than the approximate 100-year storm elevation, +9.6 ft (green), include the ocean dune ridge that diminishes in height and width between launch Pads 39A and 39B. Detailed views (box areas) are shown in Figure A-7.

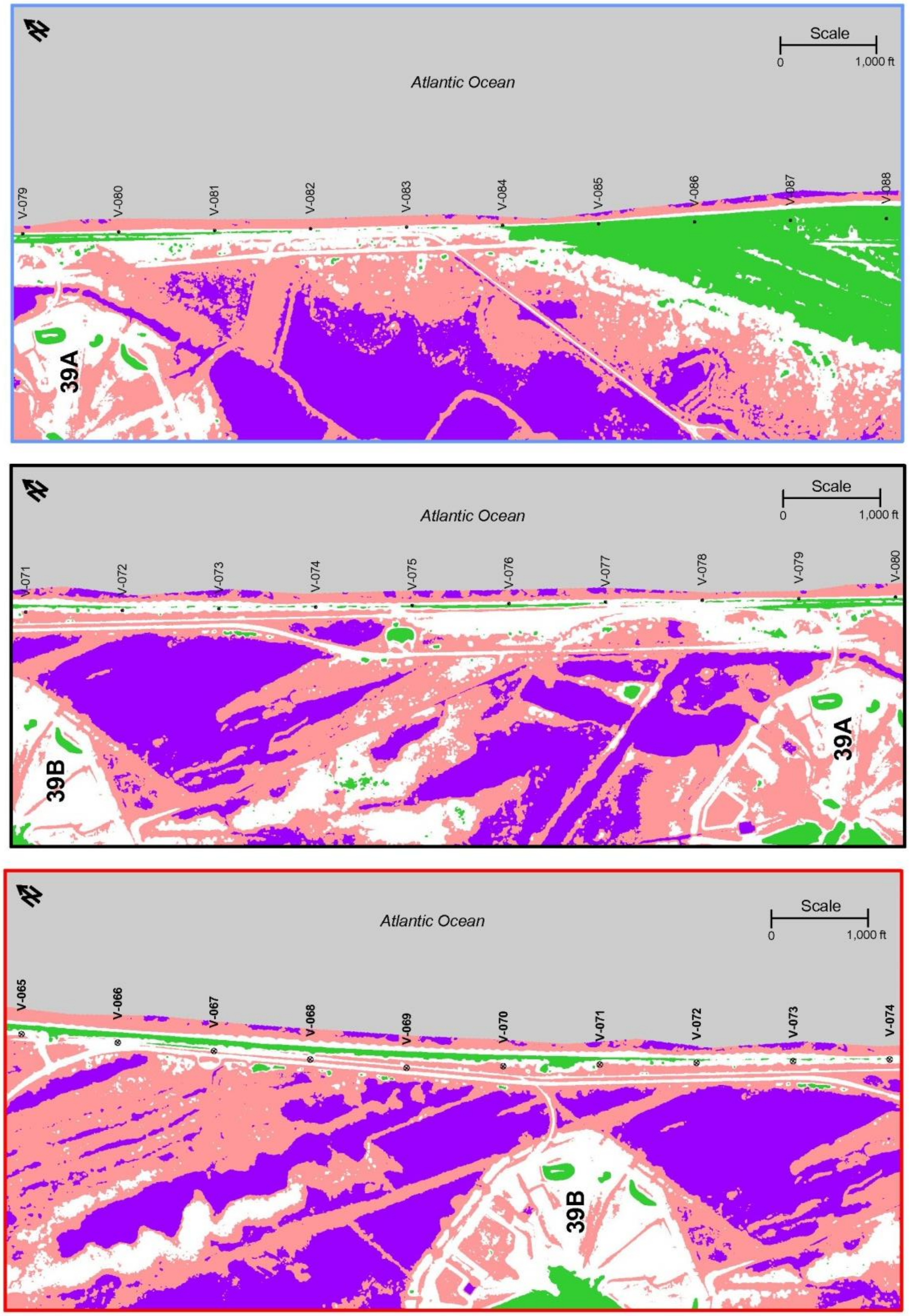


Figure A-7: Detail view of land elevations along the KSC shoreline, north of False Cape (from 2007 Lidar survey). Dunes with elevation above the approximate 100-year still-water storm level (+9.6 ft), indicated in green, are narrow or minimal along the central shoreline, from V071-V-084. Colors indicate land elevations above +9.6 ft (green), between +5 and +9.6 ft (white), below +5 ft (pink), and below +1 ft (purple). Areas in purple are below the approximate Mean High Water elevation.

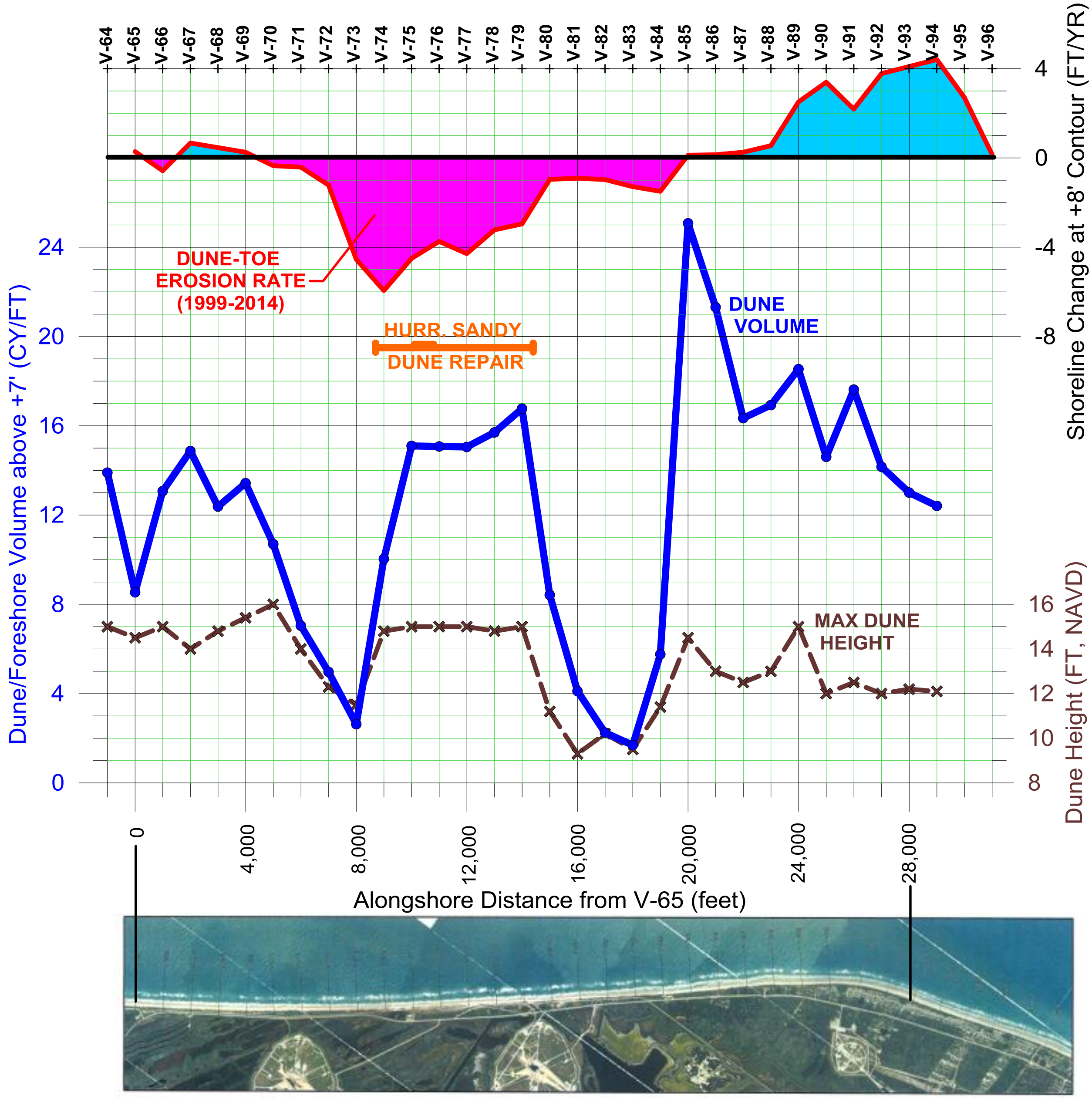


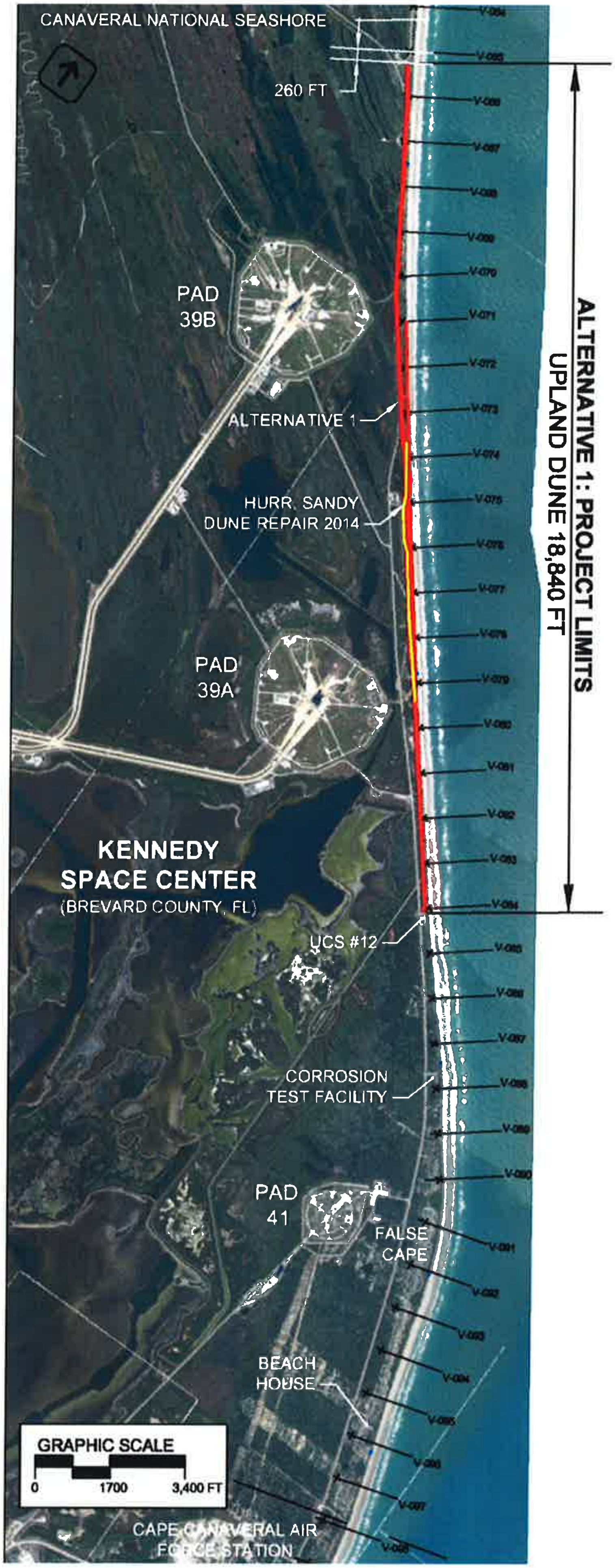
Figure A-8: Existing dune/foreshore sand volume above +7 ft NAVD (blue), and maximum dune height (brown), within 220-ft landward of the mean high water shoreline. The values include conditions measurd in September 2014, pursuant to the Post-Hurricane Sandy dune reparations in Spring 2014. (The 220-ft distance includes the landward limit of the dune reparations above +7 ft NAVD.) The average annual rate of dune erosion, measured along the +8' NAVD contour (red-erosion, blue-accretion), from 1999 through September 2014, is illustrated at the top of the figure.

References:

Dean, R. G. and Chiu, T. Y. 1986. Combined Total Storm tide Frequency Analysis for Brevard County, Florida. Beaches and Shores Resource Center, Inst. Of Science and Public Affairs, Florida State University, Tallahassee, Fl. May 1986.

USACE 2010. Final Integrated General Re-Evaluation Report and Supplemental Environmental Impact Statement; Brevard County, FL Hurricane and Storm Damage Reduction Project, Mid Reach Segment. U. S. Army Corps of Engineers, Jacksonville District. Jacksonville, FL. September 2010.

APPENDIX B



Kennedy Space Center Shoreline Protection

Upland Dune ("Alternative 1")

Planform and Section View Concept Layout, Updated – Nov. 2014

Prepared for

InoMedic Health Applications

and

NASA
Kennedy Space Center, Florida

Prepared by

Olsen Associates, Inc.
Jacksonville, Florida

14 Nov. 2014

olsen
associates, inc.
Coastal Engineering

Kennedy Space Center Shoreline Protection
Upland Dune ("Alternative 1")

Planform and Section View Concept Layout
Updated – November 2014

The following sheets (27) update the Planform and Section views of the KSC "Upland Dune" Alternative #1 to reflect 'current' shorefront conditions; i.e., after the Post-Hurricane Sandy dune repairs. The beach profile sections reflect September 2014 survey data (where profile data were collected), else they reflect the prior March 2012 (pre-Sandy) survey data. The beach profile sections are spaced 1000-feet apart, arranged north to south along the shoreline. At those locations where September 2014 profile data were not collected (well north and south of the Hurricane Sandy dune repairs), the earlier March 2012 survey is a reasonable proxy for current conditions – because it appears that there were relatively minor changes to the dune crest and uplands at these locations, between 2012 and 2014, despite the impacts of Hurricane Sandy elsewhere.

The planform drawings (Sheets 1-16) depict the fundamental footprint of the Upland Dune that was originally conceived in 2012. This schematic-level lay-out sought to minimize environmental impact from the dune's construction, avoid the existing roadway, and was mostly aligned atop the railroad bed. This footprint is not changed in the drawings, and is depicted in BLUE. The footprint and crest of the "As-Built" post-Hurricane Sandy dune repairs have been added to the drawings, depicted in YELLOW and RED, respectively.[1]

The section drawings (Sheets 17-27) depict the nominal Upland Dune, located in accordance with the footprint shown in the planform drawings, and drawn in accordance with the general elevations, widths and slopes described for Alternative 1 in the Environmental Assessment. It is depicted in BLUE. The existing beach profile conditions -- measured in March 2012 at every survey monument, and measured in September 2012 at selected monuments – are depicted in BLACK and ORANGE, respectively.

These drawings are not intended as a "construction plan". Instead, they present a schematic-level illustration of the conceptual design of the Upland Dune (Alternative 1) relative to existing conditions. There is no specific accommodation (adjustment) of the Upland Dune location or geometry relative to the existing, post-Hurricane Sandy dune conditions. It is simply a literal geometric translation of the Alternative 1 Upland Dune concept design drawn upon the current shorefront. For example, at monument V-78 (sheet 21), the Alternative 1 dune is shown to overlap the existing Post-Sandy dune by about 5 feet on its landward face. In practice, of course, the Alt. 1 dune would be shifted 5 feet seaward so as not to bury the vegetation on the existing constructed dune. Such accommodations in location and dune geometry would be made in a final design, at such future time when a specific project scope is identified for construction.

A simple measure of the state of the existing dune conditions – relative to the observed rate of dune-toe retreat – is illustrated in Figure A on the following page. This figure depicts current (Post-Hurricane Sandy dune repair) conditions. It does not depict the conditions (i.e., dune volumes) that would result from construction of the Alternative 1 Upland Dune.

---

[1] Where the Sandy dune repairs joined the previously constructed inland dune, the prior dune is shown in ORANGE.)

In Figure A, areas with the least dune volume and height (blue and brown lines) – and with the greatest observed dune erosion (red/pink) – represent shoreline areas of greatest potential vulnerability to storm erosion and overwash. [South of V-86, the smaller dune volumes and heights correspond to historical beach accretion. These represent naturally low & fast-growing dune conditions, and not necessarily areas of high vulnerability.] Prima facie inspection of Figure A suggests that the greatest apparent, immediate need for dune improvement in priority order may be:

(1) V71.5-V75 (2) V79.4-V84 (3) V75-79.4 (4) V65-71.5.

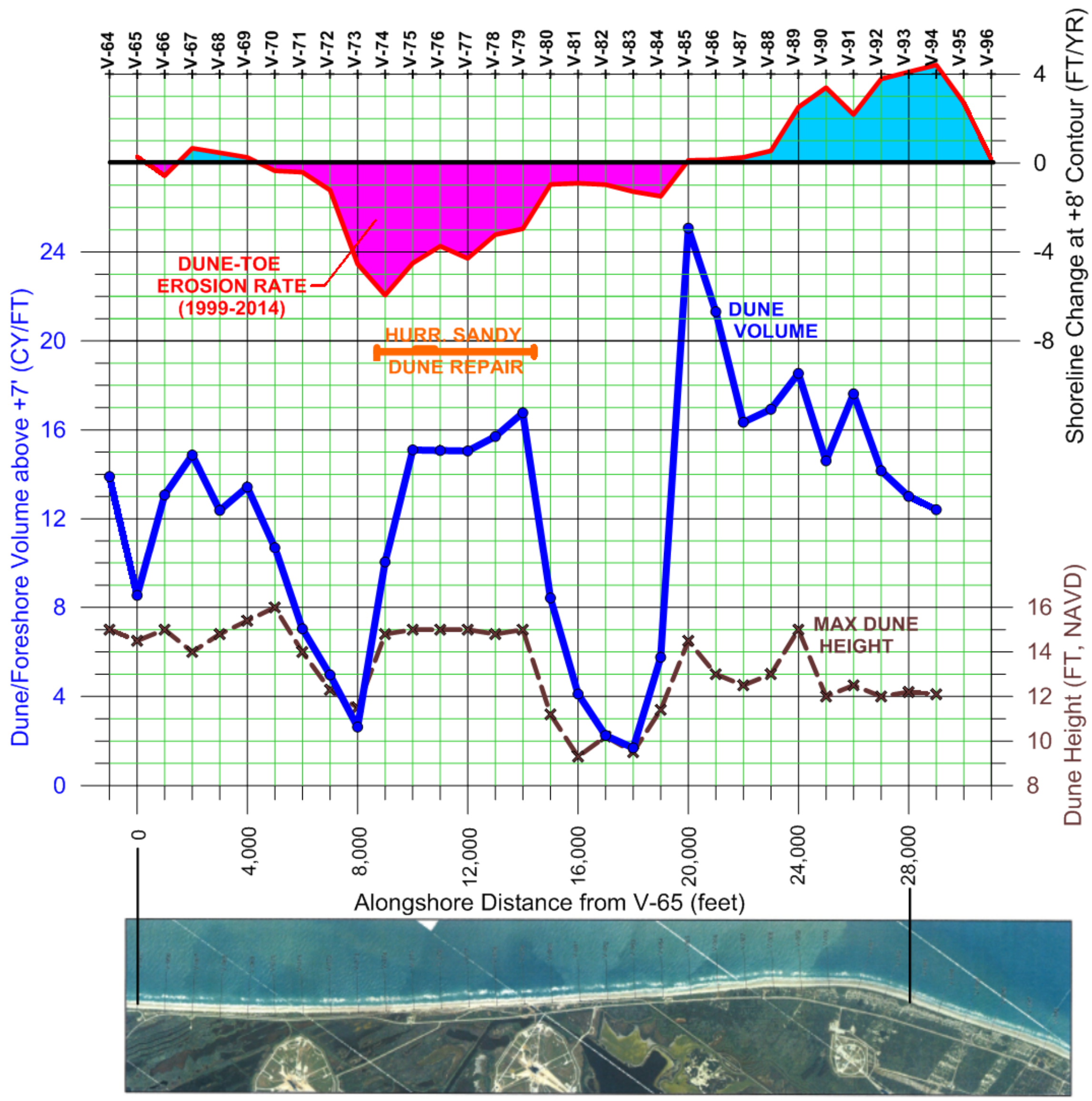
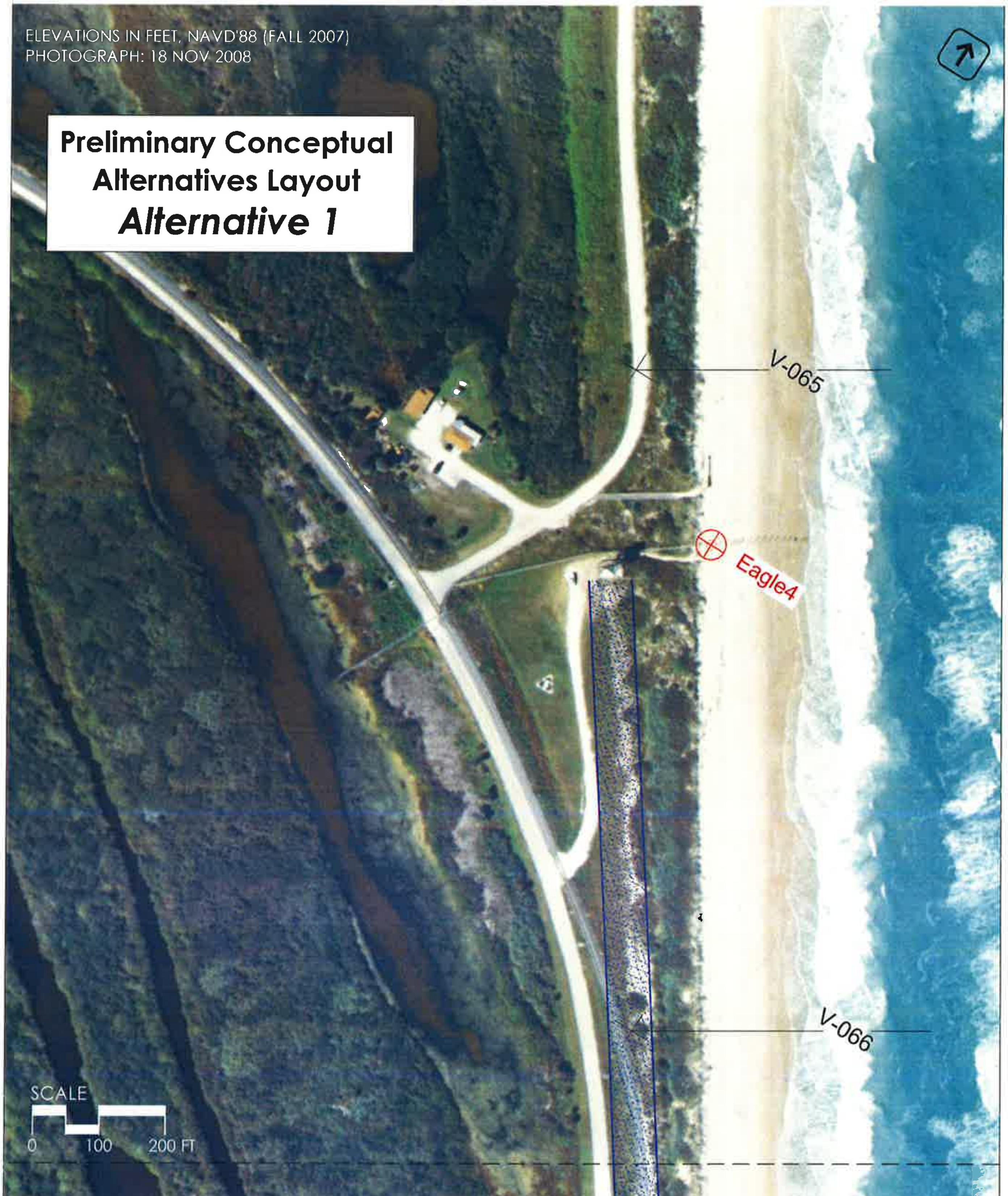


Figure A: Existing dune/foreshore sand volume above +7 ft NAVD (blue), and maximum dune height (brown), within 220-ft landward of the mean high water shoreline. The values include conditions measured in September 2014, pursuant to the Post-Hurricane Sandy dune reparations in Spring 2014. (The 220-ft distance includes the landward limit of the H. Sandy dune reparations above +7 ft NAVD.) The average annual rate of dune erosion, measured along the +8' NAVD contour (red=erosion, blue=accretion), from 1999 through September 2014, is illustrated at the top of the figure.



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KENNEDY SPACE CENTER
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ALTERNATIVE 1
SHORE PROTECTION PROJECT

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HURRICANE SANDY
DUNE REPAIR ADDED

01/02/12
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SHEET 1 of 27

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2 of 27

Preliminary Conceptual Alternatives Layout

Alternative 1

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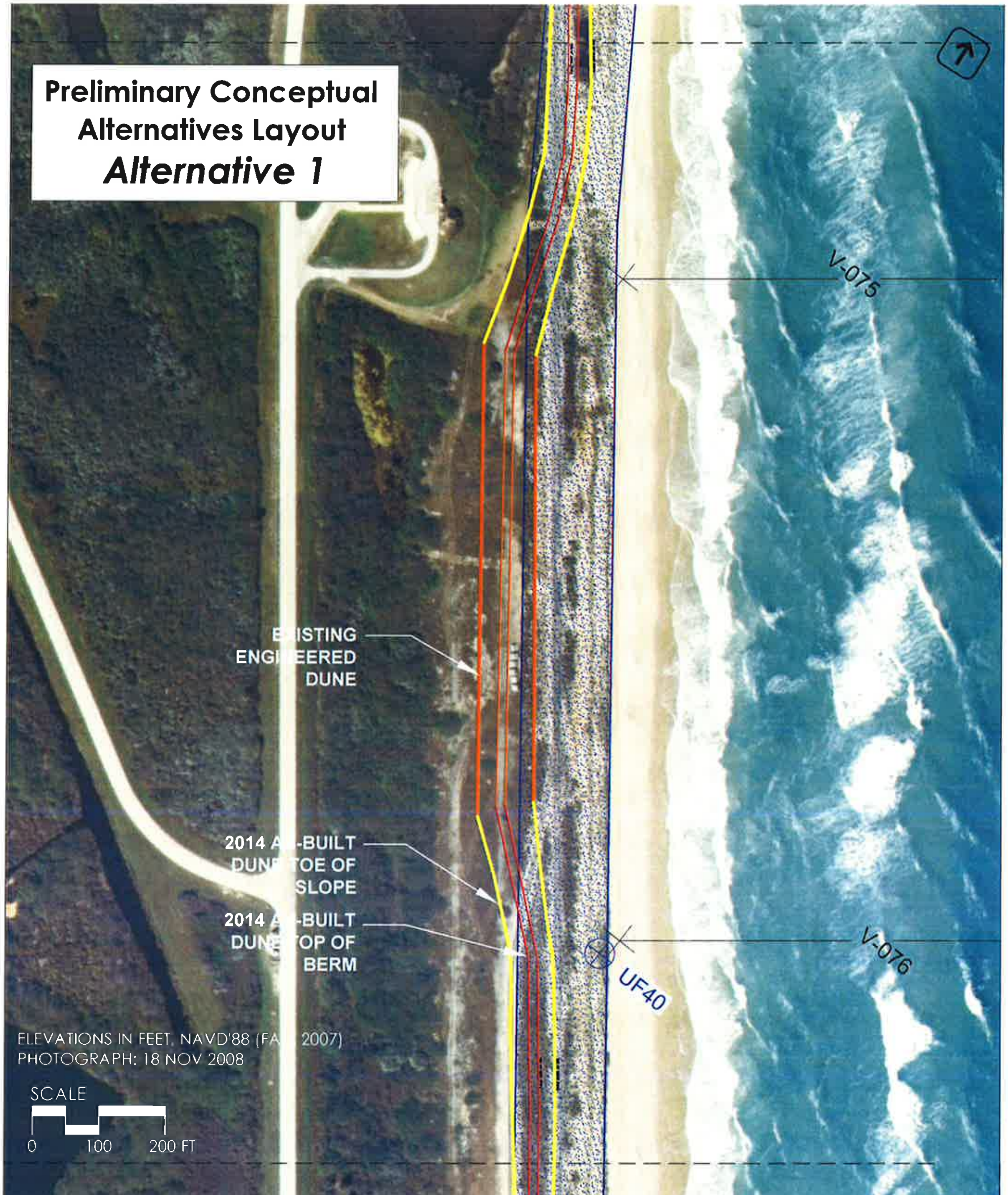

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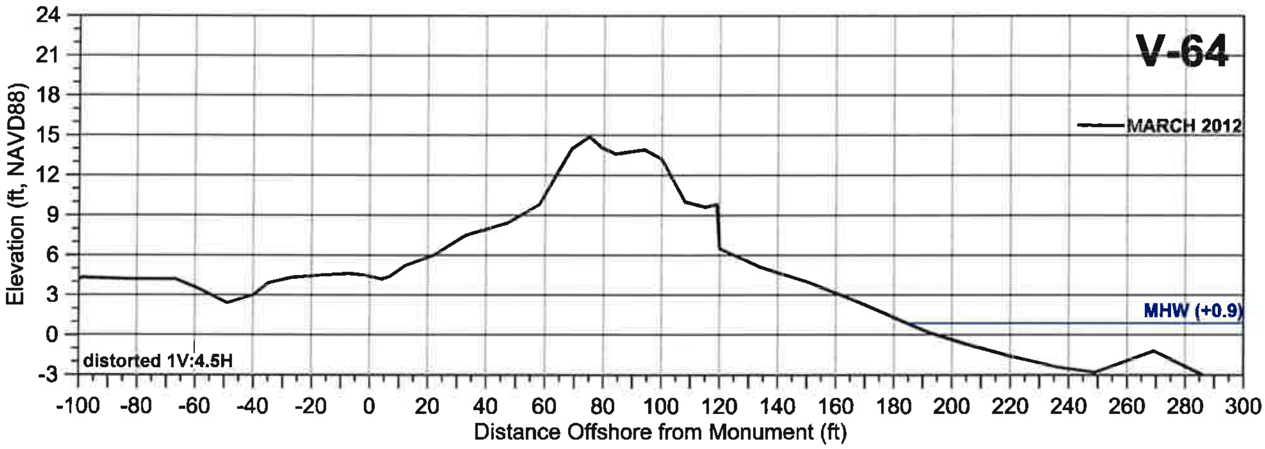

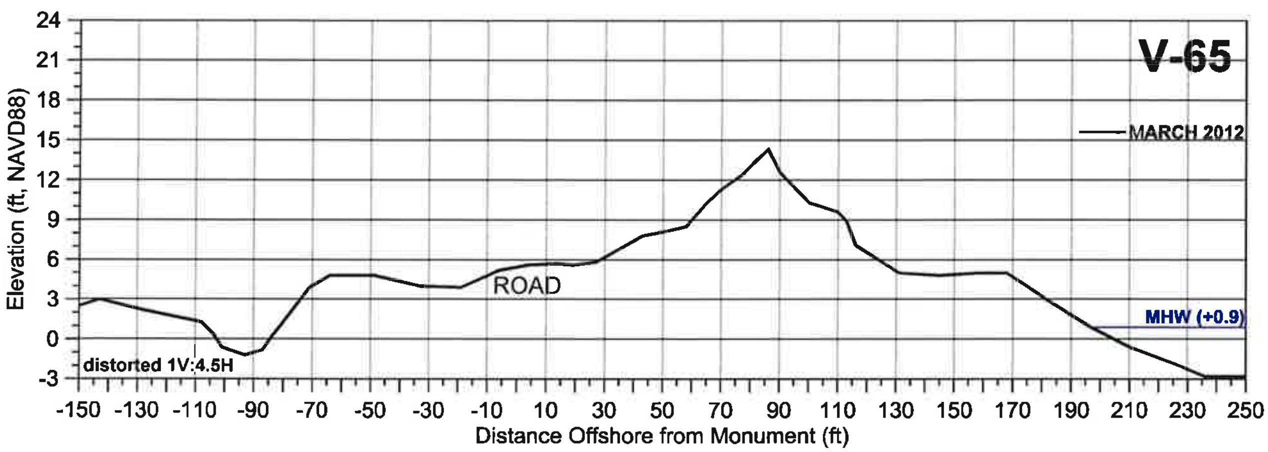

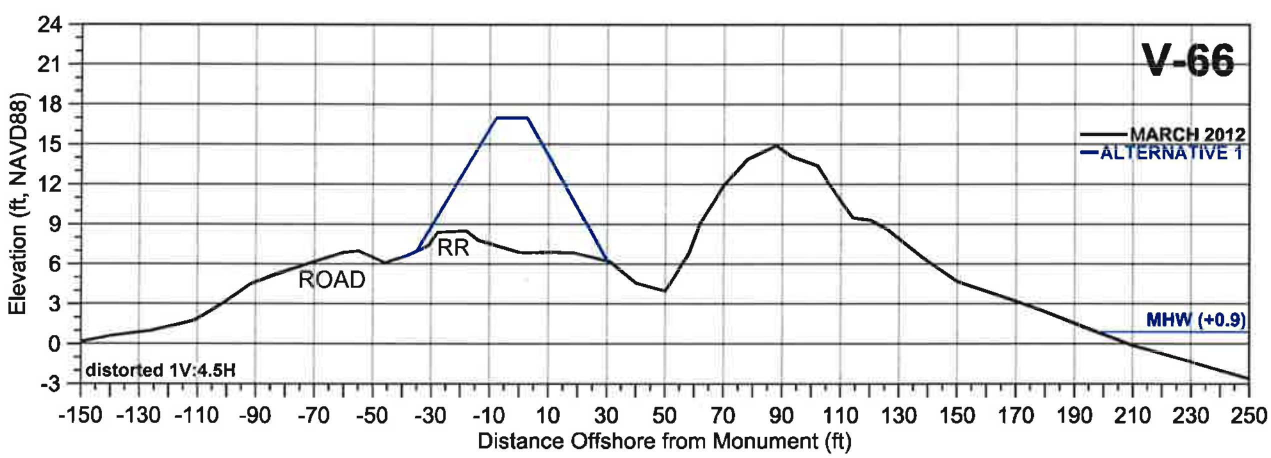

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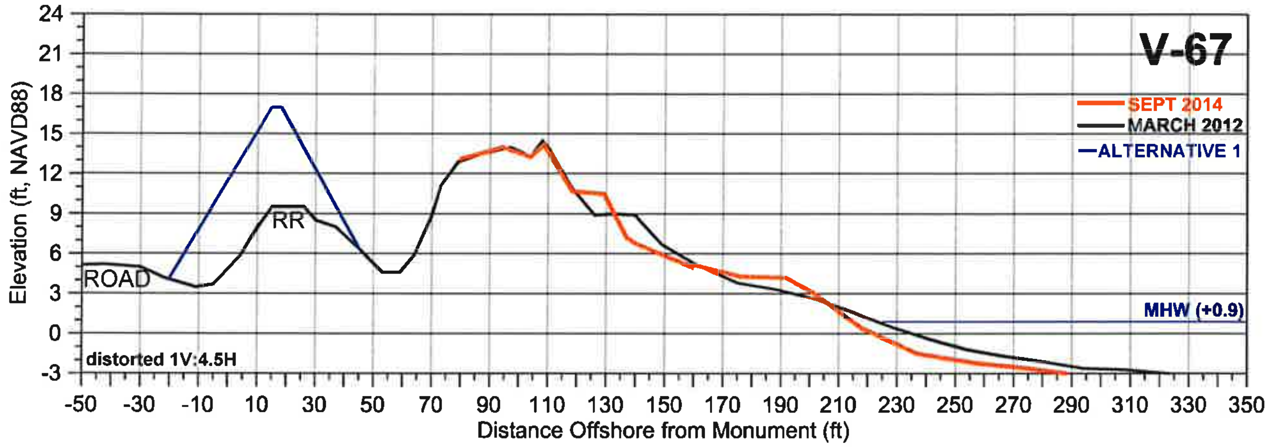

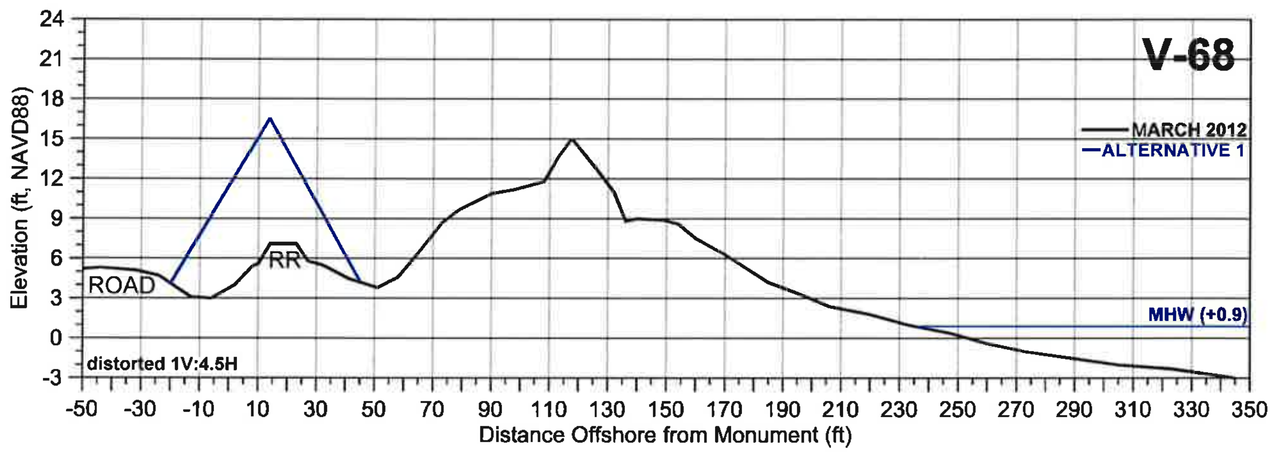

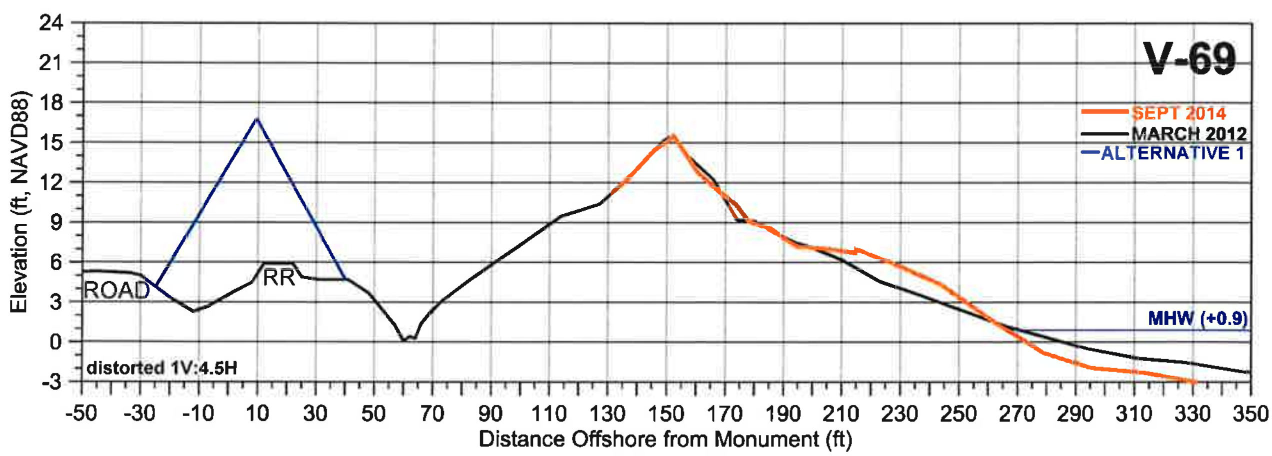

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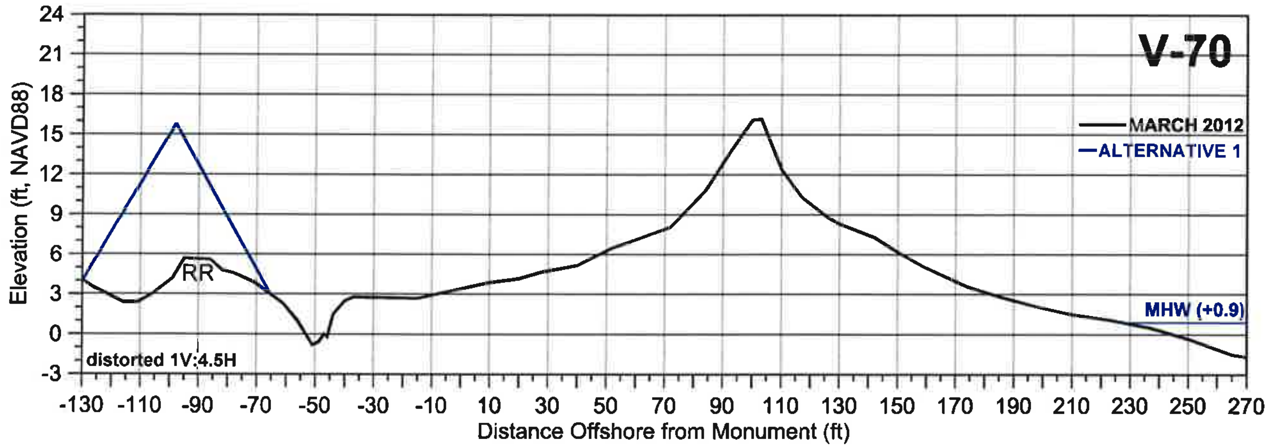

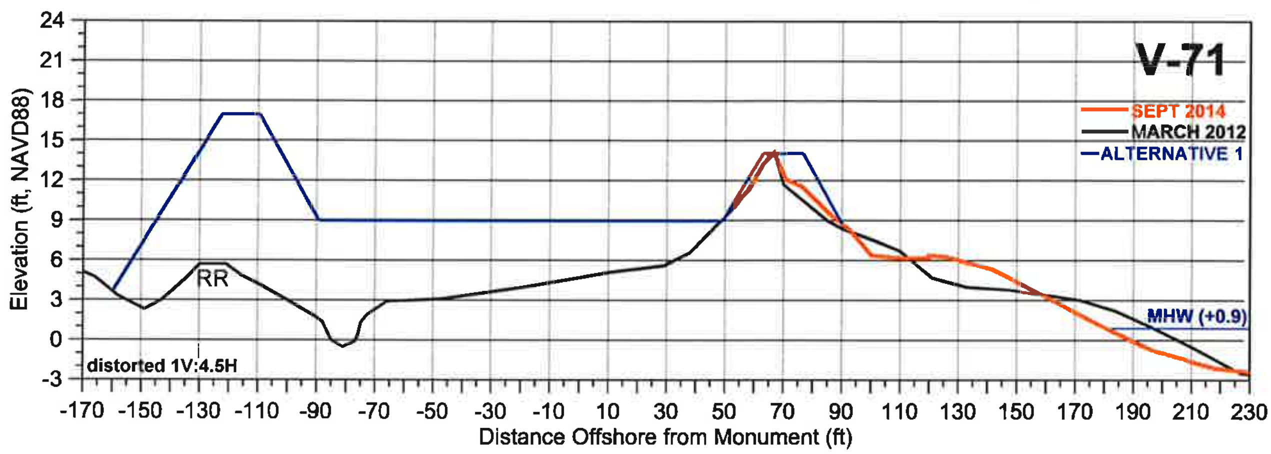

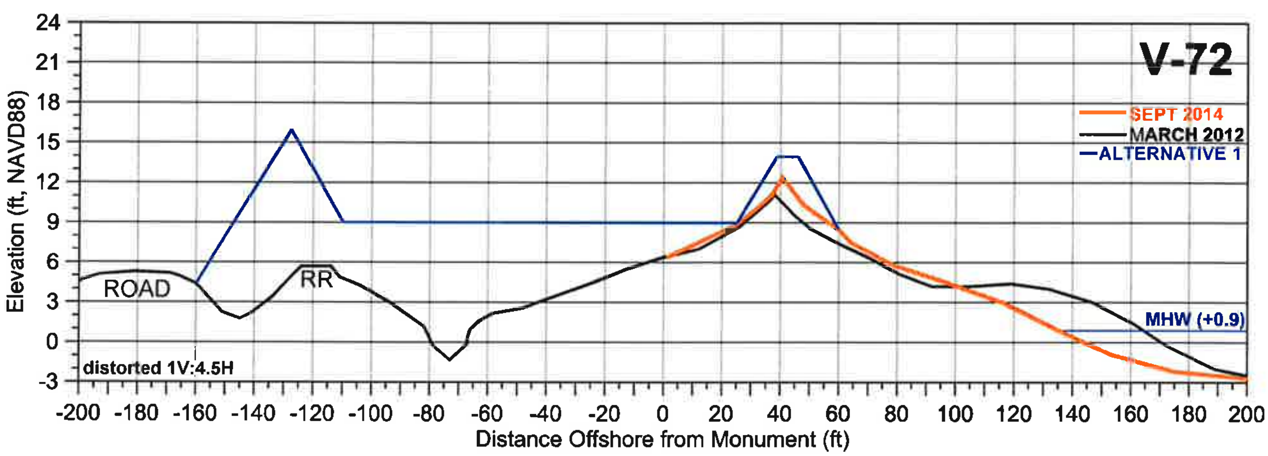

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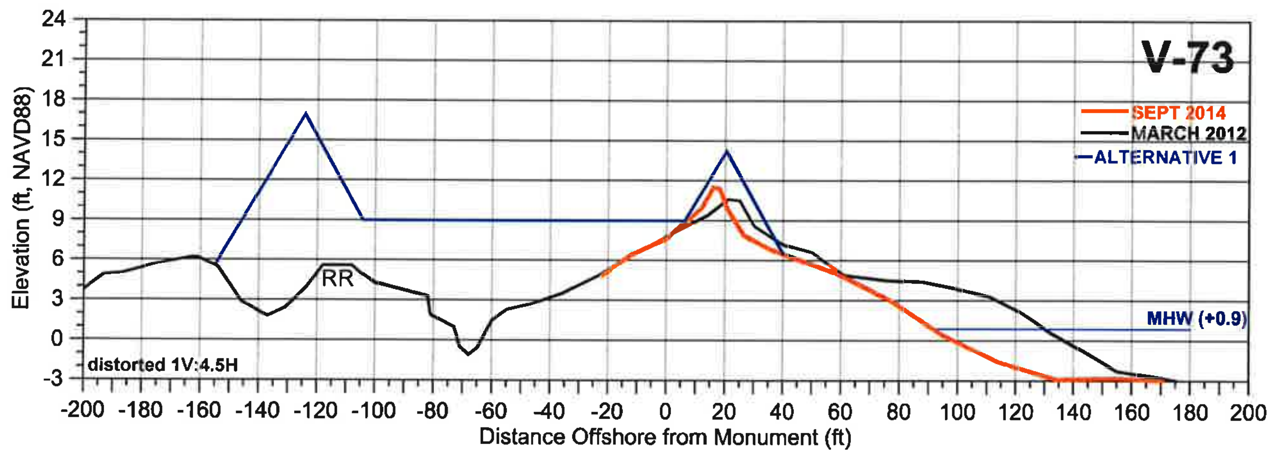

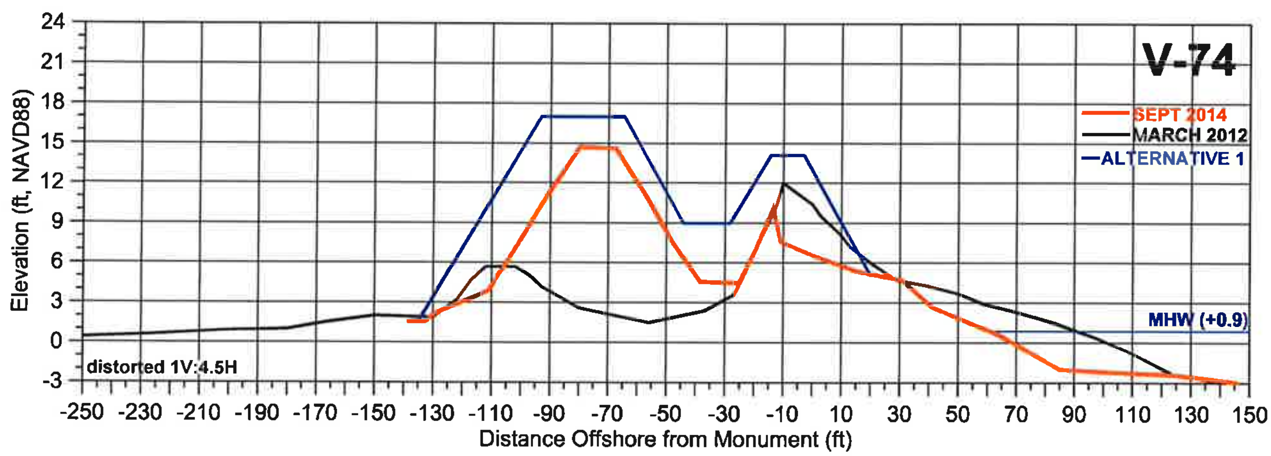

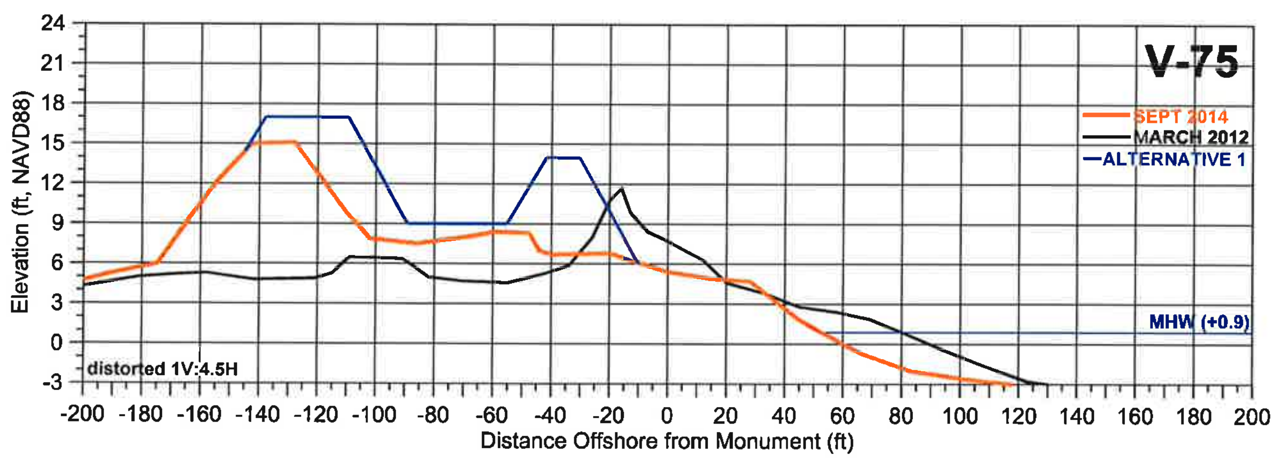

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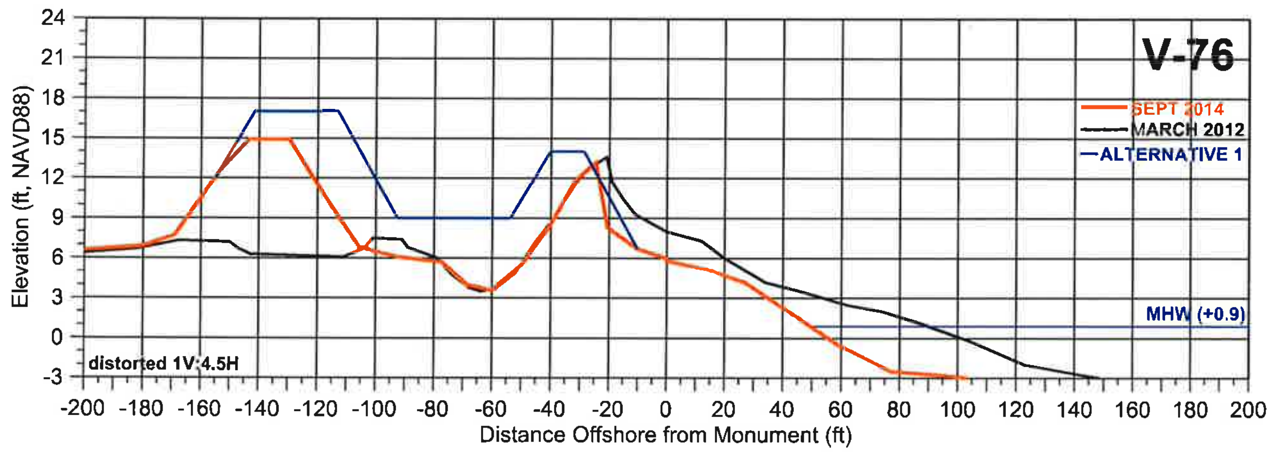

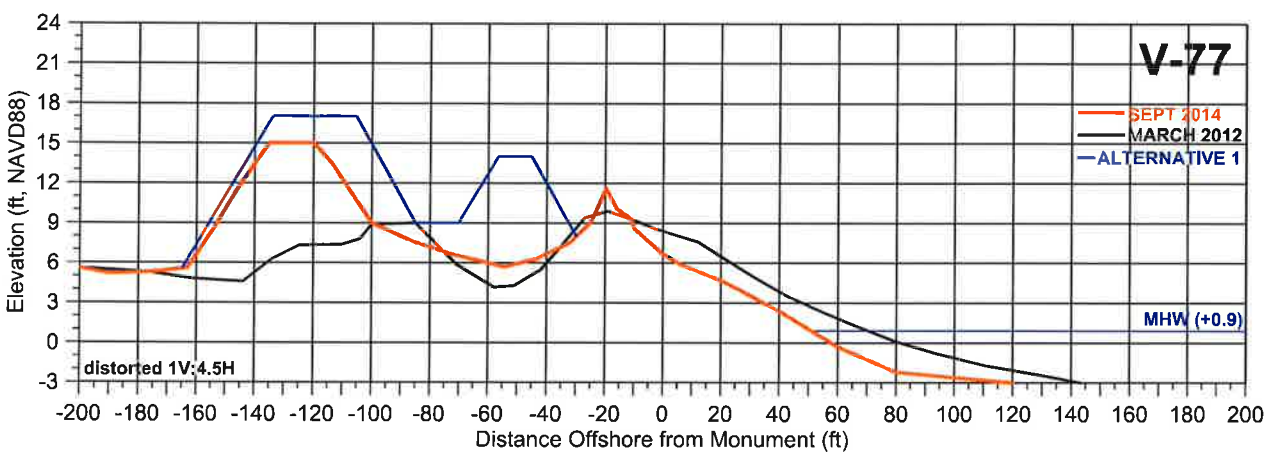

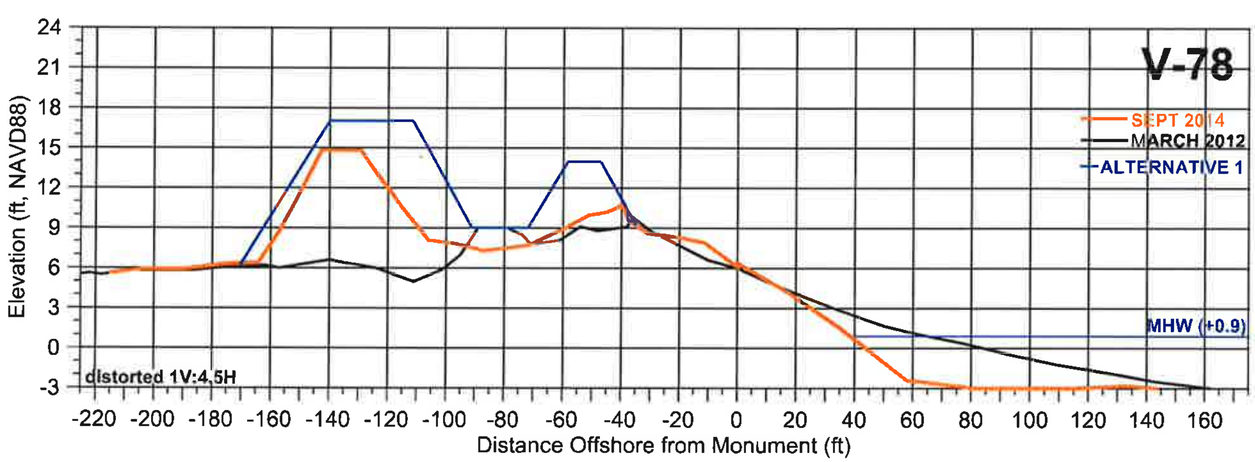

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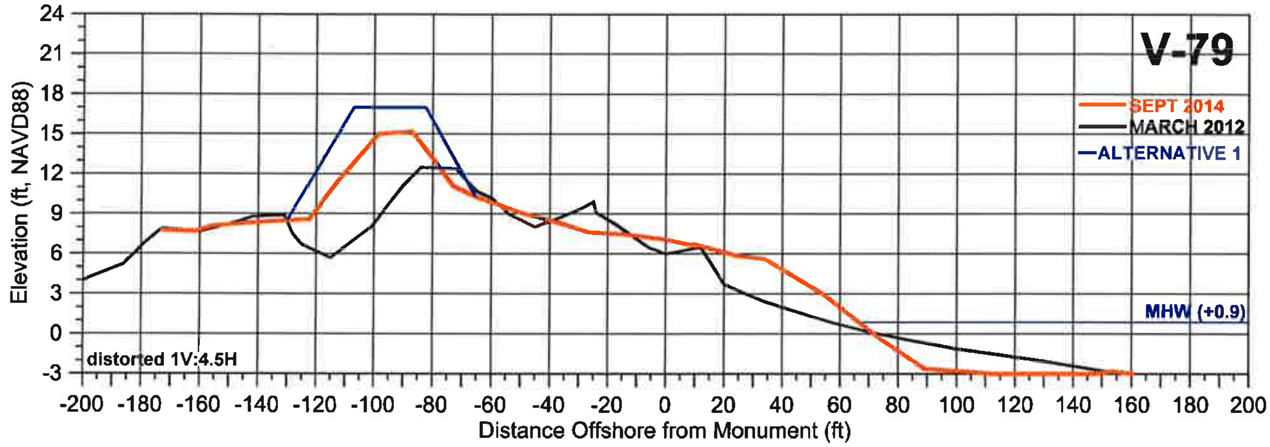

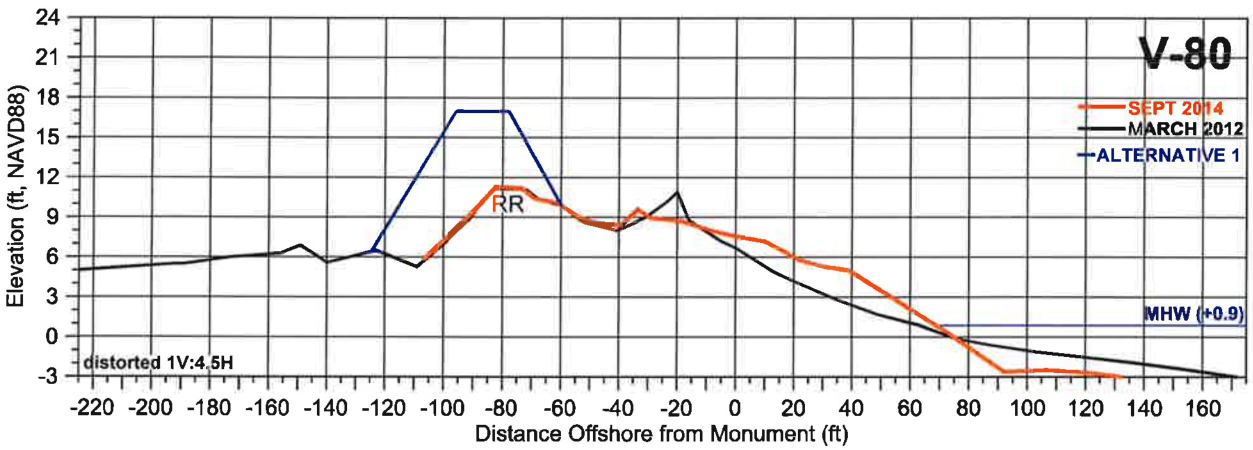

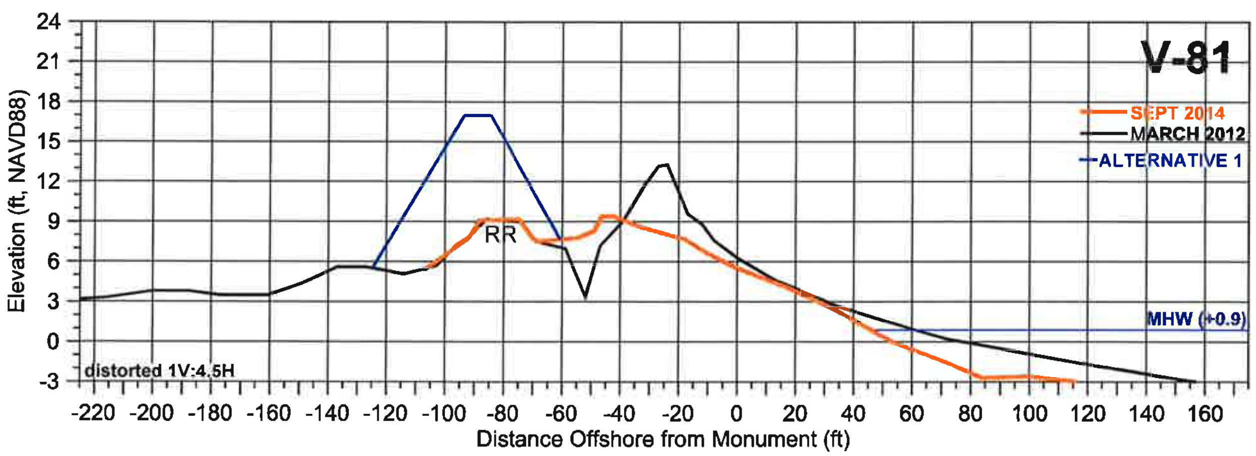

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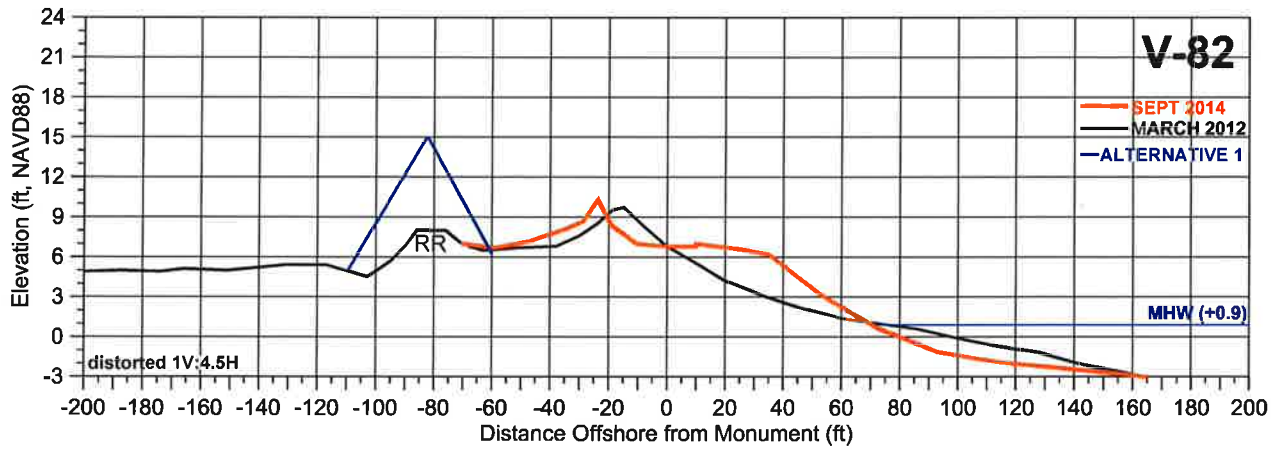

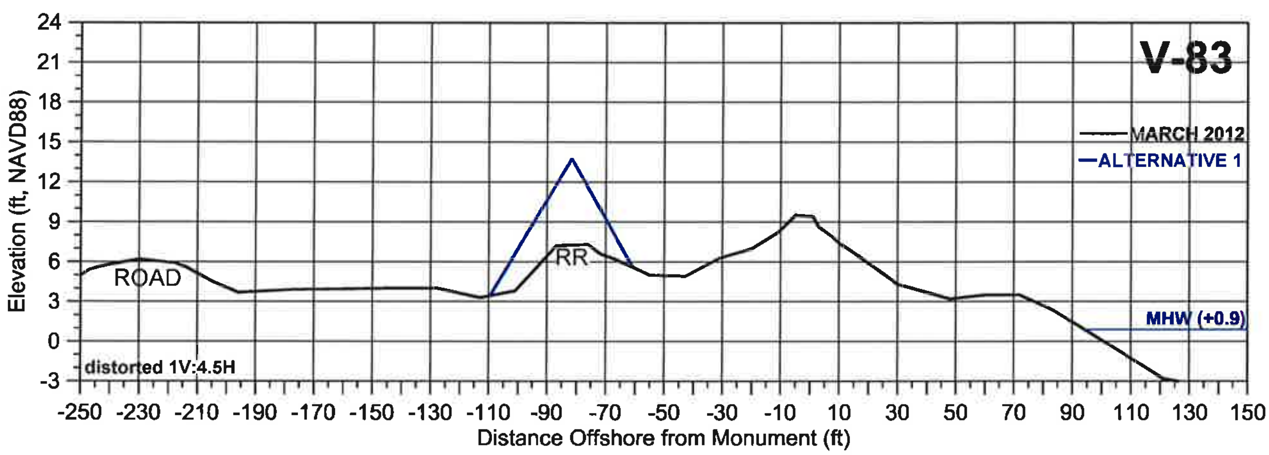

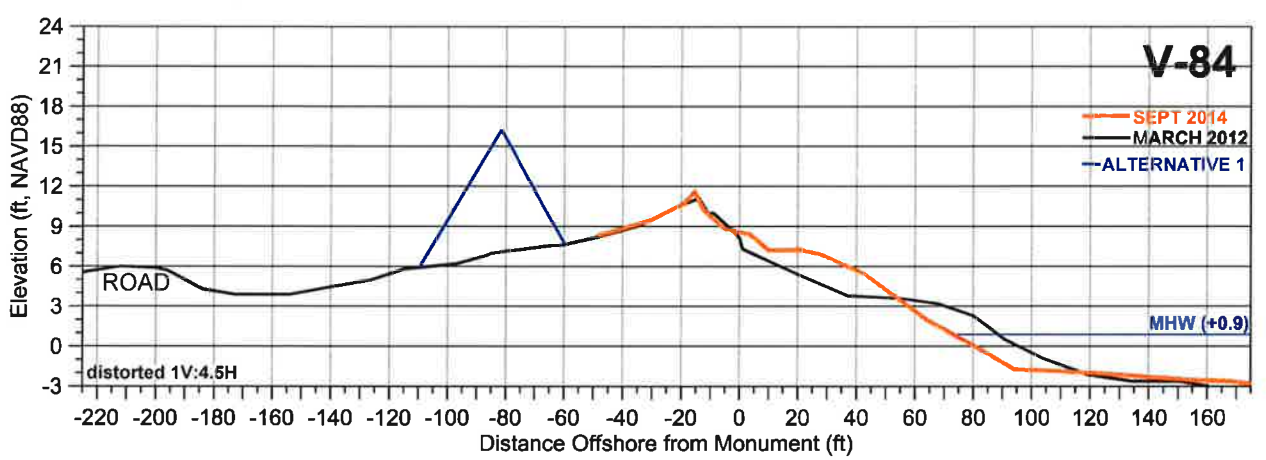

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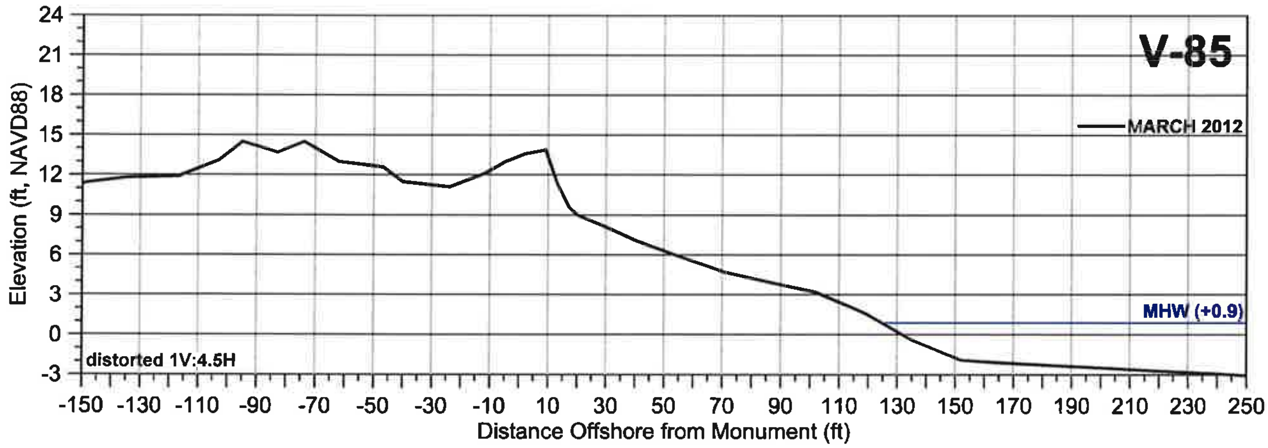

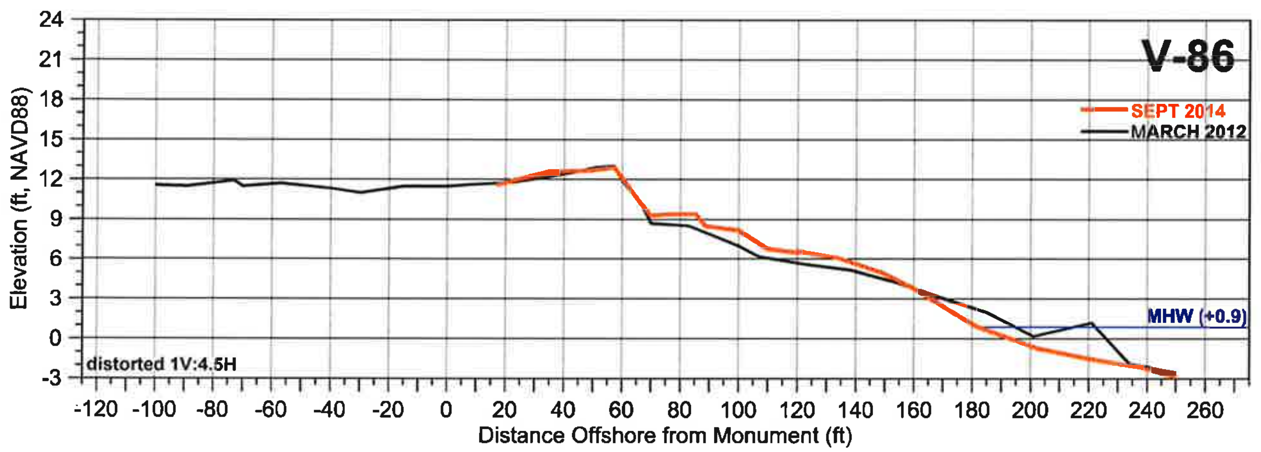

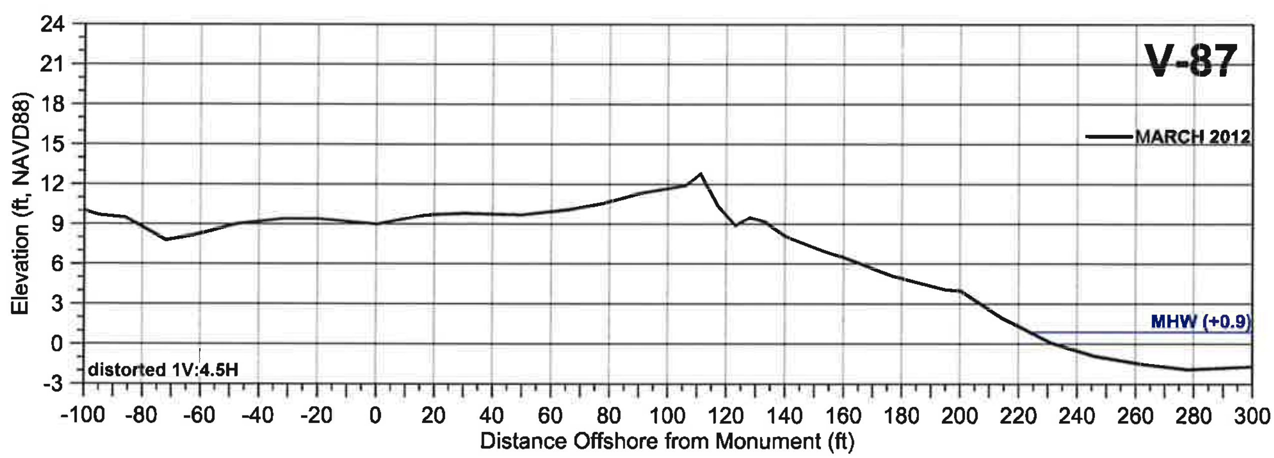

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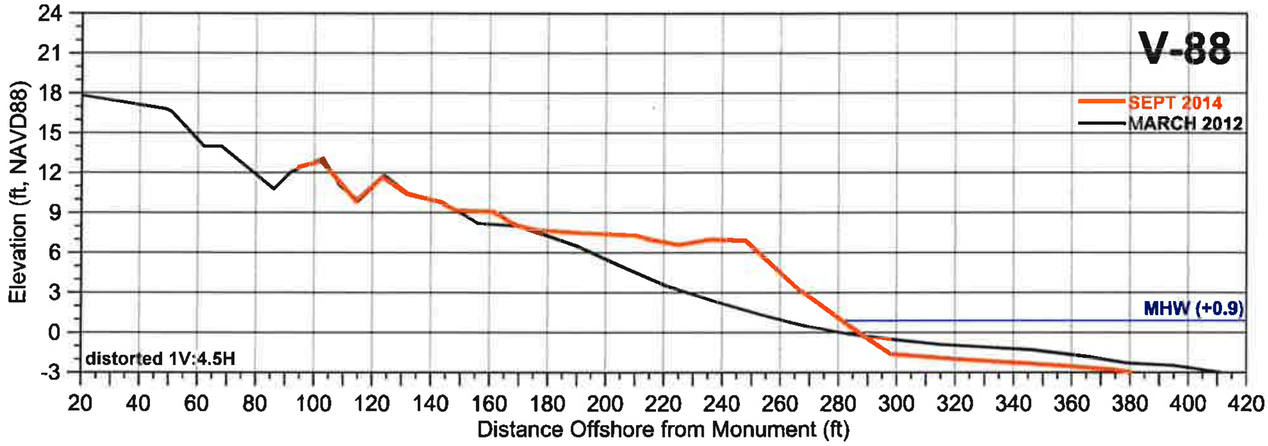

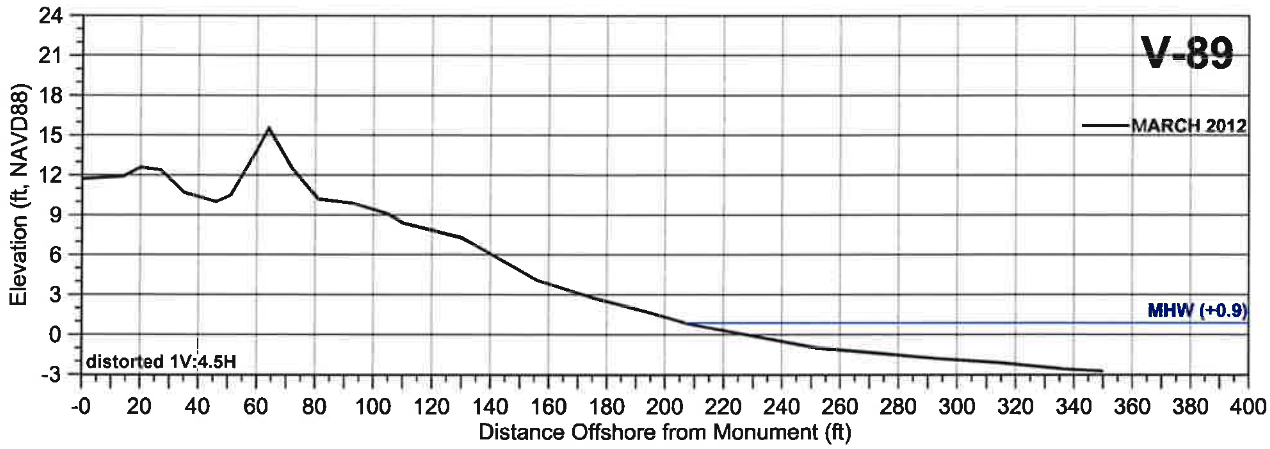

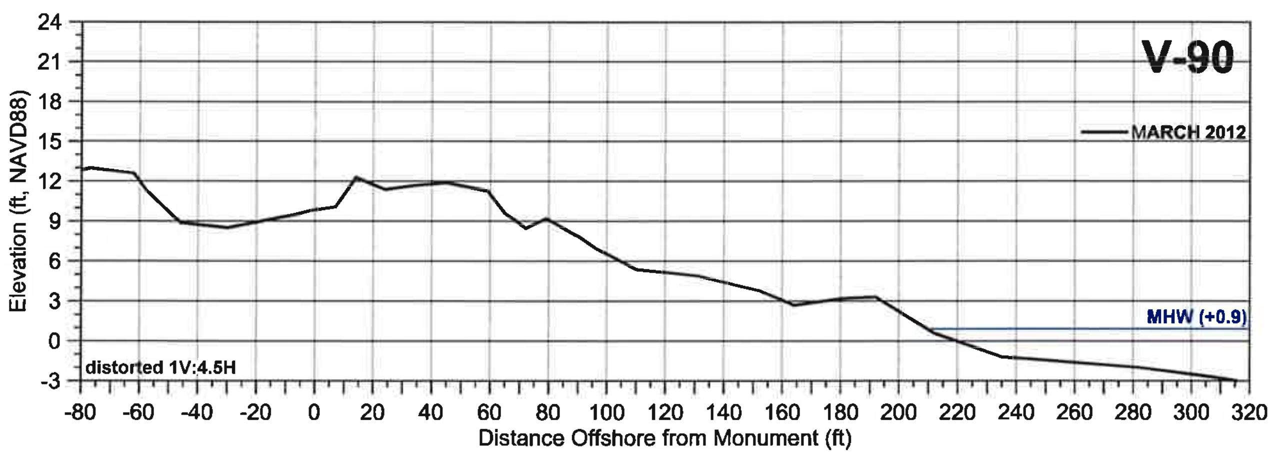

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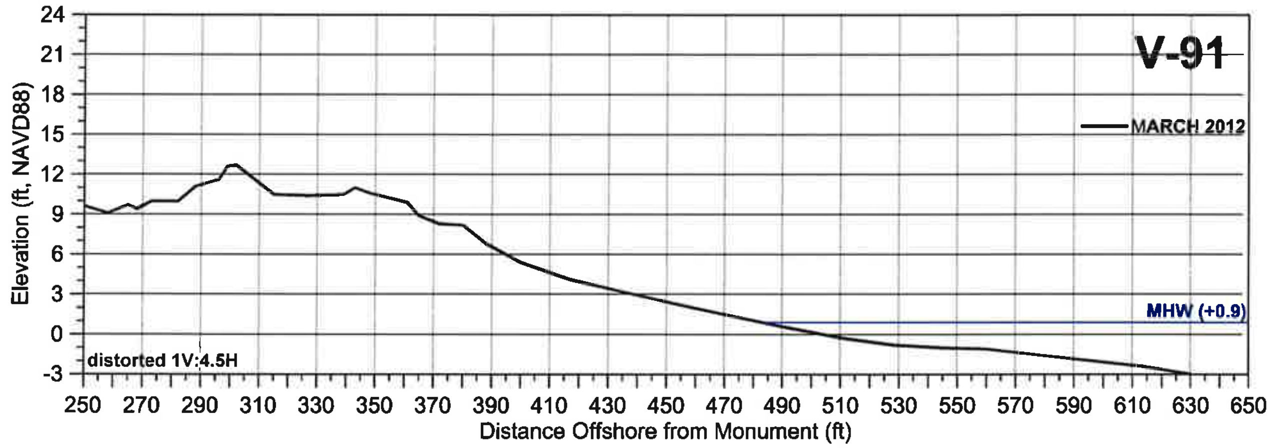

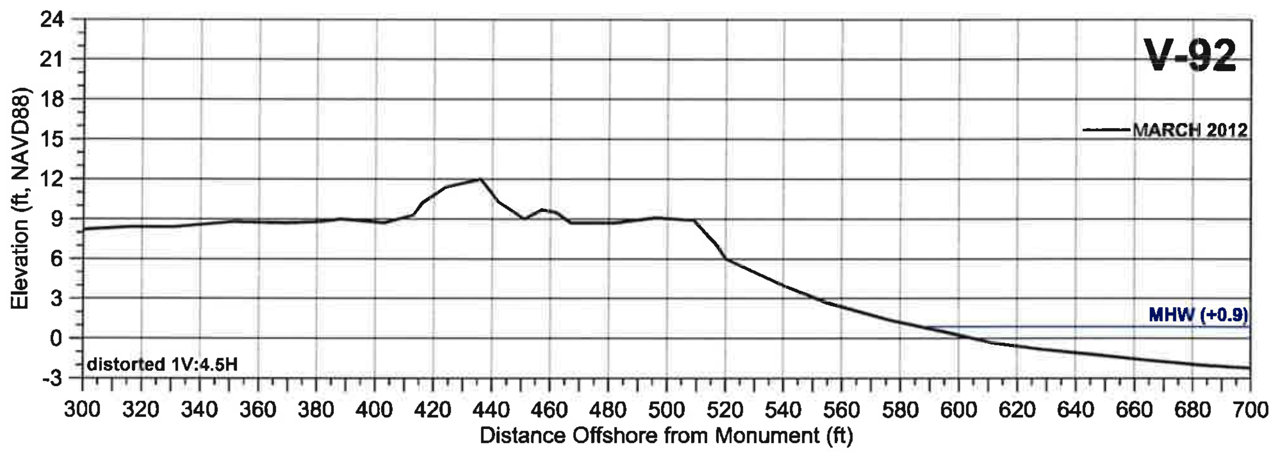

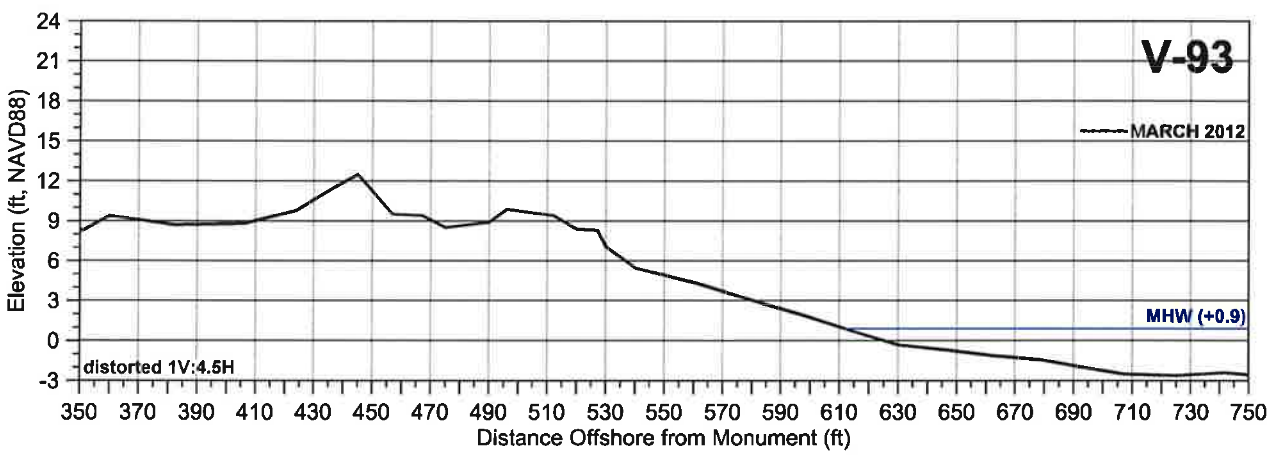

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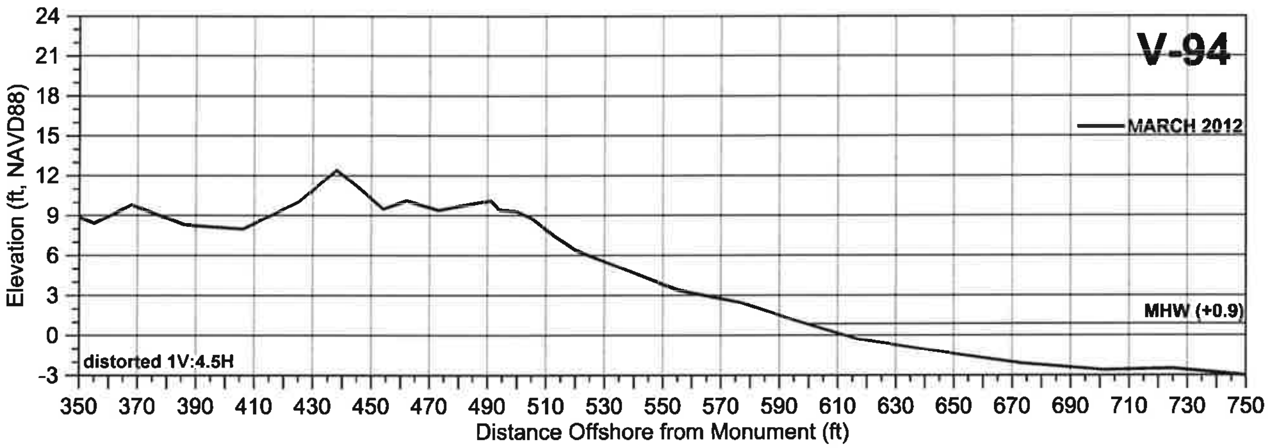

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APPENDIX C

Sand Sources for Shore Protection along Kennedy Space Center, Florida

Prepared for:
InoMedic Health Applications

and

Kennedy Space Center
National Aeronautics and
Space Administration
Kennedy Space Center, FL 32899

Prepared by:
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JANUARY 2015

olsen
associates, inc.
coastal engineering

Sand Sources for Shore Protection along Kennedy Space Center, Florida

Kevin R. Bodge, Ph.D., P.E. and William Reilly, P.E.
Olsen Associates, Inc. (OAI)

January 2015

1.0 INTRODUCTION

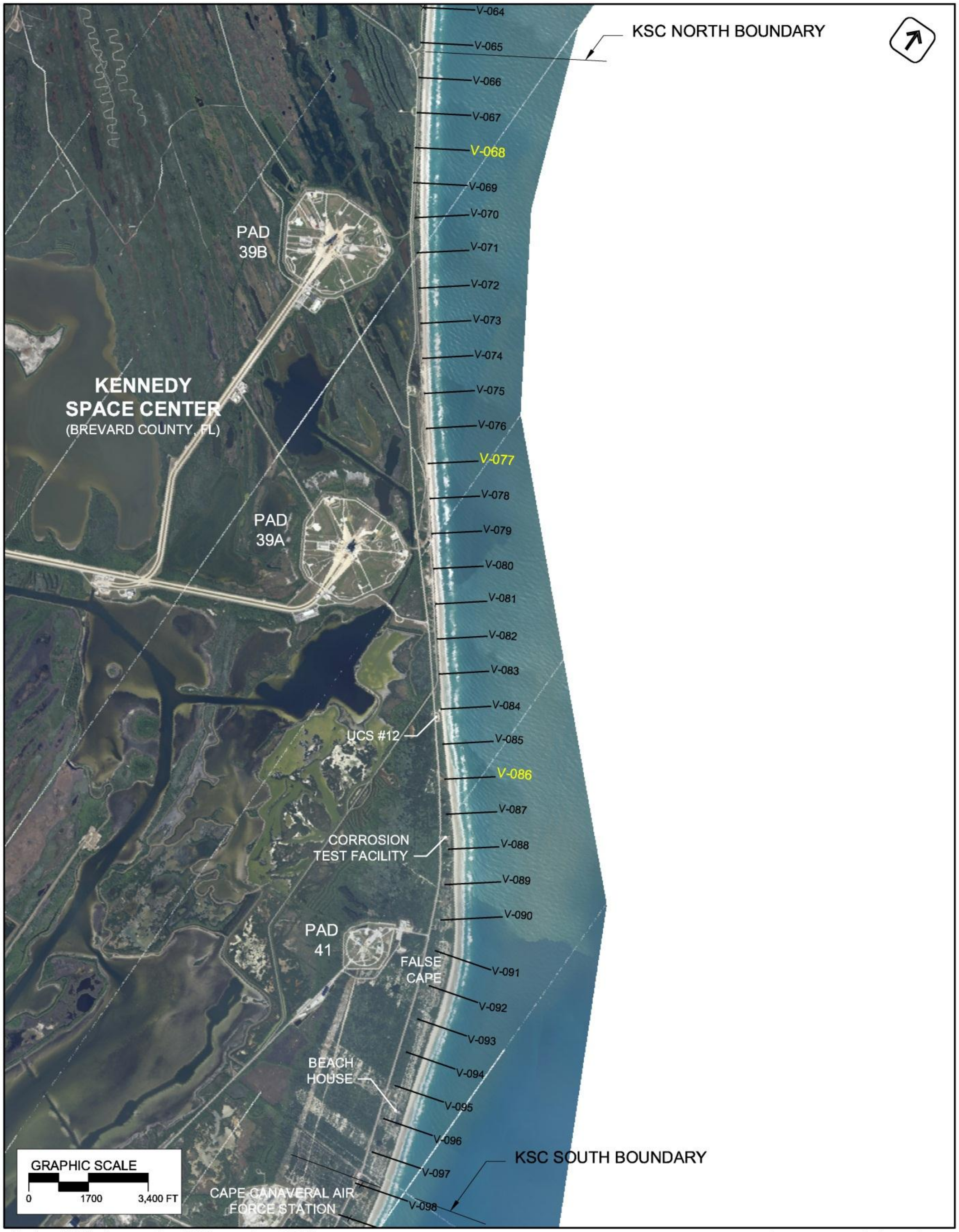
This report describes potential borrow areas for beach-compatible sediment in the vicinity of the Kennedy Space Center (KSC) at Cape Canaveral in Brevard County, Florida. Specific description is given of (1) the native dune and beach sediments at KSC, (2) existing offshore borrow areas previously permitted and used for beach nourishment in Brevard County, (3) upland borrow areas previously permitted and used for dune restoration in Brevard County, and (4) the potential for new offshore borrow areas that may be developed in the immediate proximity of KSC. Description of the compatibility (overfill ratio) of the existing borrow area sediments and native beach sediments is likewise provided. This report updates the prior, original version of the report dated June 2012.

2.0 NATIVE BEACH SEDIMENTS

For purposes of both environmental (habitat) protection and proper physical performance, sediment placed to the beach system should be compatible with the native (natural) beach sediments; i.e., generally similar in granularmetric distribution, color, and mineralogic composition, and free of debris or contaminants that are inconsistent with natural beaches. In Florida, beach compatible sediment is typically described by the State of Florida “sand rule” [FAC 62B-41.007(2)(j)]. And, along federal property such as the KSC where there is no coastal construction control line, sediment placed to the beach seaward of the mean high water line, in State waters, must demonstrate beach-compatibility as defined by the “sand rule”.

To identify the characteristics that define the native beach sediment along KSC, physical samples were collected and analyzed by OAI in March 2012. Data describing the samples, summary statistics, and compatibility/overfill ratio (with respect to permitted offshore borrow areas) is presented in **Section 5** of this report. A brief description of the native beach sediment investigation is presented below.

Ten beach sand samples were collected along each of three transects -- V-68, V-77, and V-86 – across the KSC dune/beach and nearshore seabed (see ***Figure 2-1***). The 30 samples were



Date of Photograph: 18 November 2008 olsen associates, inc.

Figure 2-1: Kennedy Space Center, Florida ocean shoreline. Native beach sediment samples were collected along transect locations V-068, V-077, and V-086.

collected by Morgan & Eklund of Wabasso, FL, and analyzed for grain size distribution, carbonate content and color by Scientific Environmental Applications, Inc. (SEA) of Melbourne, FL. Along each transect, sand samples were collected along seven general elevations: (1) dune, (2) berm, (3) high water line, (4) low water line, (5) -8 ft, (6) -13 ft, and (7) -18 ft NAVD88 contours. [1] Two samples each were collected at the dune, berm and high water line, and each pair was then averaged to characterize the dune, berm and high water line.

As detailed in **Section 5** near the end of this report, composite grain size distributions were formed for each profile (i.e., average of the seven sampled elevations from the dune to -18' depth for each individual profile) as well as for each elevation (i.e., average for each of the seven elevations among the three profiles). The upper beach composite was formed by averaging the dune, berm and high water line composites. The overall native composite was formed by averaging the three profile composites -- or by averaging the seven elevation composites (the resultant overall native composite curve is identical for each method). **Figure 2-2** depicts the composite grain size distributions for the native beach sediments, developed in this manner.

Listed below are the sediment characteristics of the native beach determined from this investigation. The grain size statistics are computed from the overall native composite distribution. The overall mean and standard deviation were computed using formulas outlined in the Coastal Engineering Manual (CEM, 2008).

- USCS Classification: SP (one sample was SW)
- Median (d_{50}): 0.20 mm -- *range 0.11 to 0.54 mm*
- Mean: 0.22 mm -- *range 0.12 to 0.49 mm*
- Standard Deviation: 1.02 φ -- *range 0.41 to 1.28 φ*
- Fines Content (passing #230): 1.0% -- *range 0.1 to 1.5%*
- Gravel Content (retained on #4): less than 0.1% -- *range 0.0 to 0.2%*
- Carbonate Content: 15.1% -- *range 5.3 to 37.9%*
- Munsell Color (moist): typical 10YR 7.5/1.0 -- *range 10YR 7.0/1.0 to 10YR 8.5/1.5*

[1] The NAVD88 datum is about 3.3 ft above Mean Lower Low Water, such that the latter three samples are from about -4.7, -9.7, and -14.7 ft MLLW; i.e., the active nearshore seabed. The typical depth of profile closure for average-annual conditions, based upon annual changes between surveyed beach profiles in Brevard County is about -17.4 ft NAVD, or -14.1 ft MLLW.

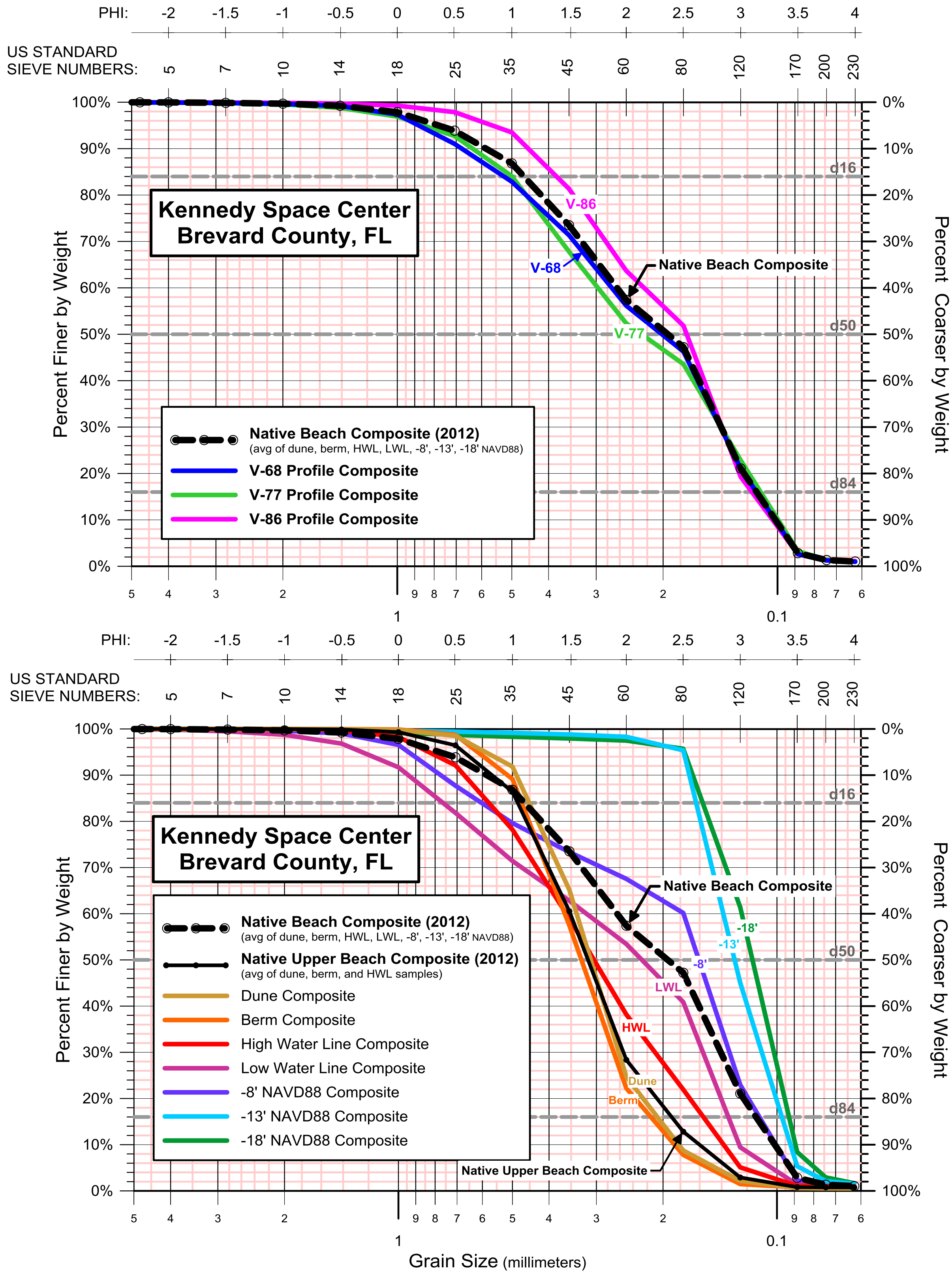


Figure 2-2: Summary native beach grain size distribution, Kennedy Space Center, FL.

3.0 OFFSHORE BORROW AREAS

The nearshore seabed in the vicinity of the Kennedy Space Center presents abundant potential for economical, beach-compatible sand borrow areas – probably the greatest along Florida's entire coastline. See ***Figures 3-1 and 3-2***, below. There are two existing, permitted sand borrow areas within about 16 nautical miles of KSC -- Canaveral Shoals I and II – located southeast of Cape Canaveral. ***Figure 3-3*** depicts the locations of these two borrow areas relative to KSC and the Brevard coastline.

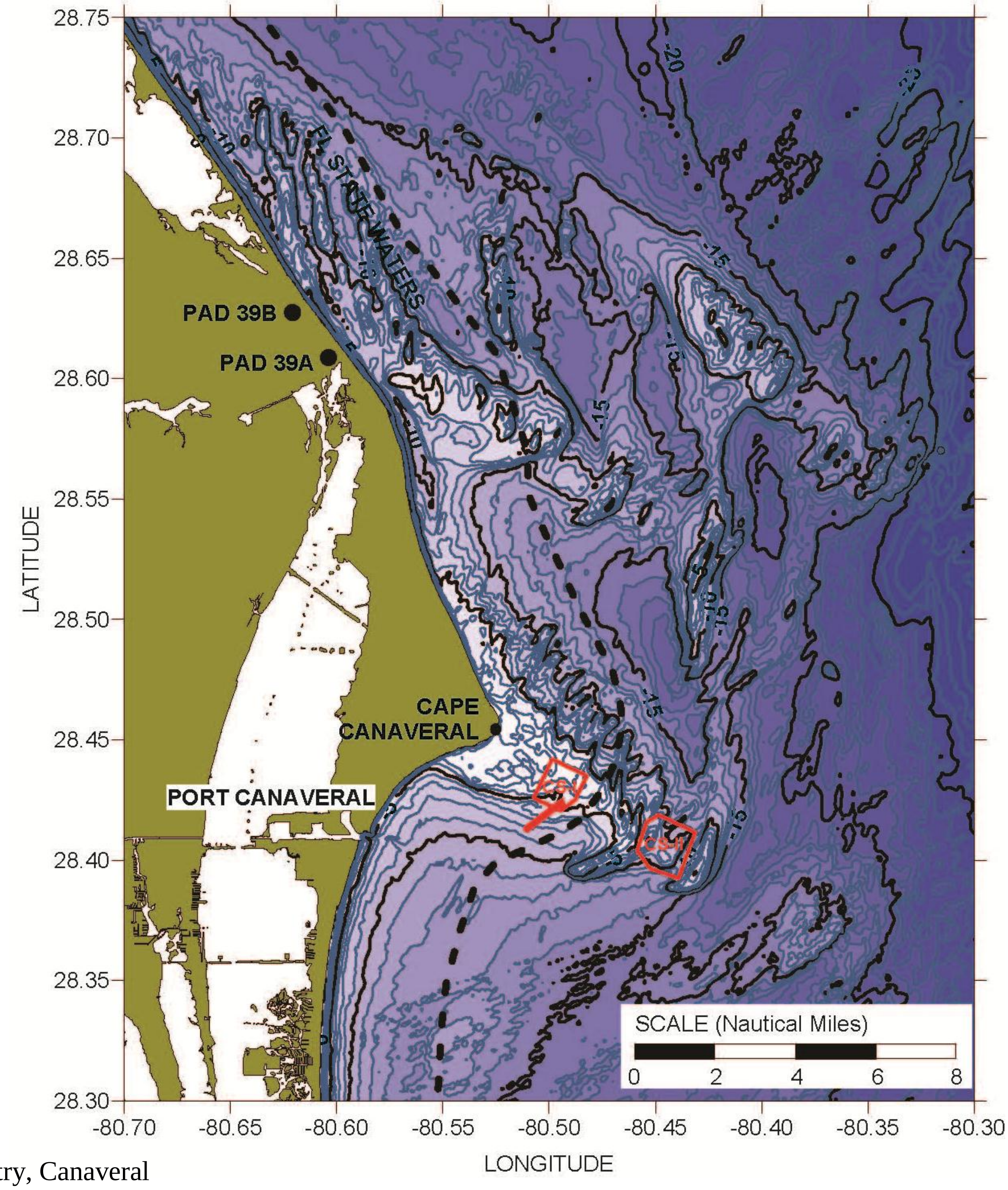


Figure 3-1:
Seabed bathymetry, Canaveral Shoals I and II borrow areas, and locations of KSC Launch pads 39A and 39B. Depths in meters, MLLW; various data sources.

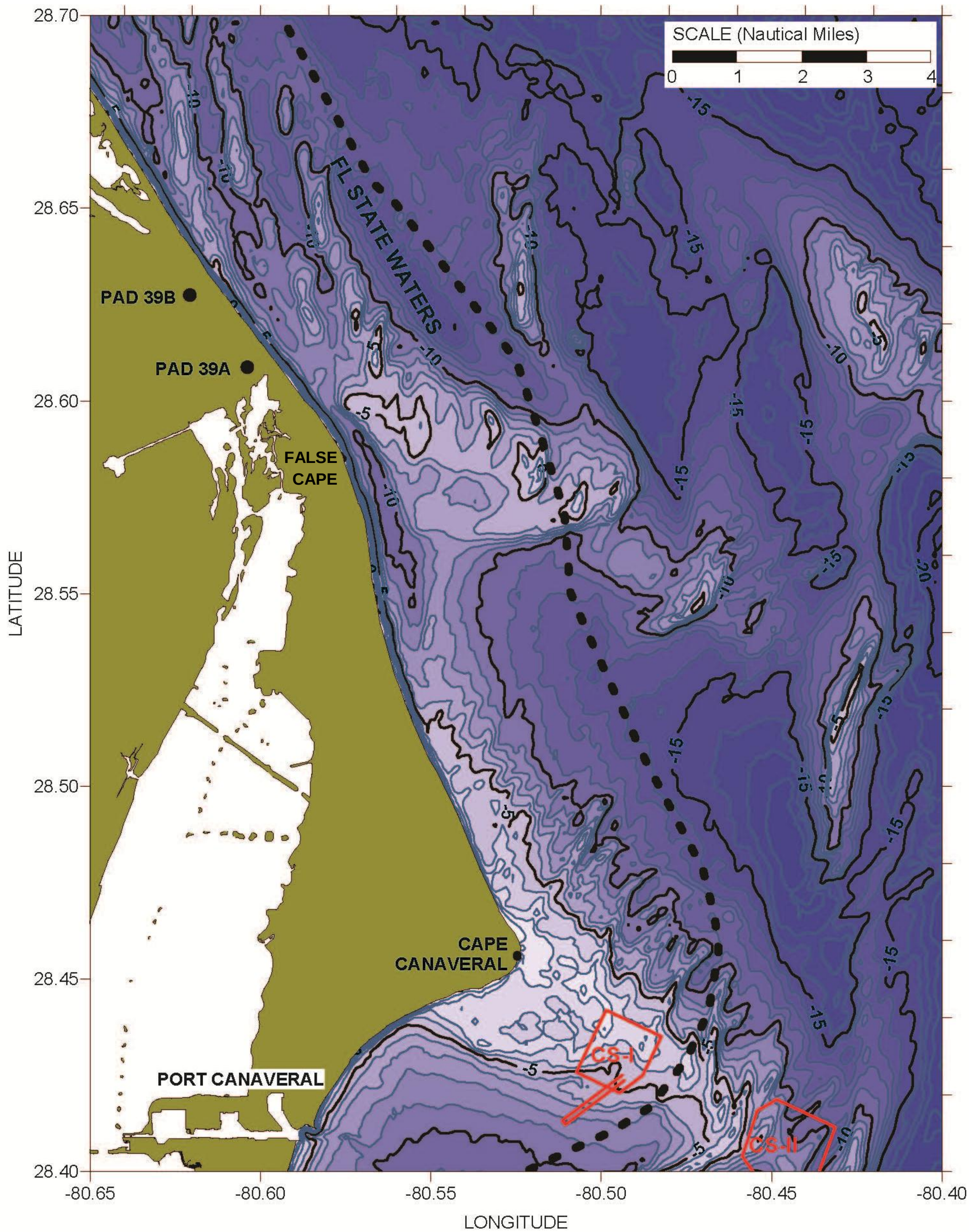


Figure 3-2: Approximate nearshore bathymetry in vicinity of Kennedy Space Center; depths in meters, MLLW. Canaveral Shoals I and II borrow areas indicated at bottom of figure. The locations of launch pads 39A and 39B are indicated at KSC.

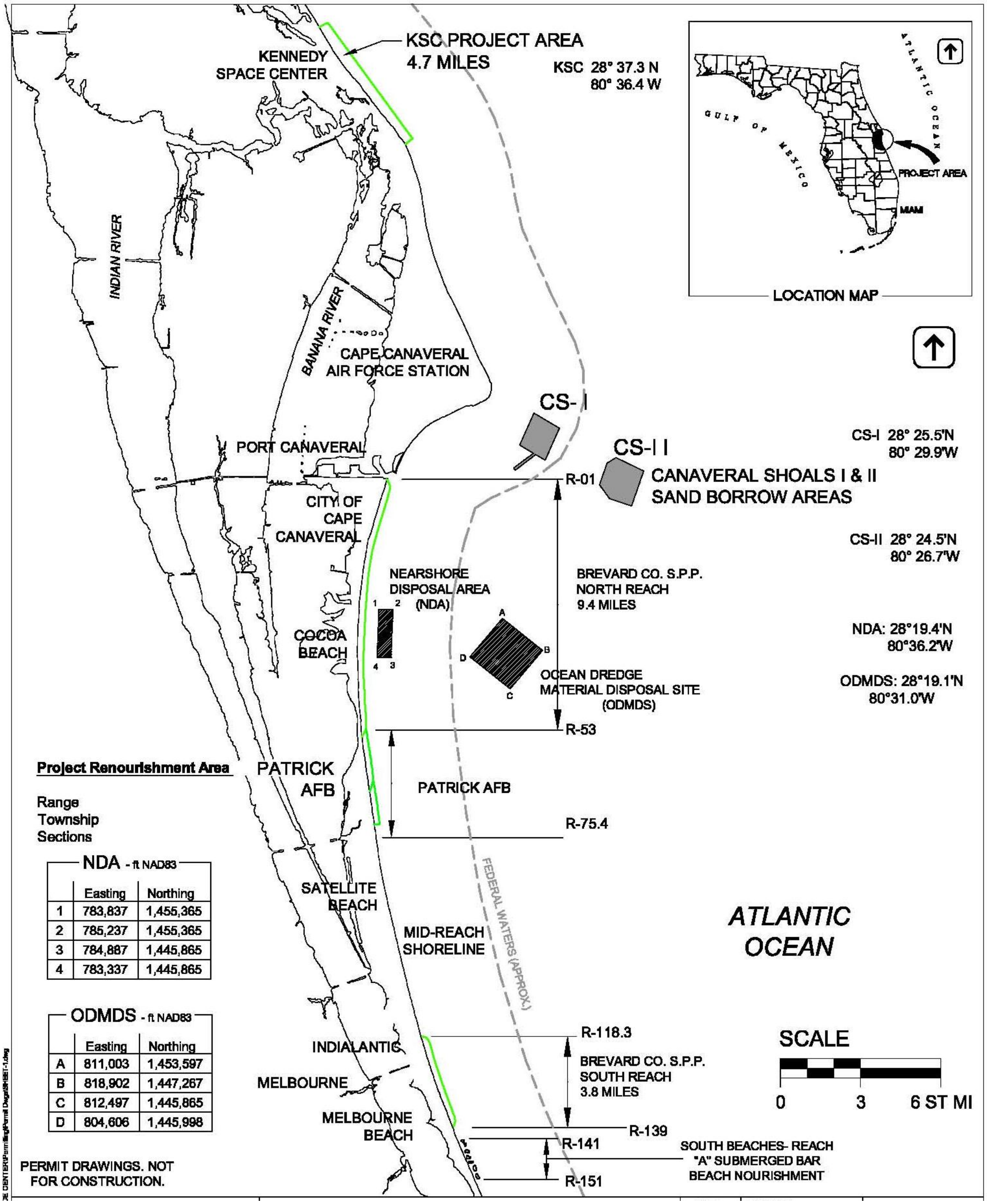


Figure 3-3: Location of CS-I and CS-II borrow areas, nearshore disposal area, and ODMDS.

3.1 Canaveral Shoals II Borrow Area

The Canaveral Shoals II (CS-II) borrow area is located in federal waters on the Outer Continental Shelf (OCS), approximately 5 nautical miles southeast of the tip of Cape Canaveral. It is about 15.5 nautical miles south-southeast of the KSC project area shoreline, or about 17 nautical miles by one-way sailing distance. **Figure 3-4** delineates the CS-II borrow area.

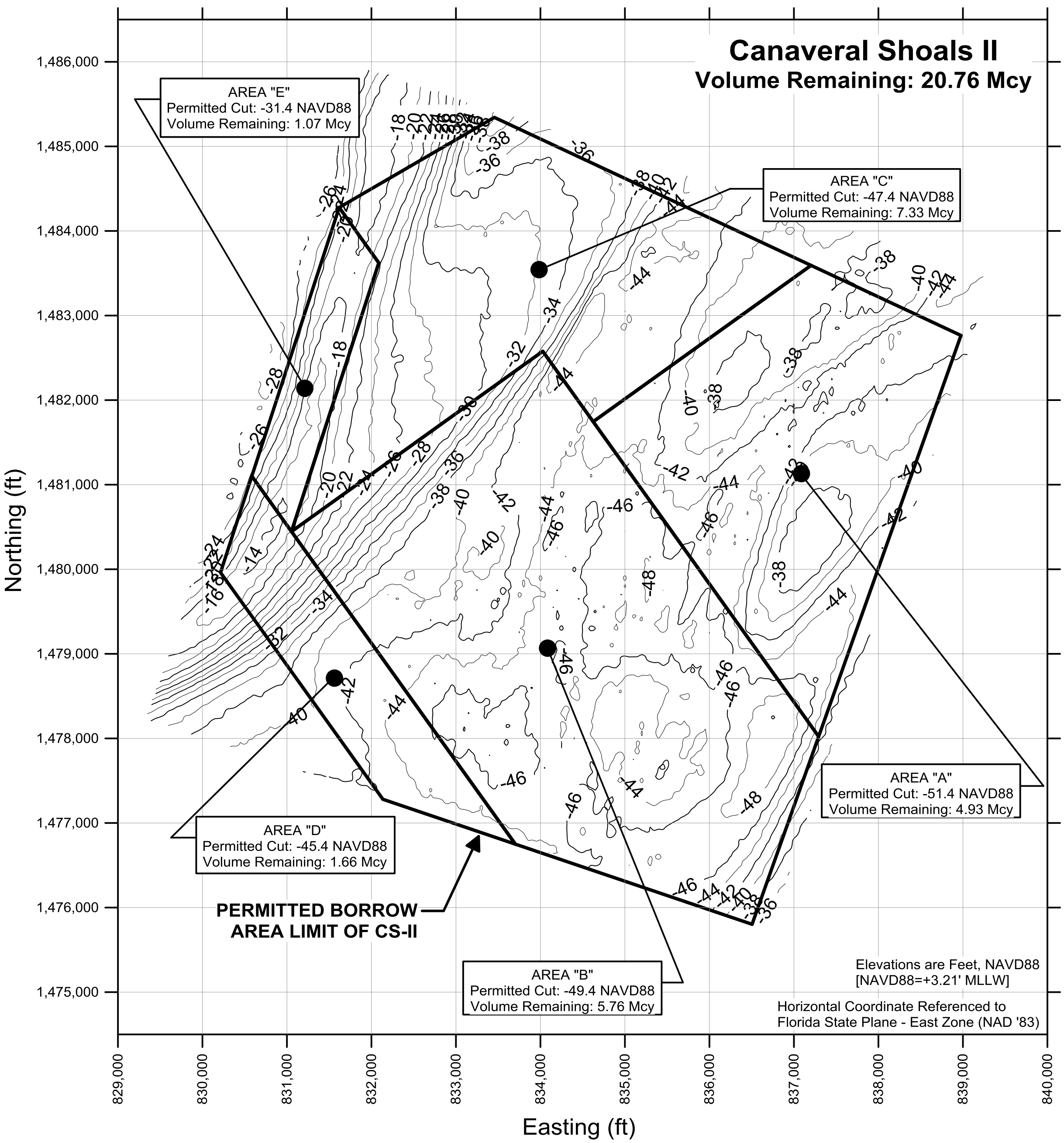


Figure 3-4: Canaveral Shoals II (CS-II) permitted offshore borrow area. May 2014 survey, subsequent to 2013/14 dredging for Brevard County Shore Protection Project renourishment.

Ambient seabed depths across CS-II range from about -13 ft to -45 ft, MLLW[2]. The limits of the borrow area, approximately 1233.4 acres in overall size, are divided into five sub-regions with varying dredge (cut) depths of -31.4 to -51.4 feet, NAVD88. Following the most recent dredging of CS-II in Nov 2013-April 2014, there is approximately 20.76 million cubic yards of sediment remaining within the permitted excavation limits (OAI, 2010, 2014). Approximately 9.3 million cubic yards of sediment has been dredged from the CS-II borrow area for purposes of beach nourishment in Brevard County on multiple prior occasions since the borrow area's development in 1998-99. These dredge events include the

- initial construction of the Brevard County Federal Shore Protection Project (BCSPP) North Reach in 2000-01 and South Reach in 2002-03,
- initial construction of Patrick AFB shore protection in 2000-01,
- renourishment of the BCSPP and Patrick AFB in 2005,
- renourishment of the BCSPP South Reach in 2010, and
- renourishment of the BCSPP North and South Reach in 2013-14.

For each of these projects, lease or similar agreements for the use of sand from CS-II were executed between the Bureau of Ocean Energy Management (BOEM, formerly Minerals Management Service) and the U. S. Army Corps of Engineers, Brevard County, and/or 45th Space Wing United States Air Force (45SW/USAF). Use of the CS-II borrow area by the KSC will require a similar lease or memorandum-of-agreement between BOEM and NASA/KSC, similar to the two-party agreements between BOEM and the 45SW/USAF.

The CS-II borrow area was investigated for cultural resources by the USACE during its initial development (Watts 2001) and most recently updated in 2014 (Panamerican 2014). From the latter, no magnetic anomalies and no sonar contacts were located in the previous or updated surveys that represent potentially significant cultural resources in the form of shipwrecks. The most recent (2014) survey identified four (4) magnetic anomalies and targets to be avoided within the CS-II borrow area, thought to potentially represent rocket cylinders. In 2014, the USACE updated its identified dredge exclusion areas in CS-II, to be described by a 200-ft radial buffer around the following four (4) coordinates:

Table 3-1:

Canaveral Shoals II Magnetic Anomalies (2014)		
ID	Easting (ft, NAD83)	Northing (ft, NAD83)
m35	836,039	1,482,530
m47	837,485	1,480,862
m57	831,766	1,482,563
m61	832,730	1,481,664
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

[2] The CS-II area was developed in 1998 by OAI for Brevard County, after OAI pointed out that the CS-I borrow area developed by the Corps for the Brevard Shore Protection Project was too far offshore for a cutterhead dredge and too shallow for a hopper dredge. OAI developed the access lane to CS-I at the same time as the CS-II area.

From core boring data and inspection of the sand placed onto Brevard County's beaches since 2000, the sediment contained in the CS-II borrow area is of consistent, excellent compatibility with the KSC beach and broader Brevard coastline. Comparison of the typical (average) grain size distribution of sediment from CS-II and the native KSC beach is shown in **Figure 3-5**. The median grain size of the CS-II borrow area ranges from about 0.3 to 0.4 mm (about 0.34 mm on composite-average). The mean grain size typically ranges from about 0.4 to 0.45 mm (three-point mean) but may locally vary between about 0.3 and 0.55 mm. Fine sediment content is low, typically less than 2% finer than the #200 and #230 sieves. The coarse fraction is less than 5% (retained on #4 sieve). The typical carbonate content is about 30% and with individual samples generally ranging between about 20% and 48%. The Munsell color (value/hue) is typically 6.5/1 to 7/1.

The overfill ratio is used to estimate the volume of additional sand that should be placed with the beach fill to compensate for textural differences between the borrow (fill) sediments and the native beach sediments. The overfill ratio computed for the CS-II borrow area relative to the KSC beach is 1.00 (perfect) – meaning that the borrow material is as coarse or coarser than the native beach; i.e., losses due to "finer-sediments" content are negligible. This reflects both the SPM/J-K method (Krumbein and James, 1965; James 1974, 1975) and the Dean method (Dean 1974), using the approaches outlined in the CEM (2008) and Bodge (2006), respectively.

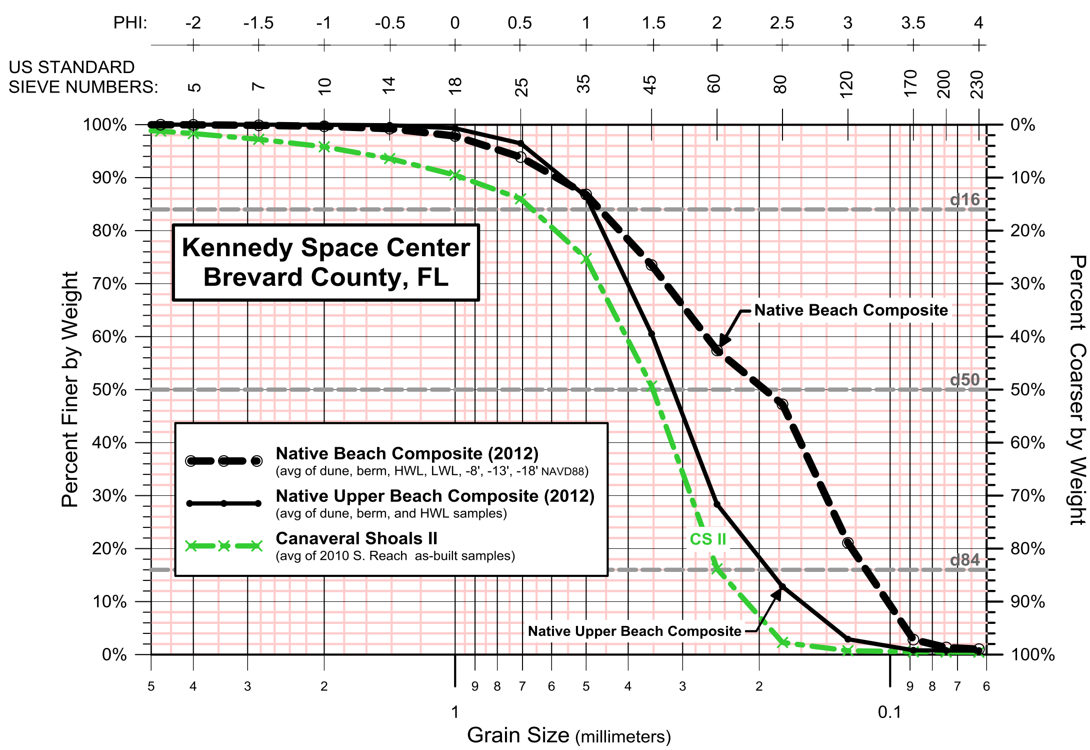


Figure 3-5: Comparison of the average (composite) sediment grain size data from CS-II offshore borrow area and native KSC beach.

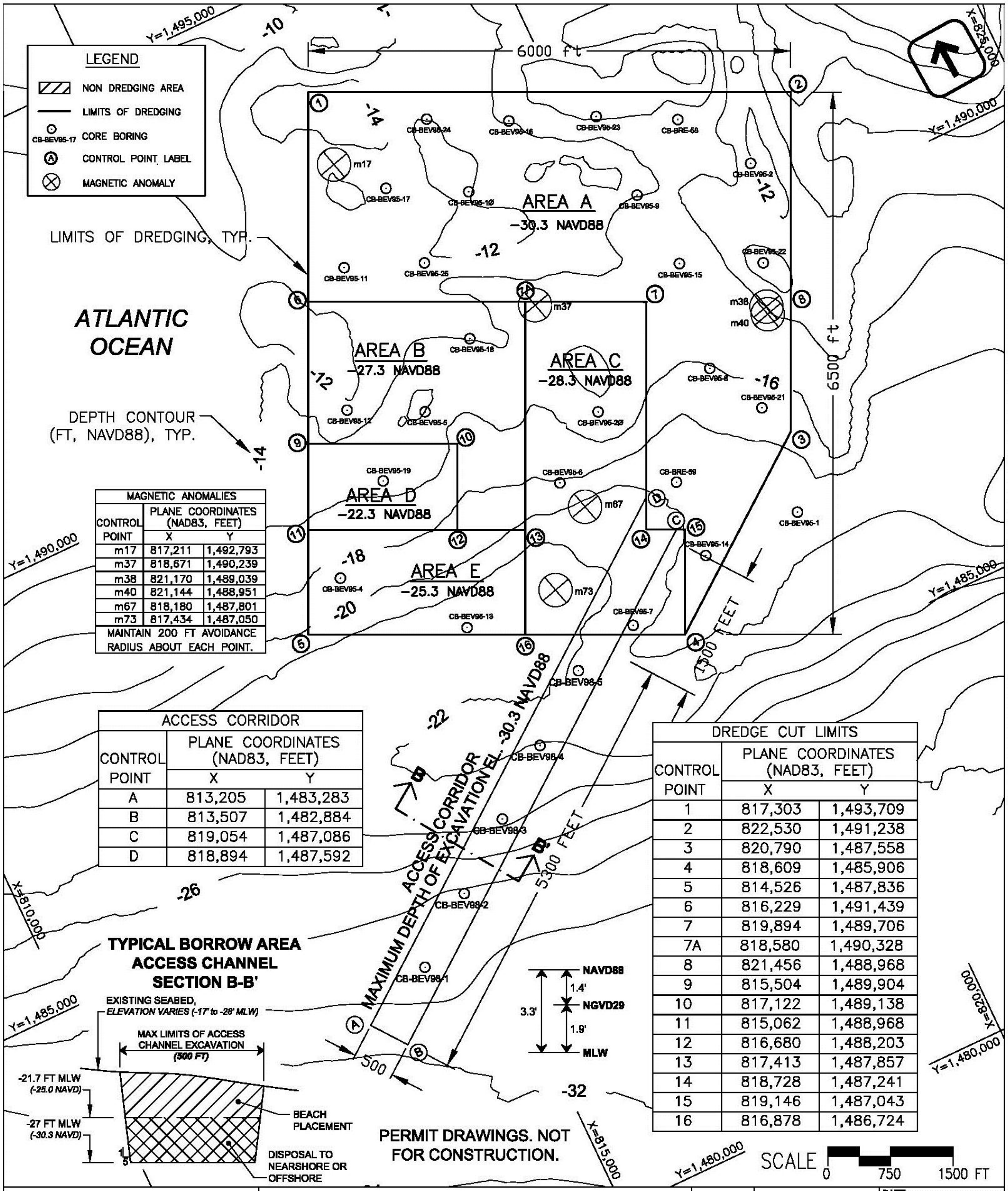
OAI (2014) compared the weighted-composite grain size distributions of the sediments remaining within the CS-II borrow area limits between pre-dredge conditions (1998) and the most recent post-dredge conditions (May 2014). Despite the removal of 9.3 Mcy of sediment from the borrow area since the original 1998 composite, the comparison indicated negligible change in the computed overall grain size distribution of the remaining sediment as of May 2014. This was attributed to the observations that (i) the prior excavations affected less than 30% of the borrow area volume, and (ii) the sediment within the borrow area appears to be fairly uniform (OAI 2014).

3.2 Canaveral Shoals I Borrow Area

The Canaveral Shoals I borrow area is located approximately 2.5 nautical miles southeast of the tip of Cape Canaveral. While it appears closer to KSC than CS-II by 2 or 3 miles, CS-I is actually the same sailing distance from KSC – about 17 nautical miles, one-way – because of the need to navigate around the shallow shoals that define False Cape and Cape Canaveral. **Figure 3-6** details the permitted limits of the CS-I borrow area and access lane.

Ambient seabed depths across CS-I range from about -8 to -18 ft MLLW. The borrow area limits, approximately 1 square nautical mile in size, are divided into five sub-regions with varying dredge (cut) depths of about -22.3 to -30.3 ft. Because of the shallow ambient depths of the borrow area, a 5300-ft long by 500-ft wide dredge access lane has been identified for this site. The total size of the CS-I borrow area and access lane is 889.1 acres. The access lane has been permitted for excavation to -30.3 ft NAVD'88 (-27 ft MLLW). Sediment dredged from the access lane above -26.3 ft is proposed for beach fill (if compatible and containing and less than 5% fines), or nearshore disposal (if containing less than 20% fines), or otherwise offshore disposal to the Canaveral Offshore Dredge Material Disposal Site (ODMDS).

A total of approximately 16 million cubic yards of sand is available from within the permitted limits of the CS-I borrow area. This borrow area has not been previously dredged. Use of CS-I to construct shore protection at KSC would be incorporated to the project through State and federal permits issued by FDEP and USACE, and a State Lands easement to KSC from FDEP. Because CS-I has not been previously dredged (unlike CS-II), it has been suggested by National Marine Fisheries Service (NMFS) that some baseline pre-dredge survey for infauna/biota at the site may be appropriate, prior to the first use of CS-I.



MAGNETIC ANOMALIES		
CONTROL POINT	PLANE COORDINATES (NAD83, FEET) X	Y
m17	817,211	1,492,793
m37	818,671	1,490,239
m38	821,170	1,489,039
m40	821,144	1,488,951
m67	818,180	1,487,801
m73	817,434	1,487,050
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

ACCESS CORRIDOR		
CONTROL POINT	PLANE COORDINATES (NAD83, FEET) X	Y
A	813,205	1,483,283
B	813,507	1,482,884
C	819,054	1,487,086
D	818,894	1,487,592

DREDGE CUT LIMITS		
CONTROL POINT	PLANE COORDINATES (NAD83, FEET) X	Y
1	817,303	1,493,709
2	822,530	1,491,238
3	820,790	1,487,558
4	818,609	1,485,906
5	814,526	1,487,836
6	816,229	1,491,439
7	819,894	1,489,706
7A	818,580	1,490,328
8	821,456	1,488,968
9	815,504	1,489,904
10	817,122	1,489,138
11	815,062	1,488,968
12	816,680	1,488,203
13	817,413	1,487,857
14	818,728	1,487,241
15	819,146	1,487,043
16	816,878	1,486,724

Figure 3-6: Canaveral Shoals I (CS-I) permitted offshore borrow area.
[From Brevard County Shore Protection Project, North Reach: FDEP Permit 0134869-009-JC]

The CS-I borrow area and access lane was investigated for cultural resources by the USACE during its initial development (Watts 2001) and most recently updated in 2014 (Panamerican 2014). From the latter, no magnetic anomalies and no sonar contacts were located in the previous or updated surveys that represent potentially significant cultural resources in the form of shipwrecks. The most recent (2014) survey identified six (6) magnetic anomalies and targets to be avoided within the CS-I borrow area, thought to potentially represent rocket cylinders. In 2014, the USACE identified dredge exclusion areas in CS-I described by a 200-ft radial buffer around the following six (6) coordinates:

Table 3-2:

Canaveral Shoals I Magnetic Anomalies (2014)		
ID	Easting (ft, NAD83)	Northing (ft, NAD83)
m17	817,211	1,492,793
m37	818,671	1,490,239
m38	821,170	1,489,039
m40	821,144	1,488,951
m67	818,180	1,487,801
m73	817,434	1,487,050
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

The median grain size of the CS-I borrow area ranges from about 0.18 to 0.3 mm (about 0.27 mm on composite-average). The mean grain size is about 0.33 mm (three-point average). Fine sediment content is variable but typically less than 5% to 3% finer than the #200 and #230 sieves, respectively. The coarse fraction is less than 5% (retained on #4 sieve). Comparison of the composite grain size distribution of sediment from CS-I and the native KSC beach is shown in **Figure 3-7**. Specific Munsell color values and carbonate content from the CS-I borrow area core samples, collected by the Corps of Engineers in 1995-98, are not available.

The overfill ratio computed for the CS-I borrow area relative to the KSC beach is between 1.00 and 1.02, for the Dean and James-Krumbein methods respectively – meaning that the borrow material is basically as coarse or coarser than the native beach, and that only 0% to 2% allowance for losses due to "finer-sediments" is recommended. Both the CS-I and CS-II material is coarser than the overall native beach sediment. While the CS-II material is *coarser* than the native berm/upper beach, the CS-I material is *slightly finer* than the native berm/upper beach. This suggests that both the CS-I and CS-II borrow area sediments are compatible with the native beach and berm, but that the CS-II sediment may exhibit *slightly greater stability* (resistance to erosion) than the CS-I borrow area sediment.

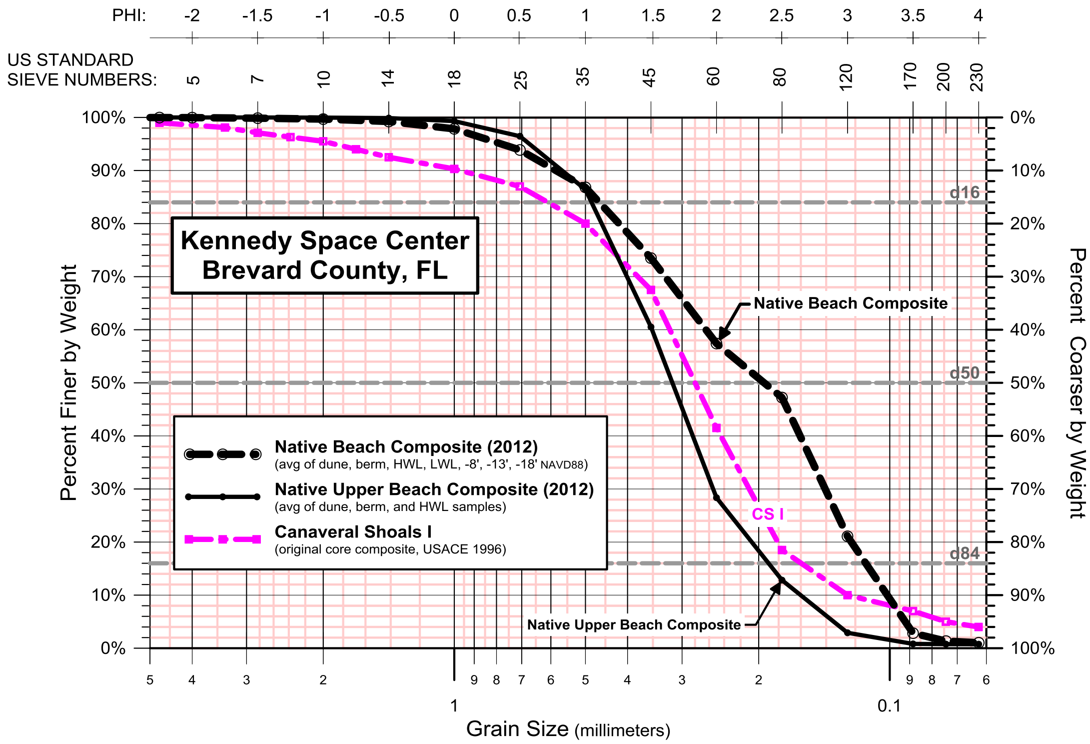


Figure 3-7: Comparison of the average (composite) sediment grain size data from CS-I offshore borrow area and native KSC beach.

<u>Nearshore and Offshore Disposal Areas.</u> Use of the CS-I offshore borrow area may require dredging of the CS-I access channel (see prior pages 11-12). Material dredged from the access channel that contains less than 5% fine sediment and is otherwise beach-compatible may be placed as beach fill. Dredged material that contains less than 20% fine sediment may be placed to an existing nearshore disposal area (NDA) offshore of Cocoa Beach, subject to FDEP and USACE permit. Dredged material that contains more than 20% fine sediment must be placed to an offshore disposal area: specifically the Canaveral Offshore Dredge Material Disposal Site (ODMDS) subject to approval by the USEPA and the Corps of Engineers. The latter requires a Section 103 evaluation prepared for the USEPA and incorporation of the approval and conditions for dredge-disposal to the ODMDS in the Department of the Army (USACE) permit for the project. The locations of the NDA and ODMDS are indicated in ***Figure 3-3***, previous page 7.

3.3 Other Offshore Borrow Areas

The only other offshore borrow area developed and permitted for dredging and beach nourishment in the general vicinity of KSC is the Space Coast Shoals II borrow area, located southeast of Patrick AFB. This area was dredged for construction of the BCSPP South Reach in 2002, exhausted of sediment, and is no longer available as a sand source.

There appear to be numerous potential opportunities to develop offshore sand sources in the immediate vicinity of the Kennedy Space Center shoreline. Reference to ***Figure 3-2***, on page 6 of this report, indicates abundant shoals that are located *within 1.5 to 2.5 nautical miles* of the KSC shoreline where beach/dune erosion is most severe; i.e., between launch pads 39A and 39B. If beach-compatible sediment of at least several feet thickness is found to reside in these areas – which is likely -- this represents the potential for very significant savings in construction costs. Specifically, a borrow area within less than about 3 to 3.5 miles of the shoreline is a ready candidate for an oceangoing cutterhead/pipeline dredge[3]. In contrast, use of the existing Canaveral Shoals I or II borrow areas requires the use of a hopper dredge, with a round-trip sail-distance of 34 nautical miles per load.

The unit cost to move sand by a cutterhead/pipeline dredge (or a hopper dredge) from within a few miles of shore may likely be at least one-third to one-half less than the unit cost of a hopper dredge from Canaveral Shoals. Assuming a fill project of about 1,400,000 cubic yards, a semi-uniform mobilization cost of about $2.9M (regardless of the borrow area), and a unit cost of about $11.50/cy, the hopper dredge cost using Canaveral Shoals may be on the order of about $19M. The same project using a borrow area within a few miles of KSC may be on the order of about $13.2M to $14.2M – or a third less than Canaveral Shoals – saving on the order of $5M.

The cost to develop and permit a new offshore borrow area is typically about $0.7M to $1M. So, even during the first use of the new borrow area, the net savings can be very significant – in this example, being on the order of $4M net cost-savings for a $1M investment in developing the borrow area. There is, of course, risk that a borrow area cannot be developed because of inadequate sediment or cultural resources; but in this instance, it is highly likely that suitable borrow areas exist that can be used without significant adverse impact to the seabed, shore or resources. The greater risk is the use of the cutterhead dredge in open seas, far from the Port Canaveral harbor, in non-summer months – for which some economic cost (risk) is borne.

A practical borrow area must be in ambient depths of at least 6 to 10 meters MLLW (for cutterhead and hopper dredge access, respectively) and of adequate bank-cut thickness and physical sailing size (for cutterhead dredges and hopper dredges, respectively) to be useful and economical. These considerations are made during proper engineering investigation and

[3] A borrow area greater than 3+ miles away can also be cut by cutterhead, but usually requires a booster pump.

development of a new borrow area. Development of a borrow area within 3 nautical miles of shore may be preferred in order to keep the site within State of Florida waters. This appears possible at the KSC location. Siting the borrow area within State waters can obviate some costly, time-consuming restrictions on the development, permitting, and use of the borrow area that are otherwise associated with the use of borrow areas in federal waters.[4]

4.0 UPLAND SAND SOURCES

Upland sand sources for dune construction may include commercial quarries and other available, permitted sites that contain sediment demonstrated to be of compatible quality with the native KSC dune and beach, and to meet the State of Florida "sand rule" FAC 62B-41.007(2)(j) if sand will be placed below the Mean High Water Line at KSC. The availability and quality of upland sources vary with time because existing sources are mined and new sources and excavation projects continually arise. Accordingly, upland sources for project implementation should be specifically identified and evaluated for suitability prior to construction.

In the recent past, upland sources for beach and dune nourishment in Brevard County have included numerous sites, each of which have successfully resulted in placement of beach-compatible material. A partial list of these sources includes the following.

1. Port Canaveral Cruise Terminal Excavation – Source of beach nourishment placed along the City of Cape Canaveral in 1993. This source was depleted after construction of the cruise terminals; however, it is typical of local excavation projects that periodically produce beach-quality sand.
2. Poseidon Dredge Material Management Area (Port Canaveral/CCAFS) – Source of beach and dune nourishment placed along PAFB in 1998. This site is currently depleted and not available. The site is proposed for continued future use of dredge disposal for Canaveral Harbor and the US Navy, and for possible stockpiling of sand from offshore borrow areas by the USACE for transfer to the Brevard County Mid-Reach shoreline; however, that sand stockpile will not be available to KSC.
3. Fischer Sand 77th Street (Indian River County) – Commercial mining operation that has provided beach quality sand for 2005 Brevard County dune restoration and other projects conducted by Indian River County and Sebastian Inlet Tax District.

[4] Sand and other mineral borrow areas in federal waters (Outer Continental Shelf, or OCS) are managed by the Department of Interior, Bureau of Ocean Energy Management (BOEM). Despite cooperative effort and recent initiatives by BOEM, there are numerous federal requirements for OCS borrow sites that do not apply in State of Florida waters. For instance, exploratory coring and surveys to identify and develop the sand borrow area require prior federal approval (versus none in State waters). Use of the borrow area requires an EA developed in cooperation with BOEM and a lease agreement with BOEM.

4. Pence Pit 6 (Palm Bay) – Commercial sand mine.
5. Cape Canaveral Air Force Station (CCAFS) - Upland beach north of Canaveral Harbor jetty. This on-beach source is permitted and was used as a sand source for beach/dune restoration at PAFB (2011 and 2014) as sand bypassing southward across the Canaveral Harbor Entrance. It is probably not available as a "backpassing" source for KSC, unless agreed by 45SW. [The sand along this beach, below the high water line, is periodically dredged and placed to the City of Cape Canaveral shoreline, by the USACE, as the Canaveral Harbor Sand Bypass Project.]
6. Port Canaveral Widening – Widening and deepening of the Canaveral Harbor Entrance channel to 46+2 ft is underway in 2014 and is anticipated to generate potentially beach-compatible material (from above -4.9 m [-16 ft] mean low water cut depth) for which disposal sites have not yet been confirmed.
7. Titan Road stockpile, CCAFS – Approximately 90,000 cy of sand stockpiled from an upland excavation project. The sand was used to construct post-Hurricane-Sandy dune repairs along KSC in Spring 2014. This source is depleted.
8. Central Sand Tico Pit (Titusville) – Principal source of dune restoration material placed by Brevard County in 2005 and 2006.
9. Fischer Sand Mine 99th Street (Indian River County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
10. Ranch Road (82nd Avenue, Indian River County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
11. Brian Davis Mine (7200 84th Ave., Vero Beach) – Commercial sand mine that provided sand for Brevard County 2014 dune restoration.
12. Rock Solid Rock, LLC Broadway Pits (Brevard County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
13. Huntington Pit (JP Donovan). Stormwater pond excavation at Huntington Lakes II in City of Rockledge, FL; used by Brevard County for 2014 dune reparations. This source is depleted.
14. Cemex Gator Mine, Lake Wales Sand Mine, Davenport Sand Mine (Davenport and Lake Wales, FL) – Commercial sand mines.

Sand sources 8 through 14 were most recently included on FDEP's approved list of sand sources for dune restoration in Brevard County, south of Canaveral Harbor, as of Spring 2014 (as itemized in the Sediment Quality Assurance/Quality Control [QA/QC] Plan for FDEP Permit BE-1307 issued to Brevard County in August 2013.) Some, but not all, of these sources have been used by the County. Brevard County's dune restoration projects have used sand from sources 8 through 13, in addition to other storm-water excavation sites from which sand is no longer available. Numerous other sources are available, including additional commercial mines not listed above. Other sand sources are added to the list of approved sources for dune/beach fill placement, for use by Brevard County, pursuant to review and approval by FDEP, as opportunities and needs arise.

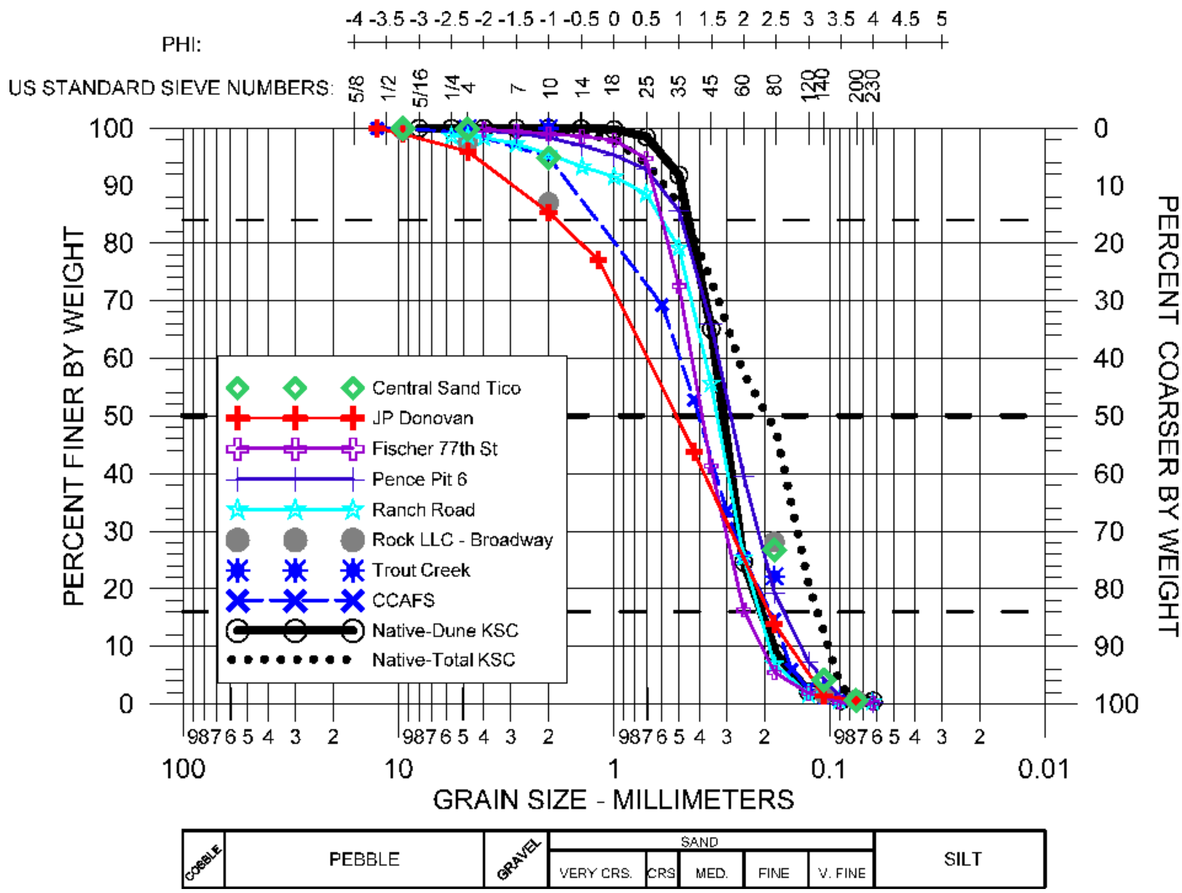


Figure 4-1: Typical grain size data from upland sand sources used in Brevard County, FL.

As noted, specific investigation of candidate upland borrow areas must be made just prior to initiating/soliciting construction of a project – due to the dynamic nature of sand supplies. The overfill ratio of the sources described above is typically about 1.0, but again, conditions vary and must be re-assessed for each candidate sand source and each specific project objective. Quality assurance & control measures must be prescribed and implemented for the import and placement of any sediment fill to the project area.

5.0 GRANULARMETRIC DATA (DETAIL)

The following pages summarize the grain size distribution (granularmetric) data describing the native beach sediments along Kennedy Space Center, the borrow area sediments of Canaveral Shoals I and II, and the overfill ratio of the borrow area sediments relative to the native KSC beach.

A comprehensive summary of the geotechnical data collected at Canaveral Shoals I and II, prepared by the US Army Corps of Engineers (USACE), is presented in the original version of this report dated June 2012 (OAI 2012). These data – including a brief narrative description, core boring logs, and grain size analysis from core samples – are routinely included in the USACE construction plans and specifications for the Brevard County Shore Protection Project, including those dated 18 September 2009 (Solicitation/Project: W912EP-09-B-0021).

Figure 5-1: Native Beach Samples (2012)

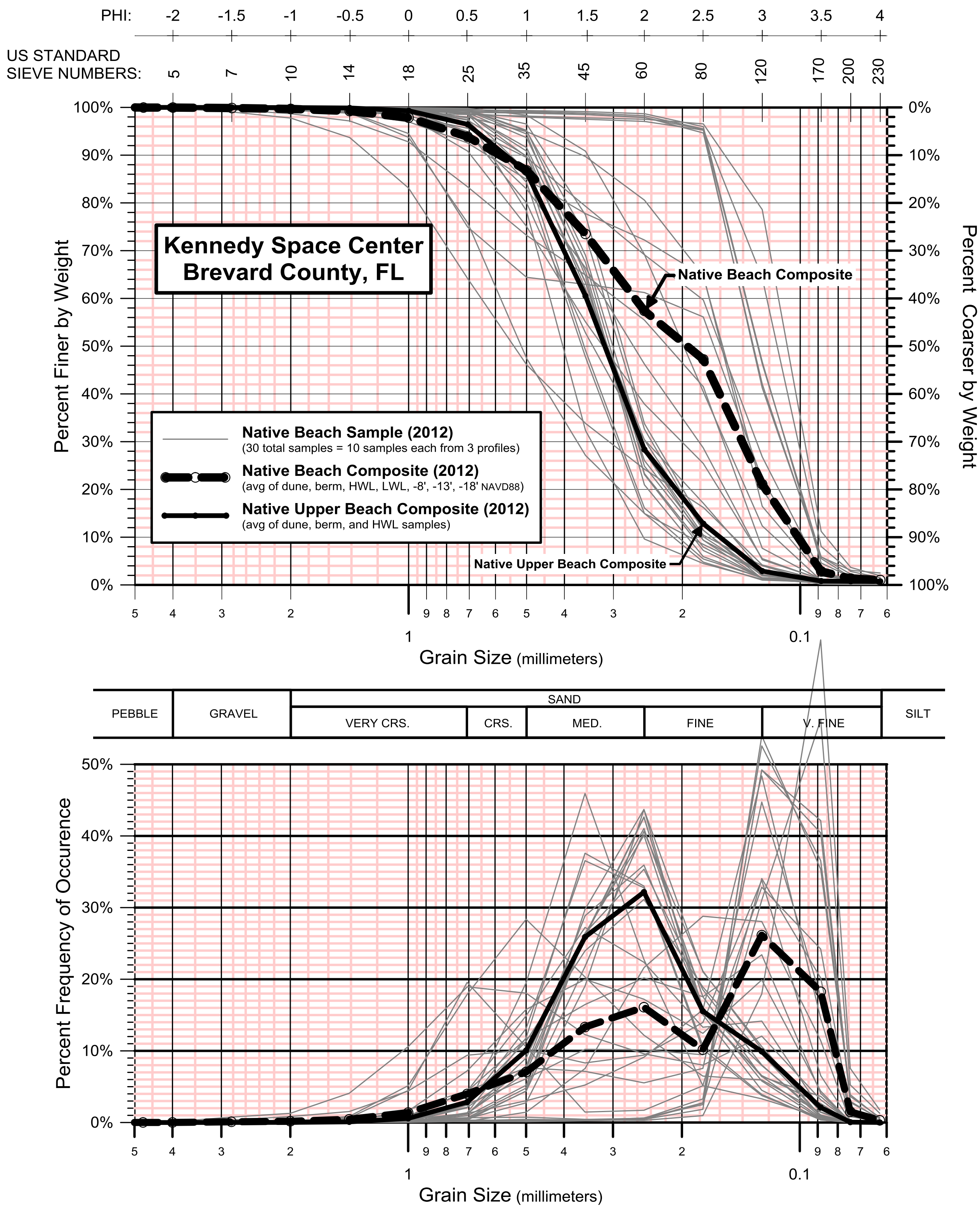


Figure 5-2: **Native Beach Profile Composites**

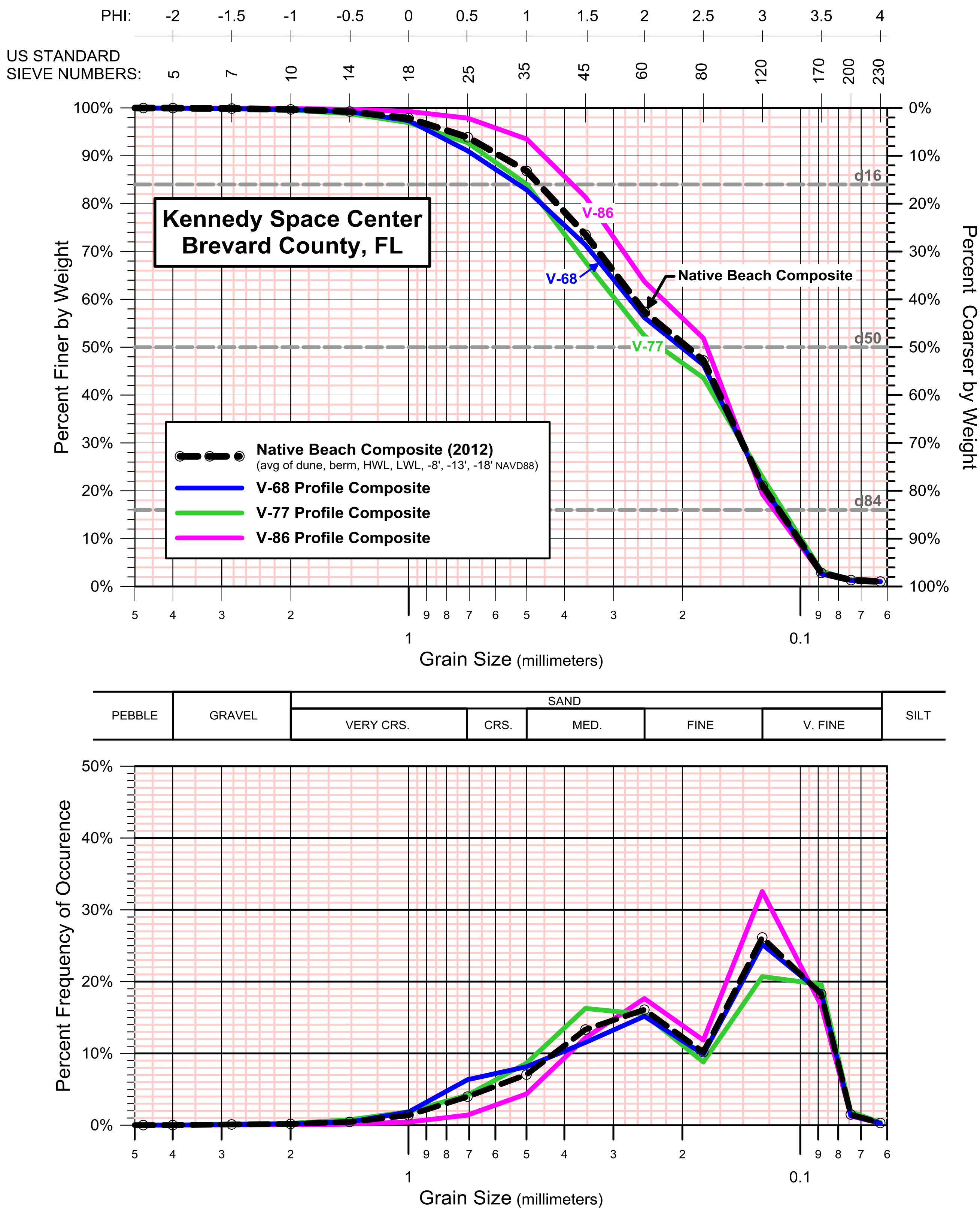


Figure 5-3: Native Beach Elevation Composites

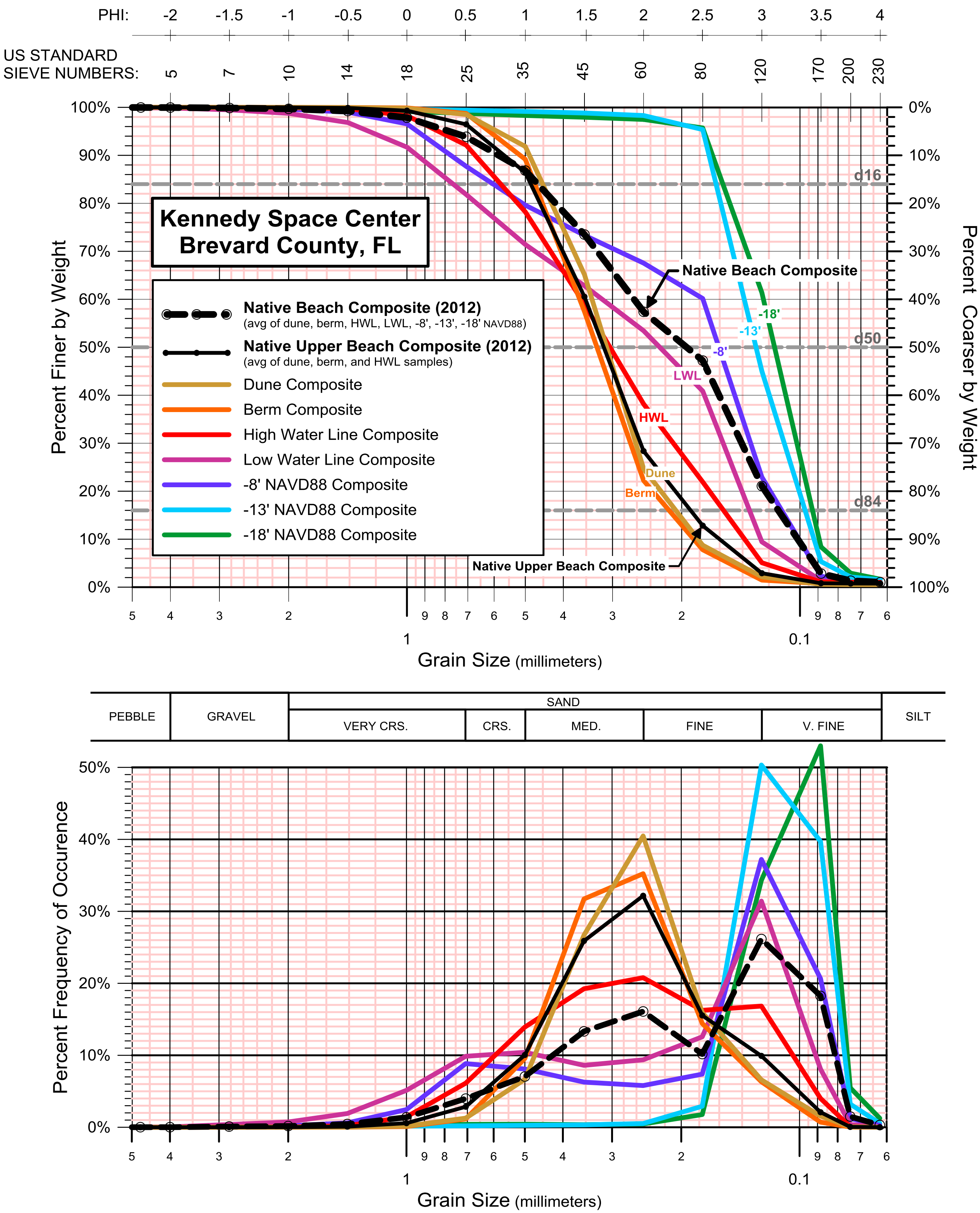


Figure 5-4: Native Beach and Borrow Area Composites

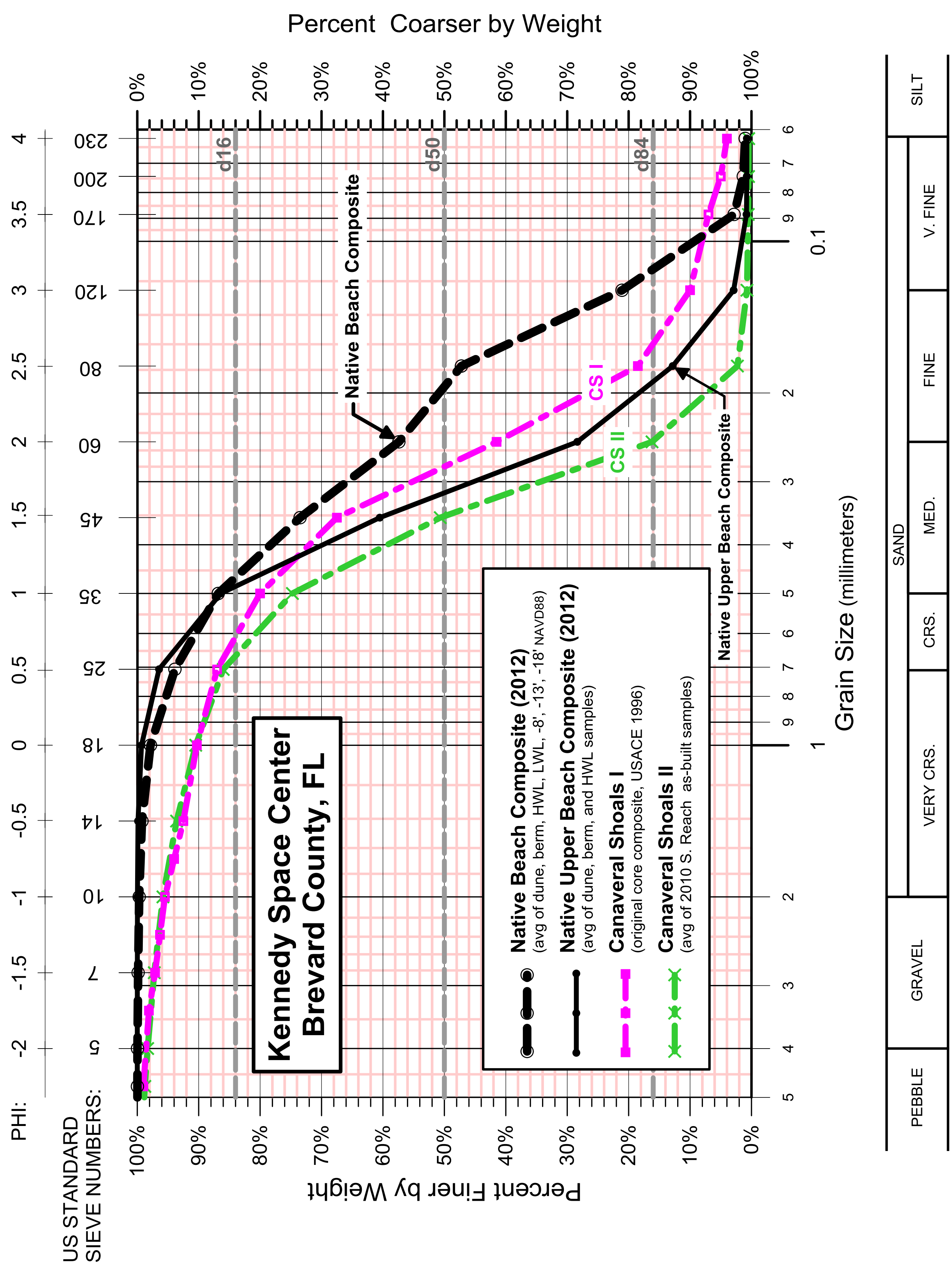


Table 5-1: Native Beach and Borrow Area Grain Size Distributions

Native Beach Composite (2012)
(avg of dune, berm, HWL, LWL, -8, -13, -18' NAVD88)

Sieve	Size (in)	Size (mm)	Size (ϕ)	% By Weight Coarser Than
5/16"	0.315	8.000	-3.0	**0.00**
3.5	0.223	5.657	-2.5	**0.01**
4	0.187	4.757	-2.25	**0.03**
5	0.157	4.000	-2.0	**0.04**
7	0.111	2.828	-1.5	**0.14**
10	0.079	2.000	-1.0	**0.31**
14	0.056	1.414	-0.5	**0.76**
18	0.039	1.000	0.0	**2.15**
25	0.028	0.707	0.5	**6.13**
35	0.020	0.500	1.0	**13.18**
45	0.014	0.354	1.5	**26.50**
60	0.010	0.250	2.0	**42.60**
80	0.007	0.177	2.5	**52.77**
120	0.005	0.125	3.0	**78.92**
170	0.003	0.088	3.5	**97.17**
200	0.003	0.074	3.75	**98.66**
230	0.002	0.063	4.0	**98.97**

Native Upper Beach Composite (2012)
(avg of dune, berm, and HWL samples)

Sieve	Size (in)	Size (mm)	Size (ϕ)	% By Weight Coarser Than
5/16"	0.315	8.000	-3.0	**0.00**
3.5	0.223	5.657	-2.5	**0.00**
4	0.187	4.757	-2.25	**0.00**
5	0.157	4.000	-2.0	**0.00**
7	0.111	2.828	-1.5	**0.01**
10	0.079	2.000	-1.0	**0.03**
14	0.056	1.414	-0.5	**0.12**
18	0.039	1.000	0.0	**0.69**
25	0.028	0.707	0.5	**3.54**
35	0.020	0.500	1.0	**13.59**
45	0.014	0.354	1.5	**39.48**
60	0.010	0.250	2.0	**71.64**
80	0.007	0.177	2.5	**87.18**
120	0.005	0.125	3.0	**97.09**
170	0.003	0.088	3.5	**99.19**
200	0.003	0.074	3.75	**99.24**
230	0.002	0.063	4.0	**99.25**

Canaveral Shoals I Offshore Borrow Area
(original core composite, USACE 1996)

Sieve	Size (in)	Size (mm)	Size (ϕ)	% By Weight Coarser Than
4	0.187	4.757	-2.25	**1.00**
6	0.132	3.364	-1.75	**1.90**
7	0.111	2.828	-1.5	**2.90**
8	0.094	2.378	-1.25	**3.70**
10	0.079	2.000	-1.0	**4.50**
12	0.066	1.682	-0.75	**6.00**
14	0.056	1.414	-0.5	**7.50**
18	0.039	1.000	0.0	**9.70**
25	0.028	0.707	0.5	**13.00**
35	0.020	0.500	1.0	**20.00**
45	0.014	0.354	1.5	**32.50**
60	0.010	0.250	2.0	**58.50**
80	0.007	0.177	2.5	**81.50**
120	0.005	0.125	3.0	**90.00**
170	0.003	0.088	3.5	**93.00**
200	0.003	0.074	3.75	**95.00**
230	0.002	0.063	4.0	**96.00**

Canaveral Shoals II Offshore Borrow Area
(avg of 2010 S. Reach as-built samples)

Sieve	Size (in)	Size (mm)	Size (ϕ)	% By Weight Coarser Than
7/16"	0.445	11.314	-3.50	**0.07**
5/16"	0.315	8.000	-3.00	**0.39**
3.5	0.223	5.657	-2.5	**0.96**
4	0.187	4.757	-2.25	**1.23**
5	0.157	4.000	-2.0	**1.69**
7	0.111	2.828	-1.50	**2.77**
10	0.079	2.000	-1.0	**4.18**
14	0.056	1.414	-0.5	**6.40**
18	0.039	1.000	0.0	**9.52**
25	0.028	0.707	0.5	**13.99**
35	0.020	0.500	1.0	**25.26**
45	0.014	0.354	1.5	**49.34**
60	0.010	0.250	2.0	**83.81**
80	0.007	0.177	2.5	**97.71**
120	0.005	0.125	3.0	**99.26**
170	0.003	0.088	3.5	**99.48**
200	0.003	0.074	3.75	**99.52**
230	0.002	0.063	4.0	**99.54**

Table 5-2: Native Beach and Borrow Area – Overfill Calculation

Native Beach Composite (2012) (avg of dune, berm, HWL, LWL, -8', -13', -18' NAVD88)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	0.37	1.11	2.35	3.14	3.45	phi
Mean	2.20	phi				
Standard Deviation	1.02	phi				

Canaveral Shoals I (original core composite, USACE 1996)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	-0.95	0.74	1.83	2.64	3.79	phi
Mean	1.74	phi				
Standard Deviation	1.27	phi				
(Mb-Mn)/Sn	-0.45					
Sb/Sn	1.24					
J-K Overfill Factor (R_A)	**1.02**					
(Mb-Mn)/Sb	-0.37					
Dean Overfill Factor (K)	**1.00**					

Canaveral Shoals II (avg of 2010 S. Reach as-built samples)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	-0.86	0.59	1.50	2.00	2.43	phi
Mean	1.36	phi				
Standard Deviation	0.90	phi				
(Mb-Mn)/Sn	-0.82					
Sb/Sn	0.88					
J-K Overfill Factor (R_A)	**1.00**					
(Mb-Mn)/Sb	-0.93					
Dean Overfill Factor (K)	**1.00**					

Table 5-3a: Granularmetric Data for Native Beach Samples along KSC shoreline (V-068).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-68									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.11
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.00	0.07
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.13	0.02	0.34	0.07	0.03	0.16
10	0.079	2.000	-1.0	0.00	0.02	0.01	0.00	0.16	0.07	0.83	0.14	0.09	0.14
14	0.056	1.414	-0.5	0.02	0.09	0.02	0.02	0.85	0.25	1.53	0.66	0.16	0.19
18	0.039	1.000	0.0	0.15	0.42	0.12	0.05	5.14	1.60	4.40	4.47	0.14	0.12
25	0.028	0.707	0.5	1.27	2.13	1.15	0.51	17.89	7.21	9.39	19.57	0.12	0.22
35	0.020	0.500	1.0	6.96	7.52	9.00	4.37	28.37	15.78	10.17	10.54	0.11	0.21
45	0.014	0.354	1.5	25.88	26.41	26.44	21.78	20.32	19.98	8.32	1.46	0.23	0.28
60	0.010	0.250	2.0	42.60	40.09	35.36	40.63	12.18	17.21	9.41	1.71	0.43	0.64
80	0.007	0.177	2.5	15.91	15.39	18.53	21.15	6.48	12.45	13.96	5.13	2.72	2.50
120	0.005	0.125	3.0	5.79	6.44	8.03	10.23	5.94	19.91	33.83	34.06	49.22	31.04
170	0.003	0.088	3.5	0.48	0.64	0.74	0.88	1.42	4.38	6.55	20.17	42.15	56.25
200	0.003	0.074	3.75	0.03	0.03	0.02	0.04	0.02	0.11	0.23	0.82	2.96	5.25
230	0.002	0.063	4.0	0.01	0.01	0.00	0.01	0.00	0.01	0.04	0.14	0.52	1.29
Total				99.10	99.19	99.42	99.67	98.90	98.98	99.14	99.08	98.88	98.47

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-68									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.11
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.07	0.00	0.18
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.18
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.13	0.02	0.48	0.21	0.03	0.34
10	0.079	2.000	-1.0	0.00	0.02	0.01	0.00	0.29	0.09	1.31	0.35	0.12	0.48
14	0.056	1.414	-0.5	0.02	0.11	0.03	0.02	1.14	0.34	2.84	1.01	0.28	0.67
18	0.039	1.000	0.0	0.17	0.53	0.15	0.07	6.28	1.94	7.24	5.48	0.42	0.79
25	0.028	0.707	0.5	1.44	2.66	1.30	0.58	24.17	9.15	16.63	25.05	0.54	1.01
35	0.020	0.500	1.0	8.40	10.18	10.30	4.95	52.54	24.93	26.80	35.59	0.65	1.22
45	0.014	0.354	1.5	34.28	36.59	36.74	26.73	72.86	44.91	35.12	37.05	0.88	1.50
60	0.010	0.250	2.0	76.88	76.68	72.10	67.36	85.04	62.12	44.53	38.76	1.31	2.14
80	0.007	0.177	2.5	92.79	92.07	90.63	88.51	91.52	74.57	58.49	43.89	4.03	4.64
120	0.005	0.125	3.0	98.58	98.51	98.66	98.74	97.46	94.48	92.32	77.95	53.25	35.68
170	0.003	0.088	3.5	99.06	99.15	99.40	99.62	98.88	98.86	98.87	98.12	95.40	91.93
200	0.003	0.074	3.8	99.09	99.18	99.42	99.66	98.90	98.97	99.10	98.94	98.36	97.18
230	0.002	0.063	4.0	99.10	99.19	99.42	99.67	98.90	98.98	99.14	99.08	98.88	98.47

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
Median (d50,mm)	0.31	0.31	0.31	0.29	0.51	0.32	0.11	0.22	0.17	0.13
Mean (μ,mm)	0.31	0.32	0.31	0.29	0.48	0.31	0.12	0.29	0.27	0.13
Standard Deviation (σ,ϕ)	0.53	0.57	0.58	0.54	0.83	0.89	0.55	1.13	1.28	0.42
Skewness (α,ϕ)	0.00	-0.15	0.06	0.10	0.46	-0.09	-5.08	-0.79	-0.53	-3.64
Kurtosis (β,ϕ)	3.57	3.81	2.98	3.09	3.07	2.20	42.39	2.77	1.72	32.74
% Fines (passing #230)	0.90	0.81	0.58	0.33	1.10	1.02	1.53	0.86	0.92	1.12
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.14	0.07	0.00
% Carbonate	15.34	17.67	18.70	14.90	33.31	22.61	7.08	25.16	12.32	5.29
Munsell Color (moist)	10YR 8.0 / 1.0	10YR 7.5 / 1.5	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 7.5 / 1.5	10YR 7.5 / 1.0	10YR 7.0 / 1.0	10YR 7.5 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0

Sample elevations are in feet NAVD88

Table 5-3b: Granularmetric Data for Native Beach Samples along KSC shoreline (V-077).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-77									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.02
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.03	0.04	0.28
10	0.079	2.000	-1.0	0.01	0.00	0.00	0.00	0.02	0.01	1.28	0.16	0.11	0.25
14	0.056	1.414	-0.5	0.02	0.01	0.01	0.02	0.05	0.13	4.08	0.54	0.18	0.37
18	0.039	1.000	0.0	0.04	0.15	0.09	0.14	0.64	0.92	10.59	1.11	0.21	0.24
25	0.028	0.707	0.5	0.33	2.43	1.18	2.05	4.38	4.34	18.93	2.53	0.24	0.33
35	0.020	0.500	1.0	4.40	13.12	7.87	19.50	14.90	11.70	18.06	6.11	0.26	0.33
45	0.014	0.354	1.5	26.17	36.55	28.85	45.93	27.23	16.47	12.27	10.22	0.43	0.36
60	0.010	0.250	2.0	41.04	32.77	35.93	22.75	22.37	20.18	9.59	10.15	0.59	0.30
80	0.007	0.177	2.5	17.56	10.19	15.97	5.13	13.30	17.56	8.01	9.46	3.29	0.97
120	0.005	0.125	3.0	6.39	3.76	7.96	3.31	14.16	23.42	12.06	32.85	52.57	17.95
170	0.003	0.088	3.5	3.64	0.44	1.06	0.76	1.85	4.07	3.18	24.22	36.56	67.37
200	0.003	0.074	3.75	0.05	0.03	0.07	0.01	0.04	0.05	0.05	1.43	3.88	7.56
230	0.002	0.063	4.0	0.02	0.00	0.01	0.00	0.01	0.01	0.01	0.35	0.60	1.75
Total				99.67	99.45	99.00	99.60	98.95	98.86	99.06	99.16	98.96	98.08

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-77									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.02
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.03	0.04	0.30
10	0.079	2.000	-1.0	0.01	0.00	0.00	0.00	0.02	0.01	2.23	0.19	0.15	0.55
14	0.056	1.414	-0.5	0.03	0.01	0.01	0.02	0.07	0.14	6.31	0.73	0.33	0.92
18	0.039	1.000	0.0	0.07	0.16	0.10	0.16	0.71	1.06	16.90	1.84	0.54	1.16
25	0.028	0.707	0.5	0.40	2.59	1.28	2.21	5.09	5.40	35.83	4.37	0.78	1.49
35	0.020	0.500	1.0	4.80	15.71	9.15	21.71	19.99	17.10	53.89	10.48	1.04	1.82
45	0.014	0.354	1.5	30.97	52.26	38.00	67.64	47.22	33.57	66.16	20.70	1.47	2.18
60	0.010	0.250	2.0	72.01	85.03	73.93	90.39	69.59	53.75	75.75	30.85	2.06	2.48
80	0.007	0.177	2.5	89.57	95.22	89.90	95.52	82.89	71.31	83.76	40.31	5.35	3.45
120	0.005	0.125	3.0	95.96	98.98	97.86	98.83	97.05	94.73	95.82	73.16	57.92	21.40
170	0.003	0.088	3.5	99.60	99.42	98.92	99.59	98.90	98.80	99.00	97.38	94.48	88.77
200	0.003	0.074	3.8	99.65	99.45	98.99	99.60	98.94	98.85	99.05	98.81	98.36	96.33
230	0.002	0.063	4.0	99.67	99.45	99.00	99.60	98.95	98.86	99.06	99.16	98.96	98.08

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
Median (d50,mm)	0.30	0.36	0.31	0.40	0.34	0.27	0.54	0.16	0.13	0.11
Mean (μ,mm)	0.29	0.36	0.31	0.39	0.33	0.28	0.49	0.20	0.13	0.12
Standard Deviation (σ,ϕ)	0.56	0.54	0.57	0.53	0.74	0.82	1.13	0.93	0.47	0.59
Skewness (α,ϕ)	0.52	0.24	0.23	0.77	0.11	-0.33	0.12	-1.02	-3.47	-5.05
Kurtosis (β,ϕ)	3.68	3.47	3.15	4.39	2.46	2.35	2.39	3.46	27.17	35.35
% Fines (passing #230)	0.33	0.55	1.00	0.40	1.05	1.14	0.94	0.84	1.04	1.92
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
% Carbonate	14.34	21.63	16.10	22.45	21.66	20.28	37.91	14.55	6.00	7.31
Munsell Color (moist)	10YR 8.5 / 1.0	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 7.5 / 1.0	10YR 7.5 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0

Sample elevations are in feet NAVD88

Table 5-3c: Granularmetric Data for Native Beach Samples along KSC shoreline (V-086).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-86									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
7	0.111	2.828	-1.5	0.02	0.01	0.00	0.00	0.00	0.00	0.07	0.26	0.00	0.01
10	0.079	2.000	-1.0	0.01	0.04	0.00	0.01	0.00	0.00	0.10	0.28	0.02	0.08
14	0.056	1.414	-0.5	0.03	0.03	0.02	0.01	0.04	0.01	0.13	0.63	0.03	0.17
18	0.039	1.000	0.0	0.14	0.12	0.09	0.10	0.35	0.02	0.41	1.79	0.12	0.37
25	0.028	0.707	0.5	0.94	0.53	0.66	1.36	2.81	0.16	1.28	4.44	0.24	0.67
35	0.020	0.500	1.0	5.20	2.75	4.80	11.82	11.34	1.44	3.03	7.64	0.44	0.74
45	0.014	0.354	1.5	26.11	19.05	29.76	37.59	23.96	7.53	5.23	7.14	0.35	0.45
60	0.010	0.250	2.0	42.67	43.68	43.71	33.00	31.14	21.62	9.12	5.53	0.54	0.44
80	0.007	0.177	2.5	15.52	21.05	15.05	10.67	18.92	28.79	15.74	7.56	2.76	1.84
120	0.005	0.125	3.0	6.55	10.60	4.50	3.92	9.54	28.06	48.38	44.73	49.20	53.97
170	0.003	0.088	3.5	2.66	1.48	0.47	0.36	0.90	11.43	14.53	17.57	40.43	35.37
200	0.003	0.074	3.75	0.05	0.12	0.06	0.01	0.03	0.13	0.87	1.39	2.81	3.64
230	0.002	0.063	4.0	0.02	0.04	0.02	0.00	0.01	0.03	0.15	0.31	0.56	0.72
Total				99.92	99.50	99.14	98.85	99.04	99.22	99.08	99.32	97.50	98.47

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-86									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.00
7	0.111	2.828	-1.5	0.02	0.01	0.00	0.00	0.00	0.00	0.11	0.31	0.00	0.01
10	0.079	2.000	-1.0	0.03	0.05	0.00	0.01	0.00	0.00	0.21	0.59	0.02	0.09
14	0.056	1.414	-0.5	0.06	0.08	0.02	0.02	0.04	0.01	0.34	1.22	0.05	0.26
18	0.039	1.000	0.0	0.20	0.20	0.11	0.12	0.39	0.03	0.75	3.01	0.17	0.63
25	0.028	0.707	0.5	1.14	0.73	0.77	1.48	3.20	0.19	2.03	7.45	0.41	1.30
35	0.020	0.500	1.0	6.34	3.48	5.57	13.30	14.54	1.63	5.06	15.09	0.85	2.04
45	0.014	0.354	1.5	32.45	22.53	35.33	50.89	38.50	9.16	10.29	22.23	1.20	2.49
60	0.010	0.250	2.0	75.12	66.21	79.04	83.89	69.64	30.78	19.41	27.76	1.74	2.93
80	0.007	0.177	2.5	90.64	87.26	94.09	94.56	88.56	59.57	35.15	35.32	4.50	4.77
120	0.005	0.125	3.0	97.19	97.86	98.59	98.48	98.10	87.63	83.53	80.05	53.70	58.74
170	0.003	0.088	3.5	99.85	99.34	99.06	98.84	99.00	99.06	98.06	97.62	94.13	94.11
200	0.003	0.074	3.8	99.90	99.46	99.12	98.85	99.03	99.19	98.93	99.01	96.94	97.75
230	0.002	0.063	4.0	99.92	99.50	99.14	98.85	99.04	99.22	99.08	99.32	97.50	98.47

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SW	SP	SP
Median (d50,mm)	0.31	0.29	0.31	0.36	0.31	0.20	0.16	0.16	0.13	0.13
Mean (μ,mm)	0.30	0.28	0.31	0.35	0.31	0.20	0.18	0.21	0.13	0.13
Standard Deviation (σ,ϕ)	0.56	0.54	0.48	0.52	0.64	0.60	0.71	1.01	0.41	0.52
Skewness (α,ϕ)	0.30	0.04	0.22	0.31	-0.08	-0.31	-1.63	-1.28	-2.60	-3.37
Kurtosis (β,ϕ)	4.10	4.20	3.87	3.50	2.80	2.72	6.77	4.03	19.10	21.27
% Fines (passing #230)	0.08	0.50	0.86	1.15	0.96	0.78	0.92	0.68	2.50	1.53
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
% Carbonate	10.58	10.83	16.05	18.19	19.38	11.66	10.10	15.89	7.31	6.24
Munsell Color (moist)	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 8.0 / 1.0	10YR 7.5 / 1.0	10YR 7.5 / 1.0	10YR 7.5 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0	10YR 7.0 / 1.0

Sample elevations are in feet NAVD88

6.0 REFERENCES

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APPENDIX D

Kennedy Space Center Shoreline Restoration
Created Inland Dune Monitoring Report
Fall 2011-February 2013

Introduction

During the summer of 2010, an inland dune was constructed behind the primary dune between Launch Complexes 39A and 39B, east of Phillips Parkway on Kennedy Space Center (KSC) (Figure 1). The dune was 221 m (725 ft) long, 24 m (80 ft) wide, and 4.6 m (15 ft) tall. The purpose of the dune was to improve sea turtle nesting habitat by creating a natural visual screen between the beach and LC 39 complexes, and to improve southeastern beach mouse (*Peromyscus polionotus niveiventris*) habitat that was highly disturbed. The stretch of primary dune in that area has been severely compromised in the past by activities associated with railroad operations, and during the last several years by wash-overs and inundation from storm surges. Free sand to construct the dune was obtained from Cape Canaveral Air Force Station, and half of the sand was transported at no cost. The other half of the transport was done by contractors, as was the shaping of the dune. The U.S. Fish and Wildlife Service (FWS) at Merritt Island National Wildlife Refuge provided funding for vegetation and planting, which occurred in April 2011. Ecological monitoring was requested by the FWS Endangered Species Office in Jacksonville in order to determine if and when southeastern beach mice would populate the new dune habitat. Monitoring funds were provided from 21st Century Launch Complex resources.

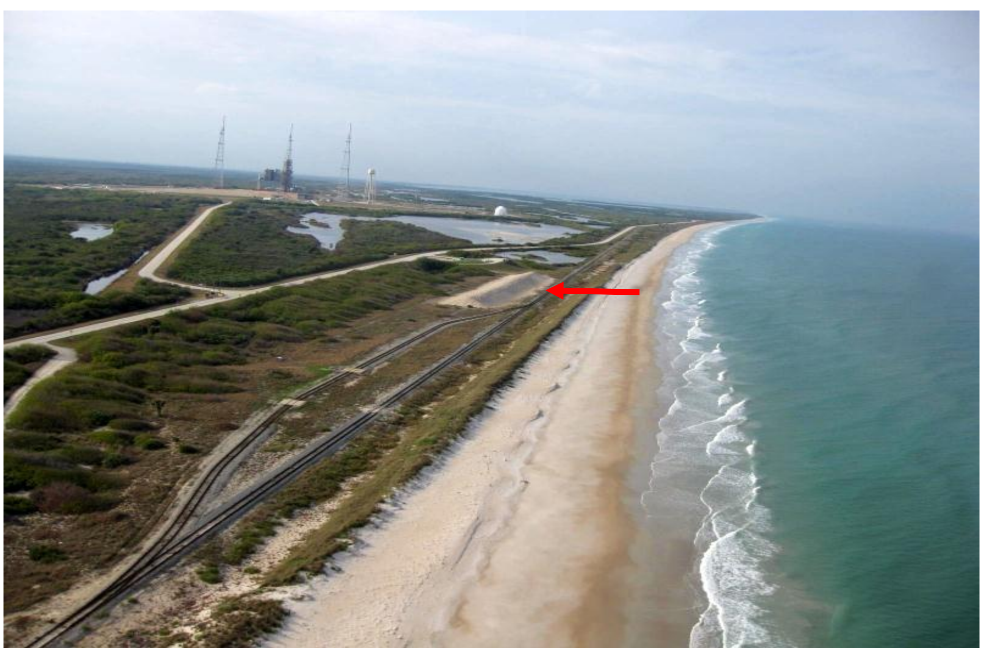

Figure 1. Location of created inland dune southeast of LC 39B on Kennedy Space Center, Florida.

Methods

A monitoring plan was developed that focused on vegetation cover, and occupancy by gopher tortoises (*Gopherus polyphemus*) and southeastern beach mice. A list of other wildlife species observed on the dune was also kept. Eleven transects were evenly spaced transversely across the dune from east to west (Figure 2). For vegetation monitoring, there were five sample points on each transect: Sample point 1 was within the first 5 meters (16.4 ft) from the base of the dune on the east face, point 2 was within the second 5 meters, point 3 was near the top of the dune, point 4 was within the first 5 meters from the top on the west side, and point five was within the last 5 meters on the west side, for a total of 55 points. Exact sample point locations were based on randomly chosen coordinates within 5 meters north or south of each transect. These random points, once chosen, were kept the same for all survey events. A one-square meter (10.8 ft^2) plot frame was used to survey the vegetation at each point. Survey methods followed Daubenmire 1968; bare ground, detritus, and each species of plant within the frame were assigned a number based on a range of cover percentages. Values were compared with subsequent sampling event data to determine changes over time in the vegetation coverage and composition.

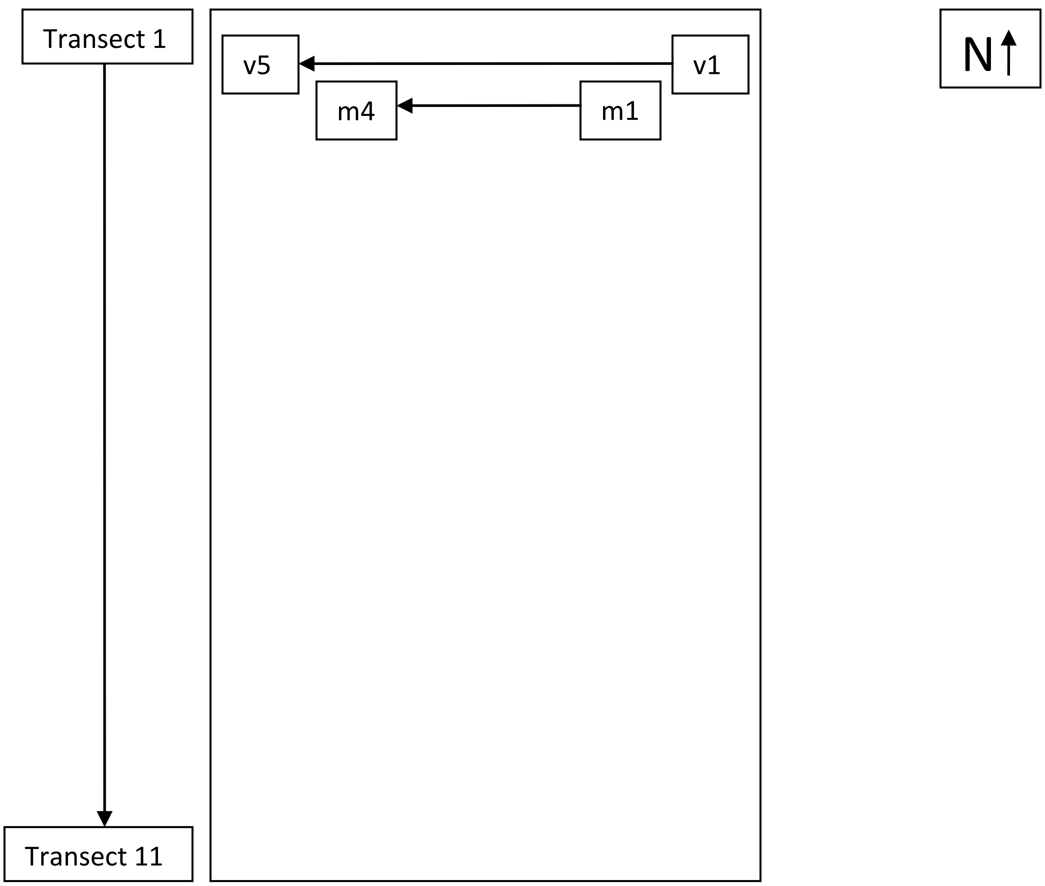

Figure 2. Layout of transects (1 -11) from north to south, vegetation sample points (v1 – v5) from east to west, and small mammal trap stations (m1 – m4) from east to west on the created inland dune on Kennedy Space Center, Florida. See text for details.

A 100% coverage gopher tortoise burrow survey was done once during each survey event by walking five parallel lines from north to south along the dune. Burrows found were examined with an infrared burrow camera to determine occupancy.

Southeastern beach mice were surveyed by trapping. On each transect, Sherman live traps were placed one-third and two-thirds of the way up the dune face on the east and west sides, for a total of four traps per transect, equaling 44 traps on the dune (Figure 2). Ten traps were placed on the primary dune directly east of the inland dune to serve as a control site. Traps were baited with sunflower seeds and a piece of cotton was placed inside for use as bedding. Trapping occurred for three consecutive nights during each survey period. Captured mice and rats were weighed, the sex and age classifications were determined, and the reproductive condition was assessed. Southeastern beach mice were ear tagged for future identification. All animals were released at their capture locations.

<u>Results</u>

Vegetation - Table 1 shows the percent cover for the parameters sampled during the vegetation monitoring. Based on the 55 samples taken during each of the five sampling events, the amount of the site that was not vegetated (bare sand and detritus) varied between 58% and 70%; vegetated area was between 30% and 40%. The vegetation that was planted accounted for about 23% of the vegetation coverage. There was some establishment of native species that were not planted; these combined with the planted species accounted for 31% of the total vegetation. Coverage by these plants increased over time (Figure 3). Nuisance plants made up 17.5% of the total coverage during the first monitoring event, but decreased substantially over time (Figure 3). Table 2 is a list of all plants documented on the dune.

Table 1. Vegetation survey results (% cover) from five quarters of sampling on the created inland dune, Kennedy Space Center, Florida.

Parameter	Nov. 11	Feb. 12	May 12	Aug. 12	Nov. 12
% vegetated	41.4	29.6	33.6	39.6	40.4
% bare (sand, detritus)	58.6	70.4	66.4	60.4	59.6
Planted vegetation	21.2	21.7	24.8	23.0	24.6
Planted & volunteer	23.9	25.1	29.7	30.9	31.9
Nuisance species	17.5	4.5	3.9	8.7	8.5

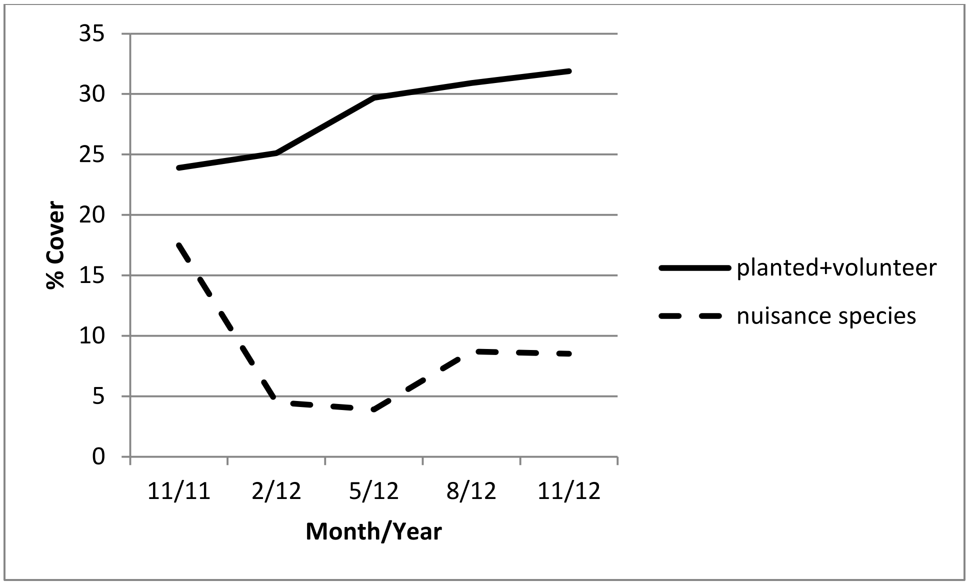

Figure 3. Percent cover of desirable plant species (those planted and native volunteers) and nuisance species on the created inland dune, Kennedy Space Center, Florida.

Table 2. List of plants documented from the created inland dune, Kennedy Space Center, Florida.

	Scientific Name	Common Name
Desirable (planted)	*Coccoloba uvifera*	Seagrape
	Gaillardia pulchella	Blanket flower
	Helianthus debilis	Cucumberleaf sunflower
	Iva imbricata	Seacoast marsh elder
	Panicum amarum	Bitter panicgrass
	Serenoa repens	Saw palmetto
	Spartina patens	Salt meadow cordgrass
	Uniola paniculata	Seaoats
Desirable (volunteer)	*Canavalia rosea*	Baybean
	Cenchrus sp.	Sandspur
	Chamaesyce sp.	Milk purslane
	Chapmannia floridana	Florida alicia
	Cyperus sp.	Flatsedge
	Ernodea littoralis	Beach creeper
	Heterotheca subaxillaris	Camphorweed
	Ipomea sp.	Morning glory
	Panicum sp.	Unid. grass species
	Paspalum sp.	Unid. grass species
	Phyla nodiflora	Turkey tangle
	Physalis viscosa	Groundcherry
	Poaceae	Unid. grasses
	Rynchosia sp.	Snoutbean
	Trifolium sp.	Clover
	Vicia sp.	Vetch
	Vigna luteola	Cowpea
Nuisance	Ambrosia artemisiifolia	Common ragweed
	Cynodon dactylon	Bermudagrass
	Dactyloctenium aegyptium	Crowfoot grass
	Digitaria sp.	Crabgrass
	Indigofera spicata	Hairy indigo
	Melinis repens	Natal grass

Gopher Tortoises - During the first monitoring event in November 2011, three gopher tortoise burrows were found, and all three were occupied. These same three burrows were present and occupied in February 2012. In May 2012, the three burrows were present and two more were found; all five were occupied. By August 2012, the number of burrows had increased to 13, but only five had tortoises. In November 2012, there were 17 burrows: one burrow that was originally found in August 2012 was abandoned; eight burrows were occupied and the rest were empty; five of the eight empty burrows showed signs of recent activity. In Aug. 2012, a tortoise was hand-captured outside of a burrow on the east side of the dune. It was an adult male, 25.7 cm (10.1 in) carapace length. The shell was permanently marked using standard techniques and he was released into the burrow.

Table 3. Results from gopher tortoise burrow surveys on the created inland dune, Kennedy Space Center, Florida.

Date	# Burrows	Occupied	Empty	Empty/Active	Abandoned
Nov. 2011	3	3			
Feb. 2012	3	3			
May 2012	5	5			
Aug. 2012	13	5	8		
Nov. 2012	17	8	8	5	1

Southeastern Beach Mice - Of the 810 potential trapnights during the five quarterly sampling events, traps were taken out of commission 90 times because they were raided (bait taken, but no animal caught), snapped without capturing anything, were disturbed and made inoperable, or caught non-target species [seven spotted skunks (*Spilogale putorius*), three ghost crabs (*Ocypode quadrata*), and one unidentified grasshopper]. This left a total of 720 effective trapnights which captured 140 small mammals. Catch-per-unit-effort was 0.19, which is within the range of what would be expected based on previous work done at KSC (Provancha et al. 2005).

Small mammals captured, besides southeastern beach mice, were eight cotton rats (*Sigmodon hispidis*), five cotton mice (*Peromyscus gossypinus*) and one least shrew (*Cryptotis parva*). There were 126 captures of 53 individual beach mice (Table 4; one mouse captured is not included in Table 4 or Table 5 because it escaped before any data were taken). There were reproductively active mice in all seasons, and subadult mice were captured in every survey except Aug. 2012. Only one juvenile was captured.

Table 4. Capture data for southeastern beach mice trapped on the created inland dune and control dune on Kennedy Space Center, Florida.

Date	Total	Males (reproductive)	Females (reproductive)	Adults	Subadults	Juveniles
Nov. 2011	23	12 (4)	11 (2)	21	1	1
Feb. 2012	35	16 (2)	19 (6)	33	2	0
May 2012	27	14 (8)	13 (4)	24	3	0
Aug. 2012	13	7 (6)	6 (1)	13	0	0
Nov. 2012	27	16 (4)	11 (4)	26	1	0

Table 5 shows the recapture data for all surveys. Thirty-two mice were captured during two consecutive surveys (three months apart), 15 were captured six months apart, and one animal originally tagged in Nov. 2011 was recaptured in Nov. 2012.

Table 5. Recapture data for southeastern beach mice trapped on the created inland dune and control dune on Kennedy Space Center, Florida.

Date	New Captures	Recaptures (same survey)	Recaptures (3 months)	Recaptures (6 months)	Recaptures (9 months)	Recaptures (1 year)
Nov. 2011	17	6				
Feb. 2012	13	6	16			
May 2012	13	7	4	3		
Aug. 2012	4	0	5	4	0	
Nov. 2012	6	5	7	8	0	1

Fifteen small mammals (five cotton rats and ten southeastern beach mice) and one spotted skunk were captured on the control dune east of the created inland dune. There was some movement by beach mice between the control dune and the created dune. One mouse was captured in May 2012 on the created inland dune and was subsequently captured twice on the control dune, once in Aug. 2012 and once in Nov. 2012. On the two next nights in Nov., it was captured from the west side of the created dune approximately 55 m (180 ft) away. Another beach mouse was tagged on the control dune in May 2012 and recaptured on the control dune the next night. On the third night, it was captured on the west side of the created dune, approximately 50 m (164 ft) away. In Aug. 2012, it was recaptured twice from the control dune. Both of these animals were females.

Miscellaneous Observations and Captures - In addition to the target species (gopher tortoises and small mammals), a number of other species of interest were observed on the created dune during the surveys and other visits to the site (Table 6).

Table 6. Wildlife species opportunistically observed or captured at the created inland dune on Kennedy Space Center.

Date	Species	#	Notes
Nov. 2011	Common ground dove *(Columbina passerina)*	5	Loafing in dune grass; seen during all subsequent surveys
Nov. 2011	Eastern spadefoot toad (*Scaphiopus holbrookii*)	1	Very small juvenile
Nov. 2011	Black racer (*Coluber constrictor*)	1	Startled by observer and crawled off of dune on the west side; another (or same) seen Aug. 2012
Nov. 2011	Mourning dove (*Zenaida macroura*)	1	Flew off of dune; seen during all subsequent surveys
Nov. 2011	Eastern indigo snake (*Drymarchon couperi*)	1	Captured at base of east side of dune; processed and released on 11/22; female, 128 cm (50 in) total length, 106 cm (42 in) snout-vent length; PIT tagged
Nov. 2011	Green anole (*Anolis carolinensis*)	1	On west side of dune; another (or same) seen Feb. 2012
Nov. 2011	Coachwhip (*Masticophis flagellum*)	1	Startled by observers on west side of dune; consuming something (rodent?) that was squeaking loudly; approximately 1.8 m (6 ft) long adult; escaped into vegetation west of dune
Feb. 2012	Marsh rabbit (*Sylvilagus palustris*)	X	Feces; seen during all subsequent surveys
Feb. 2012	Bobcat (*Lynx rufus*)	X	Feces

Discussion

The monitoring surveys went very smoothly and efficiently. Approximately 20 hours were spent setting up the survey site, and field time to complete each survey was approximately 36 hours, split between three or four people.

The results from the vegetation surveys were encouraging. Although the amount of vegetated area has fluctuated slightly, the percent of desirable species (planted and volunteer) has increased over time. Nuisance species comprised over 17% of the coverage during the first survey (Nov. 2011, seven months post-planting), but that quickly decreased and has remained low. A recommendation for future projects such as this is to clear more of the nuisance vegetation out of the general area before planting in order to provide less seed source.

On KSC, in any given area of natural habitat, the number of gopher tortoise burrows that is occupied is often lower (25 – 30%) than the total number of burrows (Smith et al. 1997). However, in many man-made habitats, such as dikes and berms, the occupancy rate is much higher, as was seen on the inland dune during the first three surveys (Nov. 2011 – May 2012; 100% occupancy of burrows). This could be an indication of a new opportunity being exploited; the tortoises may not have had time to establish home ranges and dig multiple burrows as is typical in natural habitats. Subsequent monitoring indicates that the tortoises are beginning to use the created inland dune in a more “natural” fashion. Whenever tortoises on or near the dune can be caught, they will be marked for identification, which will start giving us an idea of site fidelity. Radiotracking would be an even better method to determine site fidelity, habitat use, and carrying capacity for the dune. These data would be invaluable if shoreline restoration efforts on KSC in the future involve the natural dune or a large-scale created inland dune.

It is apparent from the small mammal trapping that these animals are quite capable of quickly taking advantage of new habitat that becomes available. A catch-per-unit-effort of 19% is excellent and indicates a robust population. Beach mice in all three age categories (adult, subadult, and juvenile) were captured. The percent of beach mice that appeared to be reproductively active ranged between 19% (May 2012) and 54% (Nov. 2012). Successful reproduction is an important indicator of ecosystem function. An area or habitat can be crowded with adults, but if there is no reproduction, the population eventually will decline and disappear.

It is interesting that so few animals were caught on the natural primary dune that was intended to be a control site. That section of the dune has been completely inundated at least four times during severe storm events since 1999, and there have been three attempts to restore the primary dune by piling sand on top of it (2005, 2008, and 2011). Apparently there has not been time for the vegetation, small mammal, or gopher tortoise populations to recover. Two incidences of beach mice moving between the control dune and the created dune are evidence of the possibility of immigration from the natural habitat onto the created habitat, but it is not likely that the large number of animals captured on the created dune came from the control dune. They may have moved in from intact primary dune to the south, as there is an impounded wetland adjacent to the north. As with the gopher tortoises, mark-recapture of the beach mice will give some indication of site fidelity, but radiotracking would provide a much clearer picture of how the mice reach the created dune and how they make use of it.

Incidental observations and opportunistic captures of frogs, lizards, birds, and snakes from the inland dune are signs that predator/prey relationships have been established. The coachwhip, eastern indigo snake, and bobcat are considered to be top level predators that eat a wide variety of prey, including small mammals (Maehr and Brady 1986; Stevenson and Dyer 2002; Stevenson et al 2010). The presence of animals at various trophic levels is another indicator of a functioning ecosystem.

Placement of the inland dune landward of the section of degraded primary dune may reduce light pollution on the beach generated from the LC 39 area. Disorientation data from hatchling and nesting marine turtles should eventually indicate whether or not the inland dune is effective.

Before April 2011 when the dune was planted with vegetation, it was a barren pile of sand. In 19 months, it has become a functioning ecosystem, supporting robust floral and faunal communities, including two federally listed wildlife species (eastern indigo snake, southeastern beach mouse) and one candidate species (gopher tortoise). If our coastline experiences violent storm surges in the future, as is predicted, it will be interesting to see if the created inland dune affords some protection to the habitat west of it. Continued monitoring of the system will provide important information that can be used as KSC contends with the realities of climate change and sea level rise that threaten valuable man-made assets and natural resources.

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Inland dune construction, Aug. 2010

Partially completed dune, Sep. 2010

Planting, Apr. 2011

Vegetation survey, Nov. 2012

Gopher tortoise burrow

Southeastern beach mouse

Cotton rat

Eastern indigo snake

APPENDIX E

Essential Fish Habitat Assessment

Shoreline Protection Project

Kennedy Space Center

Brevard County, Florida

June 2012

Prepared By:
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PROJECT BACKGROUND

Kennedy Space Center (KSC), owned and managed by the National Aeronautics and Space Administration (NASA), serves as the world's premiere launch complex for sending humans and payloads into space. In addition to its long and storied history supporting US Government space operations, KSC also plays a central and expanding role in fostering commercial space technology development and launch initiatives. At over 140,000 acres, KSC represents 67% of NASA's total landholdings nationwide and manages 20% of its 30 billion dollars in facilities infrastructure. Many of KSCs most valuable assets, most notably Launch Complexes (LC) 39A and 39B, are located within a few hundred meters of the Atlantic Ocean. The beaches and dunes along the KSC shoreline have historically protected this critical launch infrastructure from the impact of waves and storm surge inundation. They also provide high value habitat for several rare or federally protected species and serve as a physical buffer between launch facilities and important sea turtle nesting areas, thereby reducing photo-pollution and resulting turtle disorientation.

Over the past several years, there have been significant hurricane and non-hurricane storm events which have resulted in overwash and severe erosion of the dunes and beach at KSC (Jaeger et al., 2011). In 1999, Hurricane Floyd impacted the much of the Florida east coast, causing over 15 m of shoreline retreat at KSC. This shoreline loss has not been recovered. Further erosion during Hurricanes Francis, Charley, and Jeanne in 2004, and Tropical Storm Fay in 2008 coupled with other non-hurricane storm events, have further degraded the beach and dune and have required emergency, yet temporary, repairs to areas experiencing severe overwash. These processes have resulted in the loss of valuable wildlife habitat and increased rates of turtle disorientation in areas where dunes have been breached.

In support of NASA's overall mission and requirements of 10 U.S.C. 2273 (policy regarding assured access to space), KSC has identified the need for shoreline protection actions to safeguard critical launch infrastructure. The explicit purpose of the proposed beach renourishment actions outlined herein is to reduce shoreline erosion, safeguard critical launch infrastructure (e.g., launch pads, roads, utility corridors), and protect valuable threatened and endangered species habitat along the KSC coastline from future storm wave and sea-level rise damage. This project will focus on the northern 7.6 km of KSC's 10 km ocean shoreline between the KSC north boundary/Eagle 4 and the False Cape (Fig. 1). This reach, and in particular the 3.9 km of shoreline between LC 39A and 39B, features low upland elevations, very narrow and low dunes, and chronically high shoreline erosion rates.

Figure 1. Overview map of the proposed shoreline renourishment project area at KSC

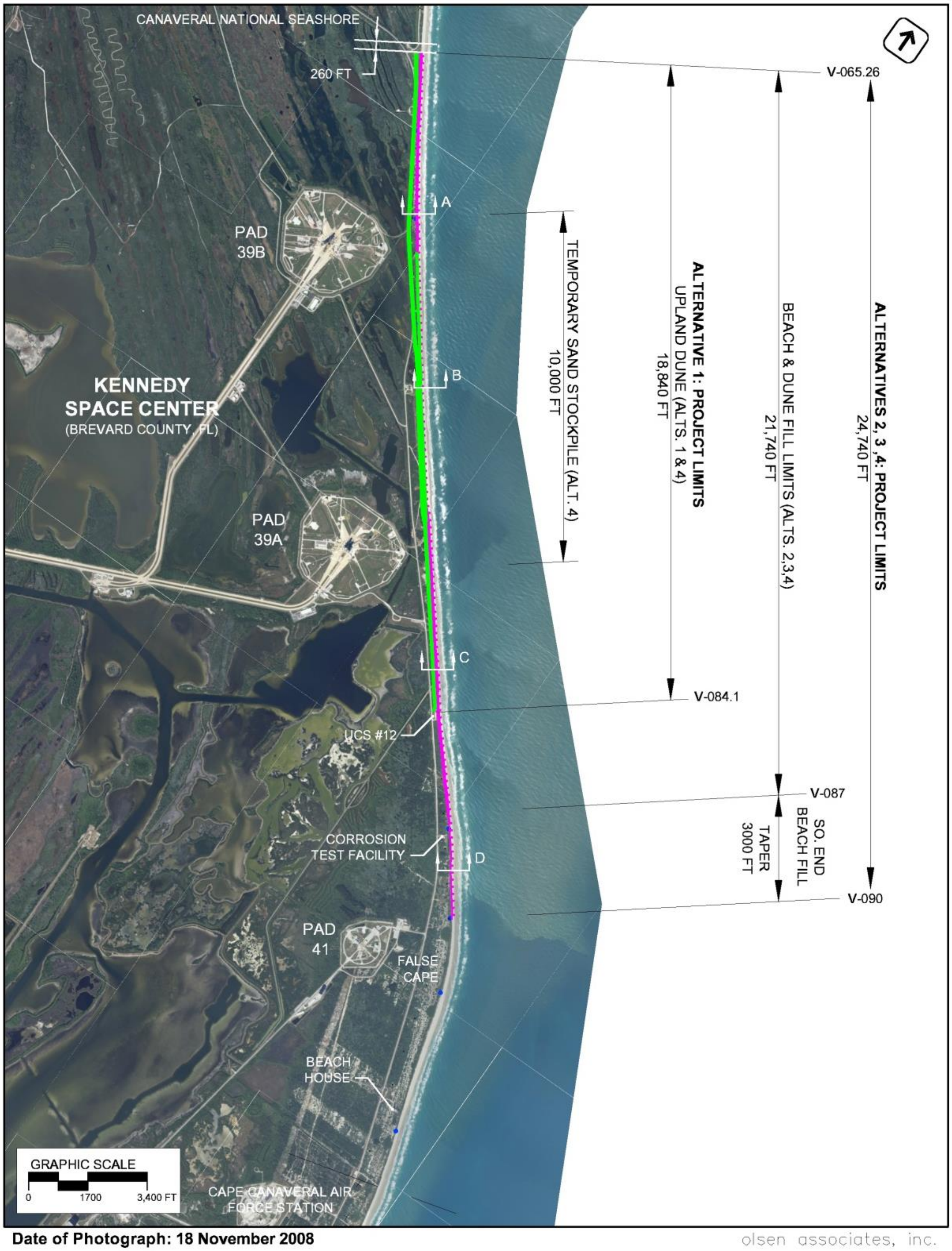

Figure 2. Map depicting the spatial extent of each of the four alternative renourishment scenarios currently under consideration

PROJECT ACTION ALTERNATIVES

Four project action alternatives (each described in detail below) are currently being evaluated for the purposes of reducing flooding and long-term loss of land along the KSC Atlantic shoreline due to impacts of beach erosion. Several other alternatives were also considered but deemed impossible to implement, environmentally adverse, or did not meet project objectives. Each of these four alternatives address all or part of the northern 7.6 km of the KSC's 10 km ocean shoreline between Florida Department of Environmental Protection (FDEP) virtual monument locations V-065.3 (Eagle 4 Watch Tower) and V-090 (False Cape) (Fig. 2). This reach, particularly the 3.9 km of shoreline between LC 39A and LC 39B (V-070 to V-082), features low upland elevations, very narrow and low dunes, and chronically high shoreline erosion rates of between 0.9 and 2 meters per year. The dune along this area has been frequently overwashed by high tides and waves and is prone to breaching (Jaeger et al. 2011). Breaching and/or loss of the dune results in extensive flooding of the uplands between the shore and the launch pads. While seasonal operational schedules are outlined below for each alternative, funding has not yet been secured to perform any of the remaining alternatives under consideration so the exact timeline of this renourishment project remains undetermined.

Alternative One: Inland Dune

Project Alternative One entails the construction of large secondary dunes behind the existing primary dune in areas most vulnerable to erosion and flooding. These areas are located along the northern 5.8 km of the KSC shoreline between monuments V-065.3 and V-084 (Fig. 2). This alternative involves placing beach-compatible sand along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune (Fig. 3). Salt-tolerant vegetation would be planted along the dune crest and slopes to further stabilize the constructed dune. Minimal sand fill would be placed on the beach. In areas where the existing primary dunes are most extensively degraded (e.g., between monuments V-071 and V-079), sand fill and vegetation would be used to both augment the existing primary dune and construct the secondary inland dune. Where there is little or no existing primary dune, frequent overwash, and narrow dune strand (e.g., between monuments V-073.8 and V-078.5), the primary and secondary dunes would be constructed as a single unit atop and behind the existing dune line.

Alternative One represents a managed retreat strategy by establishing shore protection landward of the existing dune and beach berm. It seeks to minimize impacts to the existing beach and dune and to reduce requirements for periodic beach/dune renourishment (maintenance) of the project area. Unavoidable project impacts will occur from initial dune construction in back-beach habitats. Alternative One actions are located principally within the

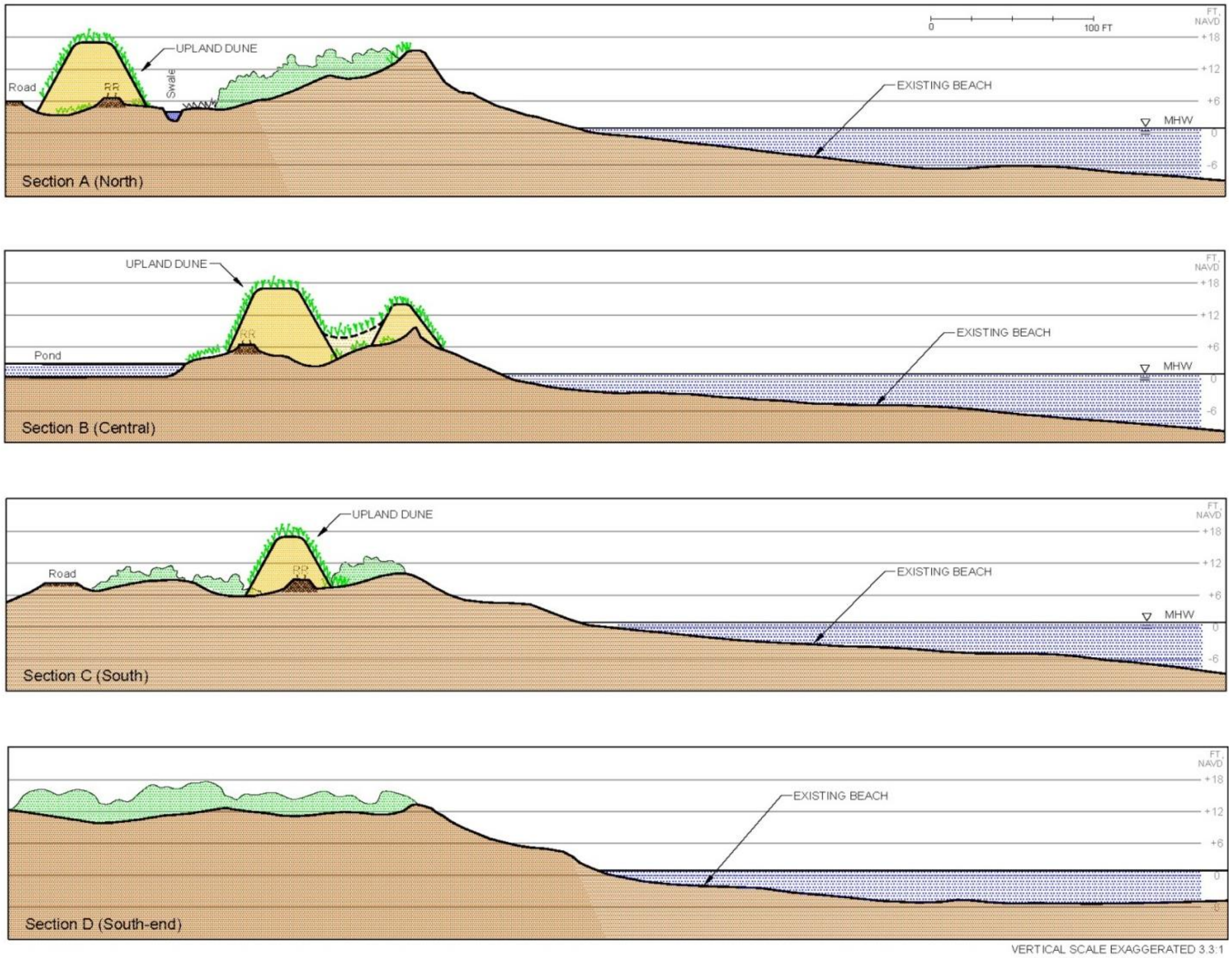

Figure 3. Alternative One: Inland Dune

uplands but will impact some natural freshwater swale wetlands and potentially remove up to 1500 m of a permanently flooded manmade ditch that parallels the roadway. Up to approximately 367,000 m^3 of sand would be required to construct this alternative which would also need subsequent native plant installation. This equates to about 19 m^3 of sand per ft on average. The fill sand would be trucked to the site from one or more upland sand sources that contain sediment compatible with existing beach and dune sediments. The specific sources of sand fill would be determined prior to construction and may include commercial upland quarries or other sites of excavation that are available. The sand would be placed and graded by mechanical excavators, payloaders, and bulldozers. Project construction would likely require on the order of 14 months, presuming that removal of unnecessary infrastructure (e.g., NASA railway), sand placement, and vegetation planting were conducted with overlapping schedules. Because construction will be landward of the primary dune, no calendar restrictions on the construction schedule are proposed. Long-term maintenance (sand replacement) may be required in areas where the existing primary dune was augmented. Otherwise, the constructed secondary dune, to be placed well landward of the primary dune, is intended to be beyond the extent of typical storm impacts and annual erosion for at least one or two decades (barring very severe hurricane overwash) and therefore, should not require frequent maintenance.

Alternative Two: Restore Beach and Dunes

Project Alternative Two involves sand placement for beach nourishment to restore the dune and beach to a condition that existed approximately 10 to 15 years ago. The twin goals of this alternative are to restore beach width lost to erosion and to reinforce the height and width of the primary dune, principally along its crest and seaward face (Fig. 4). This approach will better ensure protection from storm waves and flooding while also serving to shade nesting and hatching sea turtles from artificial lighting from launch facilities. The affected project area includes the northern 7.6 km of the KSC shoreline between monuments V-065.3 and V-090 (Fig. 2). Of this total area, dune and beach nourishment would occur along the northern 6.6 km from V-065.3 (north KSC boundary) to V-087. The remaining 1.0 km from V-087 to V-090 along False Cape would be constructed as a long tapered transition into the existing dune using beach renourishment with minor augmentation of the existing dune toe.

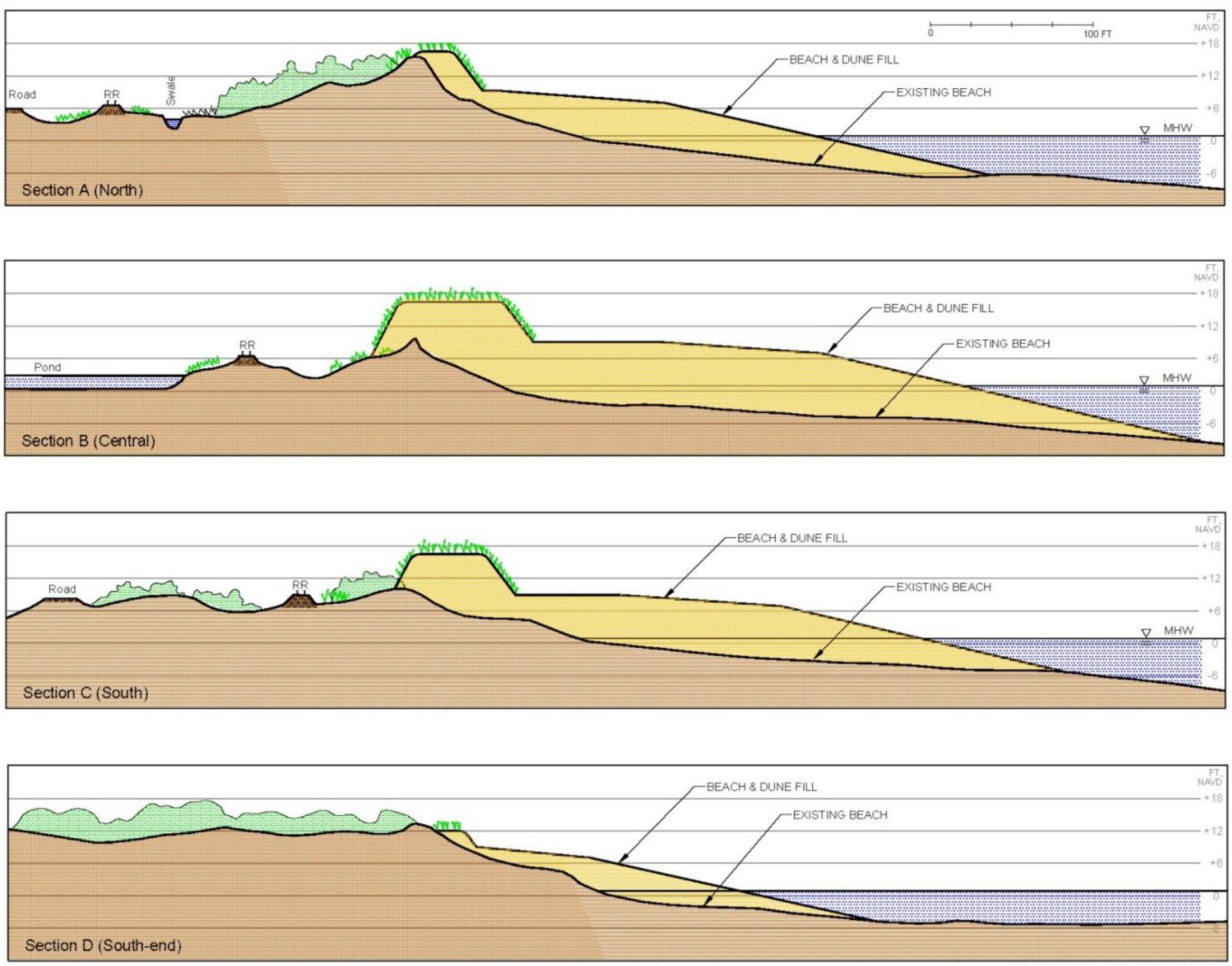

Figure 4. Alternative Two: Restore Beach and Dune

Alternative Two is an aggressive beach restoration strategy that seeks to reinforce and restore the beach/dune system on its ocean side; i.e., mostly seaward of the existing dune and vegetation line. This approach minimizes impact to existing dune and upland habitats, but because the installed fill is fully exposed to the sea, it is subject to higher erosion rates and requires dedicated future renourishment to ensure shoreline longevity. Sand fill would be placed along the existing beach, dune crest, and seaward face north of V-087 to provide a consistent dune height of about +5.0 m north of V-087 and a dune width and location that is approximately equivalent to that which existed circa 1995. The beach berm would be widened and elevated to similarly restore historical conditions, along with additional sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant dune vegetation immediately after construction.

Up to 2,140,000 m^3 of beach fill sand would be required to initially construct Alternative Two. This equates to about 287 m^3/m on average along the entire project length. The source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters (Fig. 5). The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 2,370,000 m^3 of excavation at the borrow area may be required to construct the 2,140,000 m^3 beach fill. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity.

The schedule for Alternative 2 would be driven by constraints of the sea turtle nesting season (May – October). Initial project construction would require 30 days for mobilization, a minimum of 165 days for sand placement, plus 30 to 75 days for dune vegetation installation. Sand fill placement would be limited to the period November 1 to April 30. Construction of a project of this size in one season (i.e., 2.1 million m^3 in less than 180 days) is challenging and dependent upon favorable seas. If equipment mobilization can occur in October, the schedule will require net sand placement of over 11,850 m^3 per day, every day, including weather and mechanical downtime. This will require one large hopper dredge 3060+ m^3 or two medium dredges, 1530+ m^3 each, and probably some combination thereof.

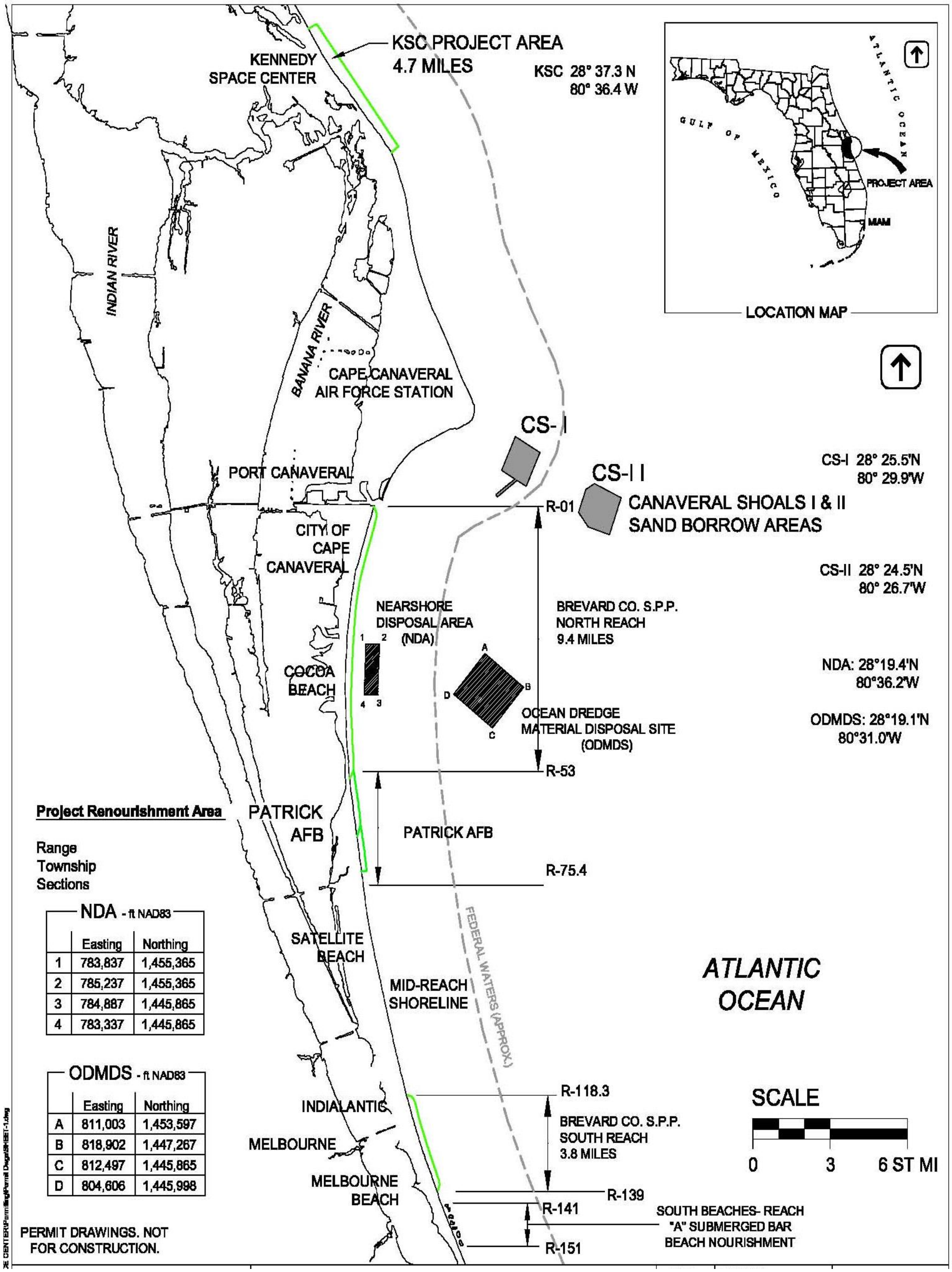

Figure 5. Map of the Canaveral Shoals I and Canaveral Shoals II offshore sand borrow sites

Maintenance renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 596,000 m^3 and 994,000 m^3 per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through prior physical monitoring. Future project renourishment would be constructed by hopper dredge, using offshore sand sources, between November 1 and April 30, as outlined above.

Alternative Three: Reinforce Dune Plus Beach Fill

This alternative includes beach fill with a significant augmentation of the existing dune. The primary dune would be reconstructed or reinforced with sand and vegetation, and sand would be placed on the beach to provide a wide berm, restoring it to a less eroded condition and protecting the dune (Fig. 6). The dune would be reinforced at its existing location, avoiding advancement toward the sea by sand placement atop the existing dune. The affected project area includes the northern 7.6 km of the KSC shoreline between approximately monuments V-065.3 and V-090 (Fig. 2). Of this total area, full dune and beach nourishment would be implemented along the northern 6.6 km from V-065.3 to V-087. The remaining 1.0 km from V-087 to V-090 would be constructed as a long taper to help integrate the newly renovated areas into the natural system.

Alternative Three represents a “hold-the-line” restoration strategy that seeks to reinforce and restore the beach/dune system at its current, eroded location. This differs from Alternative Two which seeks to restore the dune and beach to a seaward, historical location by placing the sand fill seaward of the existing duneline. In order to establish a stable dune along the existing dune line, Alternative Three places the sand fill atop the existing dune. This approach increases the chance of project success by defending against future erosion rather than attempting to reverse or combat it. Likewise, this approach decreases, but does not eliminate, the requirement for dedicated future renourishment.

Sand fill would be placed along the existing dune crest to provide a consistent dune height of about +5.0 to +5.2 m north of V-087. The dune width would be constructed to establish a fairly consistent sand volume across the entire primary dune as measured above the 25-year and 100-year still water storm surge elevations. Seaward of the improved dune, the beach berm would be widened and elevated by sand fill to protect the dune from typical high-frequency storms and wave uprush. This would include sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant vegetation immediately after construction.

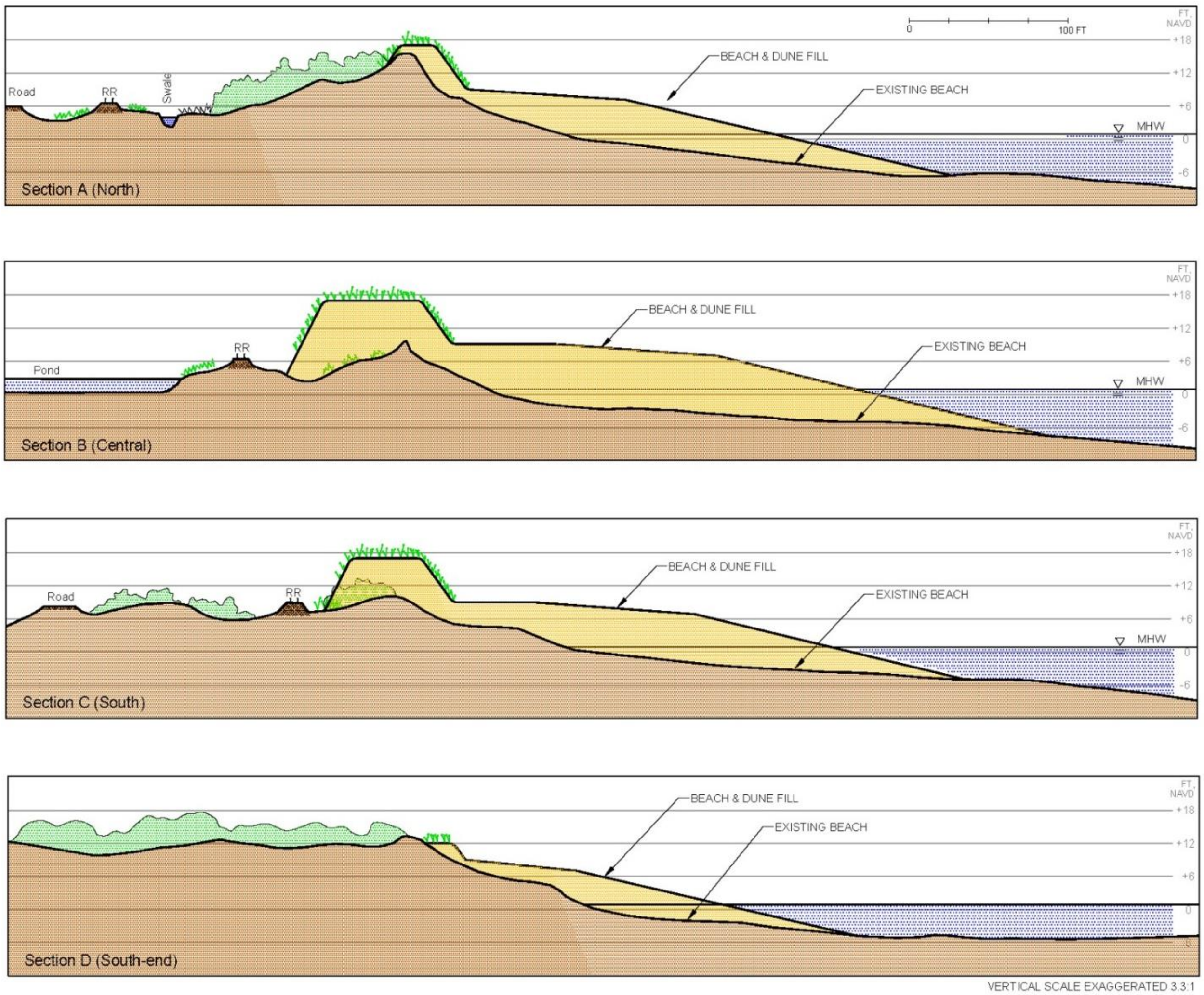

Figure 6. Alternative Three: Reinforce Dune plus Beach Fill

On the order of up to 1,760,000 m^3 of beach fill sand would be required to initially construct Alternative Three. This equates to about 237 m^3/m on average along the entire project length. These values represent a minimum typical recommended fill density for initial construction of beach restoration projects on Florida's east coast. Similarly to Alternative 2, the source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters. The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 1,950,000 m^3 of excavation at the borrow area may be required to supply the 1,758,000

m^3 beach fill. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity.

Initial project construction would require approximately 30 days for mobilization, 150 days for sand placement, and 30 and 75 days for dune vegetation installation. Sand fill placement would be limited to the period November 1 to April 30, outside the sea turtle nesting season, and vegetation installation would occur in April through July. Construction of a 1.8 million m^3 project in one season (180 days) is practical as long as winter seas are typical. Assuming initial mobilization commences October 15, net sand placement of over 9557 m^3/day, including downtime, will be required. At this site, this is a reasonable expectation for one large hopper dredge (3058+ m^3), or two medium dredges (1529 m^3) each.

The post-project loss rate of sand from the project area is preliminarily anticipated to be on the order of 91,750 m^3 per year. Periodic renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 550,480 m^3 and 917,500 m^3 per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance as determined through prior physical monitoring.

Alternative Four: Hybrid Approach – Inland Dune Plus Beach Fill

Alternative Four is a hybrid of proposed Alternatives 1, 2, and 3. This action includes placement of sand to restore beach lost to erosion, reinforcement of the existing primary dune (principally along the seaward edge and face, similar to Alternative 2), and construction of a secondary dune inland of the primary dune, identical to Alternative 1 (Fig. 7). The inland dune would be constructed from either upland sand sources or offshore dredged sources. In the latter case, sand would be temporarily stockpiled on the beach and then mechanically rehandled to construct the inland dune. Swale wetlands and critical habitat would be avoided as much as possible during construction of the secondary dune. Salt-tolerant native vegetation would be planted along the crest and face of both the primary dune and inland dune as needed for stabilization.

The affected project area includes the northern 7.6 km of the KSC shoreline, between monuments V-065.3 and V-090 (Fig. 2). Of this total area, the inland dune would be constructed along the northern 5.8 km from V-065.3 to V-084.1; nourishment of the beach and primary dune would be accomplished along the northern 6.6 km, V-065.3 to V-087. The remaining 1.0 km, V-087 to V-090, would be constructed as a long taper consisting of beach renourishment with minor augmentation of the existing dune toe. Temporary stockpiling of sand on the beach for construction of the inland dune would occur along the central 3.1 km of shoreline, between monuments V-070 and V-080.

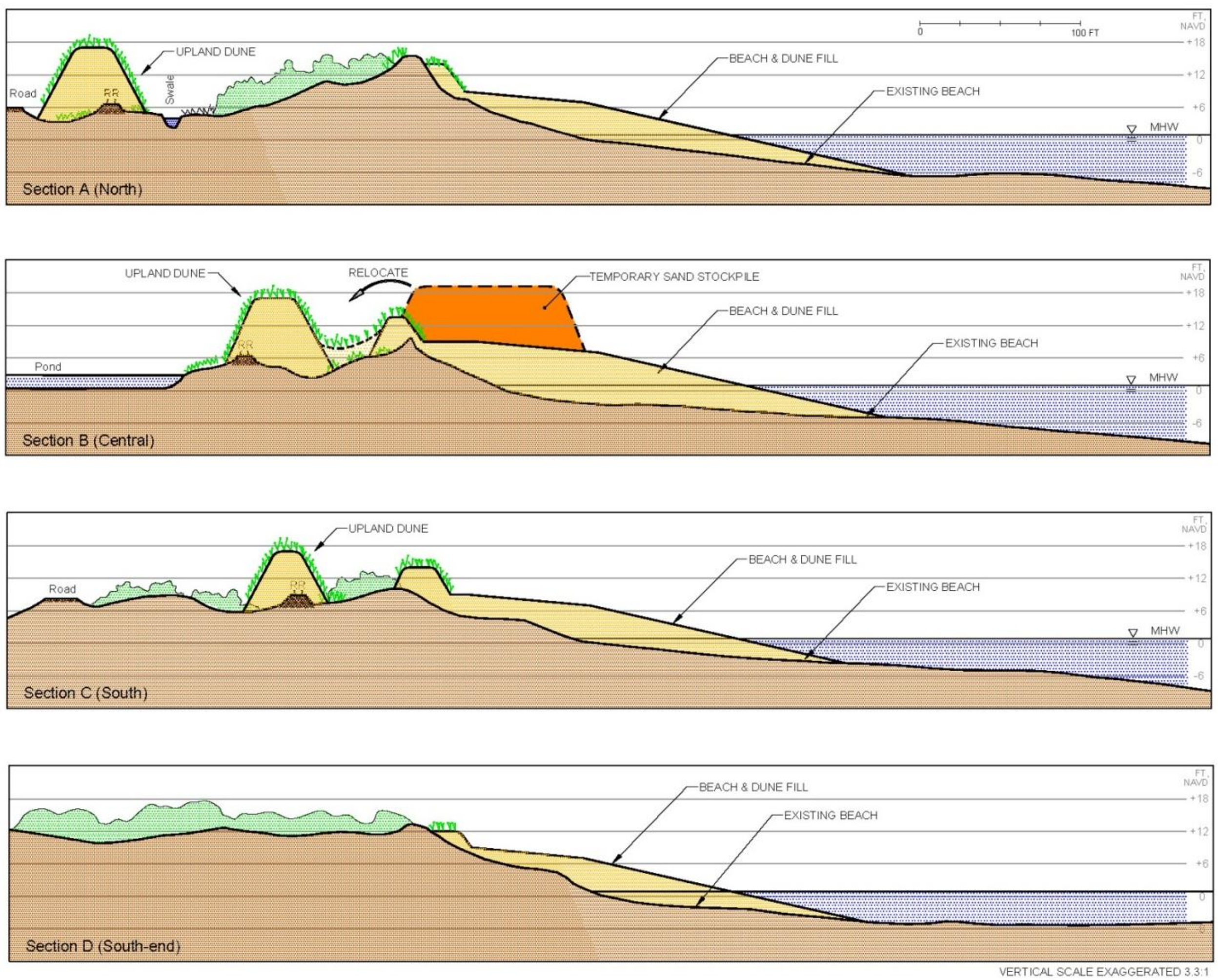

Figure 7. Alternative Four: Hybrid Approach – Inland Dune plus Beach Fill

Alternative Four represents a hybrid strategy that combines managed retreat with beach renourishment. That is, it combines construction of the inland dune (identical to Alternative 1) with a modest-scale beach/dune nourishment project (similar to Alternatives 2 and 3). But, in contrast to the latter two alternatives, Alternative Four limits the width and placement of beach fill sand to the seaward face of the primary dune in order to minimize the encroachment of the dune upon the beach and to minimize impacts to the existing dune vegetation/habitat. Alternative Four allows the inland dune to be constructed from sand dredged from an offshore borrow area in lieu of, or in addition to, upland truck-haul sand sources. The ability to construct the inland dune from offshore sands potentially improves the sediment and habitat quality of the dune, given the consistent, beach-compatible characteristics of sediment from the available offshore borrow areas. Further, it avoids impacts associated with upland truck-haul delivery of sand to the site. The nourishment of the beach and primary dune, constructed in addition to the secondary inland dune, will partly restore and stabilize the eroded beach/dune system; and as such, it will serve to protect the inland dune and therefore augment its longevity. The sand placed on the beach and primary dune will ultimately erode and require renourishment; however, future renourishment is not inherently critical to the long-term integrity of this project alternative because the inland dune provides a longer term, inland measure of shore and flood protection.

The overall dimensions and layout of the inland dune would be similar to that described for Alternative One. The beach and dune restoration north of monument V-087 would consist of augmentation of the primary dune to a crest elevation of at least +4.3 m. The beach nourishment berm would be constructed at a width of 23 to 30 m sloping from about +2.7 m at the dune to +2.1 m at the seaward edge. Along the southern 0.9 km of the project area (V-087 to V-090), the beach/dune nourishment would consist of augmentation of the existing dune toe, seaward of the vegetation line, and a berm width of about 21 m likewise sloping from elevation +2.7 to +2.1 m. For construction of the inland dune, a temporary sand stockpile would be constructed on the beach nourishment berm between monuments V-070 and V-080, above the typical limit of wave runup, to an elevation of +5.8 m. The nominal storage volume would approach 275,240 m^3. This stockpile would be created during hydraulic placement of the beach nourishment fill, and then offloaded by trucks to create the inland dune.

Up to 1,530,000 m^3 of beach fill sand would be required to initially construct Alternative Four. This equates to about 207 m^3/m on average along the entire project length. Up to 1,682,000 m^3 of excavation at the borrow area might be required to construct a 1,529,000 m^3 beach fill. The source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters. The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. The temporary sand stockpile would be constructed during the hydraulic beach fill operation using the same bulldozers and payloaders to lift and shape the stockpile. During and/or immediately after placement of the sand stockpile, excavators, payloaders and trucks would transfer the stockpiled sand to the inland dune locations. After final spreading and grading, the beach fill area would be tilled above the wave zone to reduce compaction and facilitate marine turtle nesting activity.

If properly sequenced, initial project construction would require on the order of 30 days for mobilization, 165 days for sand placement (beach fill and inland dune), plus between 30 and 75 days for dune vegetation installation after sand placement. Sand fill placement would be limited to the period November 1 to April 30. Dredging and beach placement of up to 1.5 million m^3 of sand would require about 160 days. Allowing initial mobilization of equipment upon the beach to commence October 15, and assuming a dredge start date of not later than November 15, it will require net sand placement of about 9,557 m^3 per day. At this site, this is a reasonable expectation of one large hopper dredge (3000+ m^3) or two medium dredges (1500+ m^3) each.

The post-project loss rate of sand from the project area is anticipated to be on the order of 91,750 m^3 per year. If elected, periodic maintenance renourishment of the beach element of the project would be required at intervals of 6 to 10 years, likely comprising between 550,480 m^3 and 917,470 m^3 per event, depending upon the renourishment frequency and storm severity. Interim renourishment may be required after severe storm erosion. Unlike Alternatives 2 and 3, however, periodic renourishment is optional (i.e., it can be delayed or forgone) because long-term defense against flooding and coastal inundation would be provided by the inland dune in the event that the primary dune and beach are eroded or breached by storms. Maintenance beach renourishment, when elected, would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through monitoring.

ESSENTIAL FISH HABITAT BACKGROUND AND JUSTIFICATION

The 1996 amendment to the 1976 Magnuson-Stevens Fishery Conservation and Management Act (also known as the Sustainable Fisheries Act) set forth a mandate to describe, identify, and protect high value habitats for federally managed marine and anadromous fishes. The overarching purpose of this legislation is to ensure the long term quality and quantity of our nation's fishery resources. The Magnuson-Stevens Act requires Essential Fish Habitat (EFH) be designated for all species covered under a federal fishery management plan (FMP). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1801[10]). Waters include aquatic areas and their associated physical, chemical, and biological properties. Substrate includes sediment underlying the waters. Necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. "Fish" includes finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds. Spawning, breeding, feeding, or growth to maturity covers all habitat types utilized by a species throughout its entire life cycle.

EHF designations are often geographically expansive, a result of the fact that Fishery Management Plans often encompass multiple species with similar, but rarely identical, habitat requirements. Further, a majority of marine fish and invertebrate species have varied life history strategies and are dependent on both benthic and pelagic habitats as they mature. The Magnuson-Stevens Act also allows for a subset of EFH to be classified as Habitat Areas of Particular Concern (HAPC) in order to focus conservation efforts on areas that play a particularly important role in the life history of federally managed fishery species, are especially vulnerable to human-induced degradation, are under stress, or are naturally rare.

Fishery management plans are typically developed and enforced by one or more of our nation's eight fishery management councils. In East Florida, most FMPs are implemented by the South Atlantic Fishery Management Council (SAFMC) which has jurisdiction of federal waters from North Carolina to South Florida. A small number of species are jointly managed with the Gulf of Mexico Fishery Management Council (GMFMC) if stock boundaries so warrant. In addition, highly migratory fish species (HMS) such as tuna, billfish, swordfish, and sharks, are directly managed by the HMS Division of the NMFS.

NASA, like any federal agency which permits, funds, or undertakes an action with the potential to adversely affect EFH (i.e., reduce its quantity or quality) in either federal or state waters must first consult with NMFS. Adverse affects may include direct (e.g., contamination, physical disruption), indirect (e.g., loss of prey), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. NMFS and/or the relevant

Councils review details of the project and provide advisory recommendations designed to avoid, mitigate, or offset damage to EFH during the project. While HAPC is not afforded additional regulatory protections, federal actions with the potential to cause adverse impacts to HAPC will be more carefully scrutinized during the consultation process and will be provided with more stringent conservation recommendations. The federal agency must then respond in writing to NMFS concerns and recommended conservation measures within 30 days with a plan to reduce EFH impacts or provide reasons why recommendations cannot be implemented as proposed.

Regional EFH Designations

Several federal Fishery Management Plans have been instituted to protect economically valuable fish and invertebrate resources off the east Florida coast. These include: Spiny Lobster, Shrimp, Golden Crab, Highly Migratory Species, Coastal Migratory Pelagics, Dolphin-Wahoo, and the Snapper-Grouper Complex. In addition, fishery management plans are also in place for Coral, Coral Reefs, Live/Hardbottom, and Sargassum (which does not have designated EFH) due to the large number of managed fish and invertebrate species intimately dependent on these habitats. Red drum also have a FMP and locally-designated EFH although management of the species has been largely transferred to the Atlantic States Marine Fisheries Commission because virtually all harvest now takes place in state (not federal) waters.

FISH HABITATS AND COMMUNITIES IN THE PROJECT AREA

Soft Bottom Substrates

Beach renourishment and sand mining actions described in Project Alternatives 2-4 are expected to primarily affect sub-tidal soft bottom and surf zone habitats with little if any anticipated impact to hard bottom substrates of the region. Soft bottom sand-mud substrates compose 77-90% of the inner continental shelf of the South Atlantic Bight (SAB) in terms of total areal coverage (Rowe and Sedberry, 2006). The fish fauna associated with this habitat has received some attention with early descriptions (e.g., Anderson and Gehringer, 1965; Struhsaker, 1969; Knowlton, 1972) typically the result of bycatch assessments in the penaeid shrimp fishery. The most compressive survey is the ongoing Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA), a joint effort of the South Carolina Department of Natural Resources and National Marine Fisheries Service. SEAMAP-SA began conducting annual standardized fishery-independent trawl surveys to monitor the abundance, habitat requirements, and life history attributes of coastal fishes and macroinvertebrates from Cape Hatteras to Cape Canaveral in 1973. The southern boundary of this survey lies just north of the proposed project area. In a 10-year (1990-1999) SEAMAP summary, 195 finfish taxa, 30 elasmobranchs, and 90 decapod crustaceans were collected (ASMFC, 2000). Fish captures were numerically dominated by two species, spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*), which together totaled 36% of all fish and invertebrates taken. Other abundant taxa included Atlantic bumper (*Chloroscombrus chrysurus*), porgies (*Stenotomus* spp.), and striped anchovy (*Anchoa hepsetus*). The most common macrocrustaceans included white shrimp (*Litopenaeus setiferus*), coarsehand lady crab (*Ovalipes stephensoni*), brown shrimp (*Farfantepenaeus aztecus*), iridescent swimming crab (*Portunus gibbesi*), and the lesser blue crab (*Callinectes similis*). Elasmobranchs, particularly carcharhinid sharks and pelagic and demersal rays, were collected less frequently but constituted a large percentage of overall biomass due to their large average sizes. Generally speaking, most fish species of direct economic value to the region occur at low densities in soft bottom habitats.

Soft bottom fish communities within or directly adjacent to the proposed project site at Cape Canaveral have never themselves been the subject of rigorous sampling. A brief Minerals Management Service survey (September 2000 and June 2001) of nine sand shoal sites offshore Brevard, Indian River, St. Lucie, and Martin Counties (including the Canaveral Shoals II borrow site) produced 63 fish taxa with dusky anchovy (*Anchoa lyolepis*) and silver seatrout (*Cynoscion nothus*) comprising 69% of all fish caught (Hammer et al., 2005). Macroinvertebrate catches included 32 taxa of stomatopods, decapod crustaceans, echinoderms, and squid.

Surf Zone

Surf zone habitats at Cape Canaveral (north of the Port Canaveral Jetty) differ from those further south in that they do not encompass hard-bottom resulting from exposed Anastasia limestone or the reef-building polychete *Phragmatopoma lapidosa*. Consequently, the resident fish fauna is likely qualitatively similar to sand-shell-mud communities in adjacent deeper water but may be somewhat depauperate, supporting elevated densities of those taxa [e.g., whiting (*Menticirrhus* spp.), Florida pompano (*Trachinotus carolinus*)] better adapted to surf conditions (Gilmore, 1977) while largely excluding species poorly adapted to high energy wave action. Only one published field survey (Peters and Nelson, 1987) near Melbourne and Sebastian Inlet (~75 km south of False Cape) has described the surf zone ichthyofauna of the central or north Florida Atlantic coast in any detail. This effort using beach seines documented 61 fish species with the scaled herring (*Harengula jaguana*), shortfinger anchovy (*Anchoa lyolepis*), and Florida pompano (*Trachinotus carolinus*) composing 70% of total catch.

The surf zone fish fauna at Cape Canaveral also contrasts to areas both north and south with respect to management. Due to national security and safety concerns at KSC and the adjacent Cape Canaveral Air Force Station (CCAFS), Canaveral beaches offer limited public access resulting in one of the least accessible shorelines of the Florida east coast. Shore-based fishing is allowed only by KSC and CCAFS personnel within 200 yards of three CCAFS dune crossovers (1200 yards total). Boat-based fishing is permitted on non-launch days but appears limited, especially north of the tip of the Cape (E. Reyier pers. obs.), likely due to the long distance anglers must travel from Port Canaveral as well as the shallow Southeast Shoal which hinder navigation of larger vessels. Data on surf zone fish abundance are unavailable but density of several economically valuable fish species (e.g., red drum, black drum, pompano, sheepshead, whiting) appears quite high (E. Reyier, pers. obs.). Most notably, the open surf zone and longshore troughs serve as a high value nursery for juvenile lemon sharks, which are present year round but gather in aggregations up to several hundred individuals each winter from November through March (Reyier et al., 2008). KSC and collaborating fisheries research groups are currently funding acoustic telemetry studies to assess site fidelity, habitat preferences, and migrations of several nearshore fish species including lemon sharks, red drum, black drum, pompano, and whiting.

Consolidated Substrates

Hardbottom substrates offer attachment sites for algae, sponges, corals, ascidians, and other sessile invertebrates, and serve as critical habitat for a multitude of fish taxa, many of which maintain near-obligate reliance on hardbottom for spawning, recruitment, and foraging. SAB hardbottom substrates consistently demonstrate higher levels of fish diversity and biomass than open sand-shell substrates and also support demersal species of greatest fishery valuable to the region (e.g., grouper and snapper; Sedberry and Van Dolah, 1984; Rowe and Sedberry, 2006). Consequently, hard-bottom is protected in the Coral, Coral Reef, and Live/Hard Bottom Fishery Management Plan and is considered EFH for many managed species including the snapper-grouper complex and spiny lobster.

Along the east-central and northeast Florida continental shelf, natural hard bottom substrate largely consists of low to moderate relief limestone pavement, ledges, and escarpments which are apparently relic Pleistocene dune formations. A comprehensive survey of limestone reefs and their associated fauna in the vicinity of the project area has not been undertaken although Perkins et al. (1997) compiled all available locational data of hardbottom substrates along the entire Florida Atlantic coast. This study demonstrated that hard bottom is widely distributed in waters off Cape Canaveral but did not identify any within either the proposed Canaveral Shoals I or II borrow sites or beach renourishment footprint potentially affected under Project Alternatives 2-4. The only consolidated substrate confirmed in the project area consist of low-relief (~0.25 m) humate sand outcroppings in the mid and lower-intertidal and shallow sub-tidal zones directly east of Launch Complex 39A (N 28.6070/W 80.5924; Figs. 8-9; Jaeger et al., 2011) Opportunistic field observations over the last several years suggest that these formations formations are spatially discrete, experience significant wave action, and are repeatedly exposed and reburied. The humate sands themselves have a spongy consistency supporting only poorly developed communities of algae, sessile invertebrates (e.g., sea urchins, snails, bivalves), and fish when compared to more typical nearshore reefs found in central and southern Brevard County (Reyier, pers. obs.). Further, aerial imagery suggests that sub-tidal outcroppings only encompass an estimated 2000-3000 m^2 (0.5-0.75 acres), mostly near LC39A (Fig. 9). These features have never been formally surveyed but are expected to be similarly composed of consolidated humate sands.

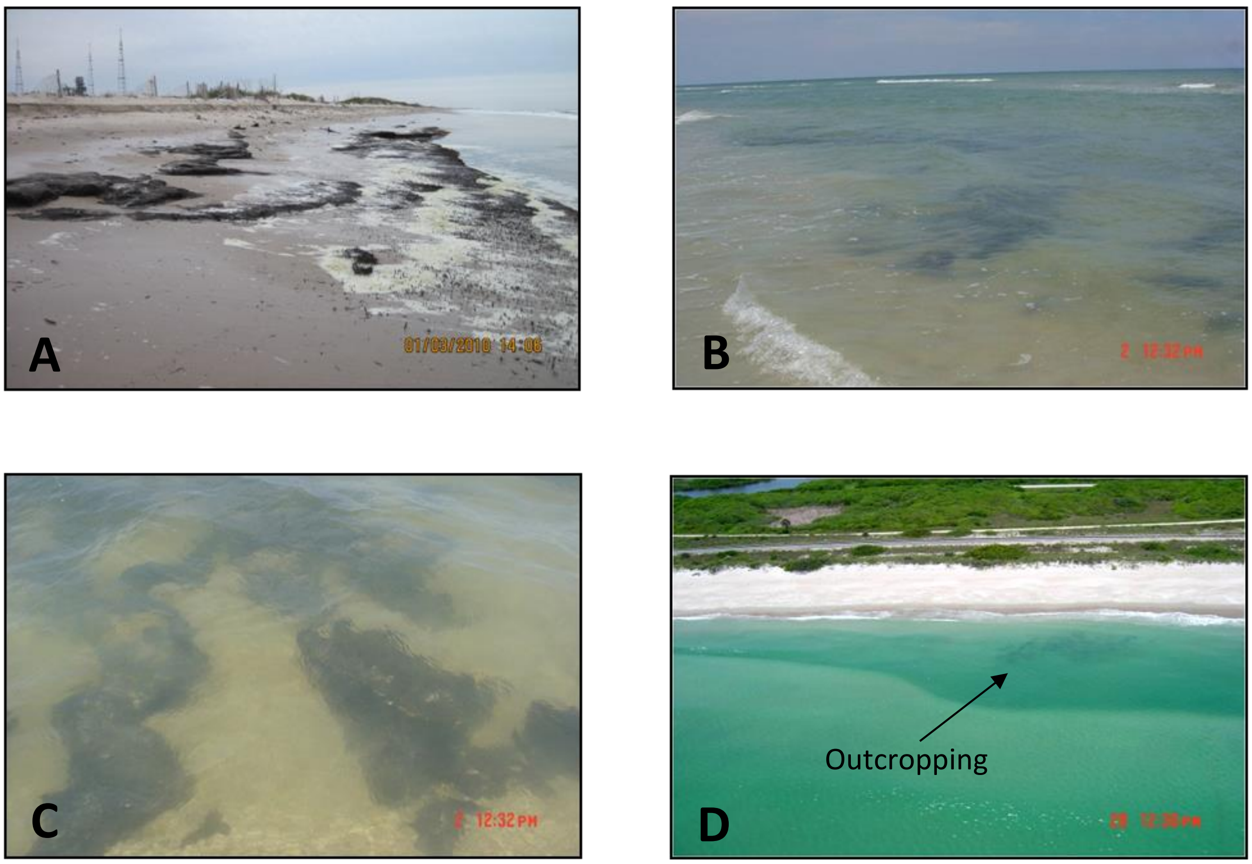

Figure 8. Consolidated low-relief humate sand outcropping. Outcrops occurs in both intertidal (A) and sub-tidal (B, C) but have a soft consistency seemingly unsuitable for extensive colonization by algae or invertebrates. Aerial observations suggest these outcrops are small, spatially discrete, and often buried (D).

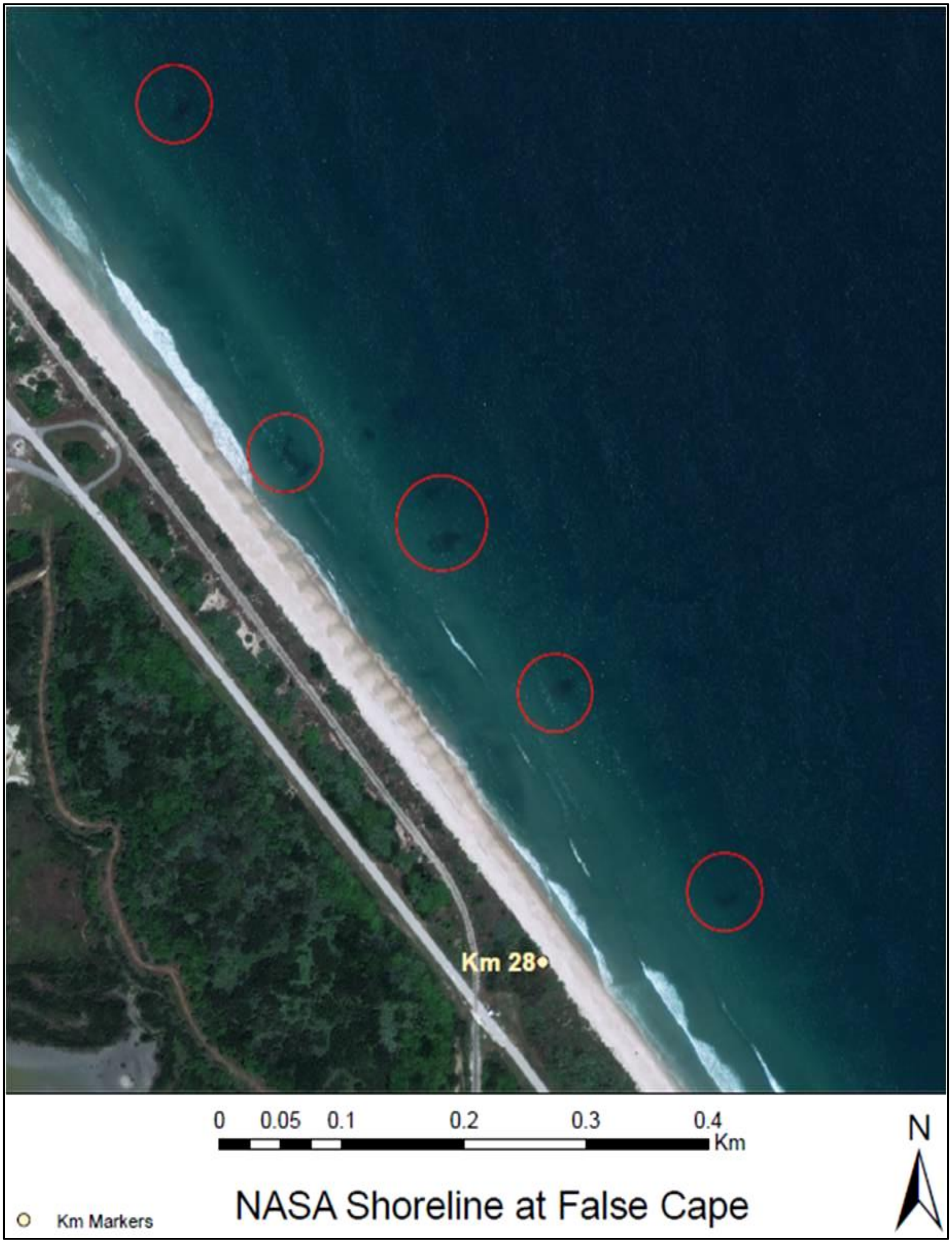

Figure 9. Aerial view of humate sand outcropping due east of Launch Complex 39A during a period of atypically good water clarity

Coastal Wetlands

The construction of an inland dune (as proposed in Alternatives 1 and 4) has the potential to temporarily impact small natural swales (via the construction of temporary access corridors, elevated turbidity, etc.) and may result in the permanent infilling of a manmade ditch near LC39B (Fig. 10). The exact project impacts are contingent on the final engineering design and construction mitigation measures. The natural swales are unquestionably landlocked and therefore unavailable for use as EFH. The connectivity of the manmade ditch is unclear. This ditch, approximately 1500 m long and 1-2 m wide (estimated surface area of 0.2 hectares), is at least 780 m from tidally-connected waters of the Banana River Lagoon and 2900 meters from Mosquito Lagoon, and water exchange with these water bodies is unquestionably hindered by numerous paved roads and impoundment dikes. Nonetheless, the ditch is connected with a culvert to a larger pond on the north side of LC39B. Even limited connectivity of this feature to the open estuary may allow it to serve as EFH for certain species such as penaeid shrimp, red drum, and sheephead. A field survey on 19 June 2012 noted a salinity of 26.3 psu but only marsh resident fishes (eastern mosquitofish, sailfish molly, and gulf killifish) were observed. Further, no sightings of large-bodied estuarine fishes (red drum, black drum, seatrout) were noted during a low altitude aerial overflight of the adjacent marsh ponds on 18 June 2012.

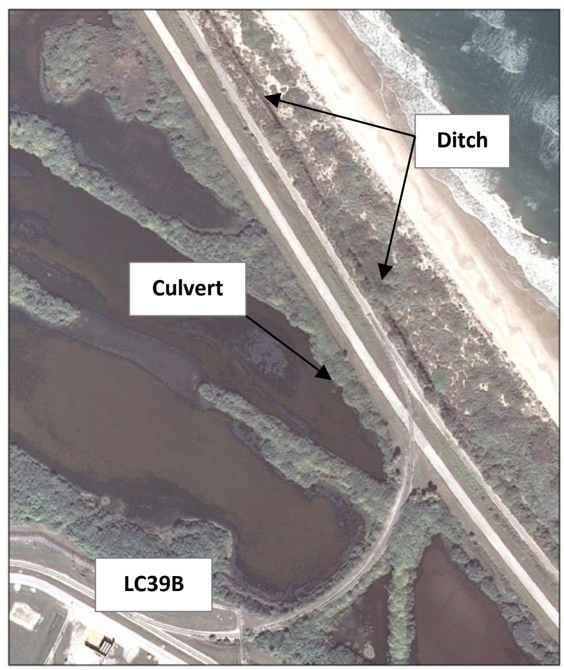

Figure 10. Aerial image of wetlands near LC39B in 1943 (left) and 1999 (right).

MANAGED SPECIES IN THE PROJECT REGION

Spiny Lobster

Spiny Lobster Life History

The spiny lobster (*Panulirus argus*) has a geographic range extending from North Carolina to Brazil including waters of the Gulf of Mexico, Caribbean Sea, and Bermuda, with scattered records from West Africa (Tavares, 2002a). Lobsters have a pelagic phase in which larvae are potentially dispersed long distances by ocean currents before they settle on rocky shorelines, coral reefs, and in seagrass beds. Lobsters tend to aggregate in ledges and crevices in reefs and rock rubble. Spiny lobsters prefer shallow water but move deeper with age can be found as deep as 90 m. Their diet consists mainly of small gastropod mollusks, isopods, amphipods, and ostracods.

The spiny lobster is the most valuable lobster species in the western central Atlantic and supports a sizeable recreational and commercial harvest out of nearby Port Canaveral. Spiny lobster should be expected to occur on any nearshore hardbottom and artificial reefs of east-central Florida and have been documented to exist in small numbers along the rock revetments inside Port Canaveral (Reyier et al., 2010) but are rare or absent in surveys of the nearby Indian River Lagoon system (Tremain and Adams, 1995; Paperno et al., 2001)

Lobster EFH and HAPC

EFH for juvenile and adult spiny lobster includes seagrass, unconsolidated soft bottom, coral and other hard bottom substrates, sponges, algal communities, and mangroves. The Gulf Stream is also considered EFH for its role in dispersing pelagic lobster larvae (SAFMC, 1998). All estuarine and nearshore waters in the Cape Canaveral region are designated as EFH (NOAA EFH Mapper, Table 1). Most spiny lobster EFH-HAPC is located in Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, Florida through the Dry Tortugas. A small area of EFH-HAPC (the northernmost HAPC established for the species) has been identified directly adjacent to the Canaveral Shoals II sand borrow site.

Project Impacts to Lobster EFH and HAPC

Impact to lobster EFH during any renourishment of KSC beaches is expected to be minimal because the project footprint is primarily comprised of open sand-shell bottoms where lobster density is expected to be low. The only consolidated substrates known in the renourishment zone are 0.5-0.75 acres of ephemerally-exposed humate sand outcrops (Fig. 8,9). These formations are located in very shallow water and experience significant wave action as well as repeated exposure and reburial. Further, the humate sands have a spongy consistency which appears less suitable for colonization by algae and sessile invertebrates. Given these factors, these outcrops are likely less than ideal substrates for settlement-size spiny lobster. Further, while EFH-HAPC is found directly adjacent to the Canaveral Shoals II borrow area, no hardbottom is known from the borrow site itself (Perkins et al, 1997).

Shrimp

Shrimp Life Histories

Five shrimp species are managed under the federal shrimp fishery management plan including the pink shrimp (*Farfantepenaeus duorarum*), brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), rock shrimp (*Sicyonia brevirostris*), and royal red shrimp (*Pleoticus robustus*). Cape Canaveral is a center of commercial shrimping on the Florida east coast. Trawlers work shallow nearshore waters for penaeid shrimp while rock shrimp (whose fishery originated in the Canaveral region) are harvested in deeper water. White and pink shrimp have been collected during limited scientific trawling surveys at the Canaveral Shoals II borrow site and within nearby Port Canaveral (Hammer et al. 2005; Reyier et al., 2010).

Pink Shrimp

The pink shrimp occurs in coastal waters from Chesapeake Bay to the Yucatán Peninsula with highest abundance off southwestern Florida and Gulf of Campeche. While occurring at depths greater than 300 m, they are generally found in water <70 m with maximum abundance in depths of 11 to 36 m (Tavares, 2002b). Adult pink shrimp prefer mud, sand, and calcareous shell bottom along the continental shelf. Spawning peaks offshore in warmer months (Bielsa et al., 1983). Females release 500,000 - 1 million eggs with post-larvae recruiting to estuaries as early as April and May. Juvenile pink shrimp typically overwinter in coastal seagrass beds and salt marshes before migrating to nearshore waters (Howe and Wallace, 2000). The pink shrimp life span is often less than one year and they can attain a maximum size of 300 mm but typically less than 200 mm. Pink shrimp are omnivorous, consuming polychetes, amphipods, nematodes, mysids, copepods, various other invertebrates, as well as organic debris. In turn, pink shrimp are a valuable prey item for a wide variety of finfish species.

Brown Shrimp

The brown shrimp ranges from Massachusetts to south Florida and throughout the Gulf of Mexico to the Yucatán Peninsula. Adult brown shrimp are most abundant over mud or sand/mud substrates in water less than 110 m (Tavares, 2002b). The spawning season is not well defined but females typically produce 500,000 - 1 million eggs. Many postlarval shrimp enter estuaries during February through late March to grow out and then migrate to deeper saltier water at night. Highest densities of post-larval and juvenile shrimp are found associated with seagrass and emergent marshes (Howe and Wallace, 2000). Both juveniles and adults are omnivorous bottom feeders on polychetes, amphipods, nematodes, caridean shrimps, mysids, copepods, and organic debris (Lassuy, 1983). The entire life span is about 1.5 years with a maximum size of 236 mm. Predators of post-larval shrimp are sheepshead minnows, insect larvae, water boatmen, grass shrimp, killifishes and blue crab. Juvenile and adult shrimp are targeted by many different finfish.

White Shrimp

The white shrimp occurs from New York to the St. Lucie Inlet in east Florida and from the Ochlocknee River on the Gulf Coast of Florida to Campeche, Mexico (Tavares, 2002b). White shrimp reach peak abundance over mud or clay bottoms in the lower reaches of estuaries and shallow continental shelf at depths less than 30 m. In the US South Atlantic, white shrimp spawn from March to November and produce about 500,000 to 1 million eggs. Post-larvae recruit to soft muddy bottoms of estuaries until growing out to the juvenile stage and migrating back to the ocean. Their lifespan is less than one year and they reach a maximum of 257 mm in length. White shrimp are omnivorous bottom feeders with a diet similar to brown shrimp (Muncy, 1984).

Rock Shrimp

Rock shrimp are typically found in deeper water than penaeid shrimp. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hard bottom and coral or more specifically, Oculina coral habitat areas (Kennedy et al., 1977). Commercial trawling for rock shrimp has caused considerable damage to coral on the Oculina Bank. Other than Kennedy et al. (1977), no characterization of habitat essential to rock shrimp has been conducted.

Royal Red Shrimp

Although no details are available regarding preferred habitats of royal red shrimp, they are often caught in association with deep water corals on the continental slope. Deep sea corals support high levels of marine biodiversity by providing habitat for numerous benthic species. As structure-forming animals, deep sea corals enhance habitat complexity by growing in the form of "reefs", fans, stalks, and "bushes". The *Enallopsamia* reefs off South Carolina, the *Oculina* habitat off Florida, and the *Lophelia* reefs from North Carolina to Florida may eventually prove important in the life history of royal red shrimp. Bottom impacting mobile gear such as trawls will likely impact these sensitive habitats.

Shrimp EFH and HAPC

For penaeid shrimp, EFH includes inshore nursery areas, nearshore Atlantic waters, and all interconnecting water bodies from North Carolina to the Florida Keys (SAFMC 1998). Inshore nurseries include tidal freshwater, estuarine, and marine emergent wetlands, mangroves, submerged aquatic vegetation, and subtidal and intertidal non-vegetated flats. Both the Canaveral Shoals I and II borrow site and renourishment areas listed in Project Alternatives 2-4 are classified as EFH (Table 1). HAPC for penaeid shrimp includes estuarine waters, tidal inlets, and state-designated overwintering areas. The project area is not classified as penaeid shrimp HAPC (NOAA EFH Mapper).

For rock shrimp, EFH consists of offshore terrigenous and biogenic sand bottom habitats from 18 to 182 meters in depth from North Carolina through the Florida Keys. The Gulf Stream is considered EFH for its role in dispersing rock shrimp larvae and deeper waters off Cape Canaveral are considered EFH because the shelf current systems here may help inshore recruitment of shrimp larvae. Nonetheless, the project will occur in water <18 deep so will not affect rock shrimp EFH. No HAPC has been identified for rock shrimp.

EFH for royal red shrimp include the upper regions of the continental slope from 180 meters to about 730 meters. The Gulf Stream is considered EFH for its role in dispersing royal red shrimp larvae. The project area is not considered royal red shrimp EFH and no HAPC has been identified for the species.

Project Impacts to Shrimp EFH and HAPC

Project alternatives 2-4 are expected to disturb penaeid shrimp EFH although these effects will be temporary and be of minimal population-level importance. While some direct mortality of shrimp should be expected at both the Canaveral Shoals borrow site and beach renourishment footprint, the primary impact may result from degradation of the epifaunal and infaunal communities that serve as a forage base for large juvenile and adult shrimp. These communities are expected to quantitatively recover in time although the species assemblage may take several years to return to a natural state. Until this occurs, the shrimp carrying capacity in the project footprint may be reduced and force existing shrimp to relocate to adjacent undisturbed habitat. The permanent in-filling of the manmade ditch near LC39B under Alternative 1 and 4 may also affect shrimp EFH if this feature has enough connectivity with the open estuary to allow shrimp recruitment. Nonetheless, the amount of area impacted (~0.2 ha) suggests that this impact will be spatially limited in scope.

Golden Crab

Golden Crab Life History

The golden crab (*Chaeceon fenneri*) is a large commercially marketable species that inhabits deep water (200-1000 m) of the continental shelf from Bermuda, the SE US, and eastern Gulf of Mexico (SAFMC, 2009). It supports a small deepwater fishery off east Florida.

Golden Crab EFH and HAPC

EFH for juvenile and adult golden crab includes benthic substrates of the continental slope from Chesapeake Bay south through the Florida Straits and into the Gulf of Mexico. The Gulf Stream is considered EFH for pelagic golden crab larvae (SAFMC, 1998). All designated EFH lies outside the project area and no HAPC has been identified (Table 1).

Projects Impacts to Golden Crab EFH and HAPC

None

Highly Migratory Species (Tuna, Billfish, Swordfish, Sharks)

Highly Migratory Species Life Histories

Tuna, billfish, swordfish, and sharks are directly managed by the Highly Migratory Species Office of the NMFS because most species in these groups are strongly migratory, a life history strategy which complicates stock management by a single Fishery Management Council. Five tuna species (albacore, bigeye, bluefin, yellowfin, skipjack), four billfish species (blue marlin, white marlin, sailfish, longbill spearfish), and the swordfish are included in the HMS Fishery Management Plan. All are pelagic, fast moving species that produce pelagic eggs and larvae (NMFS, 2009). Further, 39 of the 73 shark species known from waters of the US Atlantic (including the Gulf of Mexico, Puerto Rico, and the US Virgin Islands) are also covered under this plan. These sharks exhibit considerable variability in size, appearance, growth characteristics, reproductive strategies, and habitat preferences. Many (e.g., white sharks, tiger sharks) undertake extensive seasonal migrations although some (e.g., nurse shark) appear more sedentary. The movements and habitat preferences of many species remain largely unknown.

The Cape Canaveral region sustains a diverse shark fauna (Dodrill, 1977) and supports a modest commercial gill net and longline fishery (Trent et al., 1997; Burgess and Morgan, 2002). This fishery historically targeted blacktip and sandbar sharks but has shifted somewhat to other large coastal species (e.g., lemon and bull sharks) as the former species have become depleted. Local charter boats and recreational fishermen also directly target coastal sharks to some extent. Recent scientific studies have demonstrated that the Canaveral region serves as an especially important nursery for lemon sharks, nurse sharks (Reyier et al., 2008), spinner sharks (Aubrey, 2001) and scalloped hammerhead sharks (Adams and Paperno, 2007; Reyier et al., 2010). Young lemon sharks aggregate each winter within the surf zone and longshore troughs at Cape Canaveral in schools often containing several hundred animals. Scalloped hammerheads, nurse sharks, and spinner sharks are also found near the beach and along the shoals but in slightly deeper waters.

Highly Migratory Species EFH and HAPC

EHF has been delineated for most species under the HMS Fishery Management Plan. The project area is classified as EFH for twenty HMS species including sailfish, yellowfin and bigeye tuna, as well as sharpnose, blacknose, blacktip, bonnethead, bull, dusky, finetooth, great hammerhead, lemon, nurse, sand tiger, sandbar, scalloped hammerhead, silky, spinner, tiger, and white sharks (NMFS, 2009; Table 1). HAPC for HMS species has only been identified for bluefin tuna and sandbar shark and does not include waters off Cape Canaveral.

Projects Impacts to Highly Migratory Species EFH and HAPC

All HMS species are highly mobile as juveniles and adults and should suffer negligible direct mortality from sand mining and beach renourishment. Ephemeral increases in turbidity will also be of limited concern because Canaveral waters are not EFH for pelagic eggs/larvae of sailfish or tuna, and sharks produce precocious young capable of avoiding high turbidity conditions. Possibly the greatest concern would be changes in the behavior of juvenile lemon sharks. This species is exceedingly abundant at Cape Canaveral in winter and regularly inhabits the open surf and longshore troughs in water less than 0.5 m. While ongoing acoustic telemetry studies demonstrate that individual sharks are fairly mobile along the Canaveral shoreline, some locations appear to continuously hold sharks though the entire winter and even across years. Reworking or temporary infilling of longshore troughs resulting from renourishment may reduce foraging efficiency or cause sharks to displace to less optimal habitat.

Coastal Migratory Pelagics

Coastal Migratory Pelagics Life Histories

The coastal migratory pelagic fishery management plan includes the king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), cero mackerel (*S. regalis*), cobia (*Rachycentron canadum*), and little tunny (*Euthynnus alletteratus*). Dolphinfish (*Coryphaena hippurus*), historically included under this FMP, are now managed under a more recent dolphin-wahoo FMP (SAFMC, 2003). All species are highly migratory along the southeast US coast with stocks jointly managed (when necessary) by the SAFMC and GMFMC. All species grow fairly rapidly, mature early, produce pelagic larvae, and have relatively high fecundity. Each species is important to some extent in regional recreational and commercial fisheries.

King mackerel

King mackerel are widely distributed over the continental shelf of the Southeast US coast and are found in both open water and associated with natural and artificial hard bottom. Juveniles generally occur closer to shore than adults but rarely enter estuaries. Both sexes mature at 3 to 4 years of age and spawning takes place from April to September in water deeper than 120 feet (Finucane et al., 1986; Collins and Stender, 1987). Diet consists of small schooling fishes including anchovies, menhaden, and threadfin herring (Naughton and Saloman, 1981). Two migratory groups mix in winter off the southeast Florida coast with the Atlantic stock migrating north in spring and the Gulf of Mexico stock migrating west. The king mackerel is the most economically valuable of all mackerel species. Off east Florida, it is pursued by recreational anglers, is the target of numerous fishing tournaments, and supports commercial harvest out of Port Canaveral.

Spanish mackerel

Spanish mackerel are found throughout the US southeast coast and northern Gulf of Mexico. The species forms fast-moving schools that are highly migratory. On the US east coast, the Spanish mackerel overwinters off Florida but moves north to the Carolinas in spring and to New York by early summer. While adults are most abundant in open water of the continental shelf, juveniles also regularly enter high salinity bays, and are known to occur sporadically within Port Canaveral and the Indian River Lagoon system (Reyier et al., 2008). Females mature by year two and spawn from May through September, generally in water less than 120 feet (Collins and Stender, 1987). As with the congeneric king mackerel, juvenile Spanish mackerel feed on small schooling fishes including anchovies, menhaden, and threadfin herring (Naughton and Saloman, 1981). The species supports a sizeable recreational fishery. Off Canaveral, a gill net fishery also occurs in Federal waters.

Cero mackerel

The range of the cero mackerel is limited to the western Atlantic Ocean from Massachusetts to Brazil, the Bahamas, and Caribbean Sea. Cero are more solitary than other mackerel species but can be found in small groups over reefs and ledges. It is usually seen in mid-water and near the water's surface. Cero feeds primarily on pelagic schooling fishes such as herrings as well as squid and shrimp. Spawning occurs year round off the coast of Florida with females producing up to 2.2 million eggs each year. Predators of cero mackerel include wahoo, sharks, dolphins, and diving sea birds. The cero mackerel is of only minor commercial importance but is a valued sportfish in some areas. Locally, the Cero mackerel has been documented associated with jetties inside Port Canaveral (Reyier et al., 2010).

Cobia

Adult cobia inhabit continental shelf waters and occasionally enter high salinity estuaries. They are common in open water, over hard bottom including reefs and wrecks, and associate with large marine organisms (rays, sea turtles, sharks), as well as drifting or stationary objects (buoys, pier pilings, etc.). Juveniles utilize inshore habitats such as estuaries, river mouths, bays, sounds, and inlets, as well as coastal and barrier island or beachfront waters. Both sexes mature by 2 to 3 years of age and spawning occurs May through August, most likely in the mouths of bays and sounds. Some spawning also occurs in open ocean waters. Like other coastal pelagics, cobia generally migrate south and offshore in fall and north and inshore in spring. Cobia are opportunistic bottom feeders, consuming portunid crabs, shrimp, and fish, including elasmobranchs. The species has commercial and recreational value throughout its range. Offshore Cape Canaveral, recreational and charter fishing, while seasonal, can be intense.

Little Tunny

The little tunny has a worldwide distribution in tropical and warm temperate seas. In the western Atlantic Ocean it ranges from Bermuda, Massachusetts to Brazil, the Gulf of Mexico, and Caribbean Sea. Little tunny school according to size and are found over the inner continental shelf. Little tunny typically occur closer to land than other tuna species and commonly gather around inlets, points, jetties, and sandbars. Spawning occurs in April through November with females producing as many as 1,750,000 eggs per year. Little tunny have a broad diet, feeding on crustaceans, clupeid fishes, squids, and tunicates. It often feeds on herring and sardines at the surface of the water. In turn it is preyed on by other tuna, dolphinfish, wahoo, billfish, and sharks. The little tunny is commercially important in some areas of the western Atlantic and has some interest in recreational fisheries as well. The flesh of the little tunny is darker and stronger tasting than that of the other large tunas. It is often used as bait for larger sportfish.

Coastal Migratory Pelagics EFH and HAPC

EFH for coastal migratory pelagics in the South Atlantic Bight includes shoals, capes, and offshore bars, the surf zone, high relief hard bottom, coastal inlets, and floating sargassum from the shoreline to the Gulf Stream (SAFMC, 1998; NOAA EFH Mapper). In addition, the Gulf Stream itself is EFH because it provides a mechanism to disperse pelagic larvae. In Florida, HAPC includes the Point off Jupiter Inlet, *Phragmatopoma* (worm) reefs, nearshore hard bottom south of Cape Canaveral, The Hump off Islamorada, the Marathon Hump off Marathon, the Wall off of the Florida Keys, and pelagic sargassum wherever it occurs. In the project area, EFH occurs in the surf zone at the northern boundary of the proposed renourishment footprint (Table 1). No HAPC is designated locally except that associated with pelagic sargassum.

Projects Impacts to Coastal Migratory Pelagics EFH and HAPC

The impact to coastal migratory fish EFH is expected to be minimal. While beach renourishment actions may have temporary direct or indirect impacts to some surf zone fishes, mackerel, little tunny, and cobia are highly mobile and can rapidly displace from ephemeral disturbances caused by this action (e.g., turbidity, noise). Further, these species largely forage on pelagic fishes, not benthic invertebrate communities most likely to be altered by sand mining and fill placement.

Dolphin-Wahoo

Dolphin and Wahoo Life Histories

Dolphinfish

Dolphinfish (*Coryphaena hippurus*), commonly known as mahi mahi, are one of the most popular pelagic recreational fishery species and also support a modest commercial fishery in Florida. Dolphinfish are circumtropical with populations migrating over long distances. In the western Atlantic, dolphinfish spawn in the Florida Current from November through July with peak reproductive effort in March. Juveniles and adults migrate northward in spring, reaching northeast Florida in late spring and early summer. An extremely fast growing species, dolphinfish feed on fish (e.g., flying fish, halfbeaks, man-o-war fish, *Sargassum* fish, rough triggerfish), cephalopods, and crustaceans, and are themselves consumed by larger tunas, billfish, jacks, and dolphin. They are often associated with floating mats of sargassum, especially around the edges of the Gulf Stream. They normally stay in clear oceanic water and move over the continental shelf with meanders and eddies of ocean currents. The best available scientific information indicates there is one stock of common dolphin throughout the western Atlantic.

Wahoo

The wahoo (*Acanthocybium solandri*) is a fast growing oceanic pelagic fish found worldwide in tropical and subtropical waters. In the western Atlantic, wahoo are found from New York through Columbia including Bermuda, the Bahamas, the Gulf of Mexico, and the Caribbean. Wahoo are present off east Florida year round where they sustain commercial and recreational fishermen (SAFMC, 2003). Spawning season extends from June through August with peak spawning in June and July. Wahoo are strongly piscivorous. Based on work in North Carolina, fish (e.g., mackerels, butterfishes, porcupine fishes, round herrings, scads, jacks, pompanos, and flying fishes) accounted for 97.4% of all food organisms (Hogarth, 1976).

Dolphin-Wahoo EFH and HAPC

EFH for dolphin and wahoo includes the Gulf Stream, Charleston Gyre, Florida Current, and pelagic Sargassum (SAFMC, 2003). In Florida, HAPC for dolphin and wahoo includes the Point off Jupiter Inlet, The Hump off Islamorada, the Marathon Hump off Marathon, the Wall off of the Florida Keys, and pelagic sargassum wherever it occurs. The proposed project area does not include EFH or HAPC except when sargassum is present (Table 1).

Projects Impacts to Dolphin-Wahoo EFH

As with coastal migratory pelagics, the impact to coastal migratory fish EFH is expected to be minimal. Both species are highly mobile and can rapidly displace from habitat disturbance in the project area, and their preferred food sources (pelagic prey) will not be significantly impacted by sand mining or beach renourishment.

Snapper-Grouper

Snapper-Grouper Life Histories

Seventy-three species from ten fish families (Balistidae, Carangidae, Ephippidae, Malacanthidae, Haemulidae, Polyprionidae, Labridae, Lutjanidae, Serranidae, Sparidae) are managed under the snapper-grouper fishery management plan. This group contains among the most economically valuable finfish species in the US South Atlantic. Groupers (family Serranidae) and snapper (Lutjanidae), in particular, are of tremendous commercial and recreational value to the region. These species are managed collectively because they all exhibit some association with coral reef or other hard bottom habitats throughout their life history. Some are intimately dependent on hard bottom throughout ontogeny (spawning, foraging, shelter) while other have facultative associations or are also dependent on other regional habitat types (e.g., mangroves, seagrass), especially as juveniles. Some species are sequential or simultaneous hermaphrodites, most spawn pelagic eggs, all produce pelagic larvae, and many form distinct spawning aggregations at the same sites each year. These sites are often well known to fishermen, making overharvest more likely. Many species are highly migratory and can swim several hundred kilometers. These migrations are not well known for many taxa.

The majority of species in the snapper-grouper complex should be expected within nearshore waters of Cape Canaveral (26 species from this group were recently documented from hard-bottom habitats within nearby Port Canaveral, Reyier et al., 2010). Scamp, gag, and red grouper, gray and red snapper, and amberjack are of particular importance to recreational and commercial fishermen locally. Goliath grouper (now prohibited from harvest) are a common presence on shallow reefs, while sheepshead, gray snapper, and jack crevalle are of considerable interest to the recreational fishery in the nearby Indian River Lagoon.

Snapper-Grouper EFH and HAPC

EFH for species listed in the snapper-grouper management plan includes coral reefs, other live/hard bottom, artificial reefs, unconsolidated soft bottom, and submerged aquatic vegetation (seagrass and macroalgae), from the shore to at least 183 meters deep where annual water temperature is adequate to sustain adult populations (SAFMC, 2009). EFH also includes the water column overlying adult demersal habitats as well as pelagic sargassum because these habitats are utilized for spawning and/or pre-settlement larvae. The Gulf Stream is also EFH because it provides a mechanism to disperse snapper-grouper larvae.

Areas which meet the criteria for snapper-grouper HAPC include nearshore and offshore hard bottom where spawning normally occurs, sites of known or suspected spawning aggregations, mangrove, submerged aquatic vegetation, oyster reefs, coastal inlets, sargassum as well as specific locations including The Point, The Ten Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump (South Carolina), Hoyt Hills for wreckfish, the Oculina Bank Habitat Area of Particular Concern, all hermatypic coral habitats and reefs, manganese outcroppings on the Blake Plateau, and Council-designated Artificial Reef Special Management Zones (SAFMC, 2009). Locally, all areas within and adjacent to both the offshore sand borrow site and nearshore deposition site are classified as snapper-grouper EFH (Table 1). Snapper-grouper HAPC is limited to a small area adjacent to the northwest corner of the Canaveral Shoals II sand borrow site (NOAA EFH Mapper).

Projects Impacts to Snapper-Grouper EFH and HAPC

Impacts to snapper-grouper EFH and HAPC are expected to be modest and temporary in nature. No substantial limestone reef, hermatypic coral, or artificial reefs are known from either the Canaveral Shoals sand borrow sites or the proposed renourishment footprint (Perkins et al., 1997; NOAA EFH Mapper; E. Reyier, pers. obs.). The only consolidated substrates are small humate sand outcroppings due east of Launch Complex 39A. The location and characteristics of these outcrops suggest they do not serve as high quality reef habitat and likely supports reduced fish densities and diversity relative to true hard bottom habitats in the region. Some species in the snapper-grouper complex do not consistently associate with reefs. Sheepshead, jack crevalle, and horse-eye jack are commonly observed in the open surf at Cape Canaveral; spadefish and black sea bass are often observed associated with even small pieces of structure (debris, large shells). While these species may be most directly impacted by mining and renourishment activities, they are also highly mobile and able to relocate to nearby undisturbed settings.

Red Drum

Red Drum Life History

The red drum is a large, long-lived sciaenid which inhabits estuarine and nearshore coastal waters from Massachusetts to northern Mexico (Mercer 1984). While juvenile red drum are largely confined to estuaries, studies in many areas have concluded that as fish approach maturity at 2–5 years of age, most emigrate to the continental shelf where they often form neritic migratory schools (Overstreet, 1983; Ross and Stevens, 1992; Murphy and Crabtree, 2001). Spawning occurs annually each fall along the inner shelf, often near tidal passes (Overstreet 1983; Holt 2008; Lowerre-Barbieri et al. 2008) with larvae recruiting back to estuarine seagrass, tidal creek, and marsh nurseries (Peters and McMichael 1987). The species is of tremendous recreational importance on both the Atlantic and Gulf coasts of Florida. Commercial fishing for red drum in Florida was halted in the late 1980s after dramatic population declines.

The Indian River Lagoon system near Cape Canaveral is atypical in that adult red drum are commonly found in the estuary year round and can be found spawning in areas far removed from coastal inlets (Murphy and Taylor, 1990; Johnson and Funicelli, 1991). A recent acoustic telemetry study by Reyier et al. (2011) demonstrated that these large individuals are long term residents and that estuarine spawning is the locally dominant reproductive strategy. Red drum are also common along Canaveral beaches and shoals (E. Reyier pers. obs.) but no local information is available regarding red drum population size, spawning behavior, or migration patterns. Biologists at KSC, FFWCC, and several other research organizations have recently established a nearshore acoustic telemetry array in Canaveral nearshore waters in order to examine movements and habitat preferences of economically valuable coastal fishes including juvenile red drum.

Red Drum EFH and HAPC

EFH for red drum includes tidal freshwater, emergent vegetated wetlands, estuarine scrub/shrub (mangrove fringe), seagrasses, oyster reefs and shell banks, unconsolidated bottom, high salinity surf zones, and artificial reefs from Virginia through the Florida Keys to a depth of 50 m (SAFMC, 1998). Both the Canaveral Shoals borrow sites and shoreline renourishment footprint are classified as EFH under this definition (Table 1). Areas considered red drum HAPC include all coastal inlets, all state-designated nursery habitats of particular importance to red drum, documented spawning sites, and areas containing submerged aquatic vegetation, features not known from nearshore Canaveral waters.

Projects Impacts to Red Drum EFH and HAPC

There is currently little information regarding the potential impacts of dredging and beach re-nourishment on red drum and this topic has been identified as a priority research need by the Atlantic States Marine Fisheries Commission (ASMFC, 2008). Juvenile and adult red drum are highly mobile and negligible direct mortality should be expected from this project. Further, because red drum spawn in fall, any temporary noise or turbidity resulting from dredging will not affect spawning or larval survival. Some juvenile fish (the size class most common in the open surf) may temporarily displace from the renourishment footprint until the benthic invertebrate communities recover to provide adequate forage.

Corals, Coral Reefs, and Live/Hard Bottom

While the majority of the Florida east coast continental shelf is characterized by expansive sand and mud-covered plains with rather low biological productivity, hard bottom habitats are scattered at varying densities and depths throughout the region (Struhsaker 1969; Sedberry and Van Dolah, 1984; SAFMC, 1995). These features serve as attachment substrates for a diverse assortment of marine life including algae, coral colonies, tunicates, bryozoans, and provide shelter and provide foraging opportunities for a wide variety of invertebrates and fishes including many of considerable economic value to the region. Hard bottom in nearshore waters off east Florida consists of many different materials. Substantial hermatypic coral reefs are found in shallow water (typically in water less than 40 m) from the Florida Keys to roughly Martin County. In addition to sustaining high productivity and biodiversity, these reefs protect shorelines and shelter other marine habitats (e.g., seagrass, mangroves) from otherwise high energy conditions.

Non-coral nearshore hardbottom habitats are the primary natural reef structures in east-central and north Florida. These habitats are derived from large accretionary ridges of coquina mollusks, sand, and shell marl which lithified parallel to ancient shorelines during Pleistocene interglacial periods. Nearshore hardbottom habitats on the inner shelf are patchily distributed among large expanses of barren, coarse sediments and show reduced coral diversities. Nelson (1990) recorded 325 species of invertebrates and plants from nearshore hardbottom habitats at Sebastian Inlet. In some areas, the hardbottom reaches heights of 2 m above the bottom and is highly convoluted. Hard corals are rare due to high turbidities and wave energy. However, hard corals that are encountered are *Siderastrea radians*, *Oculina diffusa* and *Oculina varicosa*.

A keystone contributor to the biological diversity of nearshore hardbottom habitats along the east Florida coast is the polychete *Phragmatopoma lapidosa.* Worms of this species (Family Sabellariidae) bind sand particles together to make sand tubes, forming vast reefs in intertidal and shallow (<5 m) subtidal hard bottom from just south of Cape Canaveral to Key Biscayne as well as elsewhere in the Caribbean. In Florida, the structure provided by these worm reefs support a higher diversity and abundance of marine species than that of neighboring sand or hardbottom habitats. In particular, worm reefs are considered important sources of food and shelter for juvenile green turtles (*Chelonia mydas*).

Coral EFH and HAPC

EFH for corals (stony corals, octocorals, and black corals) incorporates habitat for over 200 species. Specific EFH for stony corals includes rough, hard, exposed, stable substrate from Palm Beach County south through the Florida reef tract in subtidal water to 30 m depth, subtropical

(15°-35° C), oligotrophic waters with high salinity, and turbidity levels sufficiently low enough to provide algal symbionts adequate sunlight penetration for photosynthesis. EFH for ahermatypic stony corals (which are not light-restricted) includes defined hard substrate in subtidal to outer shelf depths throughout the management area. EFH for Antipatharia (black corals) includes rough, hard, exposed, stable substrate, offshore in high salinity waters in depths exceeding 18 meters, not restricted by light penetration on the outer shelf throughout the management area. EFH for octocorals excepting the order Pennatulacea (sea pens and sea pansies) includes rough, hard, exposed, stable substrate in subtidal to outer shelf depths within a wide range of salinity and light penetration throughout the management area. EFH for Pennatulacea (sea pens and sea pansies) includes muddy and silty bottoms in subtidal to outer shelf depths within a wide range of salinity and light penetration.

In east Florida, HAPC for corals, coral reefs, and live/hard bottom include *Phragmatopoma* (worm) reefs, the Oculina Banks from Ft. Pierce to Cape Canaveral, nearshore (0-4 m) hard bottom from Cape Canaveral to Broward County; offshore (5-30 m) hard bottom off from Palm Beach County to Fowey Rocks, Biscayne Bay, Biscayne National Park, and the Florida Keys National Marine Sanctuary. Within the project area, coral EFH and HAPC is designated in the immediate vicinity of both the Canaveral Shoals I and II borrow sites as well as immediately offshore the KSC shoreline (Table 1).

Projects Impacts to Corals, Coral Reef, Live/Hard Bottom EFH and HAPC

Sand mining and beach renourishment actions have the potential to damage coral and hard bottom communities through a number of mechanisms including direct physical damage from dredge heads, pipes, and anchors, as well as elevated turbidity, and burial. However, no significant coral or hard bottom habitats have been identified within the Canaveral Shoals borrow sites or the nearshore beach renourishment footprint. Therefore, the risk to these habitats appears limited.

POTENTIAL ADVERSE EFFECTS OF PROJECT ON EFH AND MANAGED SPECIES

Coastal dredging and renourishment operations affect marine organisms in several ways. Short-term impacts can include ephemeral changes in habitat quality, water chemistry, or organism behavior derived from the mechanical disturbance of the seafloor during the act of dredging. These impacts, while harmful, are usually localized and dissipate rapidly once dredging activity ceases. Long-term impacts can consist of more permanent changes to benthic substrates and hydrodynamics, or disruptions of vulnerable life history stages of marine species. The following section summarizes the potential threats specific to fish and commercially important macroinvertebrate communities that may arise from dredging and renourishment operations along the east-central Florida continental shelf including: (1) entrainment, (2) behavioral alterations, (3) turbidity and sedimentation, (4) changes to soft-bottom bathymetry, and (5) risks to hardbottom habitats. Much of this information is derived from other regions where dredging has been more thoroughly studied, however, even where dredging impacts to biota have received considerable scrutiny, long term consequences to habitat suitability and population-level dynamics of marine organisms often remain poorly understood (National Research Council, 1995).

Entrainment

Entrainment refers to the physical uptake of organisms during dredge operation. Dredge entrainment of fish and invertebrates has long been a concern because associated mortality rates are likely quite high. Entrainment rates are a function of dredge type, water depth, speed and volume of dredge operations, as well as species-specific characteristics. Benthic macroinvertebrates tend to be especially prone to entrainment. Female blue crabs (*Callinectes sapidus*) are considered vulnerable since egg-bearing individuals overwinter within sediments and may be too lethargic to avoid uptake. Sand shrimp (*Crangon* spp.) and commercially valuable penaeid shrimp are also thought to be susceptible as are sessile bivalves such as oysters, mussels, clams, and scallops (Reine and Clarke, 1998).

Fishes are also regularly entrained in dredges although generally in low numbers. Larval and juvenile fishes are often of greatest risk of entrainment due to their limited mobility and swimming strength. In one of the more complete studies, McGraw and Armstrong (1990) recorded entrainment of 28 fish species in Grays Harbor, WA, at species-specific rates ranging from <0.001 to 0.594 individuals per cubic yard with highest entrainment suffered by burrowing or otherwise demersal fishes. To date, however, the greatest concern is directed towards anadromous sturgeon, salmon, shad, and striped bass spawning and recruitment success that may be dependent on their ability to successfully bypass estuarine and riverine dredging operations and associated turbidity plumes. Entrainment-related mortality of fishes has not been adequately assessed in open coastal waters.

On the east Florida continental shelf, the distribution of individual fish and macroinvertebrate species is largely determined by water depth, temperature, and salinity with most species ranging widely throughout the study area (ASMFC, 2000; Rowe and Sedberry, 2006). Therefore, entrainment during offshore sand dredging operations, even if associated mortality is high, is likely to have minimal population-level impacts for most taxa. Fish entrainment should be a localized, short-term concern for only a few families such as burrowing eels and gobies as well as slow moving demersal taxa including sea robins, flatfish, and batfish. Further, given the scarcity of economically valuable reef fishes in open sand habitats that serve as common borrow sites, entrainment mortality is expected to have negligible negative economic impact on coastal fisheries. Entrainment of penaeid shrimp may be more of a concern. Some entrainment should be anticipated year round but rates may be elevated during periods of high juvenile fish recruitment, likely during the spring and summer.

Behavioral Alterations

Fish use underwater sound pressure waves to locate food and detect the presence of predators. In addition, many coastal fishes are soniferous, using sound to communicate, especially during courtship and spawning. Certain macroinvertebrates such as alpheid snapping shrimp and barnacles also produce sound. It has been demonstrated that biological sounds are often considerable at certain times and places and are known to attract settlement stage fish larvae to reefs (Leis et al., 2003). While behavioral alterations of nekton resulting from anthropogenic sound pollution including dredging is poorly studied, it is possible that foraging, spawning, and recruitment success of fishes and macroinvertebrates will be impacted in the immediate vicinity of dredging operations, causing some organisms to relocate. It is also possible however that the physical presence of dredging infrastructure and light produced during nighttime operations may actually attract other species to the vicinity.

Turbidity and Sedimentation

Increased turbidity is often generated directly at the site of sediment excavation or as slurry overflow and dewatering from dredge barges. Wind, waves, and strong directional currents can also resuspend fine particles that accumulate in dredge areas for many years after excavation has ceased. Turbidity may alter the trophic dynamics of an area by reducing the feeding efficiency of planktivorous fish (Hecht and Van der Lingen, 1992; Benfield and Minello, 1996) and may clog feeding structures of infaunal taxa, leading to a reduction in benthic prey resources. In rivers and estuaries, turbidity plumes may hinder spawning migration of anadromous fishes (although some estuarine turbid zones are recognized as high value habitat for larval fishes due to high rates of survival and growth; North and Houde, 2001). Turbidity can also directly influence fishes by irritating or clogging gill membranes and sediment deposition can coat eggs of deposit spawners, hindering egg respiration and increasing mortality.

The direct impact of turbidity on mortality, growth, and spawning behavior for continental shelf fishes and macroinvertebrates is largely unstudied but is likely a minimal concern in the project footprint since most fish are mobile enough to escape or avoid areas of highest turbidity. Further many shelf fishes are likely adapted to relatively high ambient turbidity levels. Sedimentation also likely poses minimal threat to fish spawning success because most shelf taxa, including virtually all valuable fishery species, produce pelagic eggs.

Changes to Soft-Bottom Bathymetry

Sand shoals may support an ichthyofauna somewhat dissimilar to the surrounding seafloor. Many shoals that possess differing sediment types and associated infaunal communities, may also serve as shallow-depth refugia from predators, physical landmarks on which fish assemble or spawn, and may also be areas of high turbidity that enhance survival of small-bodied prey taxa. In U.S. Atlantic waters, the fisheries value of sand shoals has received some scrutiny as a result of MMS interest in mining offshore sand deposits (e.g., Byrnes et al., 1999; 2003; Hammer et al., 2005; Slacum et al., 2006) and shoals have previously been identified as valuable habitat for fishes including cod (Fahay et al., 1999) and juvenile sharks (Rountree and Able, 1996; Reyier et al., 2008).

The physical reworking during dredging and renourishment may lead to an immediate reduction in the biomass, density, and diversity of infauna and epifauna. These organisms serve as essential prey for many small-bodied benthic fishes. Loss of this forage base during dredging will have an immediate negative consequence on the survival and growth rates of benthic fishes in the immediate vicinity of dredge operations, with the most severe impacts apportioned to those species with limited mobility. Further, borrow sites are often recolonized by differing benthic communities, a factor that may eliminate some selective benthic feeders, resulting in lower local diversity of demersal fish and macrocrustaceans.

Damage or burial of hard bottom

Dredging impacts to hardbottom substrates have been a concern for many decades. Damage to reefs is caused by the dredges themselves, barge anchors and mooring chains, and sand discharge pipelines. These dredging impacts typically destroy the coral and associated invertebrate communities and reduce reef rugosity. Such changes often reduce reef carrying capacity, alter fish spawning behavior, and shift the communities toward algal dominated systems. In Florida, much dredging-related reef damage is related to sand deposition on nearshore reef structures. Lindeman and Snyder (1999) documented a dramatic decline in both fish species and individuals after the burial of a nearshore reef structure in southeast Florida.
Although substantial hardbottom is not known in the project footprint, it is widespread in the general vicinity (Perkins et al., 1997). These substrates should be expected to harbor a diverse assemblage of reef fishes and macrocrustaceans, many of which are the target of recreational and commercial fishermen throughout the region.

Cumulative Impacts

Cumulative impacts to EFH and the local fish fauna are also expected to be minimal. Dredging and renourishment operations will most adversely affect soft-bottom demersal fishes through entrainment or removal of their invertebrate forage base. However, given the planktonic dispersal strategies of most local fishes and the relatively high adult mobility of even small fish taxa, recolonization will occur after each dredge cut. This recolonization should proceed rapidly because the species assemblage adjacent to project impact areas are likely similar offering a proximate source of both adults and young recruits. Cumulative impacts to reef fish taxa, which is a legitimate issue in many areas due to mechanical damage or siltation of exposed hardbottom, is of minor concern locally since no hardbottom is within the proposed sand borrow areas. Impacts to pelagic fish species are also negligible given their high mobility and limited reliance on substrate type and benthic invertebrate prey.

NASA'S CONCLUSION REGARDING PROJECT EFFECTS TO EFH

Project Alternative One: Inland Dune

Alternative One represents a managed retreat strategy by establishing shore protection on 5.8 linear km of shoreline landward of the existing dune with minimal fill placed on the beach. Habitat impacts would occur primarily in uplands with sand fill obtained from upland sand sources. While some low salinity swales may also be impacted, these features have no existing connection to the adjacent Banana River Lagoon estuary and are therefore of no habitat value to federally managed fish and invertebrate species (e.g., shrimp, red drum) which commonly utilize coastal wetlands. A small (0.2 ha) manmade ditch may also be permanently removed as the result of dune construction. The connectivity of this ditch with the open estuary is unknown but appears limited or non-existent so its EFH value is negligible. **NASA therefore concludes that Alternative One, if implemented, will have no effect on EFH or managed fish species.**

Project Alternative Two: Restore Beach and Dunes

Alternative Two entails an aggressive beach renourishment effort intended to restore 7.6 km of the dune and beach to the dimensions that existed approximately 10 - 15 years ago. This effort will rebuild beach width lost to erosion and reinforce the height and width of the primary dune. Up to 2.4 million m^3 of beach-compatible sand fill would be mined with hopper dredges from the existing Canaveral Shoals II (preferred) or Canaveral Shoals I offshore borrow area to complete this renourishment.

A fraction of the sand fill initially placed on the beach will migrate with time into the lower intertidal and shallow sub-tidal zones. This fill has the potential to partially or completely smother epifanual and infaunal invertebrate communities, temporarily reducing overall invertebrate biomass and diversity. While these organisms are of minimal direct management concern, they serve as valuable forage for many economically valuable fishes. As such, the shallow surf zone is classified EFH for several managed fish species. Sand migration may also cause changes in beach profiles, reducing the extent and size of longshore troughs which serve as aggregation sites juvenile lemon sharks from November through March and teleost sportfish (e.g., red drum, black drum, pompano) throughout the year. The shoreline should eventually rebuild a natural bar profile and invertebrate densities should approach pre-renourishment densities over the timescale of weeks to months (although may remain qualitatively different for much longer). Dredging of the sand fill from the Canaveral Shoals II and Canaveral Shoals I offshore borrow sites will similarly affect EFH by altering or removing benthic invertebrate communities and may cause temporary displacement of mobile nekton from noise and turbidity plumes. Neither dredging nor subsequent renourishment are anticipated to have impacts to limestone or coral hard bottom substrates.

NASA concludes that Alternative Two, if implemented, is unlikely to have direct lethal effects on managed fishes (most are mobile enough to avoid direct mortality) but may adversely affect EFH by degrading benthic invertebrate food resources and altering shore profiles and bathymetry. All of these effects are expected to be temporary with physical and biological characteristics eventually returning to a relatively natural state.

Project Alternative Three: Reinforce Dune Plus Beach Fill

Under Alternative Three, the primary dune would be reconstructed or reinforced in its existing location with sand and vegetation over a 7.6 km section of shoreline, and sand would also be placed atop the existing beach to provide a wide berm protecting the dune. This strategy represents a “hold-the-line” renourishment approach. This approach differs from Alternative Two in that it does not intend to restore the dune or beach seaward to an earlier (less eroded) state. Up to 1.8 million m^3 of sand would be required and would be obtained by dredging the existing Canaveral Shoals II (preferred) or Canaveral Shoals I offshore borrow area.

As with Alternative Two, this restoration approach is unlikely to cause significant direct mortality to managed species but may affect EFH by degrading the benthic invertebrate forage base, and possibly through changes in beach morphology which reduce habitat complexity. However, given that less sand is required from offshore borrow sites as opposed to Alternative Two (1.8 million m^3 vs. 2.4 million m^3) and that sand will be placed on the beach simply to protect the dune, not extend the shoreline, overall EFH impacts are likely to be less than in Alternative Two. **NASA concludes that Alternative Three, if implemented, may adversely affect EFH. These effects are expected to be temporary with physical and biological characteristics of habitats in the project area eventually returning towards a natural state.**

Project Alternative Four: Inland Dune Plus Beach Fill

Alternative Four is a hybrid of Alternatives 1, 2 and 3 that combines managed retreat with a modest-scale beach/dune nourishment effort. This action includes placement of sand on the beach to restore that lost to erosion, reinforcement of the existing primary dune, and construction of a secondary dune inland of the primary dune. Sand fill would not be used to extend the primary dune or beach seaward to a previous, less eroded stated. The affected project area includes the northern 7.6 km of the KSC shoreline. Up to about 1.5 million m^3 of beach fill sand would be required to initially construct Alternative Four. Most material would be dredged from Canaveral Shoals II (preferred) or Canaveral Shoals I although the secondary dune could be constructed from fill derived from upland sources.

The potential impact to EFH and managed species in Alternative Four is identical to those provided in Alternatives 2 and 3. Managed fishes should suffer negligible direct mortality but may displace from the beach and offshore borrow sites due to reduction in prey densities, as well as ephemeral turbidity and noise. Given that a maximum of 1.5 million m^3 of fill is required (with some placed on the secondary inland dune), the spatial extent of EFH impacts are expected to be less than in Alternatives 2 and 3. **NASA concludes that EFH may be adversely affected under Alternative 4 through changes in invertebrate communities and habitat complexity but that conditions will eventually return to a near-natural state.**

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Table 1. EFH and HAPC for managed species present on the east-central Florida coast. Determinations drawn from NOAA EFH Mapper, NMFS (2009), and SAFMC (1998, 2003, 2009)

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Spiny Lobster FMP										
Spiny Lobster	*Panulirus argus*	SAFMC, GMFMC				X				X[b]
Shrimp FMP										
Pink shrimp	*Farfantepenaeus duorarum*	SAFMC				X				
White shrimp	*Litopenaeus setiferus*	SAFMC				X				
Brown shrimp	*Farfantepenaeus aztecus*	SAFMC				X				
Rock shrimp	*Sicyonia brevirostris*	SAFMC								
Royal red shrimp	*Pleoticus robustus*	SAFMC								
Golden Crab FMP										
Golden Crab	*Chaceon fenneri*	SAFMC								
Highly Migratory Species FMP										
Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	NMFS	X	X	X					
Bigeye Tuna	*Thunnus obesus*	NMFS		X[b]						
Blacknose Shark	*Carcharhinus acronotus*	NMFS		X	X					
Blacktip Shark	*Carcharhinus limbatus*	NMFS		X	X					
Bonnethead Shark	*Sphyrna tiburo*	NMFS	X	X	X					
Bull Shark	*Carcharhinus leucas*	NMFS	X	X	X					
Dusky Shark[a]	*Carcharhinus obscurus*	NMFS		X	X					
Finetooth Shark	*Carcharhinus isodon*	NMFS		X	X					
Great Hammerhead[a]	*Sphyrna mokorran*	NMFS				X				
Lemon Shark[a]	*Negaprion brevirostris*	NMFS		X						
Nurse Shark	*Ginglymostoma cirratum*	NMFS		X	X					
Sailfish	*Istiophorus platypterus*	NMFS		X	X					
Sand Tiger Shark[a]	*Carcharius taurus*	NMFS	X	X	X					
Sandbar Shark	*Charhinus plumbeus*	NMFS		X[c]	X					
Scalloped Hammerhead[a]	*Sphyrna lewini*	NMFS	X	X	X					

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Silky Shark[a]	*Carcharhinus falciformis*	NMFS				X				
Spinner Shark	*Carcharhinus brevipinna*	NMFS	X	X	X					
Tiger Shark[a]	*Galeocerdo cuvier*	NMFS		X	X					
White Shark[a]	*Carcharodon carcharias*	NMFS				X				
Yellowfin Tuna	*Thunnus albacares*	NMFS		X						
Coastal Migratory Pelagics FMP										
Cero	*Scomberomorus regalis*	SAFMC, GMFMC				X[c]				
Cobia	*Rachycentron canadum*	SAFMC, GMFMC				X[c]				
King mackerel	*Scomberomorus cavalla*	SAFMC, GMFMC				X[c]				
Little tunny	*Euthynnus alletteratus*	SAFMC, GMFMC				X[c]				
Spanish mackerel	*Scomberomorus maculatus*	SAFMC, GMFMC				X[c]				
Dolphin-Wahoo FMP										
Dolphinfish	*Coryphaena hippurus*	SAFMC	Sargassu	Sargassu	Sargassu	Sargassu				
Wahoo	*Acanthocybium solanderi*	SAFMC	Sargassu	Sargassu	Sargassu	Sargassu				
Snapper-Grouper FMP										
Almaco jack	*Seriola rivoliana*	SAFMC				X				X[b]
Banded rudderfish	*Seriola zonata*	SAFMC				X				X[b]
Bank sea bass	*Centropristis ocyurus*	SAFMC				X				X[b]
Bar jack	*Carangoides ruber*	SAFMC				X				X[b]
Black grouper	*Mycteroperca bonaci*	SAFMC				X				X[b]
Black margate	*Anisotremus surinamensis*	SAFMC				X				X[b]
Black sea bass	*Centropristis striata*	SAFMC				X				X[b]
Black snapper	*Apsilus dentatus*	SAFMC				X				X[b]
Blackfin snapper	*Lutjanus buccanella*	SAFMC				X				X[b]
Blue runner	*Caranx crysos*	SAFMC				X				X[b]
Blue stripe grunt	*Haemulon sciurus*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Blueline tilefish	*Caulolatilus microps*	SAFMC				X				X[b]
Coney	*Epinephelus fulvus*	SAFMC				X				X[b]
Cottonwick	*Haemulon melanurum*	SAFMC				X				X[b]
Crevalle jack	*Caranx hippos*	SAFMC				X				X[b]
Cubera snapper	*Lutjanus cyanopterus*	SAFMC				X				X[b]
Dog snapper	*Lutjanus jocu*	SAFMC				X				X[b]
French grunt	*Haemulon flavolineatum*	SAFMC				X				X[b]
Gag	*Mycteroperca microlepis*	SAFMC				X				X[b]
Golden tilefish	*Lopholatilus chamaeleonticeps*	SAFMC				X				X[b]
Grass porgy	*Calamus arctifrons*	SAFMC				X				X[b]
Gray snapper	*Lutjanus griseus*	SAFMC				X				X[b]
Gray triggerfish	*Balistes capriscus*	SAFMC				X				X[b]
Graysby	*Epinephelus cruentatus*	SAFMC				X				X[b]
Greater amberjack	*Seriola dumerili*	SAFMC				X				X[b]
Hogfish	*Lachnolaimus maximus*	SAFMC				X				X[b]
Goliath Grouper[a]	*Epinephelus itajara*	SAFMC				X				X[b]
Jolthead porgy	*Calamus bajonado*	SAFMC				X				X[b]
Knobbed porgy	*Calamus nodosus*	SAFMC				X				X[b]
Lane snapper	*Lutjanus synagris*	SAFMC				X				X[b]
Lesser amberjack	*Seriola fasciata*	SAFMC				X				X[b]
Longspine porgy	*Stenotomus caprinus*	SAFMC				X				X[b]
Mahogany snapper	*Lutjanus mahogoni*	SAFMC				X				X[b]
Margate	*Haemulon album*	SAFMC				X				X[b]
Misty grouper	*Epinephelus mystacinus*	SAFMC				X				X[b]
Mutton snapper	*Lutjanus analis*	SAFMC				X				X[b]
Nassau grouper[a]	*Epinephelus striatus*	SAFMC				X				X[b]
Ocean triggerfish	*Canthidermis sufflamen*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Porkfish	*Anisotremus virginicus*	SAFMC				X				X[b]
Puddingwife	*Halichoeres radiatus*	SAFMC				X				X[b]
Queen snapper	*Etelis oculatus*	SAFMC				X				X[b]
Queen triggerfish	*Balistes vetula*	SAFMC				X				X[b]
Red grouper	*Epinephelus morio*	SAFMC				X				X[b]
Red hind	*Epinephelus guttatus*	SAFMC				X				X[b]
Red porgy	*Pagrus pagrus*	SAFMC				X				X[b]
Red snapper	*Lutjanus campechanus*	SAFMC				X				X[b]
Rock hind	*Epinephelus adscensionis*	SAFMC				X				X[b]
Rock sea bass	*Centropristis philadelphica*	SAFMC				X				X[b]
Sailors choice	*Haemulon parrai*	SAFMC				X				X[b]
Sand tilefish	*Malacanthus plumieri*	SAFMC				X				X[b]
Saucereye porgy	*Calamus*	SAFMC				X				X[b]
Scamp	*Mycteroperca phenax*	SAFMC				X				X[b]
Schoolmaster	*Lutjanus apodus*	SAFMC				X				X[b]
Scup	*Stenotomus chrysops*	SAFMC				X				X[b]
Sheepshead	*Archosargus probatocephalus*	SAFMC				X				X[b]
Silk snapper	*Lutjanus vivanus*	SAFMC				X				X[b]
Smallmouth grunt	*Haemulon chrysargyreum*	SAFMC				X				X[b]
Snowy grouper	*Epinephelus niveatus*	SAFMC				X				X[b]
Spadefish	*Chaetodipterus faber*	SAFMC				X				X[b]
Spanish grunt	*Haemulon macrostomum*	SAFMC				X				X[b]
Speckled hind	*Epinephelus drummondhayi*	SAFMC				X				X[b]
Tiger grouper	*Mycteroperca tigris*	SAFMC				X				X[b]
Tomtate	*Haemulon aurolineatum*	SAFMC				X				X[b]
Vermilion snapper	*Rhomboplites aurorubens*	SAFMC				X				X[b]
Warsaw grouper	*Epinephelus nigritus*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
White grunt	*Haemulon plumieri*	SAFMC				X				X[b]
Whitebone porgy	*Calamus leucosteus*	SAFMC				X				X[b]
Wreckfish	*Polyprion americanus*	SAFMC				X				X[b]
Yellow jack	*Caranx bartholomaei*	SAFMC				X				X[b]
Yellowedge grouper	*Epinephelus flavolimbatus*	SAFMC				X				X[b]
Yellowfin grouper	*Mycteroperca venenosa*	SAFMC				X				X[b]
Yellowmouth grouper	*Mycteroperca interstitialis*	SAFMC				X				X[b]
Yellowtail snapper	*Ocyurus chrysurus*	SAFMC				X				X[b]
Red Drum FMP										
Red Drum	*Sciaenops ocellatus*	ASMFC				X				
Coral, Hard Bottom FMP										
Corals[a]	>200 Species	SAFMC				X				X

[a] Prohibited species in Florida waters

[b] Canaveral Shoals borrow site only

[c] Beach renourisment site only

APPENDIX F

Air Emissions Worksheets

- Hooper EM
- NEI Criteria Pollutants
- EF EPA
- EF GOADS 2000

Estimated emissions for KSC Shoreline Project Alternative Two

Emissions Estimates for Brevard County Beach Restoration, Trailing Suction Hopper

Maximum Volume Dredged from Borrow Area	3,100,000	yd3
Volume Placed on Beach	2,800,000	yd3
Mean Load	2,900	yd3
Cut/Fill Dredge Efficiency	1.11	
No. of Hopper Loads	1072	
Loads/Day	4.0	
Total Days	268	

Total Dredging Time (less lost hrs)	6430
Total Effective Time (dredging hrs)	1072
Percent Effective Time	16.7%
Percent Lost Time	0.0%

Offshore Activities

Dredging Activity

Equipment	**Horsepower**		
	mean	min	max
Propulsion	3,500	1700	9000
Dredge Pumps	2,000	1000	3000
Pumpout Pumps	2,000	1000	3000
Aux. & Misc.	1,165	185	2000
Total	8,665		

Rating or Loading Factors

Activity	**Propulsion Factor**	**Pumps Factor**	**Aux. & Misc. Factor**		**Duration of cycle**		**Hp-hr per cycle**
					hr	min	
Dredging	0.5	0.8	0.25		1.00	60	3,641
Haul & Return	0.8		0.25		2.60	156	8,037
Pumpout	0.25	0.8	0.25		0.70	42	1,936
Idle/Connect/Disconnect	0.1		0.25		1.70	102	1,090
				Total	6.00	360	14,705
				Daily Hrs	24.0	1440	

Dredge Emissions per cycle, lb-hr

Activity	NOX	VOC	SO2	CO	PM10	PM2.5
Dredging	87.5	2.3	1.5	20.1	1.5	1.4
Haul & Return	193.1	5.1	3.3	44.3	3.2	3.2
Pumpout	46.5	1.2	0.8	10.7	0.8	0.8
Idle/Connect/Disconnect	26.2	0.7	0.4	6.0	0.4	0.4
Total	353.4	9.4	5.9	81.0	5.9	5.8

Total Dredge Project Emissions, tons

Activity	NOX	VOC	SO2	CO	PM10	PM2.5
Dredging	46.9	1.2	0.8	10.8	0.8	0.8
Haul & Return	103.5	2.8	1.7	23.7	1.7	1.7
Pumpout	24.9	0.7	0.4	5.7	0.4	0.4
Idle/Connect/Disconnect	14.0	0.4	0.2	3.2	0.2	0.2
Total Dredge Emissions	**189.4**	**5.0**	**3.2**	**43.4**	**3.2**	**3.1**

Total hp-hr, dredge	15,759,703
Fuel Rate, gal/hp-hr	0.056
Total Fuel, gal	882,543

Supporting Activity

				Emissions, tons					
Relocate Mooring Buoy (5 relocations)	**Horsepower**	**Rating Factor**	**No. Hrs**	NOx	VOC	SO2	CO	PM10	PM2.5
2 Tender Tugs	1000	0.8	60	1.15	0.03	0.02	0.26	0.02	0.02
Derrick Barge	0	0.5	60	0.00	0.00	0.00	0.00	0.00	0.00
2 Work Barges	0	0.5	60	0.00	0.00	0.00	0.00	0.00	0.00
Generator/Light Crane	0	1	60	0.00	0.00	0.00	0.00	0.00	0.00
Transport Crew									
Supply/Crew Vessel	440	0.8	1072	4.53	0.12	0.08	1.04	0.08	0.15
Total Supporting Activity Emissions, tons				**5.7**	**0.2**	**0.1**	**1.3**	**0.1**	**0.2**

Emission Factors for Tugs and Barges, g/hp-hr

Source: U.S. EPA AP-42, 2002, Table 3.4-1

NOx	10.9
VOC	0.29
SO2	0.184
CO	2.50
PM10	0.182
PM2.5	0.178

Beach Fill

Placement Activity

Emission Factors - Ref. AP-42, Table 3.3-1, Diesel Engines < 600 hp

Equipment	NOx	VOC	SO2	CO	PM10	PM2.5	
3 Bulldozers / 1 Pipeline Mover - 215 hp (80% run-time)	4.155	0.269	0.754	1.791	0.327	0.327	g/hp-hr
2 Light/HD Truck (80% run-time)	1.22	1.61	0.74	15.7	0.01	0.01	g/mi

			Emissions, tons						
Equipment	**Horsepower**	**No. of hours**	NOx	VOC	SO2	CO	PM10	PM2.5	
3 Bulldozers / 1 Pipeline Mover - 215 hp (80% run-time)	215	20577	20.3	1.3	3.7	8.7	1.6	1.6	Assume 4 dozers operating 24 hours/day 80% of time
2 Light/HD Truck (80% run-time)	-	10289	0.07	0.09	0.04	0.89	0.00	0.00	Assume 2 light trucks operating 24/hrs day 80% of time at 5 mi/hr
Total Beach Fill Emissions, tons			**20.3**	**1.4**	**3.7**	**9.6**	**1.6**	**1.6**	

TOTAL PROJECT EMISSIONS, tons

	NOx	VOC	SO2	CO	PM10	PM2.5	
OCS Waters	126.5	3.4	2.1	29.0	2.1	2.1	Assume 75% of travel in OCS waters
State Waters	68.5	1.8	1.2	15.7	1.1	1.2	Assume 25% of travel in State waters
Beach	20.3	1.4	3.7	9.6	1.6	1.6	
Total State Emissions	**88.8**	**3.2**	**4.9**	**25.3**	**2.7**	**2.8**	
Total Emissions	**215.4**	**6.6**	**7.0**	**54.4**	**4.9**	**4.9**	
check	215.4	6.6	7.0	54.4	4.9	4.9	

NOX Emission factors for Diesel Engines > or = 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	3.2	0.08	0.0505	0.85	0.057	0.056	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	10.9	0.29	0.1835	2.5	0.182	0.178	g/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	438	11.0	6.9	116.5	7.8	7.7	lb/1000gal	S= Fuel oil sulfur content (0.05)

NOX Emission factors for Diesel Engines < 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	4.41	0.33	0.0505	0.95	0.31	9.31	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	14.1	1.04	0.1835	3.03	1	1	g/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	604	45.2	6.9	130.2	42.5	1275.7	lb/1000gal	

http://www.epa.gov/air/data/

	Point Source Emissions	Nonpoint+Mobile Source Emissions	Total
Nox	9,219	10,077	19,296
CO	12,021	73,578	85,599
Sox	17,042	2,271	19,313
VOC	998	13,006	14,004
PM10	1,964	3,893	5,857
PM2.5	1,762	1,426	3,188

NOX Emission factors for Diesel Engines > 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	3.2	0.09	0.055	0.85	0.0573	0.0556	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	0.024	0.000642	0.000405	0.0055	0.000401	0.00039	lb/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
EF	10.89	0.29	0.18	2.49	0.182	0.178	gm/hp-hr	
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	438	12.3	7.5	116.5	7.9	7.6	lb/1000gal	

Nox emission Factors based on GOADS 2000 report

E (g/kW-hr) = A * (Load Factor) ^-x + B

x	1.5	0.000401
B	10.4496	0.182099
A	0.1255	

Activity	**Propulsion Rating Fact.**	**Pumps Factor**	**Aux. & Misc. Factor**		**Duration of cycle**	
					min	hr
Dredging	0.45	0.5	0.3		81	1.4
Haul & Return	0.8		0.25		132	2.2
Pumpout		0.8	0.25		79	1.3
Idle			0.25		32	0.5
				Total	324	5.4
				Trips/day		4.4

Activity	**Propulsion NOX EF**	**Pumps NOX EF**	**Aux. & Misc. NOX EF**		**Duration of cycle**		Nox Emissions, lb
	EF, g/kWhr	E, g/kW-hr	E, g/kW-hr		min	hr	
Dredging	10.87	10.80	11.21		81	1.4	0.0
Haul & Return	10.62		11.45		132	2.2	0.0
Pumpout		10.62	11.45		79	1.3	0.0
Idle			11.45		32	0.5	0.0
				Total	324	5.4	0.0

Estimated emissions for KSC Shoreline Project Alternative Two (tons per year).

Activity	Emissions (tons)					
	NOx	**SO2**	**CO**	**VOC**	**$PM_{2.5}$**	**PM_{10}**
Dredge Plant (Hopper)						
Dredging/Operation	46.9	0.8	10.8	6.1	0.8	0.8
Turning/Sail	103.5	1.7	23.7	2.8	1.7	1.7
Pump-out	24.9	0.4	5.7	0.7	0.4	0.4
Idle / Connect-Disconnect	14.0	0.2	3.2	0.4	0.2	0.2
Supporting Offshore Activities	5.7	0.1	1.3	0.2	0.2	0.1
Beach Fill	20.3	3.7	9.6	1.4	1.6	1.6
Total Emissions	215.4	7.0	54.4	6.6	4.9	4.9
Total Emissions within State	88.8	4.9	25.3	3.2	2.8	2.7
Total Emissions at CS II	126.5	2.1	29.0	3.4	2.1	2.1
2002 Brevard County Emissions Nonpoint + Mobile (Point and Nonpoint + Mobile)	34,251 (46,403)	10,318 (25,865)	216,995 (218,319)	44,902 (45,561)	5,548 (6,712)	11,989 (13,350)
Brevard County 2002 emissions from EPA National Emission Inventory http://www.epa.gov/ttnchie1/net/2002inventory.html						

APPENDIX G

BIOLOGICAL ASSESSMENT FOR THE KSC SHORELINE PROTECTION PROJECT KENNEDY SPACE CENTER, FLORIDA

Prepared for:

National Aeronautics and Space Administration
Kennedy Space Center, Florida

2 November 2012

Prepared by:
Medical and Environmental Support Contract (MESC)
InoMedic Health Applications, Inc.
Environmental Services Branch
IHA-022
Kennedy Space Center, Florida 32899

BIOLOGICAL ASSESSMENT FOR THE KSC SHORELINE PROTECTION PROJECT KENNEDY SPACE CENTER, FLORIDA

November 2012

Prepared for:

Environmental Management Branch
TA-A4C
National Aeronautics and Space Administration
John F. Kennedy Space Center, Florida 32899

Prepared by:
Medical and Environmental Support Contract (MESC)
CLIN10 Environmental Projects
IHA Environmental Services Branch

IHA-022
Kennedy Space Center, Florida 32899

InoMedic HEALTH APPLICATIONS

EXECUTIVE SUMMARY

Federal agencies are required by Section 7 of the Endangered Species Act (16 U.S.C. § 1536(a)(2)) to consult with the U.S. Fish and Wildlife Service if the federal agency is proposing an action that may affect listed wildlife or plant species, or their designated critical habitats. A Biological Assessment (BA) is a document prepared by the action constituents under the Section 7 process that provides information needed to determine whether the proposed action is likely to adversely affect listed species, candidate species, or critical habitats.

The National Aeronautics and Space Administration at Kennedy Space Center (KSC) is proposing an action to restore beach and coastal dune habitat that has been severely eroded over the past several years. Changes in the coastline have brought about increased frequency and severity of inundation events that threaten KSC infrastructure and assets, including natural habitats that support federally protected wildlife species. Predictions are that this trend will continue into the future. In order to maintain and preserve launch infrastructure and coastal habitats, KSC is proposing to implement measures to protect the shoreline from continuing damage.

There are four alternatives being evaluated to accomplish shoreline protection. Seven federally protected wildlife species and one candidate for federal listing could be expected to occur within the project area; there have been no federally protected plant species documented. None of the area is designated critical habitat for any species. The purpose of this BA is to document presence, or potential presence, of the eight wildlife species and to determine if any of the four alternatives would be likely to adversely affect any of those species.

Anticipated impacts from the Shoreline Protection Project are separated into 1) impacts from construction and 2) long-term impacts. Construction impacts, depending on the species being considered and the alternative selected, range between minimal and moderate. Long-term effects from any of the four alternatives are expected to be beneficial for all species.

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ACRONYMS and ABBREVIATIONS

ac	acre
BA	Biological Assessment
BO	Biological Opinion
CCAFS	Cape Canaveral Air Force Station
CNS	Canaveral National Seashore
CTF	Corrosion Test Facility
FEMA	Federal Emergency Management Agency
ft	feet
ft^3	cubic feet
ha	hectares
km	kilometers
KSC	Kennedy Space Center
LC	Launch Complex
m	meters
m^3	cubic meters
mi	miles
MINWR	Merritt Island National Wildlife Refuge
NASA	National Aeronautics and Space Administration
pers. comm.	personal communication
pers. obs.	personal observation
STL	still water level
USFWS	United States Fish and Wildlife Service

Section 1 Purpose and Need

1.1 Purpose

The purpose of the proposed action is to reduce shoreline erosion that is caused by storms and sea level rise. Critical launch infrastructure and valuable threatened and endangered species habitat along the Kennedy Space Center (KSC) coastline are at risk.

There are seven federally protected wildlife species and one candidate for federal listing that could be expected to occur along the KSC shoreline and adjacent habitats. There have been no federally protected plant species documented within the area (Schmalzer et al. 2002). None of the area is designated critical habitat for any species. The purpose of this Biological Assessment (BA) is to document presence, or potential presence, of these eight species and to determine if any of the four alternatives proposed by National Aeronautics and Space Administration (NASA) to accomplish shoreline protection would be likely to adversely affect any species. A No Action alternative is also being evaluated.

1.2 Need

The proposed action is needed to ensure the continued ability of NASA to accomplish its mission at KSC. Prior studies have suggested that the volume of sediment contained in a dune or bluff above the 100-year storm tide still water level (SWL) is a descriptor of the dune's resistance to storm-induced erosion (Hallermeier and Rhodes, 1988). The Zone V designation is given to areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. For purposes of V-zone mapping and protection of habitable development within the coastal zone, the Federal Emergency Management Agency (FEMA) has recommended that a minimum frontal dune reservoir of between 51 and 104 m^3/m [540 and 1,100 ft^3/ft] alongshore, above the 100-year SWL, is required to prevent dune removal during a 100-year storm event (FEMA 2000). A value of at least 29 m^3/m (310 ft^3/ft) is associated with a 25-year storm event. These are empirical guidelines that reflect very wide variation in field data and refer to only the front half of the dune. The existing beach profile at KSC exhibits less than 26 m^3/m (280 ft^3/ft) which is far less than the minimum FEMA recommendation for the 100-year flood protection.

Section 2 Project Description

2.1 Proposed Action

Four alternative scenarios have been developed and are being evaluated for accomplishing the shoreline protection:

- Alternative 1 involves construction of a large secondary dune behind the existing primary dunes in areas where the primary dunes are highly eroded or non-existent. The created dunes would be planted with salt-tolerant vegetation along the dune crest and dune face to provide further stabilization. In areas where primary dunes are non-existent or minimal, the constructed inland dune would replace the primary dune and be fronted by a marginal beach.

- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 10 -15 years ago. Dunes would be constructed seaward of the existing eroded primary dune as needed to provide elevation necessary to ensure protection from storm waves and flooding.
- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative the existing primary dune would be reconstructed or reinforced at its current location. Appropriate vegetation would be planted along the dune crest and dune face.
- Alternative 4 is a hybrid of proposed Alternatives 1, 2 and 3. It includes placement of sand to restore beach lost to erosion, reinforcement of existing dune, and construction of secondary dunes in areas where the primary dune is subject to the most erosion or has a lower than desired elevation. Appropriate vegetation would be planted along the crest and face of both the primary dune and inland dune as needed for stabilization.
- Under the No Action Alternative, the KSC beach would be left in its current state. Nature would be allowed to take its course and storms would continue to erode the beach and further threaten or destroy KSC infrastructure and critical coastal habitat. The historical progression of dune and beach erosion along the northern 7.4 km (4.6 mi) of the KSC shoreline (north of False Cape) documented over the past decades, combined with the continuation or possible acceleration of sea level rise, strongly indicate that the beach and dune will continue to degrade in the absence of intervening actions. In the No Action Alternative, overtopping and breach of the primary dune, particularly between Launch Complex (LC) 39A and LC 39B, are likely to occur in the near future, which could result in large-scale inundation, habitat alteration, and land loss along the coastal strand.

Section 3 Action Area

3.1 Geographic Area

KSC is 56,500 ha (139,490 ac) located along the east coast of central Florida in Brevard and Volusia counties (Figure 1). The majority of the land areas comprising KSC are on the northern part of Merritt Island, which forms a barrier island complex with adjacent Cape Canaveral. NASA acquired the KSC lands in 1962 for the purpose of implementing the U.S. space program. NASA controls and manages 1,806 ha (4,463 ac) that are dedicated to NASA operations, which is approximately 5% of the total KSC area. Undeveloped areas, including uplands, wetlands, mosquito control impoundments, beach, coastal dune, and open water, comprise the remaining 95% of the total area. Nearly 40% of KSC is open water estuary, and includes portions of the Indian River, Banana River, Mosquito Lagoon, and all of Banana Creek. The areas of KSC not regularly used for NASA operations are managed by the U.S. Fish and Wildlife Service (USFWS) as Merritt Island National Wildlife Refuge (MIWNWR); these lands remain subject to operational controls from NASA as they may be needed to assure safety and security, may be used for future expansions, and/or provide a required buffer to other land uses (NASA 2010).

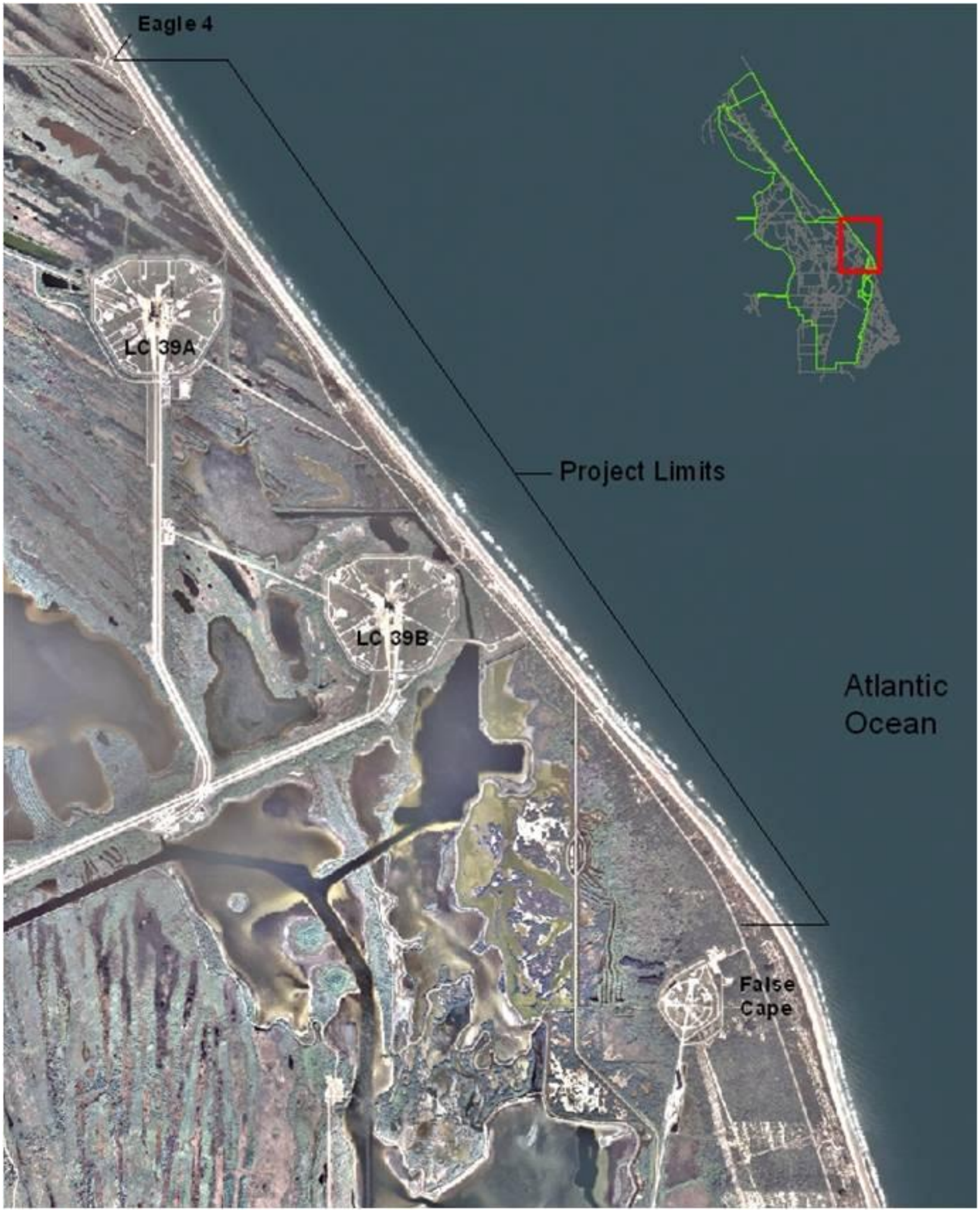

Figure 1. Shoreline Protection Project general location and boundaries, Kennedy Space Center, Florida.

3.2 Affected Area

The boundary of the affected area extends from the KSC/Canaveral National Seashore (CNS) border south 7.6 km (4.7 mi) to the False Cape on Cape Canaveral Air Force Station (CCAFS), and west from the high tide line to Phillips Parkway (Figure 1). This area encompasses approximately 150 ha (371 ac) of landcover.

Within the footprint of the four alternatives, there are six major land cover types (Table 1) that were derived from the Florida Land Use, Cover, and Forms Classification System, 3rd Edition (Florida Department of Transportation 1999). These are described in the following paragraphs; plant classification follows Wunderlin and Hansen, 2011, and species listings follow Schmalzer, Foster, and Duncan, 2002. Depending on the specific alternative chosen, different quantities of these land cover types may be impacted. Acreages potentially impacted for each alternative are given in Table 1.

Table 1. Acreages [ha (ac)] of the six major land cover types found within each Shoreline Protection Project alternative.

Land cover type	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**
beach and primary dune	0.1 (0.4)	9.8 (24.2)	2.3 (5.6)	0.1 (0.4)
coastal strand	5.4 (13.4)	5.3 (13.1)	10.9 (26.8)	5.4 (13.4)
ditch	0.2 (0.4)		0.1 (0.2)	0.2 (0.4)
marsh - saltwater	0.1 (0.2)			0.1 (0.2)
ruderal - herbaceous	7.8 (19.3)	0.1 (0.3)	2.2 (5.3)	7.8 (19.3)
water - interior - fresh	<0.1 (0.1)		0.1 (0.2)	

Beach and Primary Dune
Primary dunes are poorly stabilized deposits subjected to salt spray and wave action during storms. Depending on sediment supply, these dynamic habitats can be accreting (prograding beaches), or eroding (transgressional beaches), with seasonal variability depending on weather. Vegetation is primarily composed of colonizing species able to tolerate moving sands and the higher salinities found adjacent to the ocean. These include grasses such as sea oats (*Uniola paniculata*), bitter panic grass (*Panicum amarum*), and marsh hay cordgrass (*Spartina patens*). Additional species include railroad vine (*Ipomoea pes-caprae*), baybean (*Canavalia rosea*), seacoast marsh elder (*Iva imbricata*), and gulf croton (*Croton punctatus*). Two species of cacti, prickly-pear (*Opuntia humifusa*) and shell mound prickly-pear (*Opuntia stricta*), are common. In many areas, saw palmetto (*Serenoa repens*) is found extending to the dune crest.

There are no federally listed plant species present, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge (*Chamaesyce cumulicola*), beach-star (*Cyperus pedunculatus*), coastal vervain (*Glandularia maritima*), narrow-leaved hoary pea (*Tephrosia angustissima* var. *curtissii*), sea lavender (*Argusia gnaphalodes*), shell mound prickly-pear, and Scaevola (*Scaevola plumieri*).

Coastal Strand
Coastal strand is located adjacent to the beach zone. It is typically a densely vegetated shrub community subject to effects of salt spray and sand displacement resulting from storms (Schmalzer & Hinkle, 1985). Open patches of bare sand are common. The topography is comprised of higher dunes and inter-dune swales. In lower areas, these swales can contain wetland vegetation and standing water, providing habitat for wading birds and shore birds. Vegetation is primarily composed of shrubs including saw palmetto, sea grape (*Coccoloba uvifera*), wax myrtle (*Myrica cerifera*), nakedwood (*Myrcianthes fragrans*), and live oak (*Quercus virginiana*). These shrubs become more abundant and thick as distance from the primary dune increases. Two species of cacti, prickly-pear and shell mound prickly-pear, are also found in this habitat.

There are no federally listed plant species, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge, coastal vervain, east coast lantana (*Lantana depressa* var. *floridana*), narrow-leaved hoary pea, nakedwood, shell mound prickly-pear, and Scaevola.

Ditch
Ditches occur throughout KSC and were constructed to facilitate water movement away from facilities and roads. Ditches contain primarily fresh water, but when the nearby estuary water levels are high or there is overwash from the beach, brackish water can flow into the ditches. Increased salinity within ditches affects plant species composition by selecting for salt-tolerant species.

Typical plant species found within the ditches include the submersed widgeon grass (*Ruppia maritima*), and emergent species such as maidencane (*Panicum hemitomon*), pink red stem (*Ammannia latifolia*), herb-of-grace (*Bacopa monnieri*), sawgrass (*Cladium jamaicense*), spikerush (*Eleocharis* spp.), marsh penny wort, (*Hydrocotyle* spp.), southern cattail (*Typha domingensis*), and arrowhead (*Sagittaria lancifolia*). Ditch slopes and adjacent areas generally support ruderal – herbaceous species (see the description of ruderal - herbaceous habitat below).

There are no federally listed or state-listed plant species documented from the ditch habitat.

Saltwater Marsh
Salt marshes are found adjacent to the estuary. Most have altered hydrology and salinity due to impoundment for mosquito control that occurred in the 1960s (Schmalzer & Hinkle, 1985). Additionally, several decades of fire suppression and decreased fire frequency caused by landscape alterations have led to changes in plant species composition. Graminoid species are replaced by woody species where fire has been excluded from the landscape. Saltmarsh plant species usually occur in distinct zones due to factors such as environmental gradients or vegetative reproduction.

KSC is located within a broad biogeographic transition zone between the Carolinian and subtropical Caribbean biotic provinces (DeFreese 1995) and the vegetation present is a mixture of both zones. From KSC northward, salt marshes become increasingly dominated by graminoid vegetation, primarily smooth cordgrass (*Spartina alterniflora*) and needle rush (*Juncus* *roemerianus*). Mixed stands of saltgrass (*Distichlis spicata*), seashore paspalum (*Paspalum vaginatum*), both the annual and perennial glassworts (*Salicornia bigelovii* and *Sarcocornia perennis*, respectively), saltwort (*Batis maritima*), leather fern (*Acrostichum danaeifolium*), and sea oxeye daisy (*Borrichia frutescens*) are found throughout these marshes (Schmalzer & Hinkle, 1985; Montague & Wiegert, 1990). From KSC south, these plants are increasingly replaced by mangroves, which are essentially tropical plants. These include black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erecta*). All of these species are common at KSC and are found along lagoon shorelines and within impoundments (Schmalzer & Hinkle, 1985).

There are no federally listed plant species, but mangroves are protected by the State of Florida.

Ruderal – Herbaceous
Ruderal vegetation is found in areas disturbed by past or present land uses. This land cover is typically dominated by weedy native and introduced species. Typical plants include Brazilian pepper (*Schinus terebinthifolius*), wax myrtle, and grasses such as bluestem (*Andropogon* spp.), groundsel tree (*Baccharis halimifolia*), beggar ticks (*Bidens alba*), and common ragweed (*Ambrosia artemisiifolia*).

There are no federally or state-listed plant species documented from the ruderal-herbaceous land cover type.

Fresh Water – Interior
Interior freshwater marshes are found in various depressions, such as swales between relict dunes and littoral zones of old borrow ponds. Vegetation is primarily composed of obligate wetland species similar to those found in ditches (described above). However, the shoreline slopes tend to be less steep, allowing littoral zones of greater area that support more species diversity than present along ditches. Typical plant species include emergents such as maidencane, pink red stem, herb-of-grace, sawgrass, spikerush, softstem bulrush (*Schoenoplectus tabernaemontani*), marsh penny wort, southern cattail, and arrowhead. Various sedges are common in wet areas. Grasses include seashore paspalum, and the non-native torpedo grass (*Panicum repens*). Primrose willow (*Ludwigia* spp.) and Virginia saltmarsh mallow (*Kosteletzkya pentacarpos*) can be locally abundant.

There are no federally listed plant species in the type, but lace-lip ladies' tresses (*Spiranthes laciniata*), classified as a Threatened species in Florida, has been documented on CCAFS and might occur on KSC adjacent to freshwater wetlands (Schmalzer et al. 2002).

3.3 Existing/Proposed Projects within the Action Area

The following previous, on-going, and proposed projects within the action area could have affected or could potentially affect wildlife and/or habitats in the future:

Created Inland Dune
During the summer of 2010, an inland dune was constructed at a highly degraded site behind the primary dune between LC 39A and LC 39B, east of Phillips Parkway. The new dune is 221 m (725 ft) long, 24 m (80 ft) wide, and 4.6 m (15 ft) tall. The purpose of the dune was to improve

sea turtle nesting habitat by creating a natural visual screen between the beach and LC 39 facilities, and to improve southeastern beach mouse (*Peromyscus polionotus niveiventris*) habitat that was unproductive because of past disturbances. The stretch of primary dune adjacent to this area has been severely compromised in the past by activities associated with railroad operations, and during the last several years by wash overs and inundation from storm surges. Vegetation planting on the newly constructed dune occurred in April 2011 and was funded by the USFWS at MINWR through a grant from the National Fish and Wildlife Foundation for sea turtle management. Ecological monitoring was requested by the USFWS Endangered Species Office in Jacksonville in order to determine if and when southeastern beach mice would populate the new dune habitat. Monitoring surveys occurred in November 2011 and February, May, and August 2012. Fifty-five permanent vegetation plots are being sampled; 40% of the dune is vegetated (31% native desirable vegetation plus 9% nuisance species). Thirteen gopher tortoise burrows have been established and five tortoises inside burrows have been documented. Four species of small mammals have been trapped, including 52 individual southeastern beach mice, 25 of which were captured in two consecutive monitoring events, and 6 that were captured in three consecutive monitoring events. Ten other vertebrate species were documented on the dune, including an eastern indigo snake, which is a federally listed Threatened species. (Bolt et al. 2012).

Primary Dune Repair

In June 2011, MINWR supplied funding for equipment, labor, and materials to repair a breach in the primary dune adjacent to LC 39B, just north of the newly created inland dune (described above). The repair site was approximately 160 m (525 ft) long, 10 m (33 ft) wide, and 3 m (10 ft) in height above the existing grade of the beach. A grant to the USFWS from National Fish and Wildlife Foundation paid to furnish and install native plants on the repaired dune breach (R. Lloyd, pers. comm.).

Proposed Corrosion Test Facility Expansion

The Corrosion Test Facility (CTF) is 0.5 ha (1.3 ac) located on the primary dune 1 km (0.6 mi) north of the False Cape. The purpose of the CTF is to provide a site for exposure of a wide variety of structures and materials to the elements present along the Atlantic coast, and both government and commercial entities use the facility. The existing test beds are full and current customers have requested more room for test articles, and it is anticipated that new commercial companies will soon be requesting additional space as well. A proposal has been submitted to increase the footprint of the exposure test beds by 0.1 ha (0.2 ac). This expansion would run 91 m (300 ft) north/south and be located adjacent to the south end of the existing test beds. Habitats within the proposed expansion area are primarily well managed coastal dune and strand.

Section 4 Species Considered

Seven species of federally protected wildlife have been documented within the Shoreline Protection Project boundaries; one additional species historically occurred, but is no longer believed to be present. These eight species are listed in Table 2.

Table 2. Federally protected wildlife species documented to occur or occurred historically within the Shoreline Protection Project boundary.
Status: T - threatened; E - endangered; C - candidate for listing

Scientific Name	**Common Name**	**Status**	**Identification**
Caretta caretta	Loggerhead	T	documented
Chelonia mydas	Atlantic green turtle	E	documented
Dermochelys coriacea	Leatherback sea turtle	E	documented
Gopherus polyphemus	Gopher tortoise	C	documented
Drymarchon couperi	Eastern indigo snake	T	documented
Nerodia clarkii taeniata	Atlantic saltmarsh snake	T	historical
Aphelocoma coerulescens	Florida scrub-jay	T	documented
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	documented

4.1 Current Conditions

Marine Turtles
Three species of marine turtles have been documented using KSC beaches for nesting. The loggerhead (*Caretta caretta*) and green sea turtle (*Chelonia mydas*) are abundant during their nesting season (May – October) and numbers of leatherback (*Dermochelys coriacea*) nests have increased over the past 20+ years; they are no longer considered rare. The KSC nesting beach is 10 km (6.2 mi) long; the Shoreline Protection Project boundary consists of the northernmost 7.6 km (4.7 mi) (Figure 1). Some disorientation of marine turtles related to lighting from nighttime space operations has occurred along the KSC beach over the last decade. The USFWS Endangered Species Office issued an interim Biological Opinion (BO) in 2009 (U.S. Fish and Wildlife Service 2009) that was applicable for the 2009 - 2011 nesting seasons. This BO was based upon the review of lighting impacts and management activities on nesting sea turtles and emerging hatchlings. The resulting rate of take (i.e., hatchling disorientation) allowed by the BO was 3% (USFWS 2009).

Table 3 shows the number of nests, by species, deposited on the KSC beach from 2008 through 2011. Nesting "hot spots" are typically km 26-27 and 32-33 (Figure 2) (Gann, S.L. 2011). The area between km 30-31 has the highest percentage of false crawls (emergences that do not result in a nest); this location is also where the dune is most highly eroded and wash overs have occurred several times in the past few years (Coastal Planning & Engineering, Inc. 2011).

Table 3. Sea turtle nesting data from the Kennedy Space Center beach, 2008 – 2011.

Loggerheads	**2008**	**2009**	**2010**	**2011**
nests	1072	789	1163	1089
false crawls	826	734	869	776
total emergences	1898	1523	2032	1865
Green Turtles				
nests	104	53	142	176
false crawls	136	71	219	302
total emergences	240	124	361	478
Leatherbacks				
nests	1	2	6	3
false crawls	0	0	0	1
total emergences	1	2	6	4

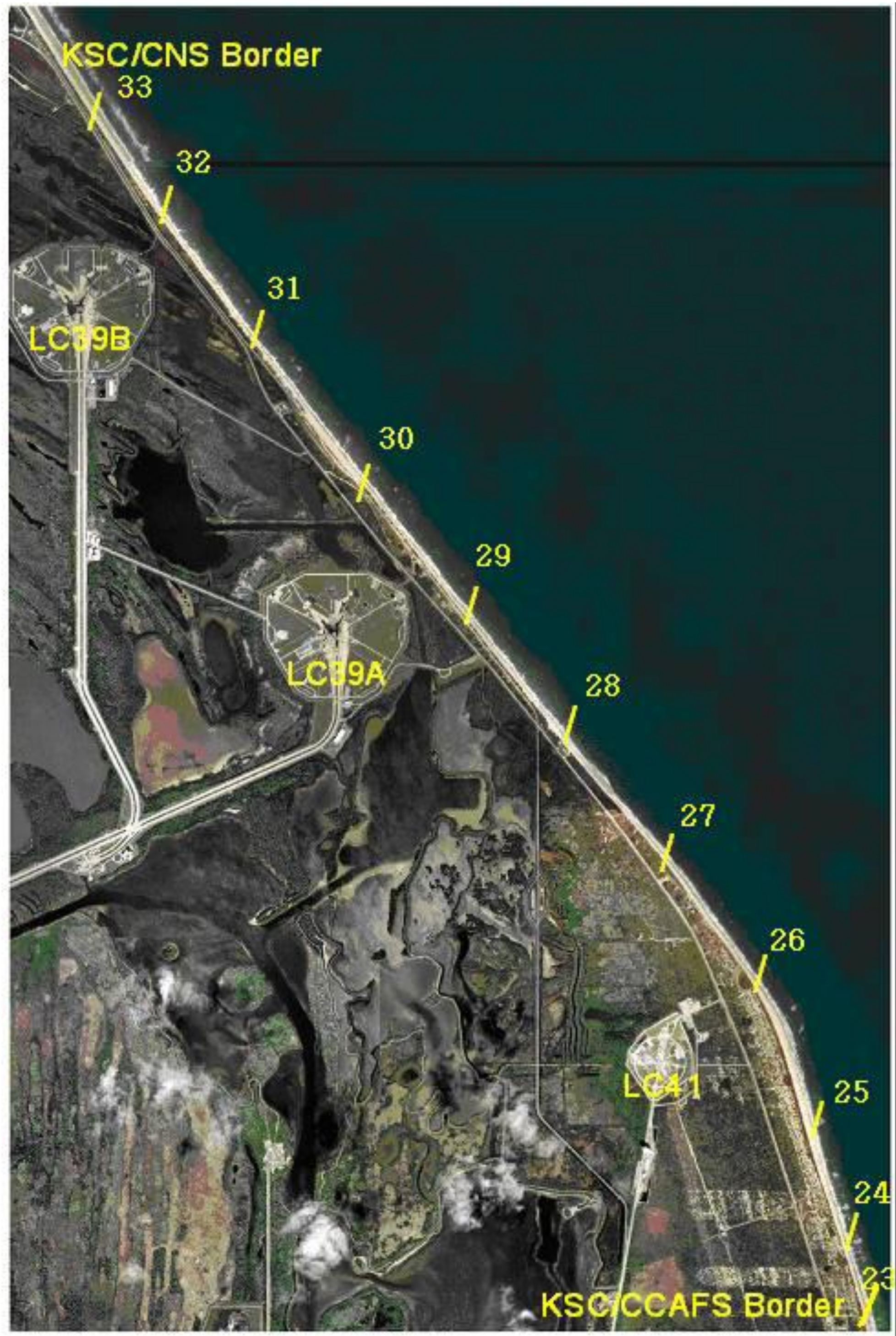

Figure 2. The Kennedy Space Center sea turtle nesting beach. Yellow numbers indicate the general locations of kilometer markers used for recording sea turtle nesting data for the Florida statewide Index Nesting Beach Survey.

Disorientation surveys for adults and hatchlings are performed every season. Adult disorientations for 2008, 2009, and 2010 were 0.3%, 0.4%, and 0.6%, respectively. Hatchling disorientation rates vary tremendously from year to year (Figure 3), depending on light pollution from facilities and the condition of the dunes between light sources and the nesting beach. The average rate for 2000 – 2009 is 5%, which is above the 3% take allowed by the interim BO issued in 2009. However, hatchling disorientation rates for 2008, 2009, and 2010 were 2.4%, 3.5%, and 2.4%, respectively, and it appears that the numerous activities and efforts being made to reduce impacts from lighting are improving conditions (Gann, S.L. 2011).

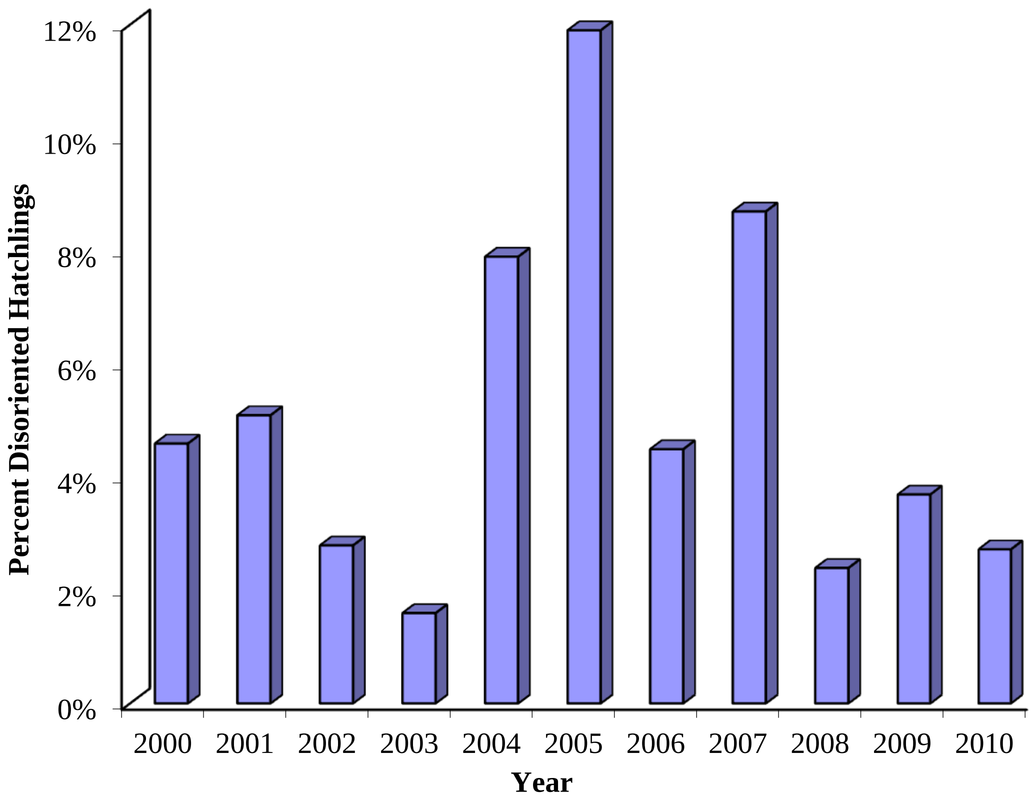

Figure 3. Disorientation rates of sea turtle hatchlings on the Kennedy Space Center beach for 2000 through 2010 nesting seasons.

Gopher Tortoise

The coastal dune habitat along the KSC shoreline is very suitable for gopher tortoises (*Gopherus polyphemus*). More than 1,000 tortoises have been captured, measured, and permanently marked from this area since the mid-1970s (R. Seigel, pers. comm.). Hatchling and juvenile tortoises are common, indicating a healthy, reproducing population. Studies to determine home range sizes have been done with radiotagged tortoises on KSC. Males' home ranges were between 0.3 and 5.3 ha (0.7 – 13.1 ac); the average size was 1.9 ha (4.7 ac) (Smith et al. 1997). Females' home ranges were smaller and they used between 0.3 and 1.1 ha (0.7 – 2.7 ac), with an average of 0.6 ha (1.5 ac). However, these studies were from scrub and scrubby flatwoods habitats where conditions are much different than those in coastal dune. KSC scrub and scrubby flatwoods have a dense shrub layer that tends to reduce the amount of light reaching the ground, which in turn reduces the herbaceous plant growth used as food by tortoises (Schmalzer and Hinkle 1992; Breininger et al. 1994). Tortoises in those less suitable habitats need larger home ranges in order to have sufficient resources (Ashton and Ashton 2008). The coastal dune is more open and the vegetation is primarily grasses and herbs, with plenty of documented species of tortoise food available (Ashton and Ashton 2008). Also, the soil of the coastal dune habitat is sandy and very suitable for burrowing. Because of these habitat characteristics, it is not surprising that the project area supports a large gopher tortoise population.

There are several man-made features within the project area that are potentially detrimental to tortoises. The railroad track is an effective trap for tortoises (and other turtle species) that crawl onto the tracks where they are flush with the road. Tortoises often cannot get out and will walk inside the tracks until they overheat or get too cold and die (B. Bolt pers. obs.; R. Seigel pers. obs.; Figure 4). Tortoise road kills are not unusual along Phillips Parkway because the tortoises feed on the grassy road shoulder and regularly cross the road. There are occasionally burrows on the shoulder that open directly onto the pavement. Another potentially unfavorable feature is the 0.5 ha (1.2 ac) of ditches in the project area. These ditches are narrow and extend over a long portion of the project, running parallel between the primary dune and the railroad track. In some places and under the right conditions, they are probably sufficient to hinder access by gopher tortoises to the various habitat types, resources, and other tortoises. All of these man-made features are likely harmful to the overall health and welfare of the tortoise population.

Figure 4. Shell from a gopher tortoise that was trapped inside the railroad tracks in the Shoreline Protection Project area, February 2012.

Eastern Indigo Snake

Eastern indigo snakes (*Drymarchon couperi*) on KSC have large home ranges, eat a wide variety of prey, and use many different habitat types (Stevenson et al. 2010, Breininger et al. 2011). Radio tagged indigos tracked in Brevard County between 1998 and 2002 had average home range sizes of 201.7 ha (498.4 ac) for males and 75.6 ha (186.8 ac) for females. A radio tagged indigo from KSC had a home range located just south of the Shoreline Protection Project area on CCAFS (Figure 5). This male's home range was 117.8 ha (291 ac) and he used habitat types that are found within the project area, including coastal dune. Indigos have been documented on several occasions in the Shoreline Restoration Project footprint (R. Bolt pers. obs.). A female was captured, measured, tagged with a Passive Integrated Transponders (PIT tag), and released in November 2011 from the newly created secondary dune (Bolt et al. 2012) (see Section 3.3 of this document for a description of the created inland dune project).

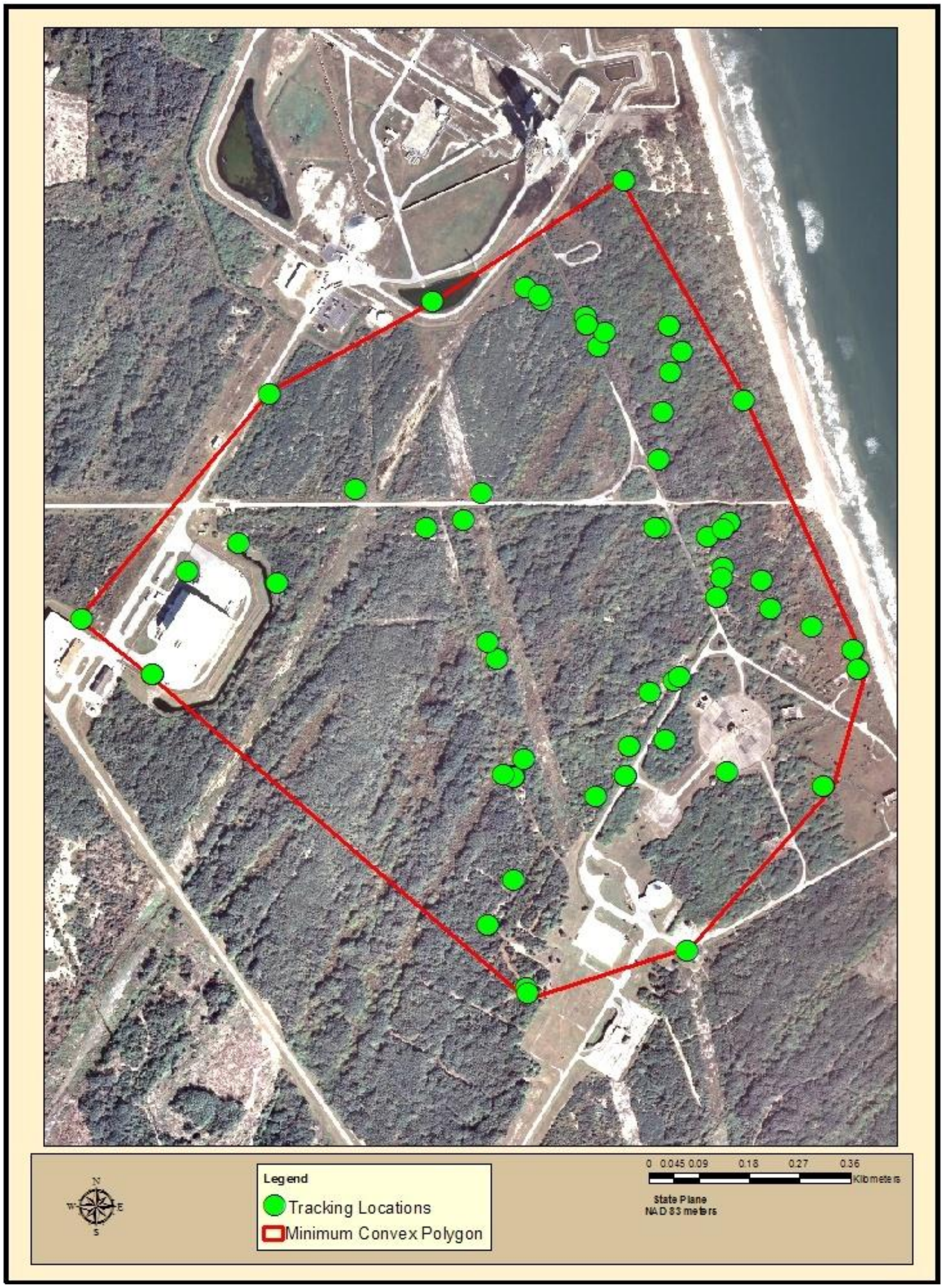

Figure 5. Radio tracking locations and the minimum convex polygon home range [117.8 ha (291 ac)] for a male eastern indigo snake tracked on Cape Canaveral Air Force Station just south of the Shoreline Protection Project boundary.

Habitat fragmentation was found to be a critical factor impacting indigo snake population persistence (Breininger et al. 2012). Snakes that occupied areas that were intact (i.e., less fragmented by roads and other features) had significantly higher survival rates than snakes living in places that were more highly fragmented (Breininger et al. 2004). The project area is relatively intact along the length of the shoreline. However, Phillips Parkway is a potential source of road mortality; road mortality was found to be the most prevalent cause of death in the radio tagged indigos studied in Brevard County (Breininger et al. 2012).

Atlantic Salt Marsh Snake

Although the Atlantic salt marsh (*Nerodia clarkii taeniata*) snake historically occurred along the coastline from Volusia County through Brevard County south into Indian River County, it is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2005). Specimens found in Brevard and Indian River counties are believed to be intergrades between the Atlantic subspecies and the mangrove salt marsh snake (P. Moler pers. comm.). Little is known about the population size or status of Atlantic salt marsh snakes, but none are expected to occur within the project area.

Florida scrub-jay

Within the project area, there are 45.5 ha (112.4 ac) of coastal strand habitat that could potentially support Florida scrub-jays (*Aphelocoma coerulescens coerulescens*). However, in order for scrub-jays to occupy the habitat and persist, the habitat must have a narrow range of characteristics related to vegetation height and open space (Johnson et al. 2011). These conditions were historically maintained by wildfires, and along the coastline, by salt spray. Now, scrub-jay habitat types are typically kept suitable through controlled burning and mechanical treatment, although little controlled burning is done along the coast.

Depending on the alternative chosen for the Shoreline Protection Project (except for No Action), between 5.3 ha (13.1 ac) and 10.9 ha (26.8 ac) of coastal strand would be impacted. Most of the coastal strand within the project area does not support jays (Figure 6), likely because there is too little scrub oak of the appropriate height. There are two territories that have been documented on the southern end of the project area; territory A is 33.6 ha (83 ac) with two jays and territory B is 23.4 ha (57.8 ac) with four jays (Figure 6; G. Carter pers. comm.).

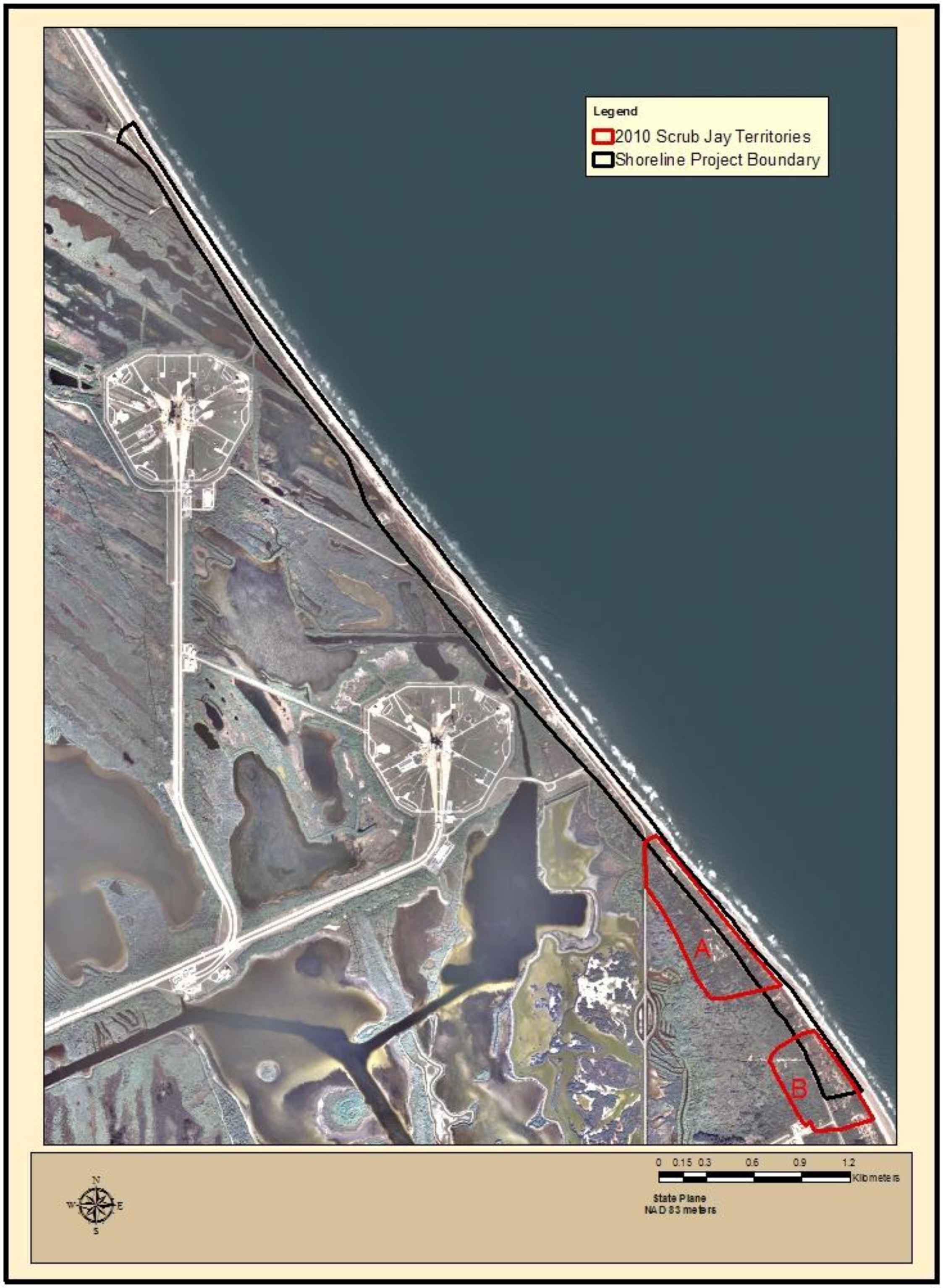

Figure 6. Florida scrub-jay territories located within the Shoreline Restoration Project boundary in 2010.

Southeastern beach mouse

Studies and surveys have been done on the southeastern beach mouse (*Peromyscus polionotus niveiventris*) population on KSC since the 1970s. Populations appear to have remained stable over the years, likely due to the continuity of the habitat (CNS/KSC/CCAFS) that allows recolonization when subpopulations are extirpated by natural incidents. Four seasonal trapping events done between 2003 and 2005 at seven transects located in the Shoreline Restoration Project area yielded results similar to previous studies (Provancha et al 2005). Capture rates of beach mice were good, but less than those experienced further south on CCAFS where the expanse of suitable habitat is much wider. Age classes captured included mostly adults, but also sub-adults and juveniles; many of the adults from each trapping event were in reproductive condition. Subsequent studies using tracking tubes that record footprints of mice indicated that beach mice are distributed along the entire coastline of the project area (Figure 7; E. Stolen pers. comm.).

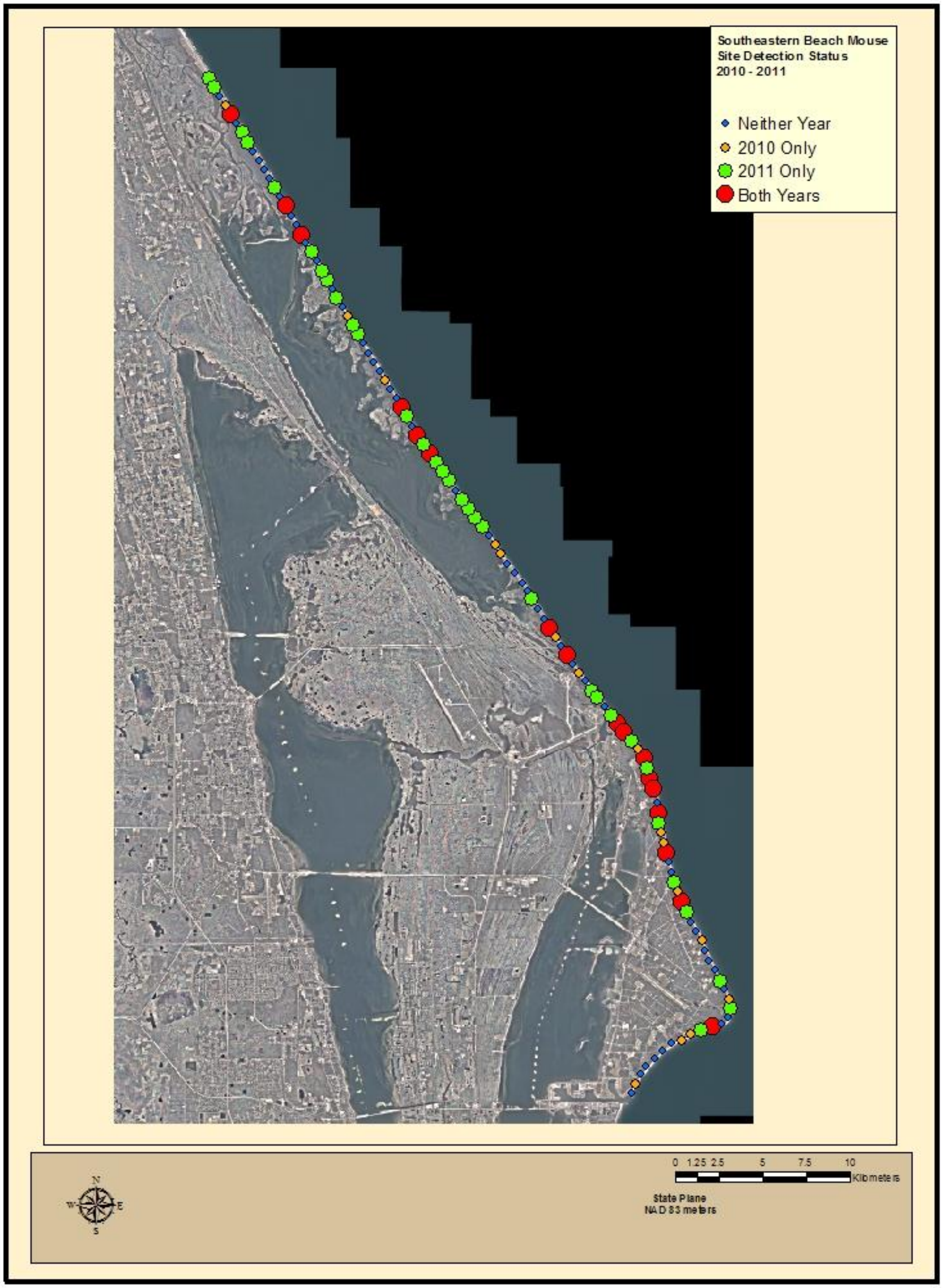

Figure 7. Detections via tracking tubes of southeastern beach mice on Canaveral National Seashore, Kennedy Space Center, and Cape Canaveral Air Force Station, 2010 and 2011.

Over the last 10 to 15 years, several significant hurricane and non-hurricane storm events resulted in over wash and severe erosion of the KSC dunes and beach (Coastal Planning & Engineering, Inc. 2011). In August and September 2004, three hurricanes directly hit Florida, and each affected the Shoreline Restoration Project area either by rainfall, winds and/or serious beach erosion. One of the transects established for the 2003-2005 beach mouse trapping study experienced overwash that eliminated much of the vegetation and some of the trapping stations; the primary dune at two other transects was eroded approximately 2 m (6.6 ft) on the ocean side. Sampling was conducted three weeks after the last storm, but no conclusions could be made as to the impact of the storm damage on beach mouse populations. Mice were trapped at all sampling locations, although numbers were lower at the transect that lost much of its vegetation (Provancha et al. 2005). Significant storms also caused damage within the project area in 2007 and 2008, but there were no corresponding mouse trapping surveys done after those storms. In 2005 and 2008, dune restoration projects were implemented to repair breaches and rebuild dune height in order to protect the beach from lighting from nearby facilities that could potentially disorient marine turtles. Sand was acquired on-site, either by digging out from the landward side of the primary dune (creating ditches and swales) or pulling sand from the ocean side. It is unknown how long the impacts from such activities will affect beach mouse populations, but these impacts are expected to be short term. Monitoring of a newly created secondary dune (see Section 3.3 of this document for a description of the created inland dune project) showed that at least 33 individual beach mice of all age classes were occupying the new dune within ten months of the bare sand being planted with native vegetation (Bolt et al. 2012).

As with the gopher tortoise, the railroad track and ditches located west of the primary dune may be impediments to beach mouse movements, obstructing access to habitat, as well as other sub-populations. If primary dune habitat is destroyed by storm surges, recolonization of those areas may be slowed down or prevented in areas where the railroad track and/or ditches hamper movement of mice from more inland populations.

Section 5 Impacts Analysis

Depending on the shoreline protection alternative chosen, or no action, impacts would differ for the seven federally protected wildlife species known to occur within the Shoreline Protection Project boundaries. Table 4 shows the potential impacts for each species for each action alternative and if no action is taken. These impacts are further broken down by impacts from construction (C) and the anticipated long-term impacts (L-t).

Table 4. Impact categories matrix for seven federally protected wildlife species documented as occurring within the Shoreline Protection Project boundaries on Kennedy Space Center. C = Construction impacts; L-t = Long-term impacts (i.e., after recovery from construction); Alternative descriptions and Impact Category descriptions are given below the table.

Species	Alt. 1		Alt. 2		Alt. 3		Alt. 4		No Action
	C	L-t	C	L-t	C	L-t	C	L-t	
Marine turtles	1	4	2	4	2	4	2	4	2
Gopher tortoise	2	4	2	4	2	4	2	4	2
Eastern indigo snake	2	4	2	4	2	4	2	4	2
Florida scrub-jay	2	4	2	4	2	4	2	4	2
Southeastern beach mouse	2	4	2	4	2	4	2	4	2

Alternative Descriptions (see Section 2 for more detail):

- Alternative 1 involves construction of a large secondary dune behind existing primary dunes in areas where the primary dunes are highly eroded or non-existent.
- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 15-20 years ago. The primary dunes would be reinforced as needed.
- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative, the entire primary dune would be reconstructed or reinforced.
- Alternative 4 is a hybrid of proposed Alternatives 1, 2, and 3.

Impact Category Descriptions:

1. Minimal – impacts are not expected to be measurable, or are too small to cause any discernable degradation to the environment
2. Moderate – impacts would be measureable, but not substantial, because the impacted system is capable of absorbing the change, or impacts could be reduced through appropriate mitigation
3. Major – impacts could individually or cumulatively be substantial

4. Beneficial – impacts would be positive in nature

5.1 Construction Impacts

Alternative 1 - Construction impacts to marine turtles are expected to be minimal because none of the work would be done on the beach. Most of the secondary dune would be constructed on the west side of the primary dune. In areas where the primary dune is severely degraded, the secondary dune would be extended eastward to the beach to replace the primary dune. For the other four species, construction impacts are predicted to be moderate because of the loss of coastal dune habitat from the placement of sand for the dune.

Alternative 2 - Impacts to all seven species are expected to be moderate. Construction would be limited to the beach, except where the primary dune is already severely degraded. No sand would be placed on the beach during the marine turtle nesting season so as to avoid disrupting adult females coming to shore or covering existing nests.

Alternative 3 – In this alternative, the entire primary dune would be rebuilt, or at least reinforced. Therefore, impacts to all species are expected to be the same for Alternative 3 as they would be for Alternative 2 (moderate).

Alternative 4 – This alternative is a combination of the other three alternatives, so construction impacts to all species would be moderate.

No cumulative impacts are expected to occur from construction, regardless of the alternative chosen. Once construction was completed, the habitat would recover to a condition that was at least the same, if not improved, as compared to pre-construction conditions.

5.2 Long-term Impacts

Regardless of the action alternative chosen, long-term impacts are anticipated to be beneficial. The beach and primary dune are expected to continue to degrade over time (Coastal Planning & Engineering 2011) and intervention of some sort will be necessary if the beach and dune habitats are to persist. Alternative 1 represents a managed retreat scenario in which resources are put into providing new habitat away from the source of degradation (i.e., the ocean). Initial results from the secondary dune created in 2010-2011(see Section 3 for a more detailed description) indicate that in less than one year after the original construction, the created secondary dune has become a functioning ecosystem. Alternatives 2 and 3 are stop-gap measures designed to buy time before the eventual destruction of the beach and primary dune system; both of these alternatives would require maintenance every six to ten years to continue to be useful. Alternative 4 would provide both short-term and long-term benefits after recovery from the initial construction.

Cumulative long-term impacts from Alternative 1 are expected to be beneficial as new habitat is created and becomes self-sustaining. Alternatives 2, 3, and 4 are also expected to produce long-term beneficial cumulative impacts, but will require periodic maintenance to ensure the continued integrity of the beach and primary dune. In the event of intense or persistent storm events, additional maintenance may be required.

5.3 No Action

Failure to take any action would result in the continued degradation and loss of the beach and inland dune habitats, as well as the wildlife that depends on them. These impacts would likely take decades to manifest, so would be classified as moderate for the time-scale of this assessment.

Section 6 Conservation Measures

A variety of conservation measures designed to lessen impacts of the restoration activities are being proposed. These include:

- Work that directly impacts the beach will be done from November 1 through the end of February, outside the sea turtle nesting/hatching season.
- Work that occurs in areas other than the beach will only occur in daylight hours during the sea turtle nesting/hatching season to avoid light pollution from construction activities.
- Laydown sites for equipment and materials will be carefully chosen and placed in already developed areas or degraded habitat, as will access points between the existing road (Phillips Parkway) and construction sites. The number and size of the areas will be dependent on the alternative chosen.
- Activities will be limited as much as possible to areas that are degraded with little value as wildlife habitat. There may be instances, depending on the alternative chosen, when impacts to habitats that are potentially occupied by protected species are unavoidable. Reasonable efforts will be made to relocate southeastern beach mice (*Peromyscus polionotus niveiventris*) and gopher tortoises (*Gopherus polyphemus*) from those areas to nearby suitable habitat.
- Beach restoration that most closely approximates the historic, natural conditions will be attempted. The beach fill slope will be designed to a) promote nesting by marine turtles, b) block artificial light from reaching the beach and disorienting nesting marine turtles and hatchlings, and c) reduce the threat of back beach flooding.

The Shoreline Protection Project, regardless of the alternative chosen (other than No Action), would have a positive effect on conservation of wildlife habitat, once the area has recovered from the initial restoration work. The No Action alternative would allow the continued erosion of the beach and inundation of back dune areas, compromising space operations-related infrastructure and degrading and eventually destroying vital wildlife habitat.

Section 7 Determination of Effects

Compliance with Section 7 of the Endangered Species Act dictates that the impacts (i.e., effects) to the protected wildlife species for each alternative and the No Action alternative be determined so that the appropriate response from the USFWS can be initiated. Below are the descriptions for the effects that are applicable for this BA, and the Alternatives descriptions:

Effects Descriptions

- "May affect, but not likely to adversely affect" – All effects are beneficial, insignificant, or discountable, or can be made so by using conservation-oriented construction practices and/or mitigation.
- "May affect, and is likely to adversely affect" – Protected species are likely to be impacted by the action or its environmental consequences, and will respond in a negative manner.

Alternatives Descriptions (see Section 2 for more detail):

- Alternative 1 involves construction of a large secondary dune behind existing primary dunes in areas where the primary dunes are highly eroded or non-existent.
- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 15-20 years ago. The primary dunes would be reinforced as needed.
- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative, the entire primary dune would be reconstructed or reinforced.
- Alternative 4 is a hybrid of Alternatives 1, 2, and 3.

Below, a determination of effects is made for the seven species for each of the four alternatives (construction impacts and long-term impacts), and the No Action alternative in the Shoreline Protection Project. Marine turtles are combined into one group as the impacts to them are expected to be the same for the three species. Gopher tortoises, eastern indigo snakes, Florida scrub-jays, and southeastern beach mice are also grouped together; impacts to them from all of the alternatives are anticipated to be very similar.

Marine Turtles

Anticipated impacts from construction of any of the four alternatives are either minimal or moderate, and are not expected to adversely affect marine turtles. Construction done on the beach habitat itself (Alternatives 2, 3, or 4) would be done outside of the marine turtle nesting season. Any material added to the beach would first be deemed compatible with current sand conditions, and the construction would be done in such a way as to mimic the historic beach profile. Although declines in the number of marine turtle nests have been documented during the first season after restoration, this phenomenon appears to be short-lived (Brock et al. 2007; Rumbold et al. 2001).

Long-term impacts from any of the four action alternatives would be anticipated to be beneficial because the continued degradation of the shoreline without intervention will eventually result in loss of the nesting beach (Coastal Planning and Engineering, 2011).

Gopher Tortoise, Eastern Indigo Snake, Florida Scrub-jay, Southeastern Beach Mouse
Construction impacts to these species would be from direct loss of habitat and are not expected to have adverse effects. If Alternative 1, 3, or 4 were chosen, much of the existing primary dune would be covered with new sand and then planted. Impacts would be measurable (moderate), but could be reduced through a variety of conservation-oriented construction practices and mitigation. If Alternative 2 were chosen, most of the construction would occur on the beach and the existing primary dune would only be restored in areas where it is already severely degraded.

As with the marine turtles, long-term impacts from any of the action alternatives would be beneficial once there was recovery from the initial construction. Results from the created inland dune project (see Section 3.3 for details) indicate that ecosystem recovery can occur quickly (less than one year) once the bare sand is planted with vegetation (Bolt et al. 2012).

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