

**Pinellas County Shore Protection Project
Comprehensive Borrow Area Study
Borrow Area Resource Identification and
Impact Assessment**



May 2002

**Prepared for:
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U.S. Army Corps of Engineers
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EXECUTIVE SUMMARY

Dial Cordy and Associates, Inc. (DC&A) was contracted by the U.S. Army Corps of Engineers (USACE) to conduct a biological survey of proposed borrow areas in conjunction with the Pinellas County Shore Protection Project. To accommodate future nourishment projects, nine offshore borrow areas and four ebb tidal shoals have been identified for consideration as probable borrow sites. These sites were surveyed and the results discussed herein. DC&A conducted field investigations to locate, delineate, and characterize existing hardground and/or other benthic community resources within the proposed borrow areas. Marine resources were mapped and documented with underwater still and video photography. The field survey was conducted during July-September 2001. This report analyzes the potential direct and indirect impacts associated with removing borrow material from each of the proposed offshore borrow sites. Within each area there may be more than one potential borrow site. Potential borrow sites were determined from mapping and groundtruthing conducted by EMC Corporation (1998) and DC&A (2001). Impacts to benthic and pelagic communities could be considered as relatively minimal when examined on a spatial scale. Since construction of Pinellas County nourishment projects will most likely be staggered over time, biological communities common to the soft bottom habitat in the borrow areas will have time to recover. No significant or adverse impacts are expected to occur to hardbottom resources as a 200-foot buffer from adjacent hardbottom habitat has been established for each borrow site.

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1.0 INTRODUCTION

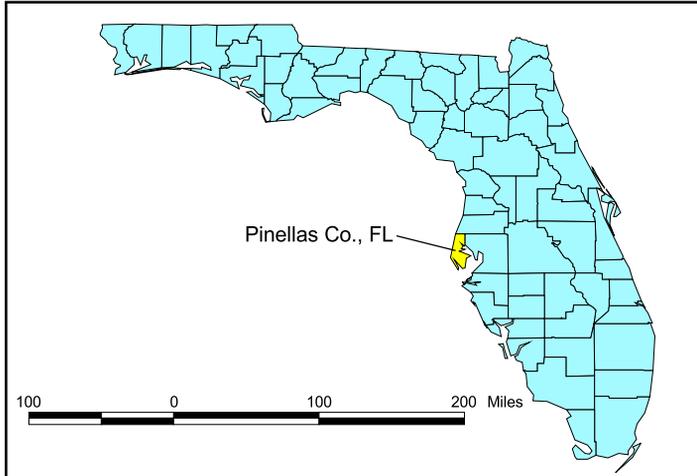
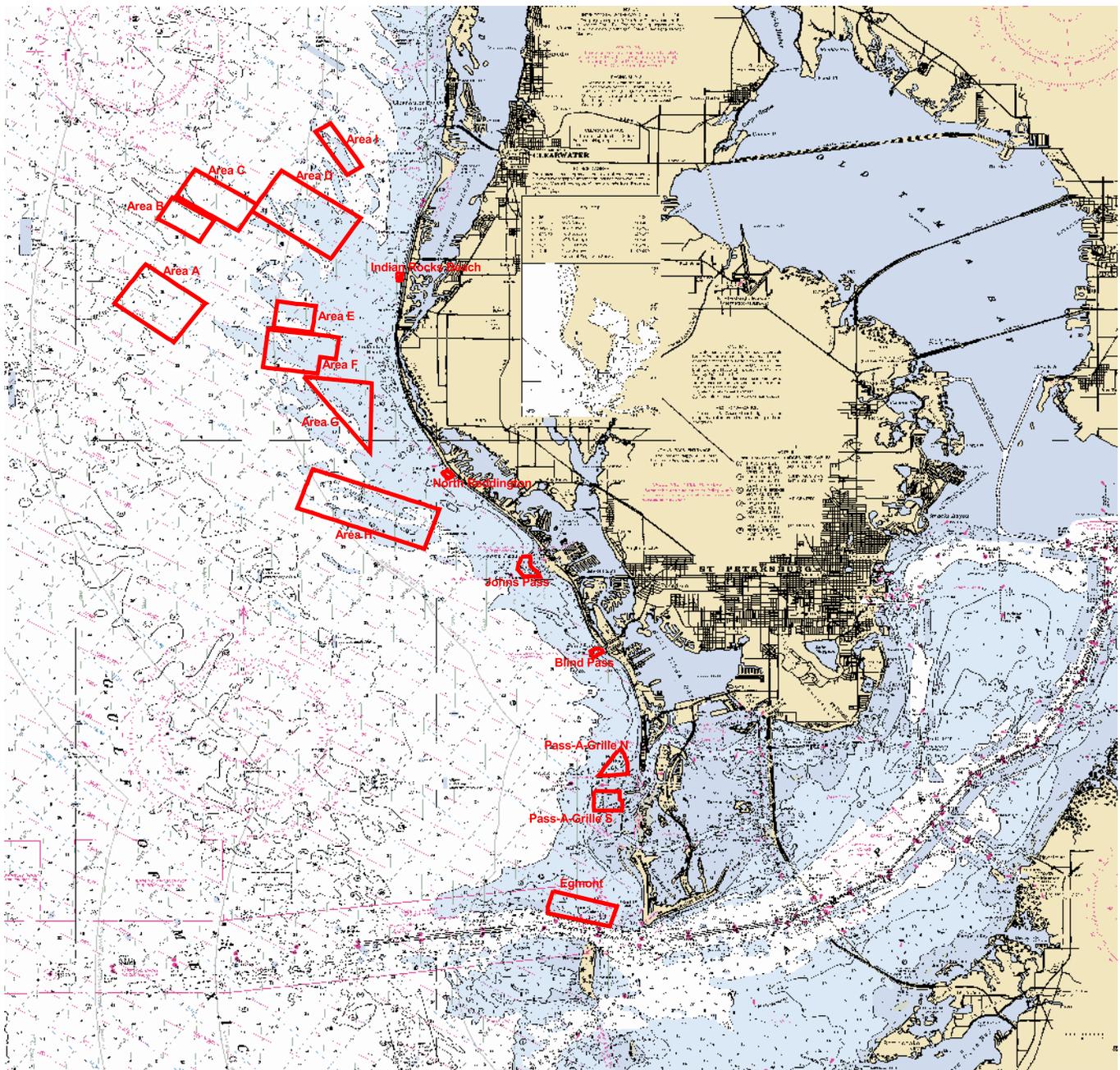
Dial Cordy and Associates, Inc. (DC&A) was contracted by the U.S. Army Corps of Engineers (USACE) to conduct a biological survey of proposed borrow areas in conjunction with the Pinellas County Shore Protection Project (DC&A, 2001). This report assesses the impacts to these biological resources. This work was conducted under contract No. DACW17-01-F-0060.

1.1 Purpose and Need

The barrier island beaches of Pinellas County, Florida have had serious problems with shoreline erosion and a lowered beach profile caused by storms, wave action, and currents. As a means of controlling this erosion and increasing storm protection to the island, fill material has been placed along the shoreline. Recent fill projects have included Clearwater Beach, Mullet Key, Treasure Island, Sand Key, and Long Key. Traditionally, the material for these and other Pinellas County Shore Protection projects was obtained from Egmont Channel Shoal, which involved moving the sand a considerable distance (11-25 miles). To accommodate future nourishment projects, nine potential offshore borrow areas and four ebb tidal shoals have been identified. These sites were surveyed and the results discussed in DC&A, 2001.

1.2 Location

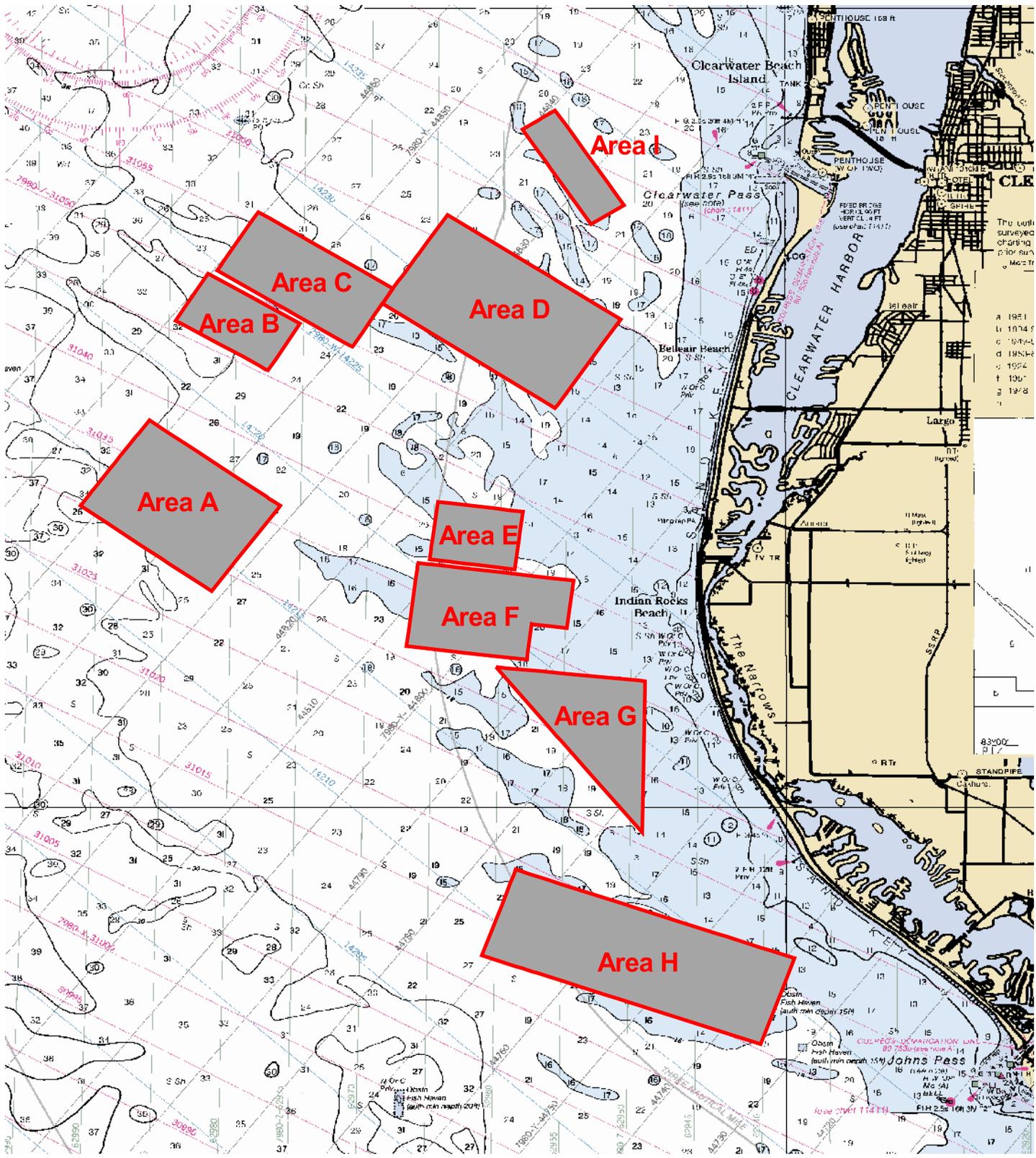
The project area surveyed is located off the Gulf of Mexico coast of Florida, Pinellas County Florida (Figure 1). Specifically, the investigation included nine potential offshore borrow areas (Figure 2) and five ebb tidal shoals (Figure 3).



 Pinellas County Marine Biological Survey Areas



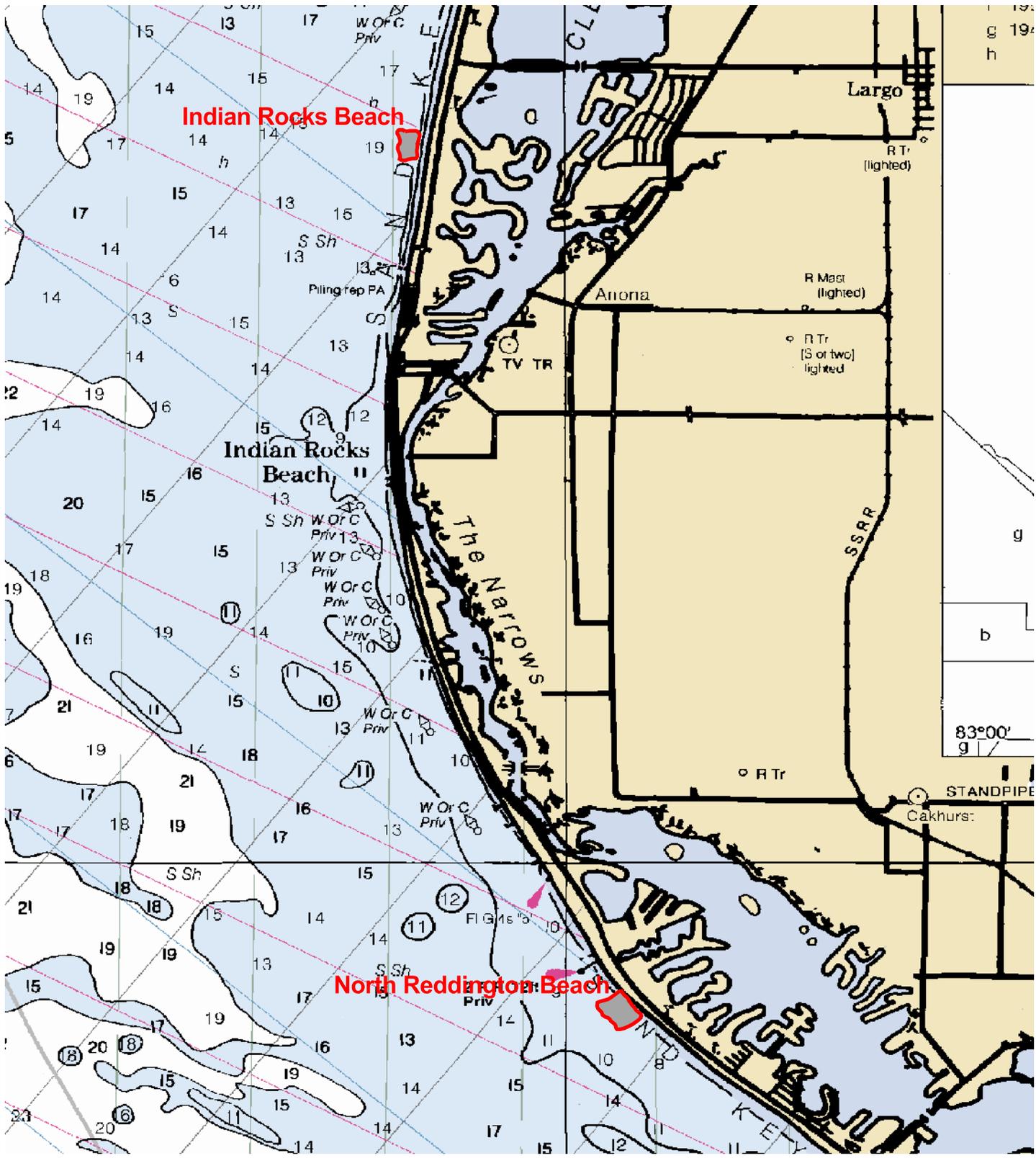
Location Map	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 5 miles	Drawn By: MR
Date: February, 2002	
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	Figure 1



 Offshore Borrow Areas



Offshore Areas	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 2 miles	Drawn By: MR
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	J01-493 Figure 2



 Nearshore Breakwater Areas



Nearshore Areas	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 1 mile	Drawn By: MR
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	Figure 3

2.0 TECHNICAL APPROACH

DC&A (2001) conducted field investigations to locate, delineate, and characterize existing hardground and/or other benthic community resources within the proposed borrow areas. Marine resources were mapped and documented with underwater still and video photography. The field survey was conducted during July-September 2001.

The purpose of this survey was to verify and groundtruth existing side-scan records (EMC, 1998). Prior side-scan mapping recorded extensive areas of consolidated material within each of the proposed borrow areas (2,309 acres). This survey was used to map and characterize the extent of marine resources in relation to the previous side-scan survey.

Hardbottom resources within each respective borrow area were mapped and a 200-foot buffer established around each resource area. Sand areas within the borrow areas were then identified and isopach contours of available sand were analyzed to approximate the total amount of available borrow material available within each borrow area. Isopach contours were provided by the USACE from previous geo-technical analysis. An analysis of the impacts associated with sand removal within each area is assessed in the following sections.

3.0 MARINE RESOURCE IMPACT ANALYSIS

This section will analyze the potential direct and indirect impacts associated with removing borrow material from each of the potential offshore borrow sites. Within each area there may be more than one potential borrow site. Potential borrow sites were determined from mapping and groundtruthing conducted by EMC Corporation (1998) and DC&A (2001).

3.1 Overview of Borrow Area Resources

A total of nine offshore borrow areas, representing a total of 13,829 acres was surveyed. Within these areas, over 75 percent of the habitat surveyed was open sand (10,000.4 acres) while the remaining 3,828.6 acres consisted of hardbottom habitats.

The water depths of these potential borrow areas varied from 20 to 33 feet. Lyons and Collard (1974) describe these communities as areas of moderate wave energy with quartz sand and shell fragment sediments extending offshore. Large temperate molluscs and echinoderms tend to be the dominant faunal elements. In areas over 33 feet in depth, exposed rock substrate allows for the establishment of scleractinians, molluscs, crustaceans, tunicates, and other species more common to shallower waters of south Florida (Lyons and Collard, 1974). Quartz sand, with biologically influenced carbonates present, also dominates the sediments within this area.

3.2 Offshore Borrow Areas

This section summarizes the potential sand sources for each offshore borrow area. A summary of available sand resources is found in Table 1.

Table 1 Volume of Potential Borrow Material Located Within Each Borrow Area

Borrow Area	Minimum Sand Depth (ft)				Total (Area)
	2 ft	4 ft	6 ft	8 ft	
Borrow Area A	885,129 CY	572,212 CY	144,778 CY	1,612,730 CY	1,612,730 CY
Borrow Area B	562,177 CY	7,016 CY	76,881 CY	-	646,074 CY
Borrow Area C	974,282 CY	318,315 CY	156,882 CY	71,043 CY	1,520,522 CY
Borrow Area D	2,693,648 CY	532,873 CY	609,153 CY	43,312 CY	3,878,986 CY
Borrow Area E	407,460 CY	419,150 CY	106,414 CY	286,746 CY	1,219,770 CY
Borrow Area F	1,558,533 CY	33,517 CY	207,630 CY	-	1,799,680 CY
Borrow Area G	689,243 CY	583,858 CY	256,006 CY	9,879 CY	1,538,986 CY
Borrow Area H	1,332,821 CY	775,733 CY	371,455 CY	253,535 CY	2,733,544 CY
Borrow Area I	183,793 CY	49,141 CY	121,575 CY	-	354,509 CY
Total (isopach)	9,287,086 CY	3,291,815 CY	2,050,774 CY	675,126 CY	15,304,801 CY

3.2.1 Borrow Area A

Offshore Borrow Area A lies six miles offshore of Indian Rocks Beach, FL. This borrow area encompasses 2,030 acres, of which 1,153 acres are sand, and 877 acres of area is exposed hardbottom habitat (Figure 4).

3.2.1.1 Available Borrow Material

Within Borrow Area A, there is a total of 1,612,730 cubic yards (CY) of potential borrow material (Table 1). This volume was determined by using the minimum depth as determined from the isopach contours. Open sand habitat areas within Area A that have a minimum sand depth of 4 feet or greater consists of 727,601 CY of material (Table 1).

3.2.2 Borrow Area B

Borrow Area B is a 703.8-acre block located 5.6 nautical miles offshore of Bellair Beach, FL. Figure 5 shows the relative layout of sand and exposed hardbottom. Within Area B there is 210.3 acres of hardbottom compared to 493.5 acres of open sand habitat

3.2.2.1 Available Borrow Material

Borrow Area B has a total of 493.5 acres of open sand habitat. Analyses of sand habitats that exist outside the 200-foot buffer include a total of 646,074 CY of material. The majority of the sand available within Area B has a minimum depth of 2 feet (Table 1). Potential borrow areas within Area B with a minimum depth of 4 feet or greater have a total of 83,897 CY of material available. The majority of these sand resources are located in the central portion of Area B (Figure 5).

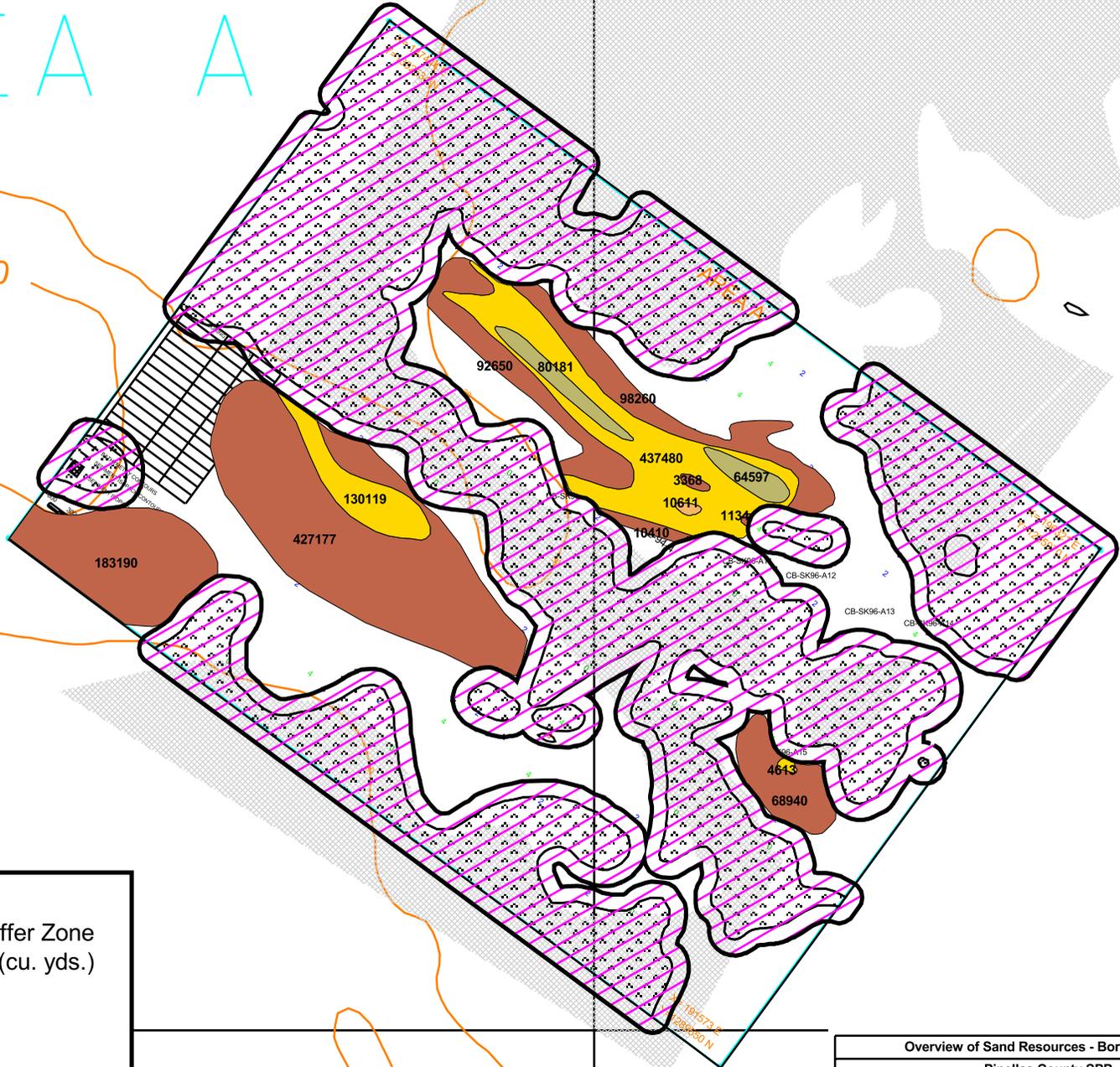
3.2.3 Borrow Area C

Five miles west of Bellair Beach is Borrow Area C. Area C lies in approximately 20-25 feet of water and has a total area of 1,363.7 acres. Within this area, 1,055.7 acres is open sand, while the remaining 308 acres is composed of exposed rock/live bottom habitat (Figure 6).

3.2.3.1 Available Borrow Material

A total of 1,520,522 CY of sand are available within Borrow Area C. The majority of these sand resources have a minimum depth of between 2-4 feet. A total of 546,240 CY of material is available in areas with a minimum depth of 4 feet (Table 1). This material is located in the southern portion of the borrow area (Figure 6).

AREA A



Area A

LEGEND

-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

2000 0 2000 4000 Feet



Overview of Sand Resources - Borrow Area A	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 2,000'	Drawn By: MR
Date: February, 2002	
	
	J01-493
	Figure 4

Area C



LEGEND

-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

1500 0 1500 3000 Feet



Overview of Sand Resources - Borrow Area C

Pinellas County SPP
Borrow Area Resource Identification
and Impact Assessment

Scale: 1" = 1,500' Drawn By: MR

Date: February, 2002

 DIAL CORDY AND ASSOCIATES INC. <small>Environmental Consultants</small>	J01-493 Figure 6
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3.2.4 Borrow Area D

Borrow Area D lies 2.8 nautical miles offshore of Bellair Beach in the northern portion of the study area (Figure 2). Area D contains 2,653.7 acres of bottom with 1,819.2 acres of sand and 834.5 acres of hardbottom habitats (Figure 7). Area D has the second most available acres of open sand habitat of the nine offshore borrow areas surveyed.

3.2.4.1 Available Borrow Material

Borrow Area D has the largest amount of potential borrow material (3,878,986 CY) of the nine offshore borrow areas mapped. Over 2.6 MCY of this material is composed of a sand layer that has a sediment depth of between 2 feet and 4 feet. Sediment layers with a minimum depth of 4 feet or greater, total 1,185,338 CY (Table 1). A majority of this material is accessible in the northeastern corner of the borrow area away from many of the hardbottom resources (Figure 7).

3.2.5 Borrow Area E

Offshore Borrow Area E is the second smallest area surveyed at 592.7 acres (Figure 8). Within this area, the survey revealed 201.8 acres and 390.9 acres of hardbottom and open sand habitat, respectively. Borrow Area E is 2.5 miles west of Indian Rocks Beach.

3.2.5.1 Available Borrow Material

Available borrow material within Borrow Area E totals 1,219,770 CY. Although Area E is a relatively small area, a large amount of potential borrow material exists there. Sand resources within this borrow area are located primarily in the center portion of the study area (Figure 8). Sand areas with depths of at least 4 feet total 419,150 CY while an additional 393,160 CY of material is located in isopach contours of over 6 feet in depth (Table 1).

3.2.6 Borrow Area F

Directly south of Area E is 1,410.5-acre Area F (Figure 2). Habitat distribution within this area consists of a total of 315 acres of hardbottom habitat and 1,095.6 acres of open sand (Figure 9).

Area D

COE-94-21

LEGEND

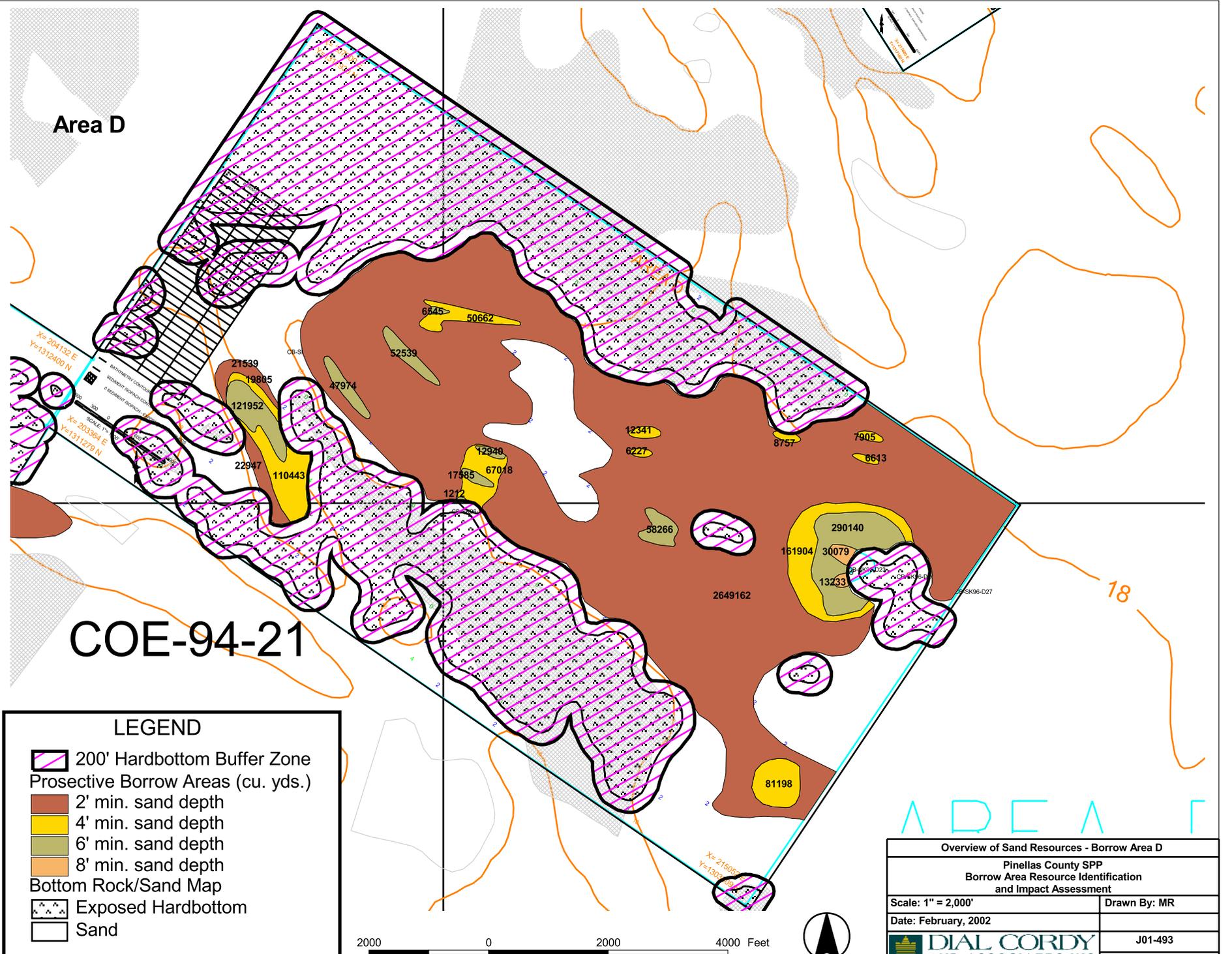
-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

2000 0 2000 4000 Feet



ADCA

Overview of Sand Resources - Borrow Area D	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 2,000'	Drawn By: MR
Date: February, 2002	
 DIAL CORDY AND ASSOCIATES INC. <small>Инженерная Компания</small>	
	J01-493 Figure 7



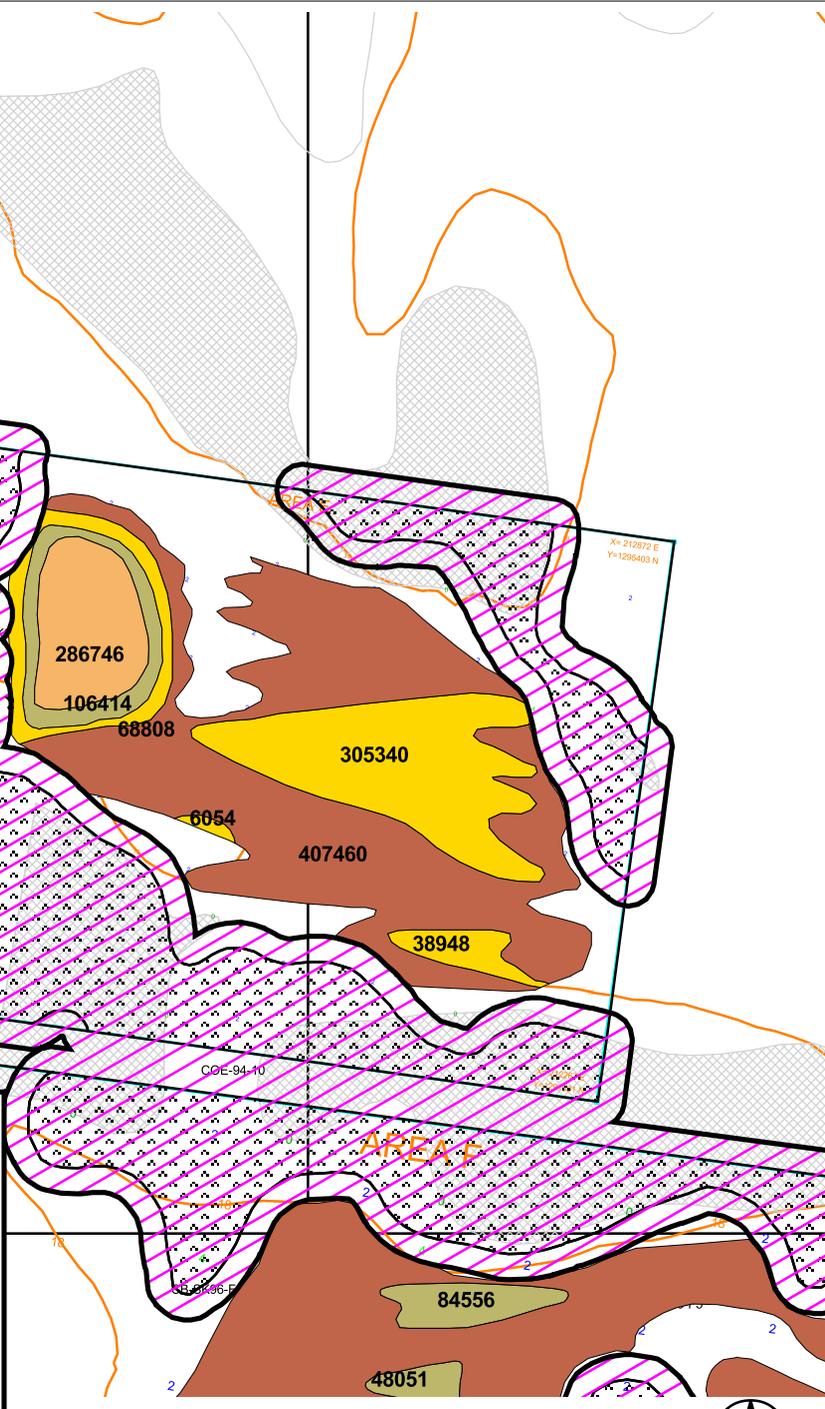
Area E

78

ARE

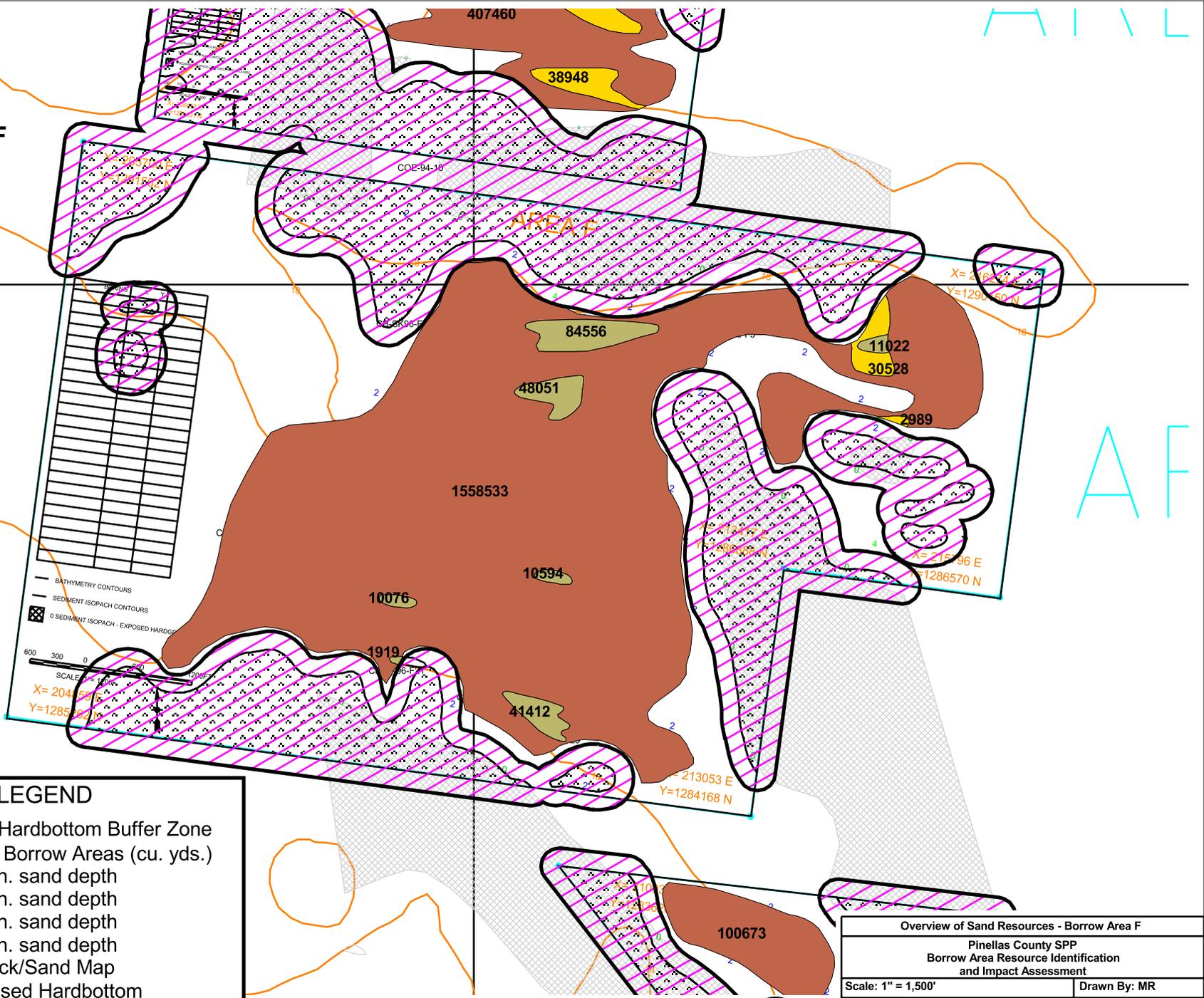
LEGEND

-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand



Overview of Sand Resources - Borrow Area E	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 1,500'	Drawn By: MR
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Area F



LEGEND

-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

1500 0 1500 3000 Feet



Overview of Sand Resources - Borrow Area F	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 1,500'	Drawn By: MR
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 DIAL CORDY AND ASSOCIATES INC. <small>Engineering and Construction Services</small>	J01-493 Figure 9

3.2.6.1 Available Borrow Material

While geographically close to Area E, Area F has a different distribution of available sand resources. Within this potential borrow area the majority of the sand resources available have a sediment depth of 2 feet. There is a total of 1.5 MCY of material contained within the 2-foot isopach contour. In relation, there are a total of 241,147 CY of borrow material located in the 4-foot and 6-foot isopach contours. These occur in small isolated areas throughout the borrow area (Figure 9).

3.2.7 Borrow Area G

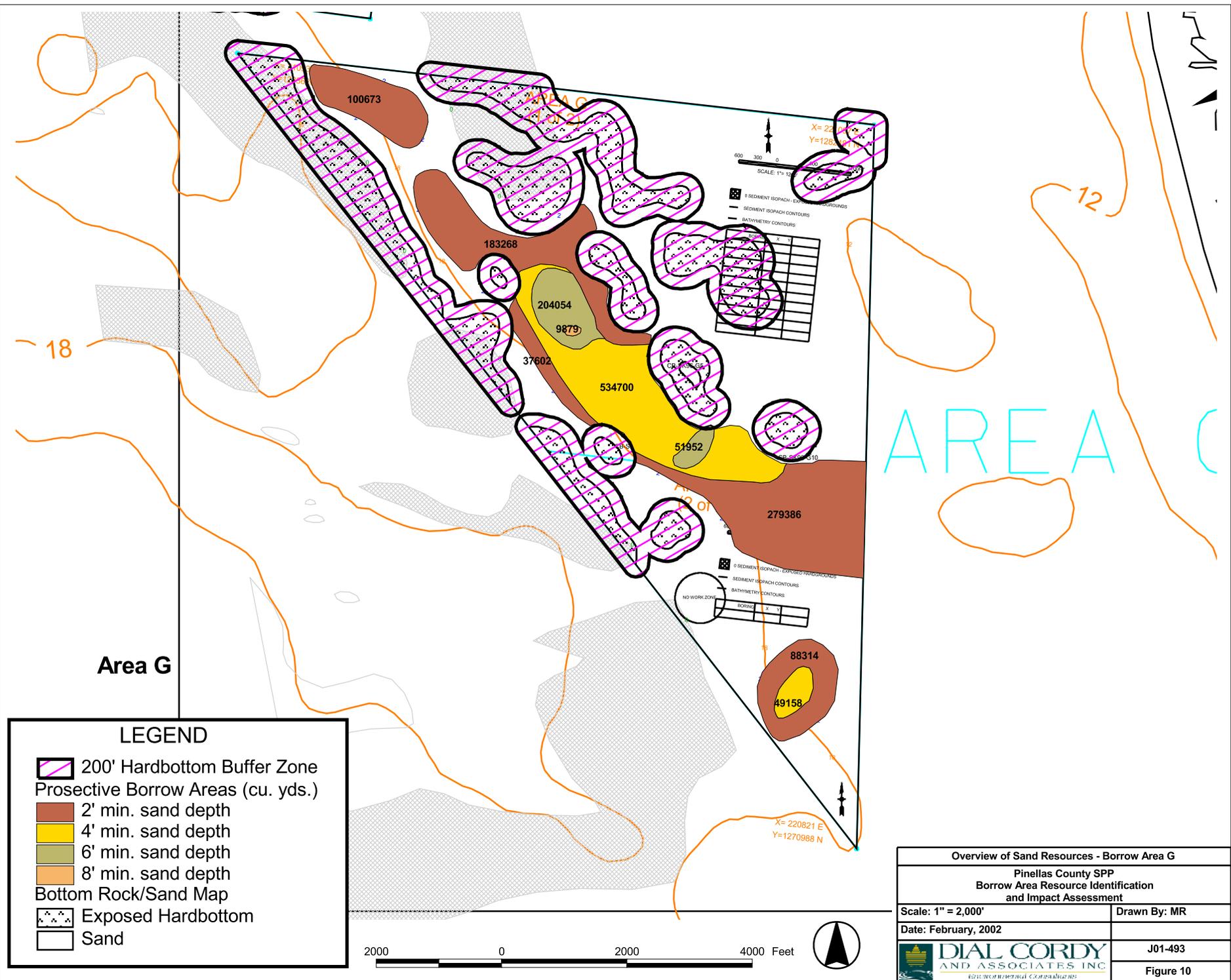
Borrow Area G is the closest to shore (1.8 nm) of all the borrow areas surveyed. It also has a large percentage of sand available (1,142.5.0 acres, 85 percent) compared to the hardbottom acres (201.9 acres, 15 percent). Most of these hardbottom areas were small distinct patches of low/medium relief hardbottom scattered throughout the area. These patches ranged in size from 1.3 acres to over 17 acres. The remainder of the hardbottom present within the area was found along the western and northern ends of the borrow area and included areas of dense hardbottom (Figure 10).

3.2.7.1 Available Borrow Material

Available borrow material in Area G is generally located within the center of this triangular area (Figure 10). Overall, there is a total of 1.5 MCY of material available within Area G. Areas that have a depth > 4 feet have a total of 849,743 CY of material available for use in beach restoration projects (Table 1). This material is located in a large continuous area within the center of Borrow Area G (Figure 10).

3.2.8 Borrow Area H

The largest borrow area surveyed was Area H (Figure 11). In total, Area H encompasses a total of 3,202.1 acres of seafloor, 2.8 miles offshore of Sand Key. Within this area there was a total of 2,533.8 acres of open sand habitat, the largest of all areas surveyed. This represents 80 percent of the total acreage within Area H. Hardbottom habitats within this potential borrow area covered 668.3 acres.



Area G

AREA C

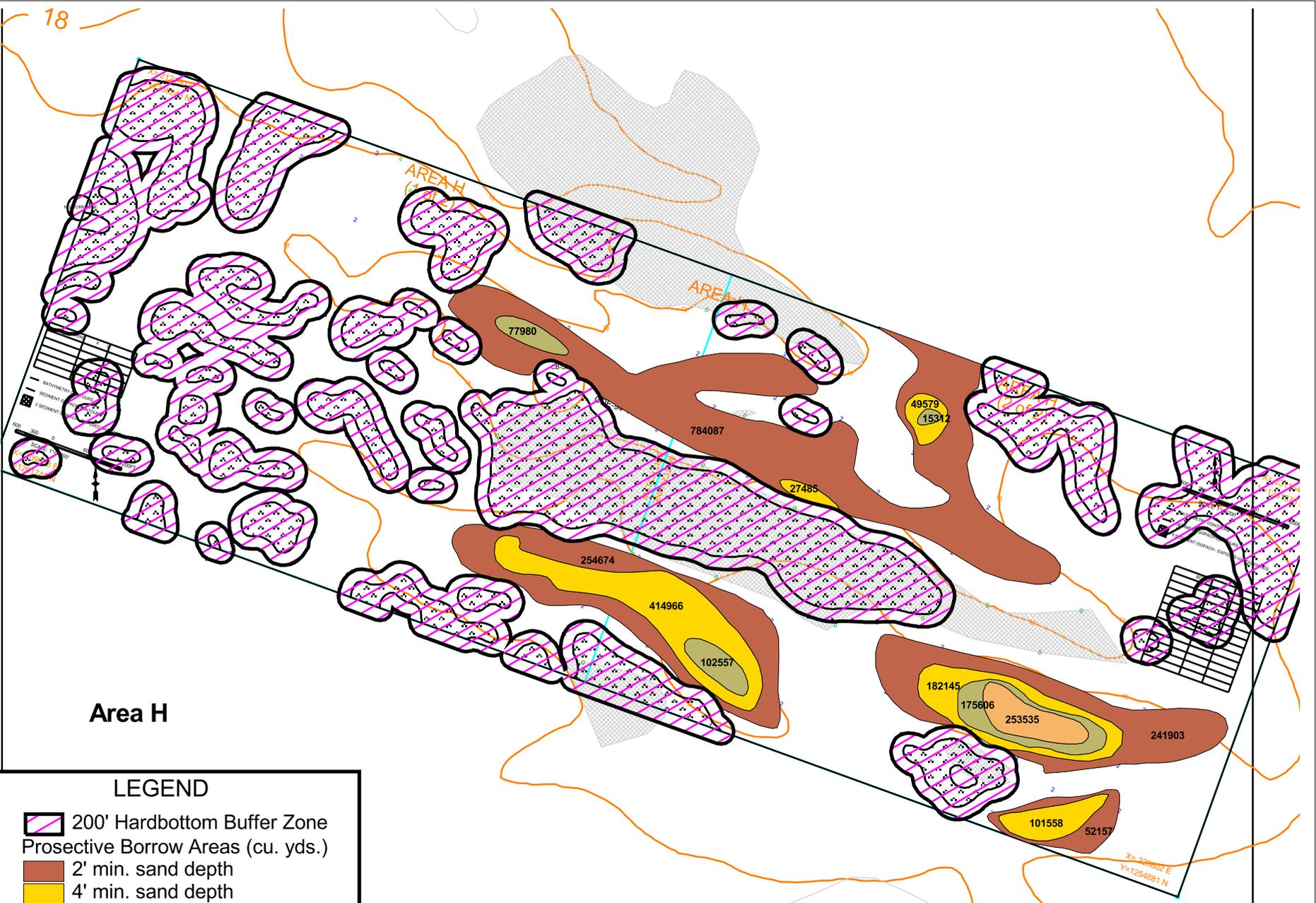
LEGEND

-  200' Hardbottom Buffer Zone
- Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
- Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

2000 0 2000 4000 Feet



Overview of Sand Resources - Borrow Area G	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 2,000'	Drawn By: MR
Date: February, 2002	
 DIAL CORDY AND ASSOCIATES INC. <small>Engineering and Construction Services</small>	J01-493 Figure 10



Area H

LEGEND

-  200' Hardbottom Buffer Zone
-  Prosective Borrow Areas (cu. yds.)
-  2' min. sand depth
-  4' min. sand depth
-  6' min. sand depth
-  8' min. sand depth
-  Bottom Rock/Sand Map
-  Exposed Hardbottom
-  Sand

2000 0 2000 4000 Feet



Overview of Sand Resources - Borrow Area H	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 2,000'	Drawn By: MR
Date: February, 2002	
	
	J01-493
	Figure 11

3.2.8.1 Available Borrow Material

Borrow Area H has over 2.7 MCY of available borrow material (Table 1). The areas with the most potential as borrow areas are located within the southeastern portion of Area H (Figure 11). These areas have a total of 1.7 MCY of material. Within the southeastern corner, sand resources are deeper than in other areas of the borrow area. This area has a minimum of 700,000 CY of material present in isopach layers of ≥ 4 feet (Figure 11).

3.2.9 Borrow Area I

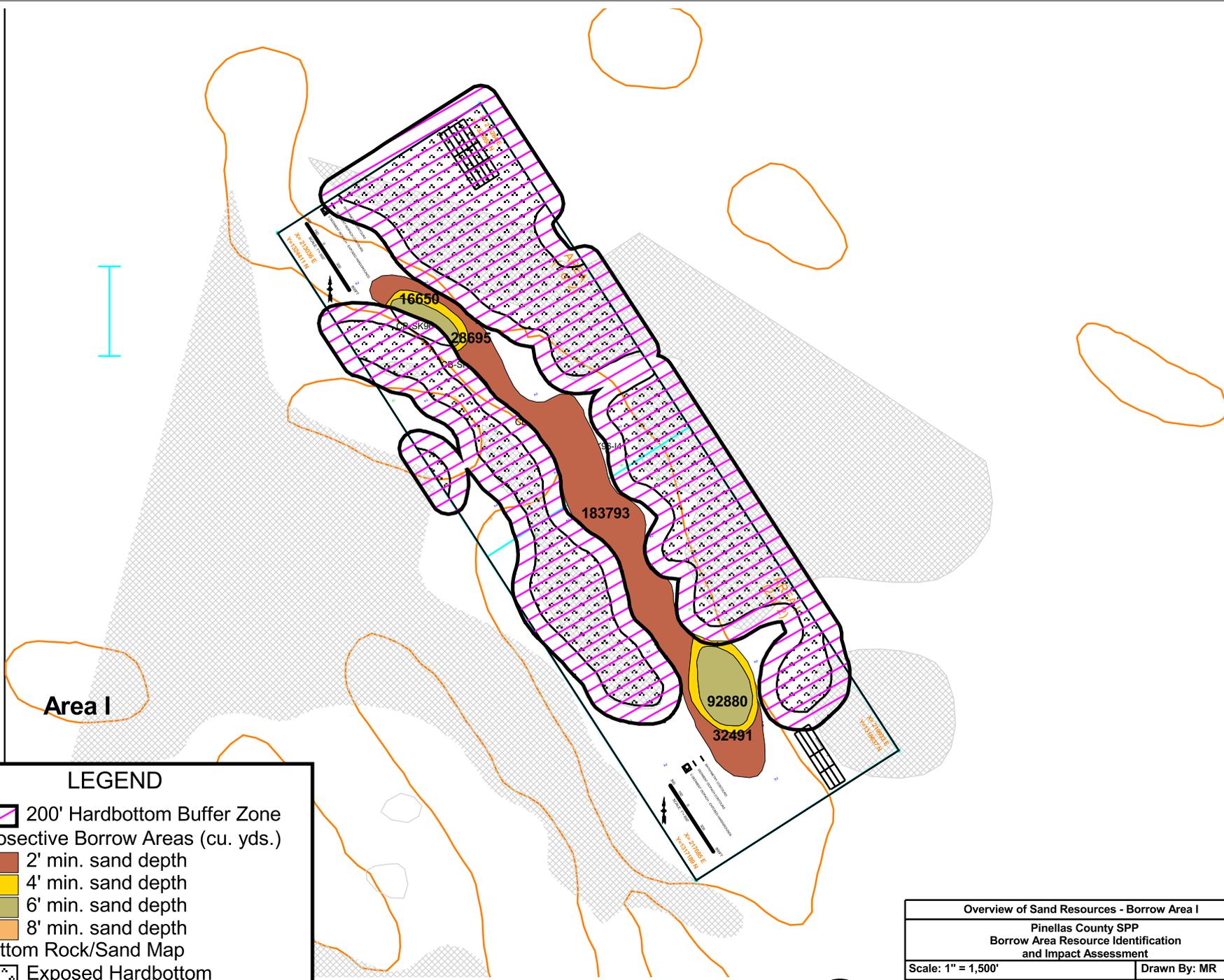
The northern most offshore area surveyed in Borrow Area I, located 3.0 nautical miles offshore of Clearwater Pass (Figure 2). Area I is also the smallest area surveyed at only 527.3 acres. Within Area I, a total of 212.3 acres of hardbottom resources were mapped. The remaining 315.3 acres consisted of open sand habitat (Figure 12).

3.2.9.1 Available Borrow Material

Borrow material within Area I totals 354,509 CY. The majority of this material is located in the center of the borrow area at a depth of ≥ 2 feet. Along the southeastern edge of Area I sand resources maintain a depth of ≥ 4 feet, totaling 125,371 CY of material (Figure 12).

3.3 Ebb Tidal Shoal Borrow Areas

In addition to the nine offshore borrow areas, five ebb tidal shoal borrow areas were also surveyed for marine resources. These included John's Pass, Blind Pass, Pass-A-Grille north, Pass-A-Grille south, and Egmont Shoal (Figures 13 and 14). No hardbottom or seagrass was documented within these ebb shoal areas. All areas consisted of large shallow areas of sand. In the John's Pass, Blind Pass, and the Pass-A-Grille survey areas, portions of the shoals are exposed during low tide events. Within these ebb tidal shoal survey areas a total of 1,569.5 acres of sand habitat was identified. Further geo-technical analysis of these areas will estimate the total amount of sand material available for placement.



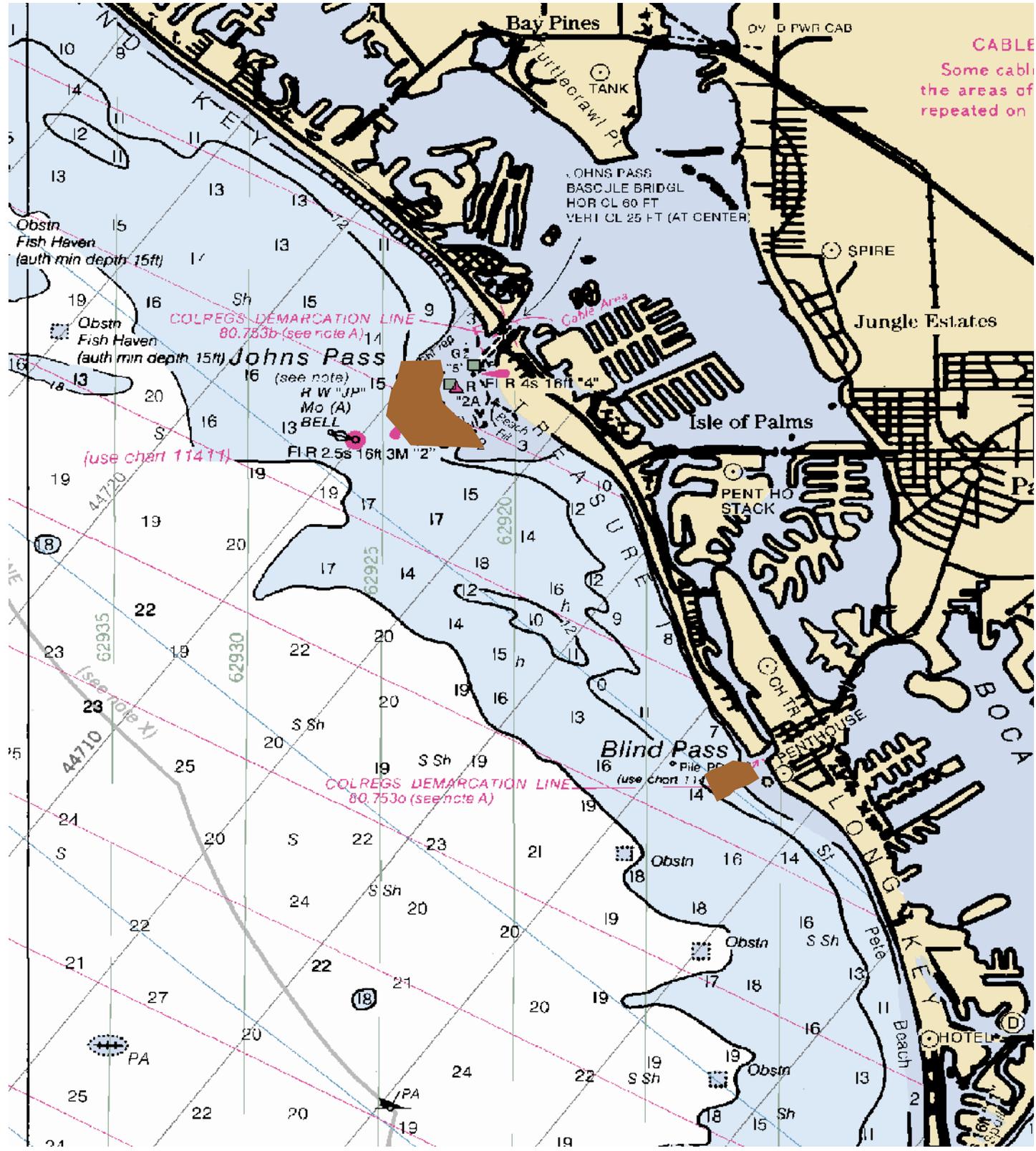
Area I

LEGEND

- 200' Hardbottom Buffer Zone
- Prosective Borrow Areas (cu. yds.)
- 2' min. sand depth
- 4' min. sand depth
- 6' min. sand depth
- 8' min. sand depth
- Bottom Rock/Sand Map
- Exposed Hardbottom
- Sand



Overview of Sand Resources - Borrow Area I	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 1,500'	Drawn By: MR
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DIAL CORDY AND ASSOCIATES INC <small>Engineering and Construction</small>	
	J01-493 Figure 12

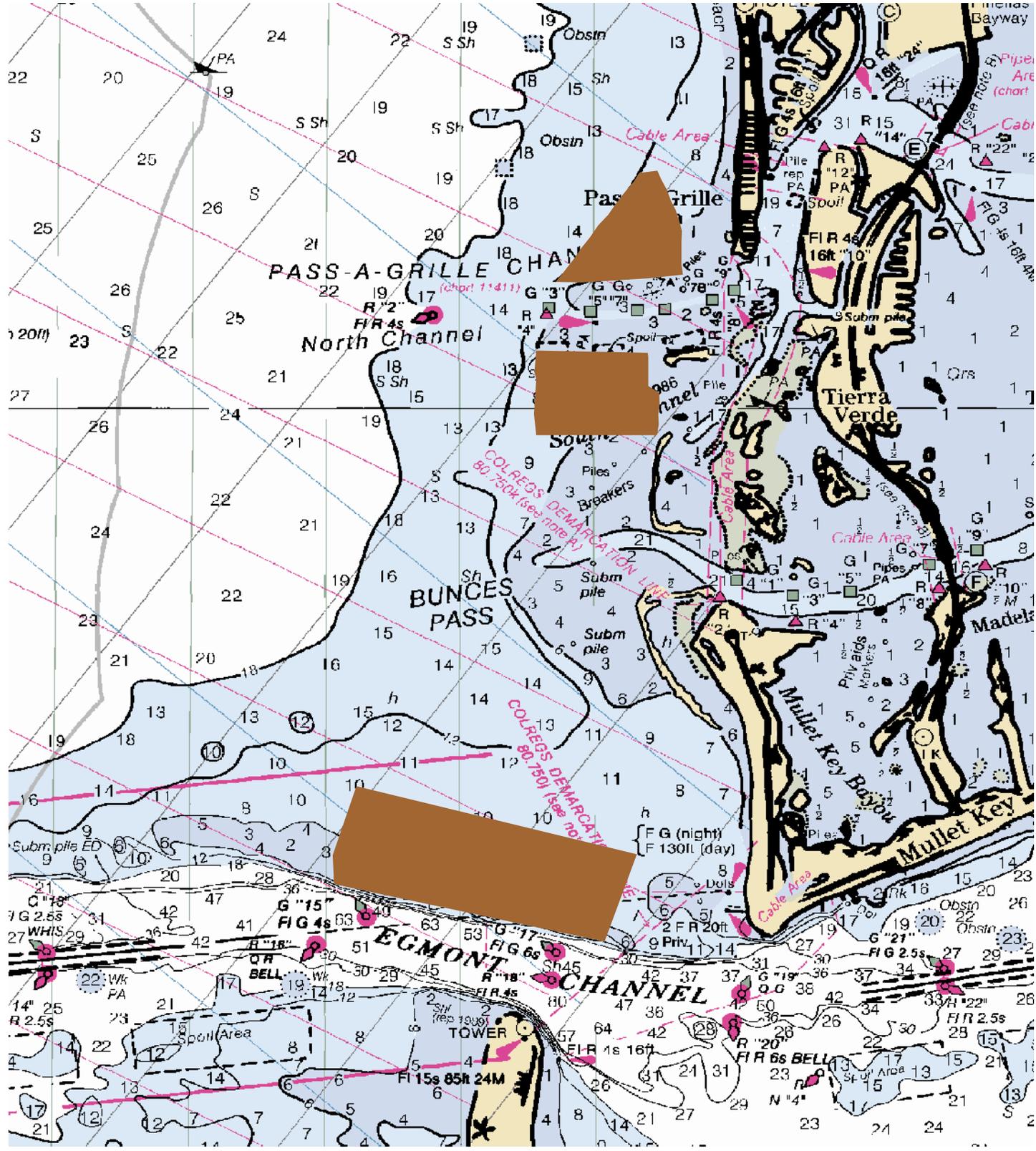


CABLE
Some cable
the areas of
repeated on

Ebb Tidal Shoals Bottom Classification Map
 Sand



Overview of Sand Resources - Shoal Areas (North)	
Pinellas County SPP Borrow Area Resource Identification and Impact Assessment	
Scale: 1" = 1 mile	Drawn By: MR
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Ebb Tidal Shoals Bottom Classification Map

 Sand



1 0 1 2 Miles

Overview of Sand Resources - Shoal Areas (South)

Pinellas County SPP
Borrow Area Resource Identification
and Impact Assessment

Scale: 1" = 1 mile

Drawn By: MR

Date: February, 2002



J01-493

Figure 14

4.0 IMPACT ANALYSIS

The purpose of this section is to identify the preliminary effects of dredging activity on the marine resources located within the offshore borrow areas. This section discusses the potential impacts associated with sand removal on softbottom and hardbottom habitats and their associated biological communities.

4.1 Impacts to Benthic Habitats

4.1.1 Softbottom Benthic Resources

The physical removal of surficial sediments from a borrow site results in the loss of benthic infaunal habitat, as well as, any epifaunal species which cannot avoid entrainment. This results in localized drastic reductions in numbers of individuals, species richness, diversity, and biomass. This would most greatly affect infaunal species, which are incapable of avoiding the dredging activities. Within the study area, these communities are comprised of predominately invertebrates, which include crustacean, echinoderm, mollusc, and annelid species.

Impacts to benthic infaunal and epifaunal communities would be considered as relatively minimal when examined on a spatial scale. Since construction of nourishment projects within Pinellas County will most likely be staggered over time, impacts to borrow area resources will have time to recover between nourishment events. Infaunal communities in particular have very high reproductive potential and recruitment. Adjacent areas that have not been impacted would most likely be the primary source of recruitment to the impacted areas. Previous studies have shown a relatively short recovery time for infaunal communities following dredging (Culter and Mahadevan, 1982; Saloman et. al, 1982). Succession of infaunal communities post dredging should begin within days following construction. This initial settlement usually consists of pelagic larval recruits settling within the borrow area. Later succession from adjacent non-impacted areas will be more gradual, and involve less opportunistic species. Saloman et. al (1982) stated that communities would be close to pre-dredge conditions within one year and potentially as quickly as 8-9 months. Culter and Mahadevan (1982) found similar results and no long-term effects to benthic communities resulting from beach nourishment in Panama City Beach, FL. Based on these previous studies infaunal communities will most likely be re-established within 1-2 years post dredging.

Impacts to epifaunal and demersal ichthyofaunal populations would be less than those to infaunal communities; however, some minor impacts can be expected to occur. Loss of some members of the community can be expected due to entrainment during dredging activities. These losses should have a small impact on local populations. The majority of impacts to

these species would most likely be indirect, through alteration of benthic habitats after dredging is completed. The reduction of benthic infaunal communities following dredging may have an adverse affect on demersal ichthyofaunal communities, which utilize these species as prey. These predators would most likely migrate to areas that have not been impacted. This would result in no net loss in production within the region.

The method of dredging utilized during construction will determine the amount of sediment suspension that will take place. Should a cutterhead suction dredge be utilized for removing sand, the amount of suspended material should be insignificant. This type of dredging generally limits the amount of sediment re-suspended to lower portions of the water column. These impacts would be short term and localized.

Implementation of sediment removal of material from the borrow area with a hopper dredge may suspend more material in the water column and as such require a larger mixing zone. Care should be taken to monitor turbidity levels associated with this type of dredging and to also monitor the amount of material settling on adjacent hardbottom areas. The inclusion of a 200-foot buffer around all hardbottom resources identified in each area should help to reduce indirect impacts to these resources.

4.1.3 Hardbottom Resources

There are 3,828.6 acres of hardbottom habitats present within the nine proposed offshore borrow areas. Due to exclusionary mapping, there should be no direct impacts to hardbottom resources in the area during dredging. Mapping and analysis of impacts for this project were designed to include a 200-foot buffer around all identified hardbottom resources (Figures 4-12). Care should be taken during the dredging operation to avoid anchoring in these buffer zones. If the total exclusion of construction equipment and pipelines from these buffer zones is followed during construction there should be no direct impacts.

Indirect impacts to adjacent hardbottom areas may occur. However, with the 200-foot buffer zone impacts should be minimal from suspension and deposition of sediments. These impacts can be more easily identified once a definite dredging method and exact cut areas are outlined. Monitoring of turbidity during the dredging activities and sedimentation rates on adjacent hardbottom should be implemented to ensure no adverse impacts to the hardbottom resources occur.

Pipeline corridors to and from these borrow areas have not yet been defined. Once potential areas for material removal are identified, pipeline corridors will be established to avoid direct impacts to hardbottom resources within the study area from pipeline placement. Mapping of hardbottom resources within pipeline corridors from borrow areas to the beach needs to be studied to determine the most effective corridors for placement.

4.2 Impacts to Pelagic Environment

This section discusses the adverse potential impacts to organisms utilizing the water column in the vicinity of the borrow areas.

4.2.1 Zooplankton

4.2.1.1 *Entrainment*

Entrained zooplankton are assumed to die from physical trauma (Reine and Clarke, 1998). The most detrimental consequence of zooplankton entrainment is the death of fish and invertebrate larvae. This loss of larval organisms may in turn have an adverse effect on adult populations. The rate of zooplankton entrainment by hydraulic dredges depends upon local hydrographic patterns and the spatial and temporal dynamics of local populations. The characteristics of the dredging operation also affect the rate of entrainment of zooplankton. The use of suction dredges will have a greater affect on zooplankton near the seafloor, while a hopper dredge may entrain species utilizing the entire water column. Taxa or life stages that spend part of their time associated with the benthic environment, such as demersal fish eggs or demersal zooplankton would be especially vulnerable from either method. Unfortunately, no information exists on the abundance or composition of demersal zooplankton in the sand resource areas or borrow site. Owing to the high reproductive capacity of zooplankton along with the relatively small area of the dredge suction field and the volume of water entrained compared to the overall volume of surrounding waters, it is unlikely that entrainment would greatly affect zooplankton populations or assemblages in the offshore borrow sites.

4.2.1.2 *Turbidity*

Sediment suspended and dispersed by the action of a working dredge can affect zooplankton by impeding feeding activity and physiological impairment. Most larvae are filter feeders and inorganic particles can easily foul the fine structures on feeding appendages of crustaceans such as copepods, and crab and shrimp larvae (Sullivan and Hancock, 1977). Zooplankton feeding by ciliary action (e.g., echinoderm larvae) also would be susceptible to mechanical effects of suspended particles (Sullivan and Hancock, 1977). In contrast, larval fishes are visual feeders that depend on adequate light levels for their foraging success (Blaxter, 1968). High turbidity reduces light levels in the water column, which in turn shortens the reactive distance between a larval fish and its prey.

While increase turbidity is likely to occur in the vicinity of the dredging operation, little impact to zooplankton communities should occur. Due to the limited extent and transient nature of the sediment plume, it is unlikely that turbidity would greatly affect zooplankton populations or assemblages in the borrow sites.

4.2.2 Fishes

4.2.2.1 Entrainment

Entrainment of adult fishes by hydraulic dredging has been reported for several projects (McGraw and Armstrong, 1988; Reine and Clarke, 1998). Results from these previous studies show that relatively few species of fish become entrained during dredging activity. The most commonly entrained species were demersal fishes (McGraw and Armstrong, 1988). Use of hopper dredging techniques would lower the numbers of entrained fishes further. Few of the coastal pelagic fishes occurring offshore of Pinellas County should become entrained and many pelagic species have sufficient mobility to avoid the dredging operations.

4.2.2.2 Turbidity

Turbidity can cause feeding impairment, avoidance and attraction movements, and physiological changes in adult pelagic fishes. As discussed for larval fishes, pelagic species are primarily visual feeders and when turbidity reduces light penetration, the fish's reactive distance decreases (Vinyard and O' Brien, 1976). Turbidity can also have an effect on light scattering, which also will hamper fish predation (Benfield and Minello, 1996).

Suspended sediments can also clog gill cavities preventing normal respiration and mechanically affecting food gathering in planktivorous species (Bruton, 1985). Storm events have increased the amount of suspended sediments enough to contribute to the death of nearshore and offshore fishes by clogging gill cavities and eroding gill lamellae (Robins, 1957).

Due to the limited extent and transient nature of the sediment plume, it is unlikely that turbidity would greatly affect fish populations or assemblages in the borrow sites.

4.2.2.3 Essential Fish Habitat (EFH)

The Gulf of Mexico Fisheries Management Council (GMFMC) (1998) has designated unvegetated bottom and water column areas within the study area as Essential Fish Habitat (EFH), in compliance with the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267).

The Gulf of Mexico in this region also provides essential forage, cover, and nursery habitats for other species that are important commercially and recreationally. These include the blue crab (*Callinectes sapidus*), flounder (*Syacium* sp.), and mullet (*Mugil* sp.), as well as prey species, such as the longspine porgy (*Stenotomus caprinus*) and dwarf goatfish (*Upeneus parvus*).

Dredging will impact both the open water and unvegetated bottom habitats within the borrow areas. These impacts should only temporarily displace fishes utilizing these habitats. Impacts to larval fishes within the vicinity of the dredging operation will also occur. However, due to the relatively small area covered by the removal of sand from the borrow areas and the length of time between borrow events the impacts should be insignificant.

4.2.3 Sea Turtles

4.2.3.1 Physical Injury

Although any of the five sea turtle species may be present in the project area, loggerhead, green, and Kemp's Ridley turtles are considered to be most at risk from dredging activities because of their life cycle and behavioral patterns (Dickerson et al., 1992). Loggerheads are expected to be the most abundant of these three turtles in the project area (LeBuff, 1990, Meylan et. al, 1999).

The main potential effect of dredging on sea turtles is physical injury or death caused by the suction and/or cutting action of the dredge head. Numerous sea turtle injuries and mortalities have been documented during dredging projects, particularly along Florida's east coast (Studt, 1987; Dickerson et al., 1992; Slay, 1995). Impacts typically can be minimized by a combination of project scheduling and equipment selection, accompanied if necessary by turtle removal and/or monitoring.

4.2.3.2 Turbidity

Sea turtles in and near the project area may encounter turbid water during dredging. Since removal of material is likely to occur over a relatively small area, turbidity is considered unlikely to significantly affect turtle behavior or survival.

4.2.3.3 Noise

Many human activities in the marine environment produce underwater noise. The noise associated with dredging is unlikely to significantly affect sea turtles because of their limited hearing ability (Ridgway et al., 1969; Lenhardt, 1994). These animals do not rely upon sound to any significant degree for communication or food location.

4.2.4 Marine Mammals

4.2.4.1 Physical Injury

Marine mammals commonly present within the waters nearshore and offshore the study area include manatee and bottlenose dolphin. Bottlenose dolphins were commonly observed while conducting this survey. As many as 15 dolphins were observed at one time in the areas adjacent to the offshore borrow areas. Weigle (1990) documented that at least three distinct herds of dolphin are common within the Lower Tampa Bay area. This includes as many as 246 individual animals. Many of the dolphins observed may have been transient in nature. However, 75 individuals were observed on more than one occasion. Dolphins are fast, agile swimmers and are presumed capable of avoiding direct physical injury from dredging operations. Dolphins also may avoid the immediate vicinity of the project due to the associated noise and turbidity. Manatees are unlikely to venture offshore in the vicinity of the dredging activity and would most likely avoid dredging activity.

4.2.4.2 Turbidity

Marine mammals in and near the project area may encounter turbid water during dredging. This turbidity could temporarily interfere with feeding or other activities, but the animals could easily swim to avoid turbid areas. Turbidity is unlikely to significantly affect marine mammals within the study area.

4.2.4.3 Noise

Underwater noise from dredging activities could have minor impacts on marine mammals. Noise can cause marine mammals to temporarily avoid certain areas (Gales, 1982; Richardson et al., 1995). However, sound levels from dredging activities are unlikely to account for hearing loss or other auditory discomfort or damage to marine mammals. Dolphins and manatees could easily move away from noise that would cause them discomfort, danger, harm, or interfere with normal behaviors. Observations of marine mammals in the vicinity of boat traffic suggest that routine vessel operations have little effect on normal behavior.

4.3 Potential Cumulative Impacts

Cumulative impacts resulting from removal of material from multiple borrow sites are a concern when evaluating potential long-term effects on marine resources in the area offshore Pinellas County. This analysis assumes that a different area or a different shoal, would be dredged each replenishment interval. With the replenishment interval expected to be 5 to 7 years, and that the recovery time of the affected benthic community after sand removal anticipated to be within 1-2 years, the potential for significant cumulative benthic biological impacts is remote. No cumulative impacts to the pelagic environment, including zooplankton, fishes, sea turtles, and marine mammals, are expected from multiple beach nourishment borrow site operations from the nine offshore borrow sites.

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