

APPENDIX E. SPATIAL DATA FILES AND EXCLUSIONARY MAPPING FOR BIOLOGICAL FIELD SURVEY DESIGN

E1. INTRODUCTION

Spatial data files and exclusionary mapping were used to design the biological field surveys as mentioned in Section 6.2.1.1. Appendix E provides the details concerning the spatial data files and exclusionary mapping.

Spatial data are primarily information on the geographic location and characteristics of environmental features. Typically, spatial data for environmental features include the spatial coordinates (e.g., latitude and longitude) and attributes (e.g., depth, size, number, etc.).

Spatial data are best managed and analyzed using specialized or dedicated software called Geographic Information Systems (GIS). GIS software facilitates the representation of environmental features in the real world in a two-dimensional model such as a map. GIS also allows efficient handling of various types of spatial data representing environmental features. Once information on environmental features is captured within a GIS environment, users are provided a highly dynamic and efficient tool for conducting environmental assessments.

The Minerals Management Service (MMS) adopted ArcView GIS (Environmental Systems Research Institute, Redlands, California), the leading industry product for desktop GIS, as an agency standard and therefore required submission of spatial data files in ArcView format. The requirement for submission of spatial data files also is an outgrowth of the increasing recognition that environmental information acquired or used in Federal projects be stored in a manner that allows access and efficient use for other relevant data applications.

ArcView GIS (Version 3.2) procedures were used to prepare the required spatial data files and conduct the exclusionary mapping that assisted in designing the biological field surveys. An ArcView project was created for the spatial data files and exclusionary mapping process as described below.

E2. SPATIAL DATA FILES

The following spatial data files in ArcView format (shapefiles) were required as project deliverables:

- Proposed Borrow Areas (Sand Resource Areas)
- Bathymetry (Depth Contours or Isobaths)
- Artificial Reefs
- Natural Reefs (Hard Bottom, Potential Hard Bottom)
- Disposal Sites (Ocean Dredged Material Disposal Sites)
- Sediment Type Distribution
- Identified Shoal Fields
- Infauna and Epifauna Distribution and Location
- Military Firing Fans (Military/NASA Warning Areas)
- Shipping Traffic Separation Schemes (Shipping Lanes)
- Shipwrecks
- Submarine Cables
- Fishing Areas
- Essential Fish Habitat
- Endangered and Threatened Species

In addition to the required spatial data, other files were included as follows:

- 3 Nautical Mile Federal/State Boundary
- Aids to Navigation
- County Boundaries
- Martin County Artificial Reef Areas
- Northern Right Whale Critical Habitat
- *Oculina* Habitat Area of Particular Concern
- *Oculina* Experimental Research Reserve
- Shoreline
- Vibracores

Base map features (e.g., shoreline and county boundaries) and many other spatial data files were obtained in ArcView format (shapefiles) from the Statewide Ocean Resource Inventory (SORI) developed by the Florida Marine Research Institute, St. Petersburg, Florida. Additional spatial data files were obtained from various sources including Applied Coastal Research and Engineering, Inc., National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, and U.S. Coast Guard. Because the files come from many sources that compiled the spatial data based on a wide range of historical and recent information, accuracy and precision of the data are variable. **Table E-1** lists the primary spatial data files according to environmental feature, data source, and data format.

Applicable spatial data files for fishing areas, essential fish habitat, and most endangered and threatened species were not available for the study area. Government agencies (e.g., National Marine Fisheries Service, Florida Marine Research Institute) are currently developing some of these geographic data. For species with extensive spatial distributions, mapping their areas of occurrence is of limited value to the exclusionary mapping effort. For example, calico scallop distribution shapefiles are available from the SouthEast Area Monitoring and Assessment Program (SEAMAP), however, the distribution

includes the entire study area. All endangered or threatened sea turtle species of the region also may be found throughout the entire study area. Northern Right Whale Critical Habitat was mapped because it occupies a specific location near the study area.

E3. EXCLUSIONARY MAPPING

Available spatial data were used in an exclusionary mapping process to guide the biological field sampling design. The purpose of exclusionary mapping was to ensure that sampling would include the areas of concern to the MMS (e.g., areas in Federal waters shallower than 30 m) and exclude areas that would not be dredged due to the presence of environmental features (e.g., natural and artificial reefs, ocean dredged material disposal sites, shipwrecks, etc.).

To facilitate the utility of the results of the exclusionary mapping effort in designing and conducting the biological field survey program, a standard geodesy was adopted (i.e., Universal Transverse Mercator [UTM] Zone 17 North, North American Datum 1983 [NAD 83] in meters). This allowed use of a standard grid for positioning sampling stations and determining relative distances between stations and environmental features.

Sand resource areas were incorporated in a base map (**Figure E-1**). The Florida Geological Survey (FGS) identified eight sand resource areas mostly in Federal waters along the central east Florida shelf offshore Brevard, Indian River, St. Lucie, and Martin Counties. The eight sand resource areas and other data files were provided by the FGS as shapefiles. The eight areas were designated as Sand Resource Areas A1, A2, B1, B2, C1, C2, D1, and D2 (**Figures E-2 to E-5**). In addition, a ninth sand resource area was identified for sampling at the request of Brevard County to the MMS. The area called Space Coast Shoals II in Federal waters was designated as Sand Resource Area A3 and incorporated into the biological field sampling program (**Figures E-1 and E-2**).

Spatial data files then were added to the ArcView project to display environmental features of concern relative to each sand resource area. Features that were located in or near sand resource areas were noted (**Figures E-6 to E-9**). Other environmental features that were not in close proximity to sand resource areas are shown in **Figure E-10** along with features in and near sand resource areas.

Portions of the sand resource areas lying inshore of the 3 nmi Federal/State boundary were delineated and excluded from the biological field sampling program. Portions of the sand resource areas that were offshore of the 30 m isobath also were delineated and eliminated from sampling because dredging would likely occur in shallower water depths.

Limited buffer zones were added to appropriate environmental features with the goal of assisting the design of the biological field surveys (**Table E-2**). The objective of adding buffer zones and conducting the exclusionary mapping was to eliminate areas from biological sampling that would not be dredged, rather than resource protection. A buffer distance of 150 m was applied to hard bottom features based on the dredging industry practice of setting out anchors to a distance five times the water depth to ensure that anchors hold securely. Assuming that dredging would occur inshore of the 30 m isobath, a 150 m buffer was considered appropriate for designing the biological field surveys. For artificial reefs, shipwrecks, submarine cables, and navigation aids with positions that were uncertain or possibly can shift, a buffer distance of 300 m was used based on industry practice. Some features such as the Northern Right Whale Critical Habitat and Military

Warning Areas were mapped but were not excluded. Because confidence levels of environmental feature positions are variable and change with time, regulatory agencies should re-examine spatial data files and evaluate buffer zones in the future for specific dredging projects in the study area with the goal of protecting resources and avoiding conflicts.

Buffer areas for the environmental features were combined, then consolidated buffer areas were removed from each of the remaining sand resource areas. Four final exclusionary maps depicting the original sand resource areas along with the area remaining after the exclusionary mapping process were prepared for the station selection process described in Section E4 of Appendix E and Section 6.2.1 of the main report (**Figures E-11 to E-14**). **Table E-3** summarizes the results of the exclusionary mapping process including the reasons for the areas excluded (exclusionary features). After completing the exclusionary mapping process, the area remaining in each of the sand resource areas was compared to the total area remaining to proportionately determine the number of available samples (sampling stations) to allocate to each sand source area. Station allocations for each sand resource area resulting from the exclusionary mapping process are shown in **Table E-4**.

E4. BIOLOGICAL FIELD SURVEY DESIGN

For each of two soft bottom surveys, 62 stations originally were proposed for samples that would be analyzed for both sediment and infauna, and 48 additional stations originally were proposed for sediment analysis only. The following rationale was used to determine the number of samples that would be collected in the sand resource areas and at adjacent stations. The results of applying this rationale are illustrated in **Figures E-15 through E-20**. The locations also are listed in Appendix F1.

Of the original 62 stations, 7 stations were assigned to adjacent stations near the sand resource areas, leaving 55 stations to be taken within the 9 sand resource areas. The 7 adjacent stations were located so that samples would be collected approximately 1,000 m north or south of the nine sand resource areas at median water depths as illustrated in **Figure E-20**.

To determine the number of samples to collect in each sand resource area for sediment and infaunal analyses during each survey, the surface area and percent of the total surface area for each of the sand resource areas were calculated before and after exclusionary mapping was completed (**Table E-3**). The percent of the total surface area remaining after exclusionary mapping for each of the sand resource areas then was multiplied by 44 stations, leaving 11 stations for discretionary placement within the sand resource areas. Multiplication by 44 stations indicated that some sand resource areas had none or too few samples due to very small surface areas relative to the total surface area (i.e., Sand Resource Area A3 had 0 samples, C2 had 2 samples, D1 had 2 samples, and D2 had 1 sample; see **Table E-4**). Therefore, 7 of the 11 discretionary samples were added to the sample numbers for Sand Resource Areas A3, C2, D1, and D2 such that there would be 3 stations in each of these sand resource areas. This brought the total number of samples to be analyzed for both sediment and infauna to 51. Four of the 11 discretionary samples remained for later location.

Whereas 62 stations were proposed for samples that would be analyzed for both sediment and infauna, 48 additional stations were proposed for sediment analysis only for

each survey. The purpose of collecting these additional 48 sediment samples was to extend the interpretation of the infaunal data. To determine the number of samples to collect during each survey in each sand resource area for sediment analysis only, the percent of the total surface area remaining after exclusionary mapping for each of the sand resource areas was multiplied by 48 stations (**Table E-4**).

Attention then was directed to selecting locations for the 51 samples that would be analyzed for both sediment and infauna, and the 48 samples that would be analyzed for sediment only. The goal in placement of the stations was to provide broad spatial and depth coverage within the sand resource areas and, at the same time, ensure that the samples would be independent of one another to satisfy statistical assumptions. To accomplish this goal, a systematic sampling approach was used to provide broad spatial and depth coverage of the target populations. This approach can, in many cases, yield more accurate estimates of the mean than simple random sampling (Gilbert, 1987). The ArcView extension "Sample" by Quantitative Decision was used to create sampling grids with cell sizes appropriate for the number of samples required for an area. Grids were placed over figures of each sand resource area. One sampling station then was randomly placed within each grid cell of each sand resource area such that sediment and infaunal sample cells alternated with sediment-only sample cells. Randomizing within grid cells eliminates biases that could be introduced by unknown spatial periodicities in a sampling area. This systematic sampling approach resulted in designation of 99 sample locations.

The 51 locations for collecting samples that would be analyzed for both sediment and infauna then were examined to determine where best to place the remaining 4 of the 11 discretionary stations. Because the 51 locations were randomly located, there were cases where isobaths indicated that high points of shoals would not be sampled. Therefore, the remaining four discretionary stations were located on the tops of shoals in Sand Resource Areas A1, B1, B2, and C1.

Spatial data and exclusionary mapping files were used for selecting locations of sample types other than sediment and infauna. Epifaunal and demersal fish trawl transects were placed using files including bathymetric contours relative to the sand resource areas. One north-south transect was placed near the eastern boundary and one north-south transect was placed near the western boundary of each sand resource area to allow characterization of the existing assemblages with respect to water depth. In addition, the files including natural reefs (hard bottom and potential hard bottom) relative to the sand resource areas were used for selecting video and still camera sampling locations. The purpose of the photodocumentation was to characterize hard/live bottom in and near the sand resource areas.

After completing the biological field survey design, the sampling locations were exported from ArcView, assembled in an Excel file, and provided to the survey team for use with the field survey navigation and positioning software Hypack. After completion of the ArcView project, the project files and shapefiles were placed on CD-ROM and submitted to MMS as a deliverable.

E5. LITERATURE CITED

Gilbert, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York, NY. 320 pp.

Table E-1. Primary spatial data files according to environmental feature, data source, and data format.		
Environmental Feature	Data Source	Data Format
Proposed Borrow Areas (Sand Resource Areas)	FGS	Shapefile
Space Coast Shoals II	Brevard County	Manually plotted
Identified Shoal Fields	NOAA nautical chart	Manually digitized
Bathymetry (Depth Contours or Isobaths)	FMRI SORI/AC	Shapefile/DXF file
Natural Reefs (Hard Bottom, Potential Hard Bottom)	SEAMAP	Shapefile
Artificial Reefs	FMRI SORI, USACE	Shapefile
Disposal Sites (Ocean Dredged Material Disposal Sites)	NOAA OPIS	Shapefile
Shipwrecks	NOS	dBase file
Submarine Cables	NOAA nautical chart	Manually digitized
Shipping Traffic Separation Schemes (Shipping Lanes)	FMRI SORI	Shapefile
Military Firing Fans (Military/NASA Warning Areas)	NOAA nautical chart	Manually digitized
Distribution of Sediment Types	CSA	
Distribution and Location of Infauna and Epifauna	CSA	
Fishing Areas	Not available	Not available
Essential Fish Habitat	Not available	Not available
Endangered and Threatened Species	Not available	Not available
3 Nautical Mile Federal/State Boundary	OPIS	Shapefile
Aids to Navigation	USCG	dBase file
County Boundaries	FMRI SORI	Shapefile
Martin County Artificial Reef Areas	USACE Notice	Manually plotted
Northern Right Whale Critical Habitat	NMFS Notice	Manually digitized
<i>Oculina</i> Habitat Area of Particular Concern	NMFS Notice	Manually plotted
<i>Oculina</i> Experimental Research Reserve	NMFS Notice	Manually plotted
Shoreline	FMRI SORI	Shapefile
Vibracores	FGS	Shapefile
AC	Applied Coastal Research and Engineering, Inc.	
CSA	Continental Shelf Associates, Inc.	
FGS	Florida Geological Survey	
FMRI	Florida Marine Research Institute	
NASA	National Aeronautics and Space Administration	
NMFS	National Marine Fisheries Service	
NOAA	National Oceanic and Atmospheric Administration	
NOS	National Ocean Survey	
OPIS	Ocean Planning Information System	
SEAMAP	SouthEast Area Monitoring and Assessment Program	
SORI	Statewide Ocean Resources Inventory	
USACE	U.S. Army Corps of Engineers	
USCG	U.S. Coast Guard	

Table E-2. Environmental features and buffer zones for exclusionary mapping*.		
Environmental Feature	Buffer Zone	Rationale For Exclusion
Seaward of 30 m contour	None/Complete Exclusion	Sand extraction would not be done in areas deeper than 30 m (industry practice)
Hard bottom	150 m	Need to avoid during sand extraction to protect live bottom benthos and fish habitat from anchor damage
Potential hard bottom	150 m	Need to avoid during sand extraction to protect live bottom benthos and fish habitat from anchor damage
Artificial reefs and designated artificial reef areas	300 m	Need to avoid during sand extraction because of safety concerns and to protect fish habitat from anchor damage
Ocean Dredged Material Disposal Sites	None/Complete Exclusion	Sand extraction would not be done in disposal sites because of sediment quality concerns
Shipwrecks	300 m	Need to avoid during sand extraction because of safety concerns and to protect cultural resources from anchor damage
Submarine cables	300 m	Need to avoid during sand extraction because of safety concerns and to protect cables from anchor damage
Shipping Lanes	None	Mapped but not excluded
Military/NASA Warning Areas	None	Mapped but not excluded
State waters within 3 nmi Federal/State boundary	None/Complete Exclusion	MMS determined that no sampling was to occur within State waters
Navigation aids	300 m	Need to avoid during sand extraction because of safety concerns and to protect navigation aids from anchor damage
Protected areas	300 m	Mapped but not excluded
<p>* The objective of adding limited buffer zones and conducting the exclusionary mapping was to assist in designing the biological field surveys by eliminating areas from sampling that would not be dredged, rather than the goal of resource protection. Because confidence levels of environmental feature positions are variable and change with time, regulatory agencies should re-examine spatial data files and evaluate buffer zones in the future for specific dredging projects in the study area with the goal of protecting resources and avoiding conflicts.</p>		

Sand Resource Area	Original Area (m ²)	Area Excluded (m ²)	Percent Area Excluded	Remaining Area (m ²)	Percent Area Remaining	Percent of Total Area	Reason(s) for Exclusion
A1	53,289,280	2,993,781	6	50,295,498	94	13	Hard bottom, potential hard bottom, shipwrecks, submarine cable
A2	68,279,893	3,081,888	5	65,198,004	95	17	Hard bottom, disposal site
A3	188,789	0	0	188,789	100	0	None
B1	122,397,880	11,708,428	10	110,689,451	90	29	Federal/State boundary
B2	24,997,834	762,234	3	24,235,600	97	6	30 m isobath
C1	108,776,177	11,517,985	11	97,258,192	89	25	Hard bottom, shipwrecks, Federal/State boundary
C2	26,421,335	9,687,302	37	16,734,033	63	4	Martin County artificial reef area, shipwreck
D1	14,674,932	331,512	2	14,343,420	98	4	30 m isobath
D2	15,355,029	7,640,912	50	7,714,117	50	2	30 m isobath, submarine cable, Federal/State boundary
TOTAL	434,381,148	47,724,043	11	386,657,105	89	100	

Table E-4. Summary of rationale for allocating sediment/infaunal and sediment-only samples inside the sand resource areas for each survey (seven additional sediment/infaunal samples were allocated to seven adjacent stations [1 sample/adjacent station] outside the sand resource areas for each survey).							
Sand Resource Area	Percent Area Remaining	Percent of Total Area	Sediment/Infaunal Samples				Sediment-Only Samples Based on 48 Total
			Based on 44 Total Samples	Discretionary Samples		Based on 55 Total Samples	
				Adjustment for 3 Sample Minimum	Adjustment to Sample Shoals		
A1	94	13	6	0	1	7	6
A2	95	17	7	0	0	7	8
A3	100	0	0	3	0	3	0
B1	90	29	12	0	1	13	14
B2	97	6	3	0	1	4	3
C1	89	25	11	0	1	12	12
C2	63	4	2	1	0	3	2
D1	98	4	2	1	0	3	2
D2	50	2	1	2	0	3	1
TOTAL	89	100	44	7	4	55	48

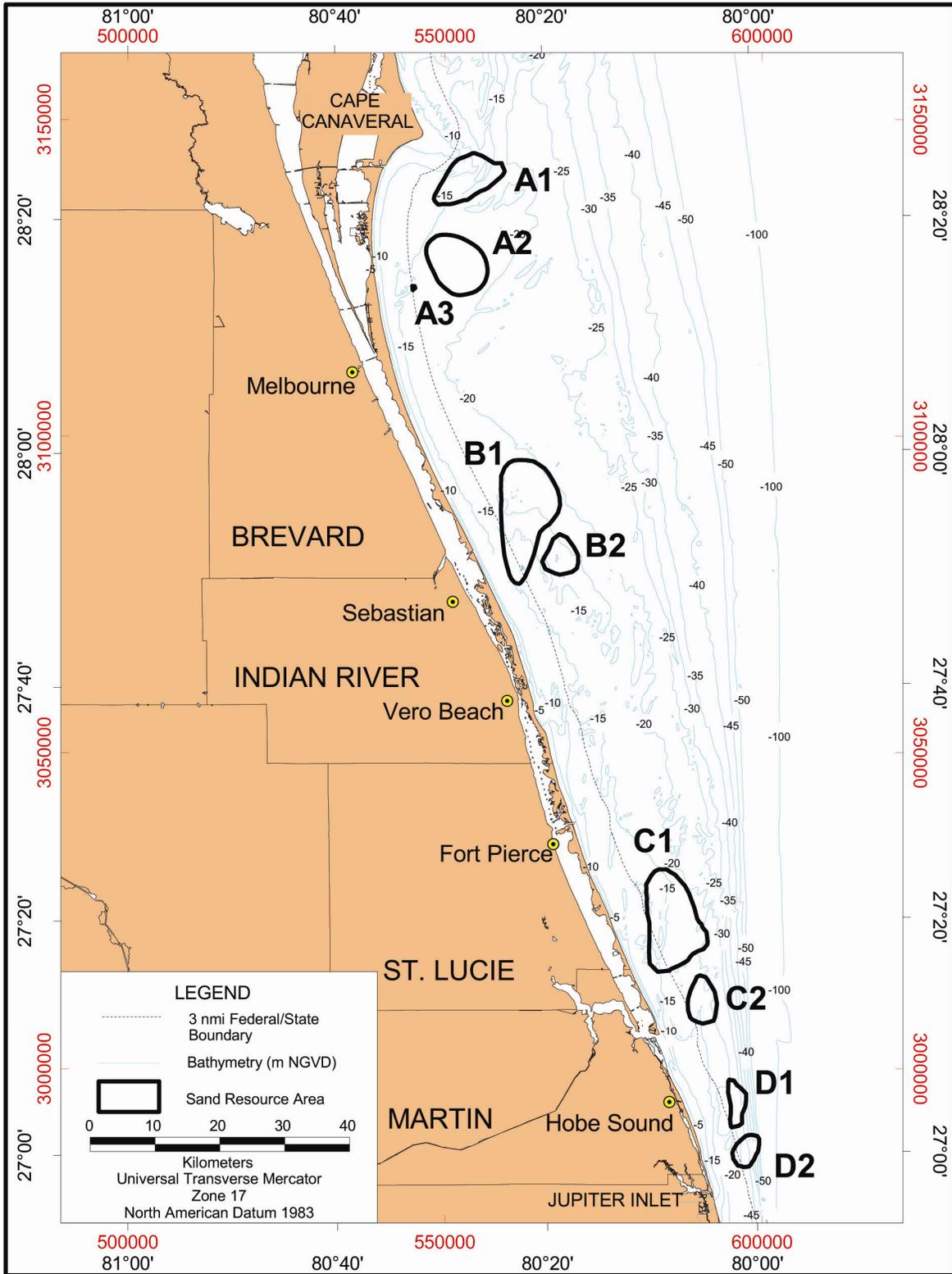


Figure E-1. Central east Florida base map.

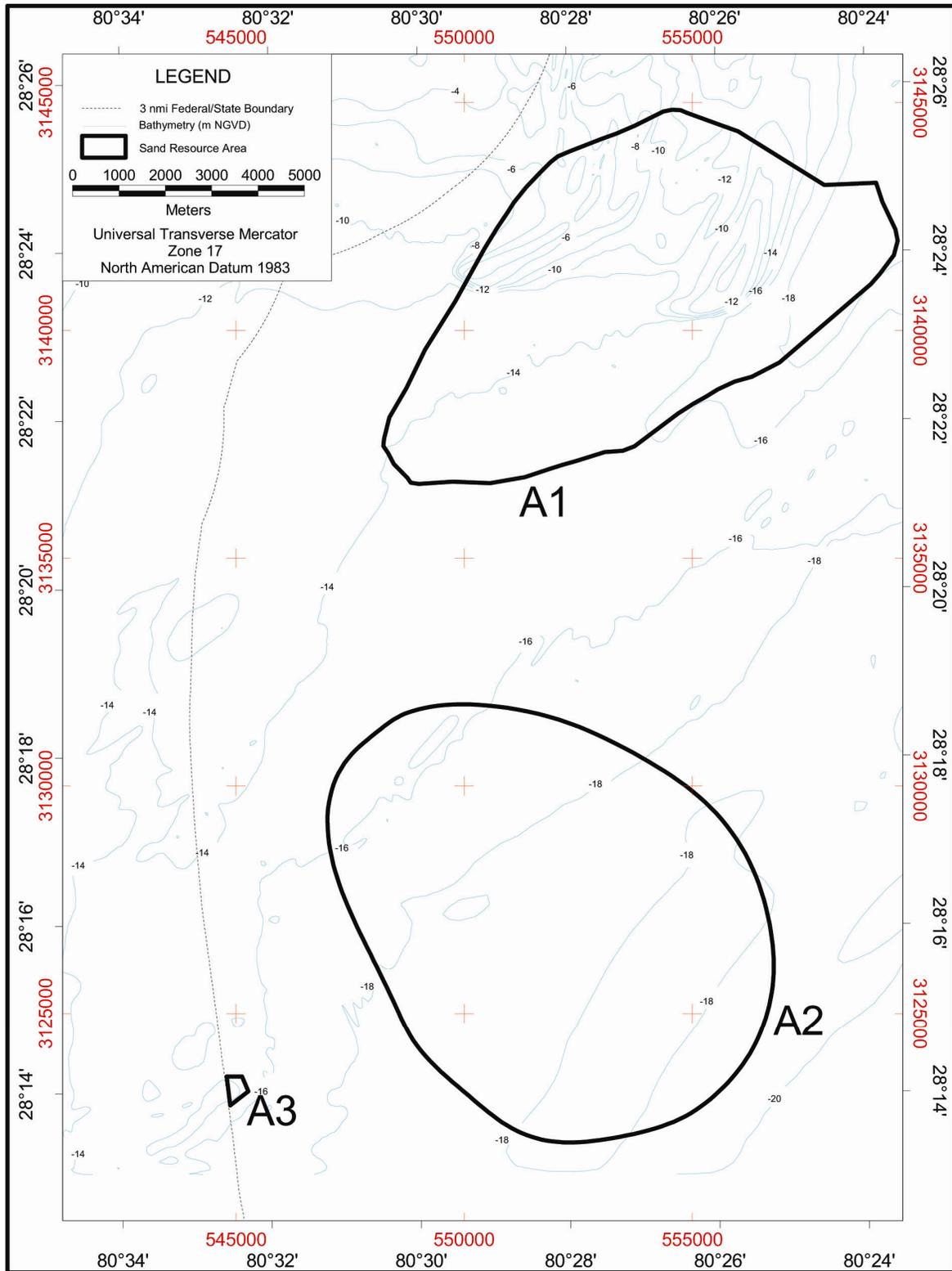


Figure E-2. Sand Resource Areas A1, A2 and A3.

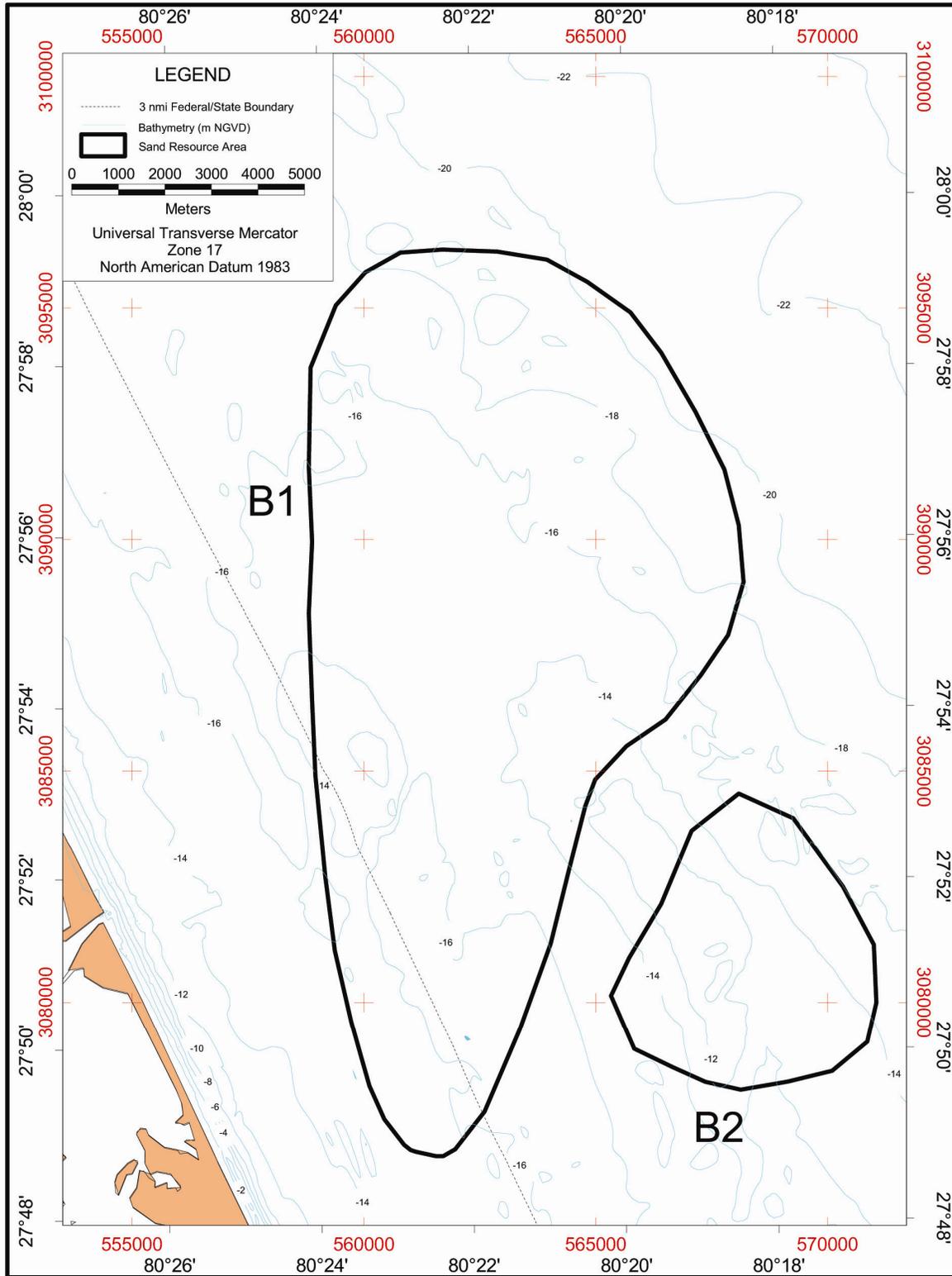


Figure E-3. Sand Resource Areas B1 and B2.

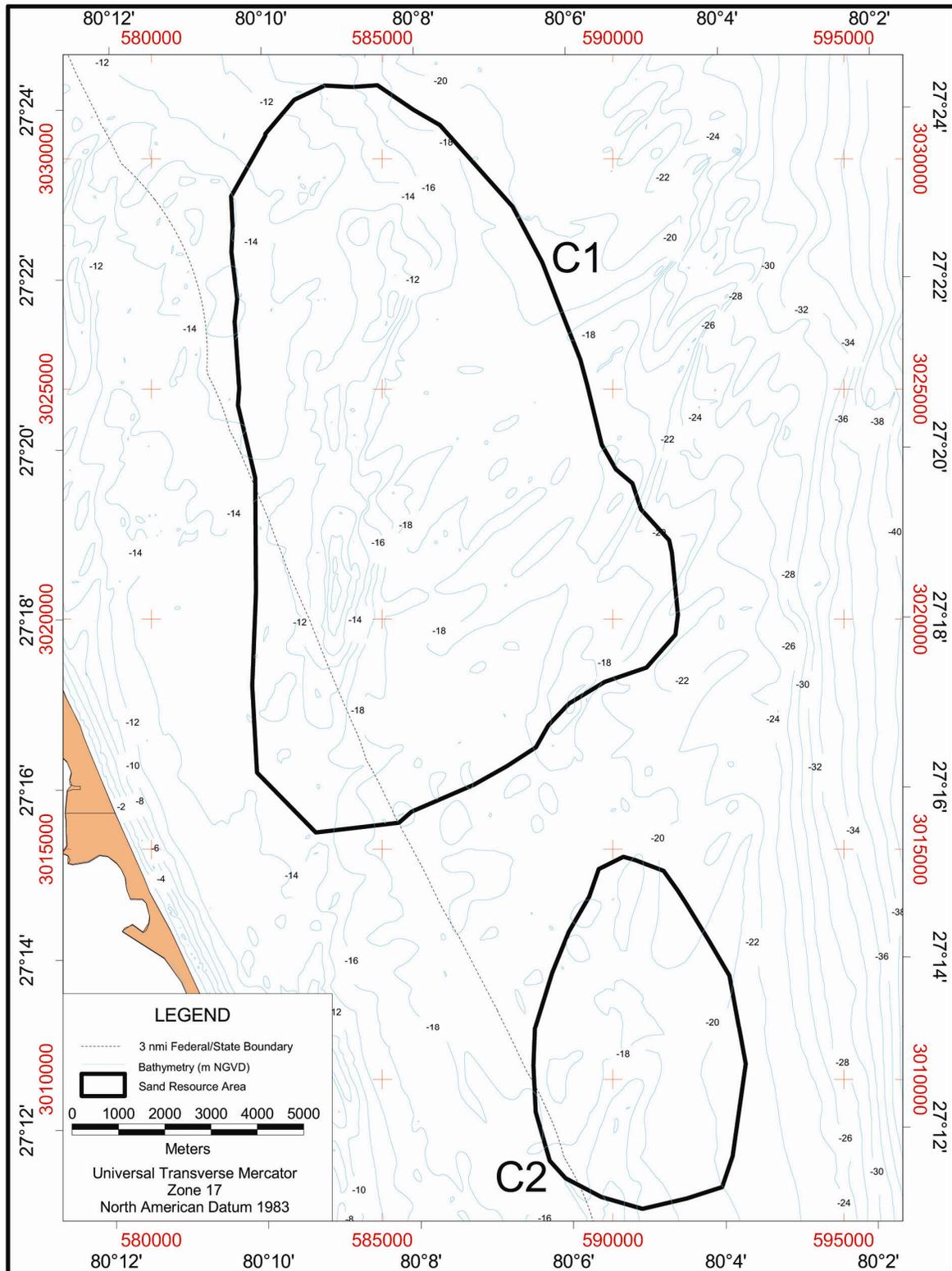


Figure E-4. Sand Resource Areas C1 and C2.

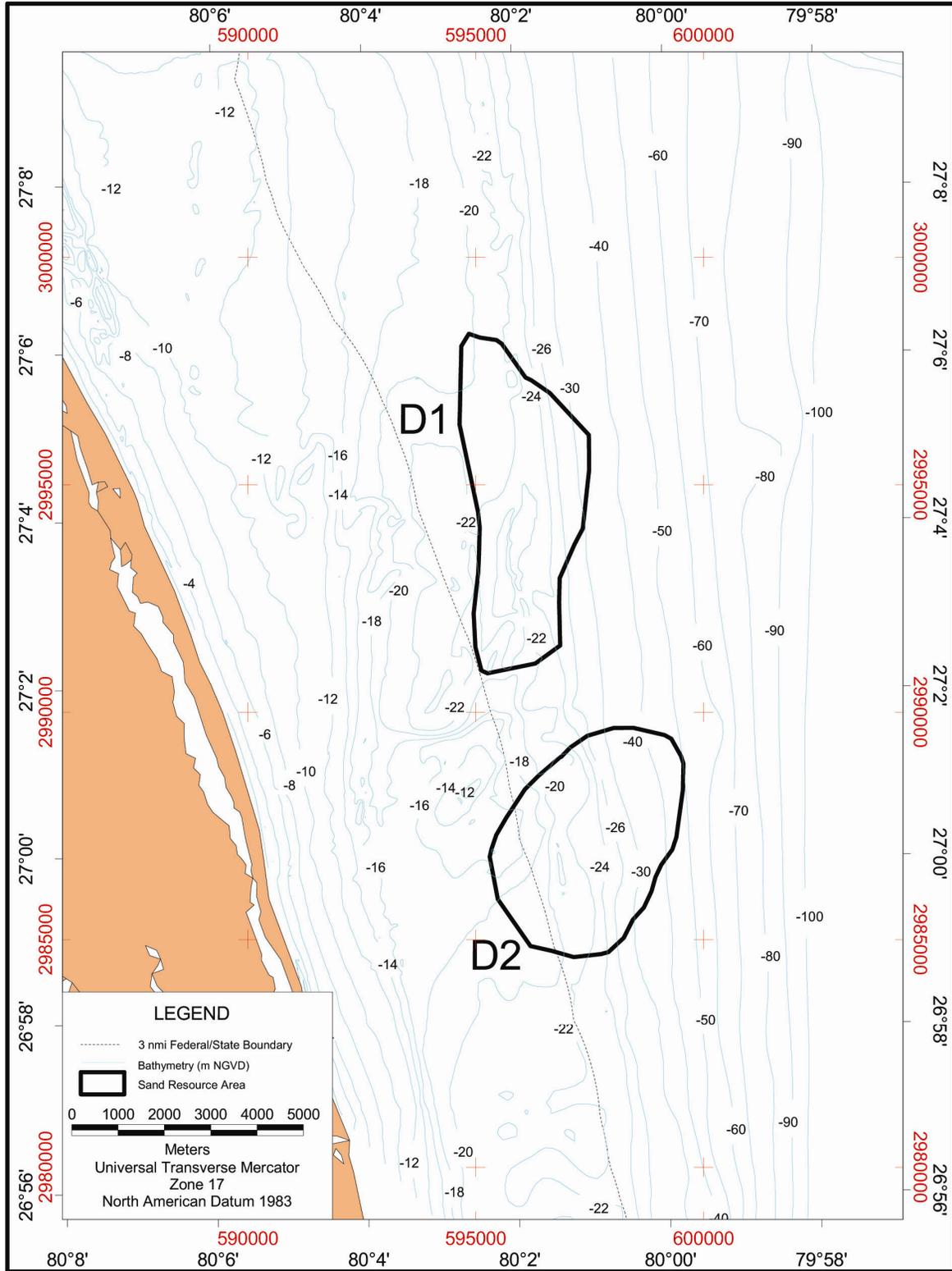


Figure E-5. Sand Resource Areas D1 and D2.

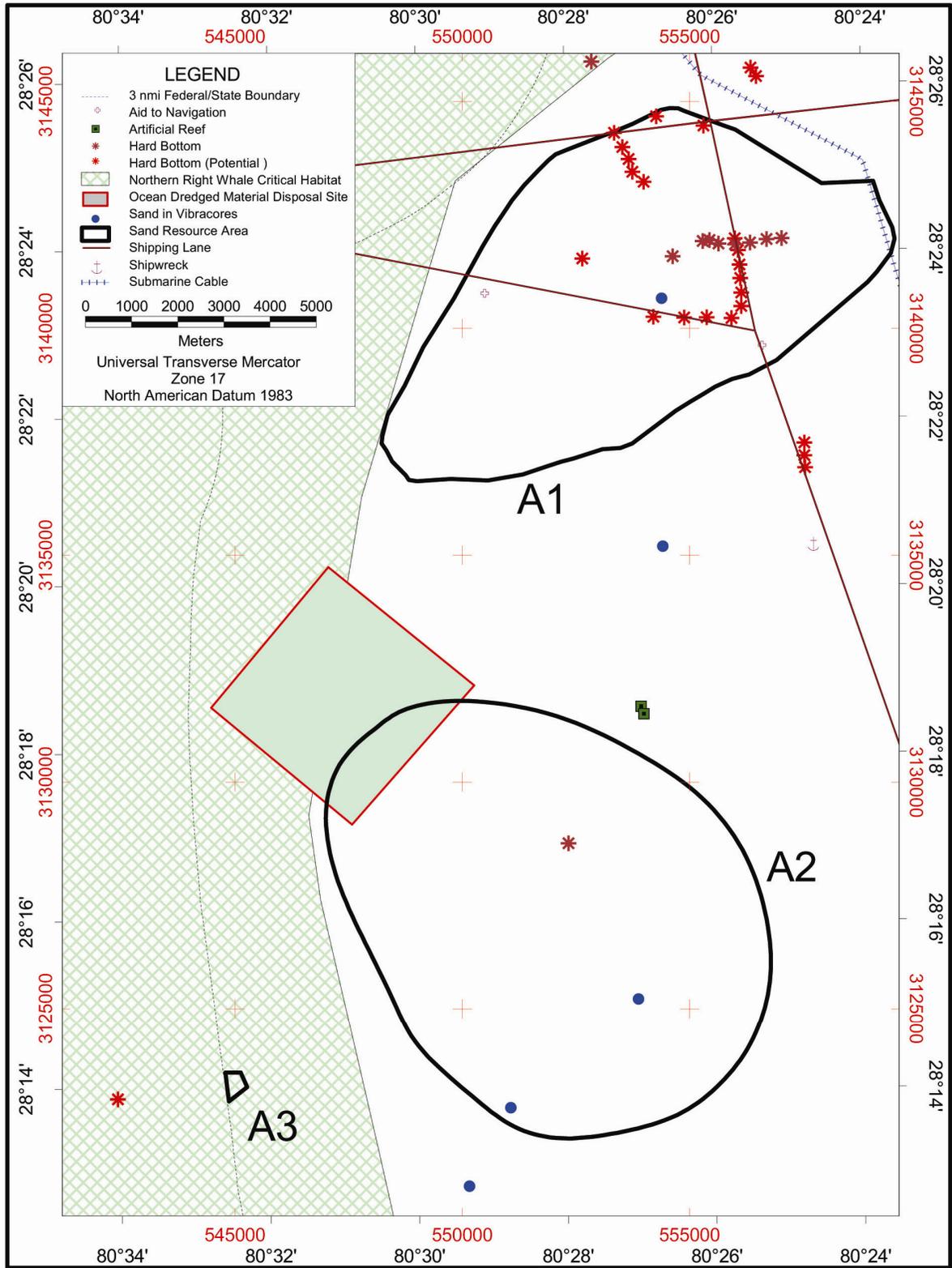


Figure E-6. Environmental features relative to Sand Resource Areas A1, A2 and A3.

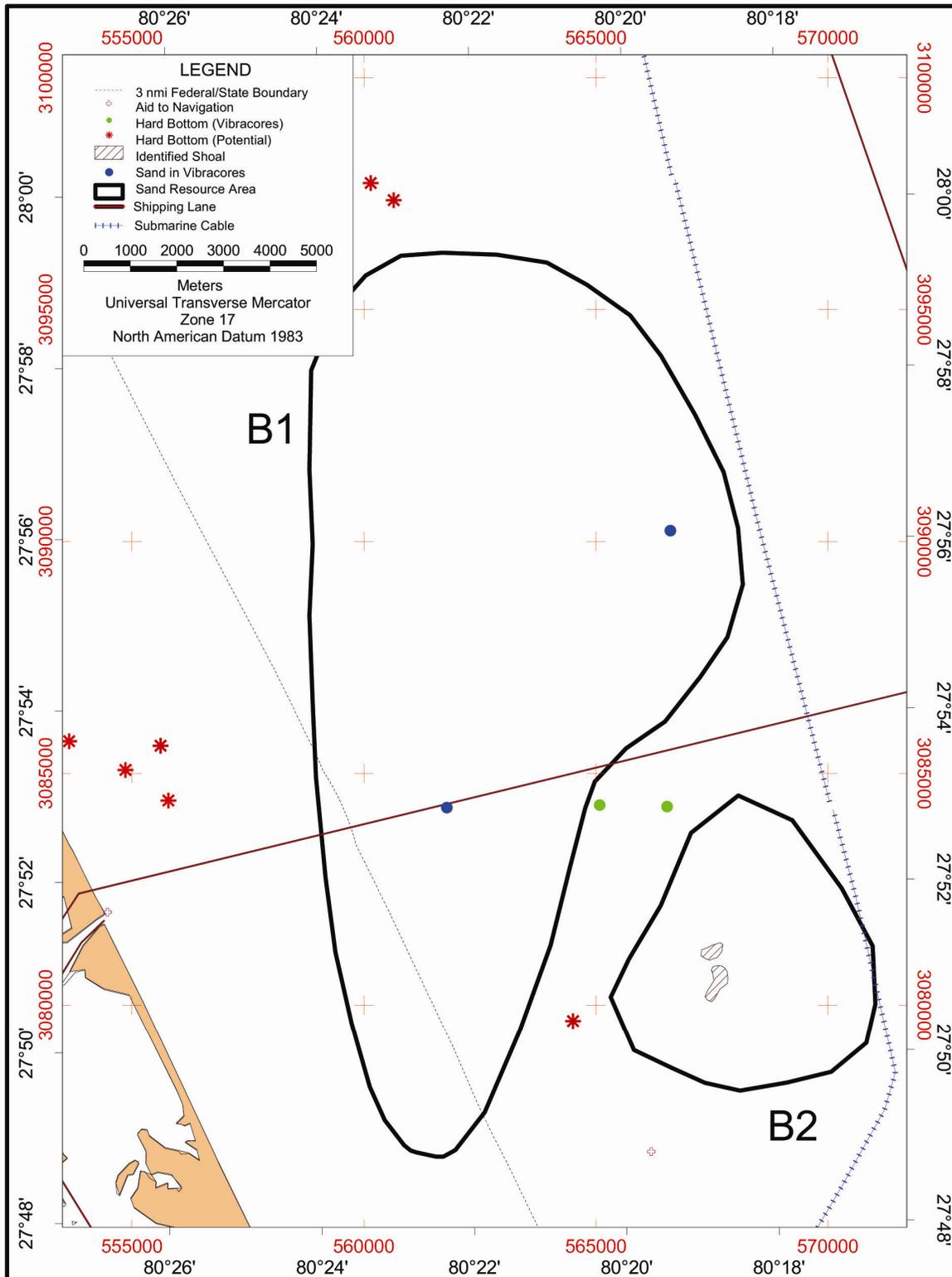


Figure E-7. Environmental features relative to Sand Resource Areas B1 and B2.

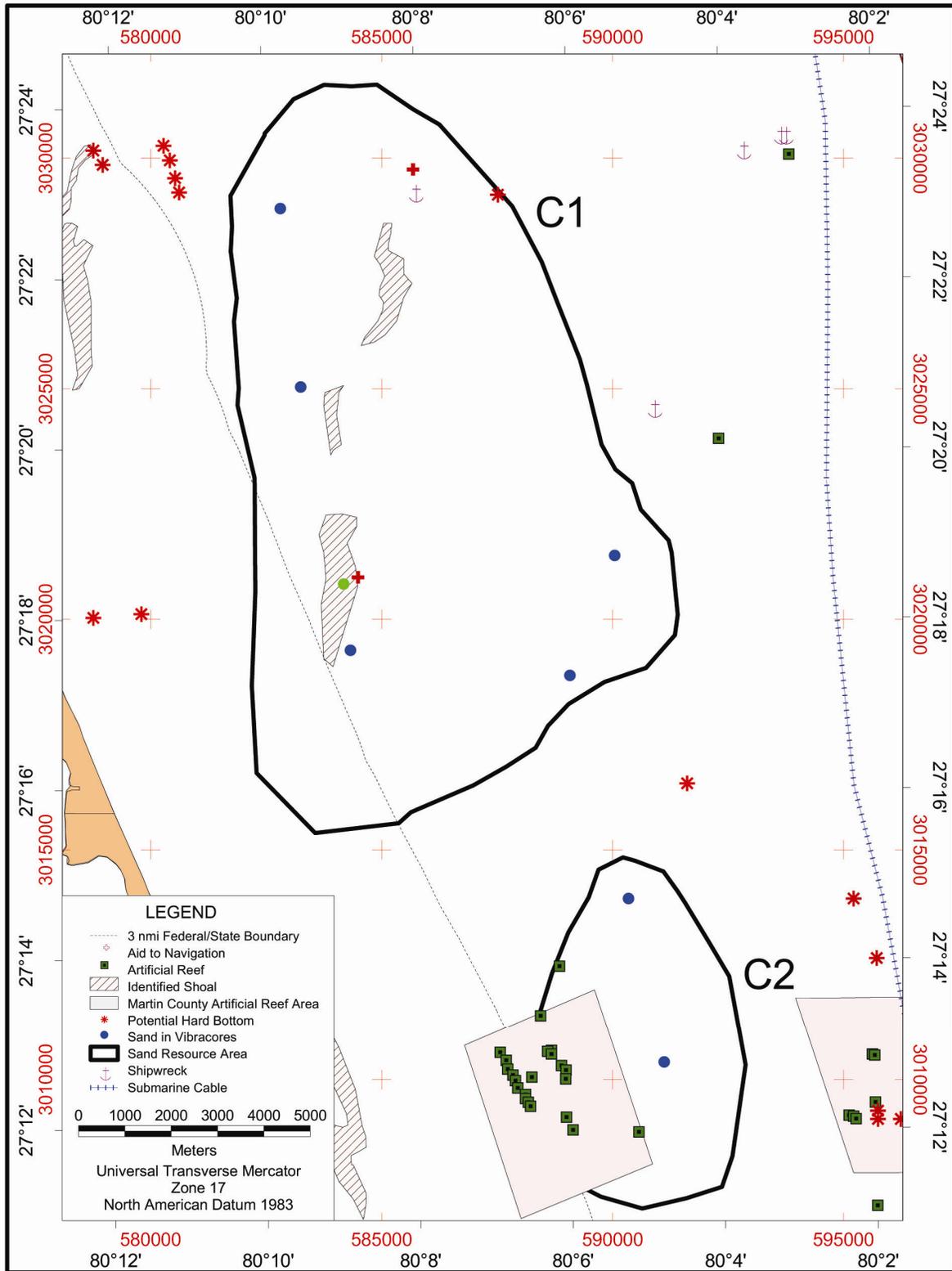


Figure E-8. Environmental features relative to Sand Resource Areas C1 and C2.

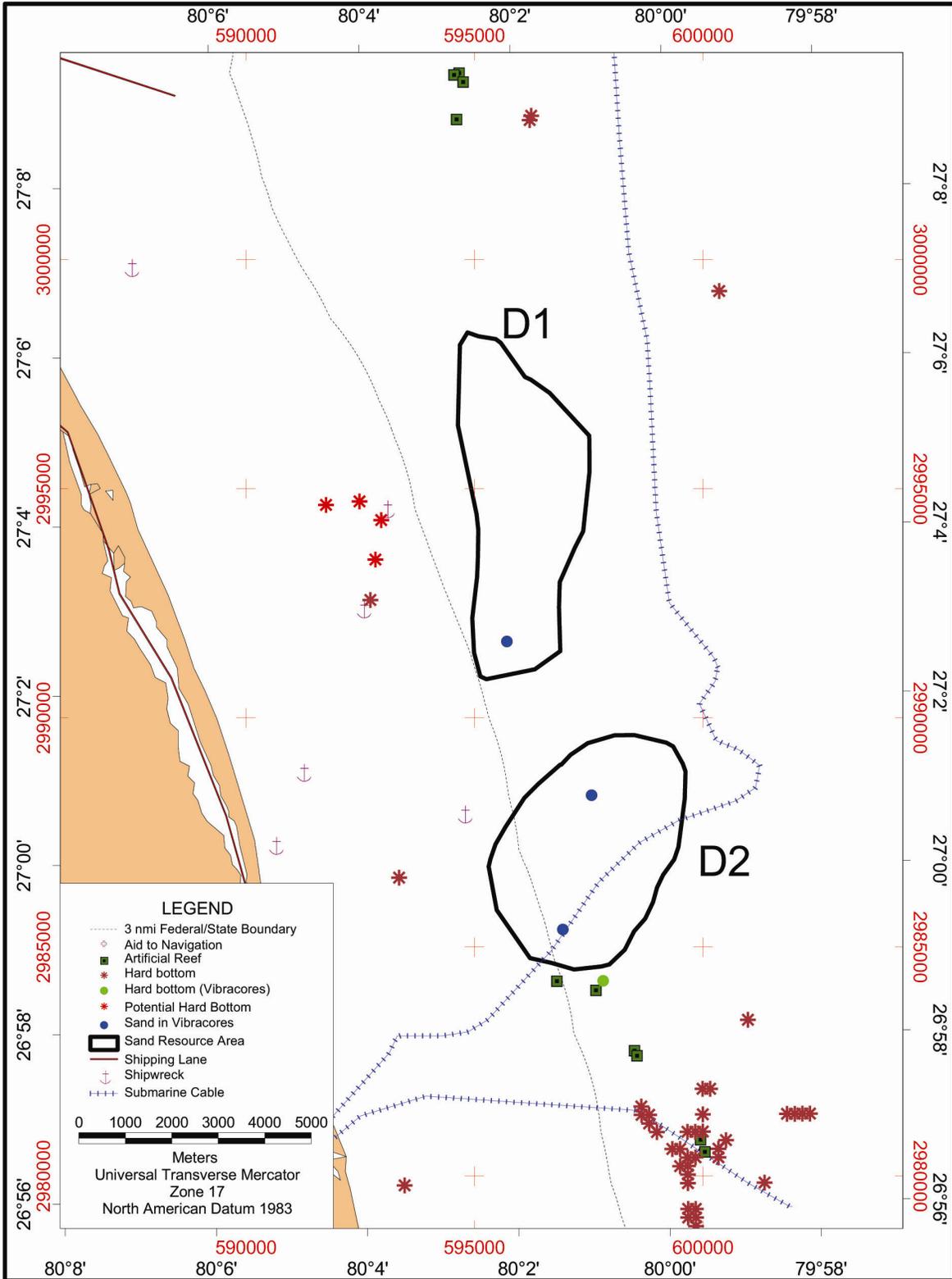


Figure E-9. Environmental features relative to Sand Resource Areas D1 and D2.

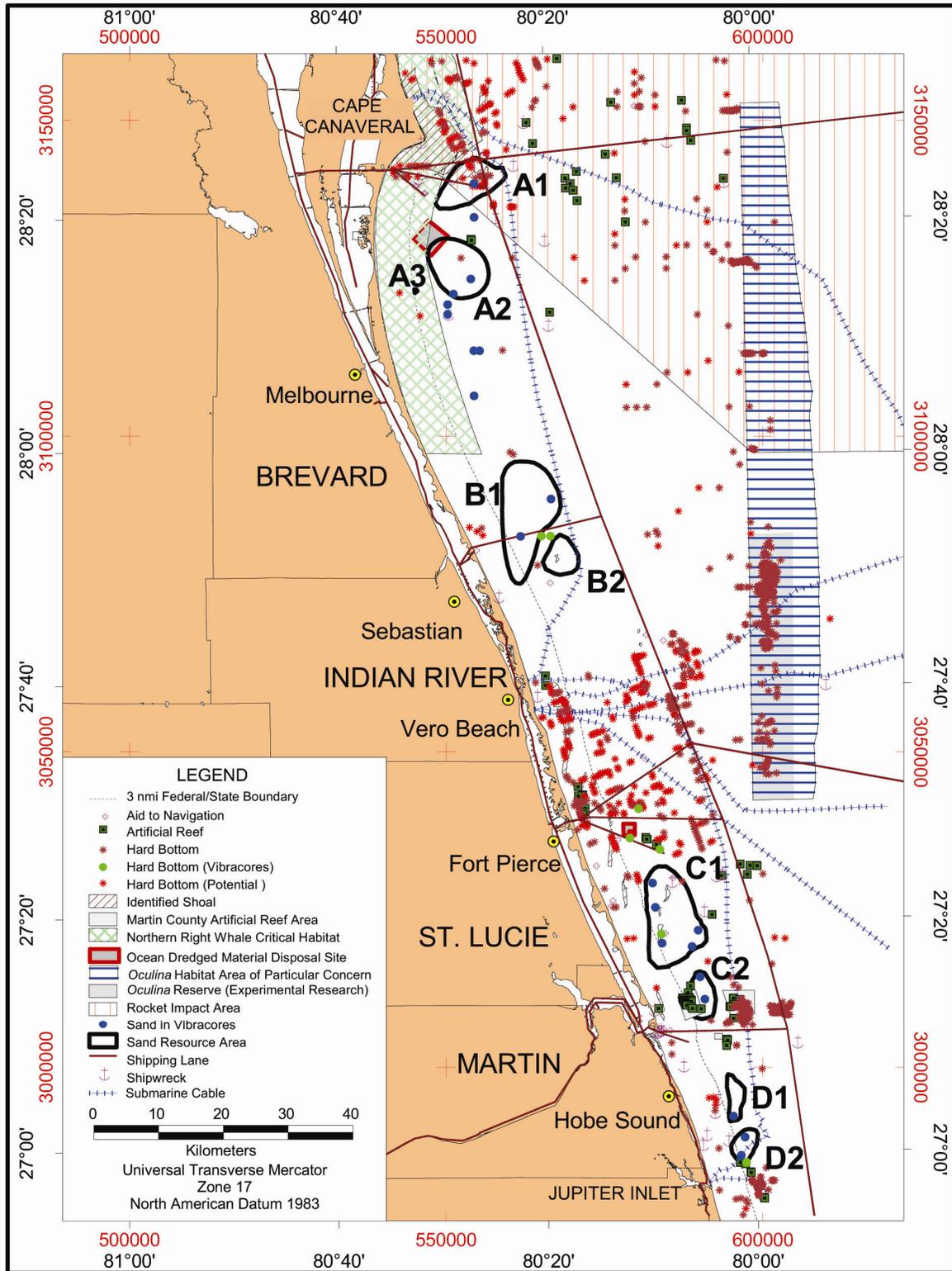


Figure E-10. Environmental features present in the study area.

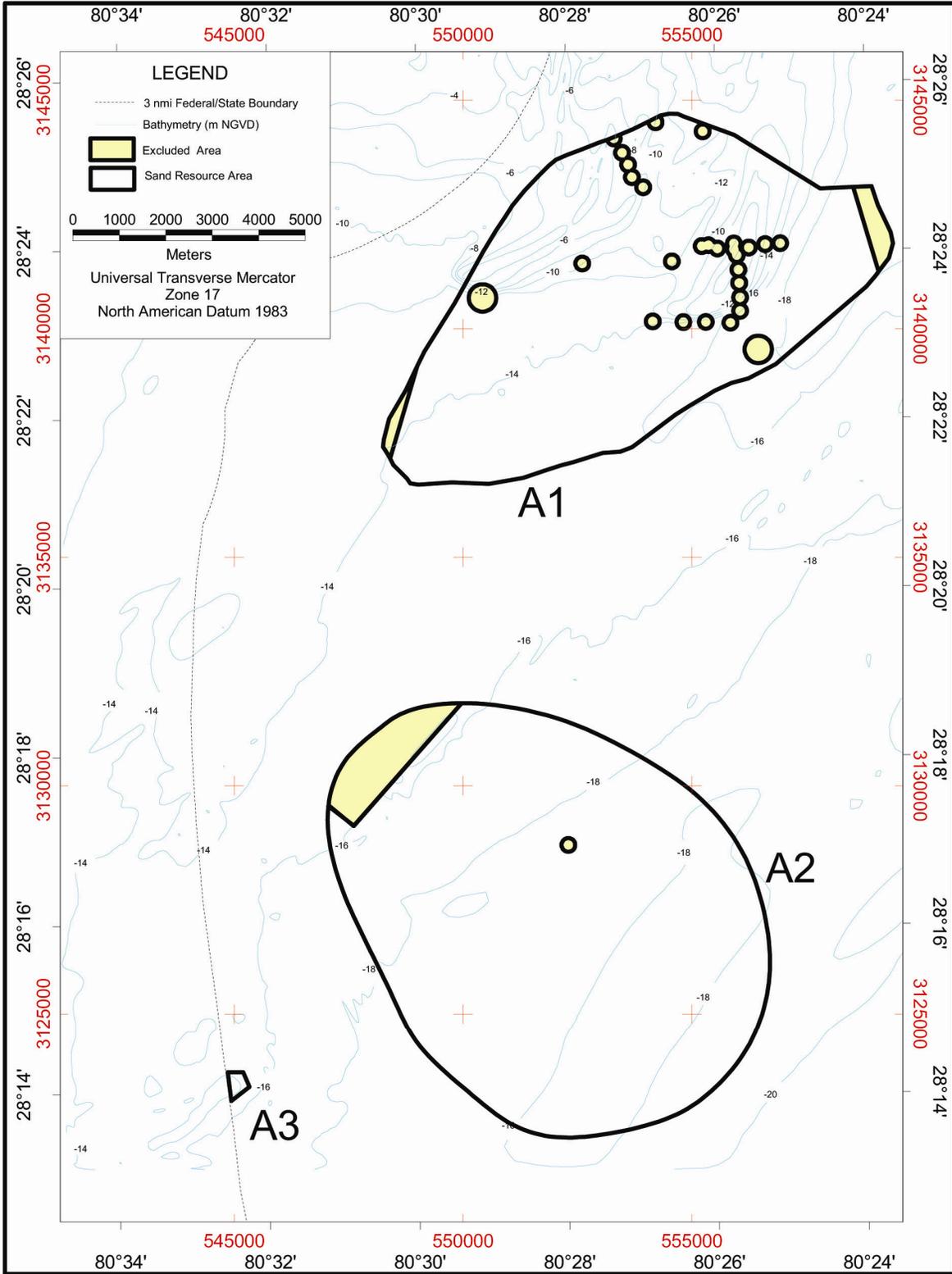


Figure E-11. Area remaining in Sand Resource Areas A1, A2 and A3 after exclusionary mapping.

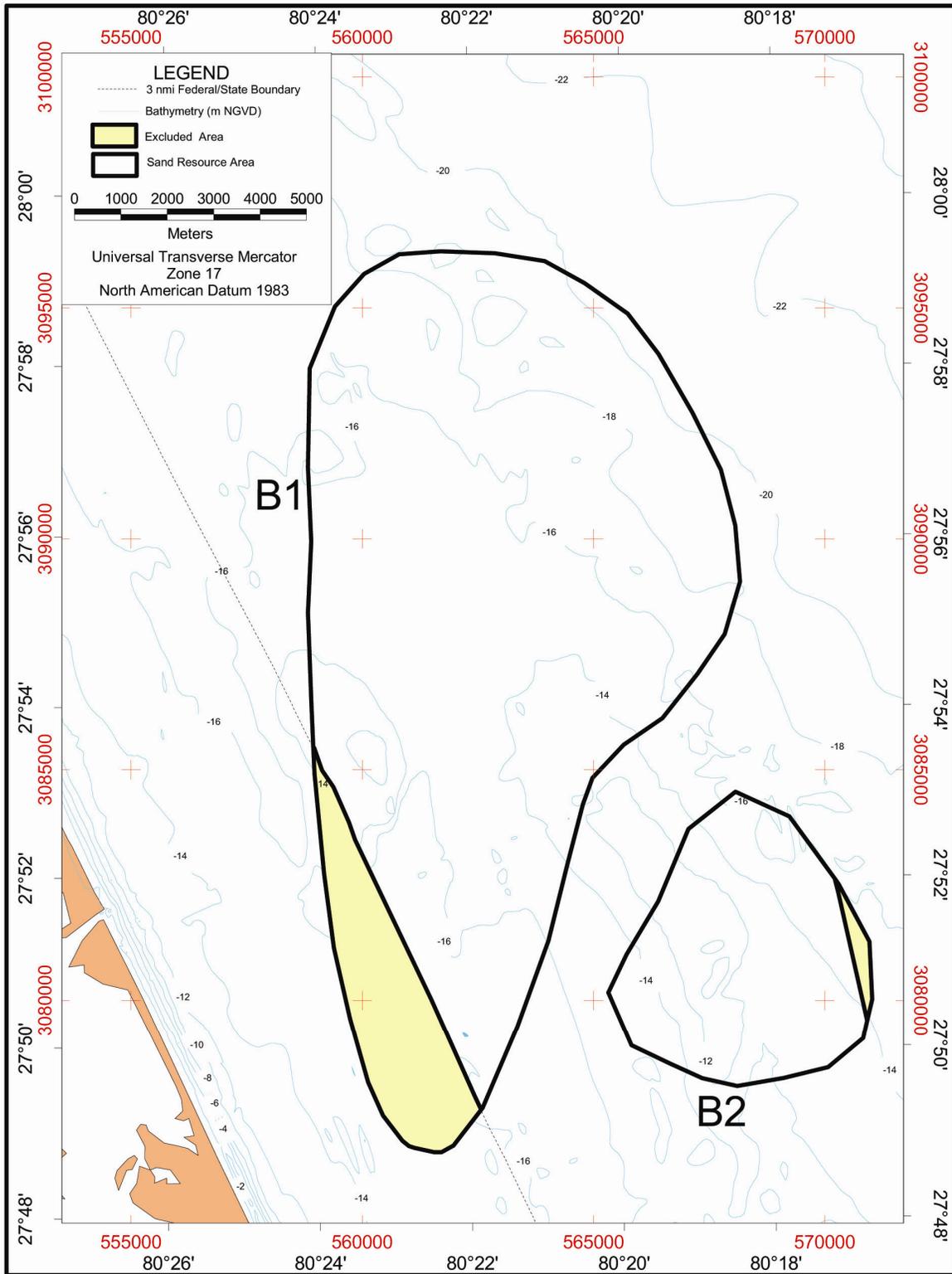


Figure E-12. Area remaining in Sand Resource Areas B1 and B2 after exclusionary mapping.

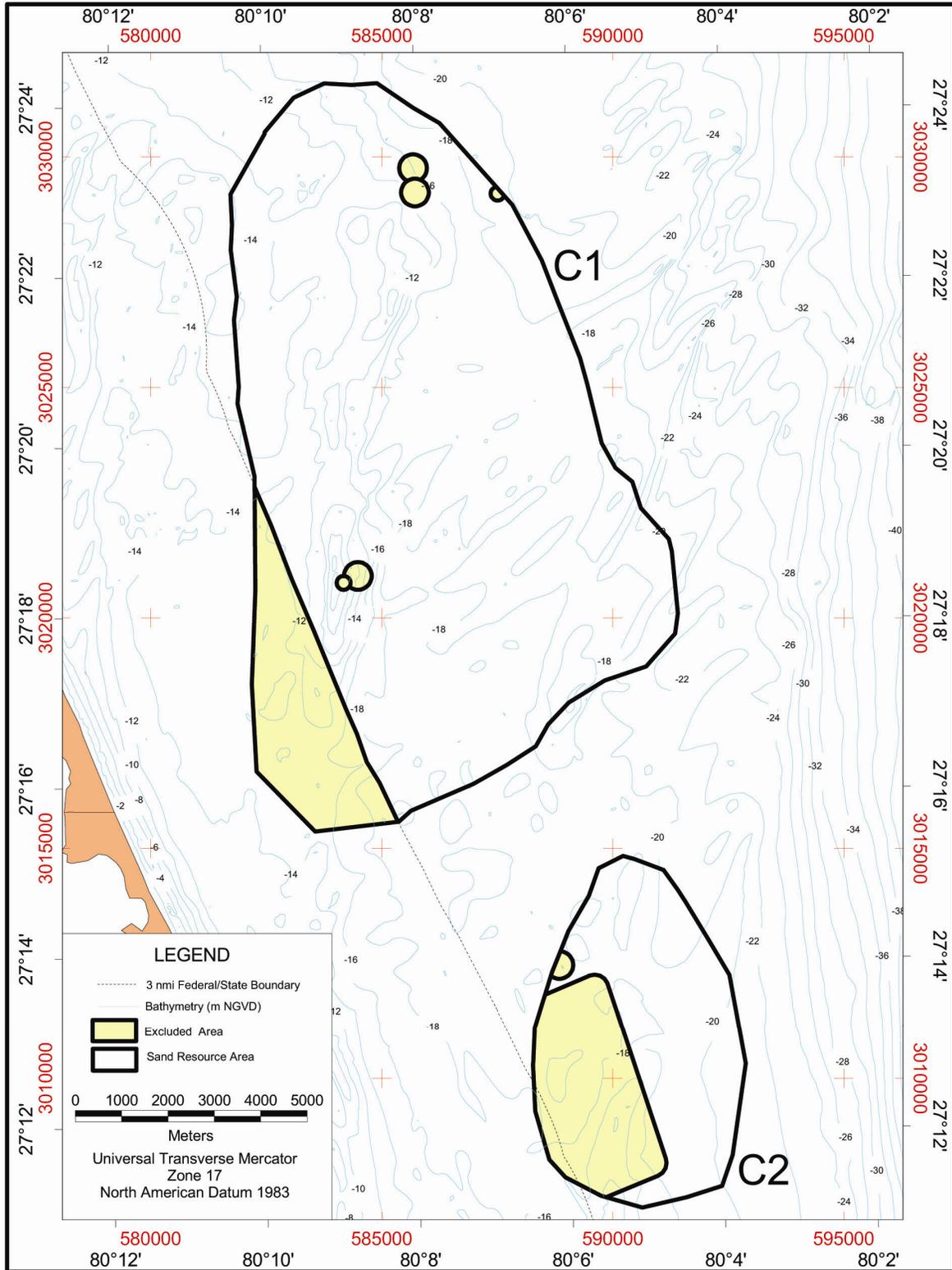


Figure E-13. Area remaining in Sand Resource Areas C1 and C2 after exclusionary mapping.

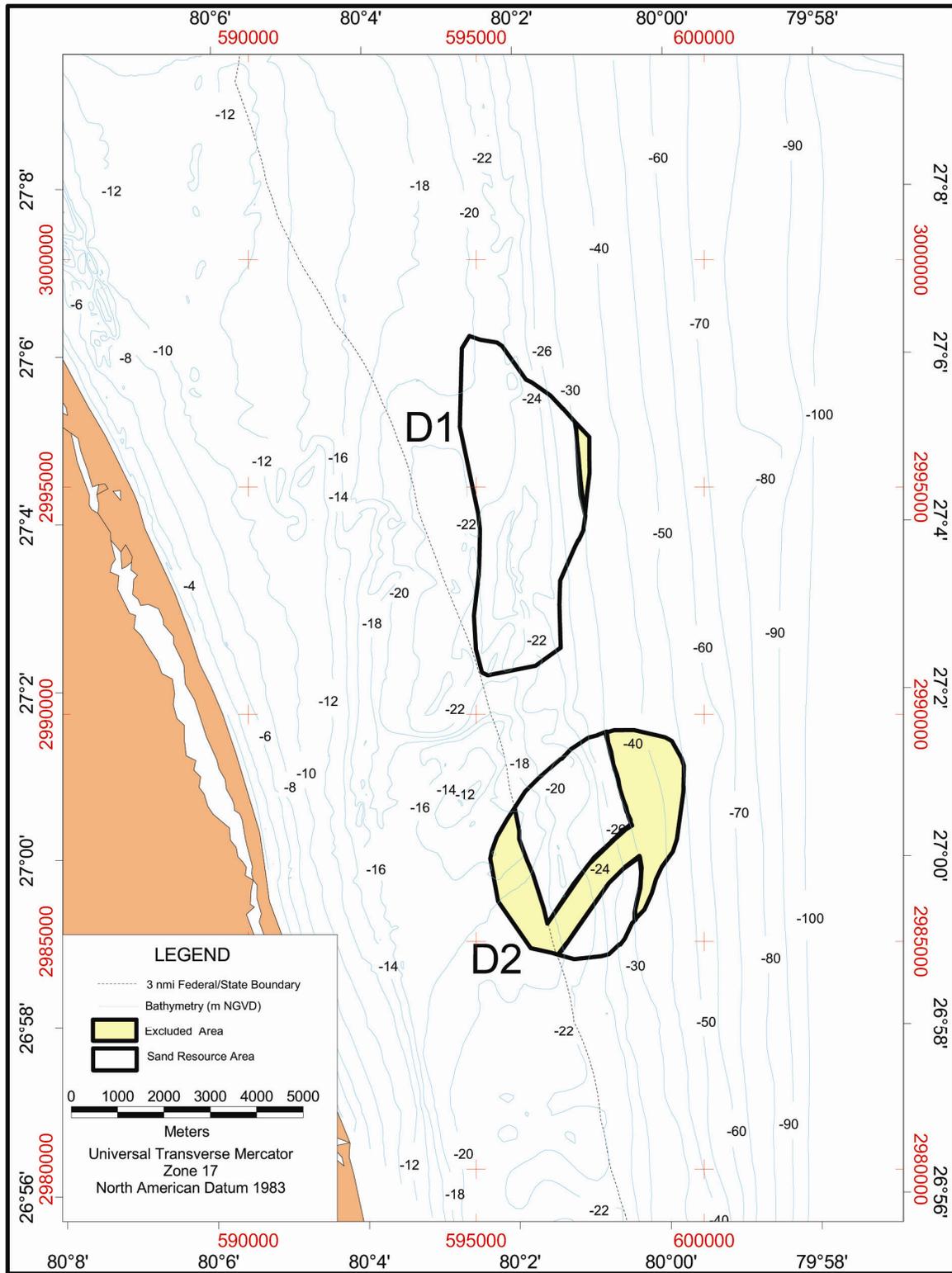


Figure E-14. Area remaining in Sand Resource Areas D1 and D2 after exclusionary mapping.

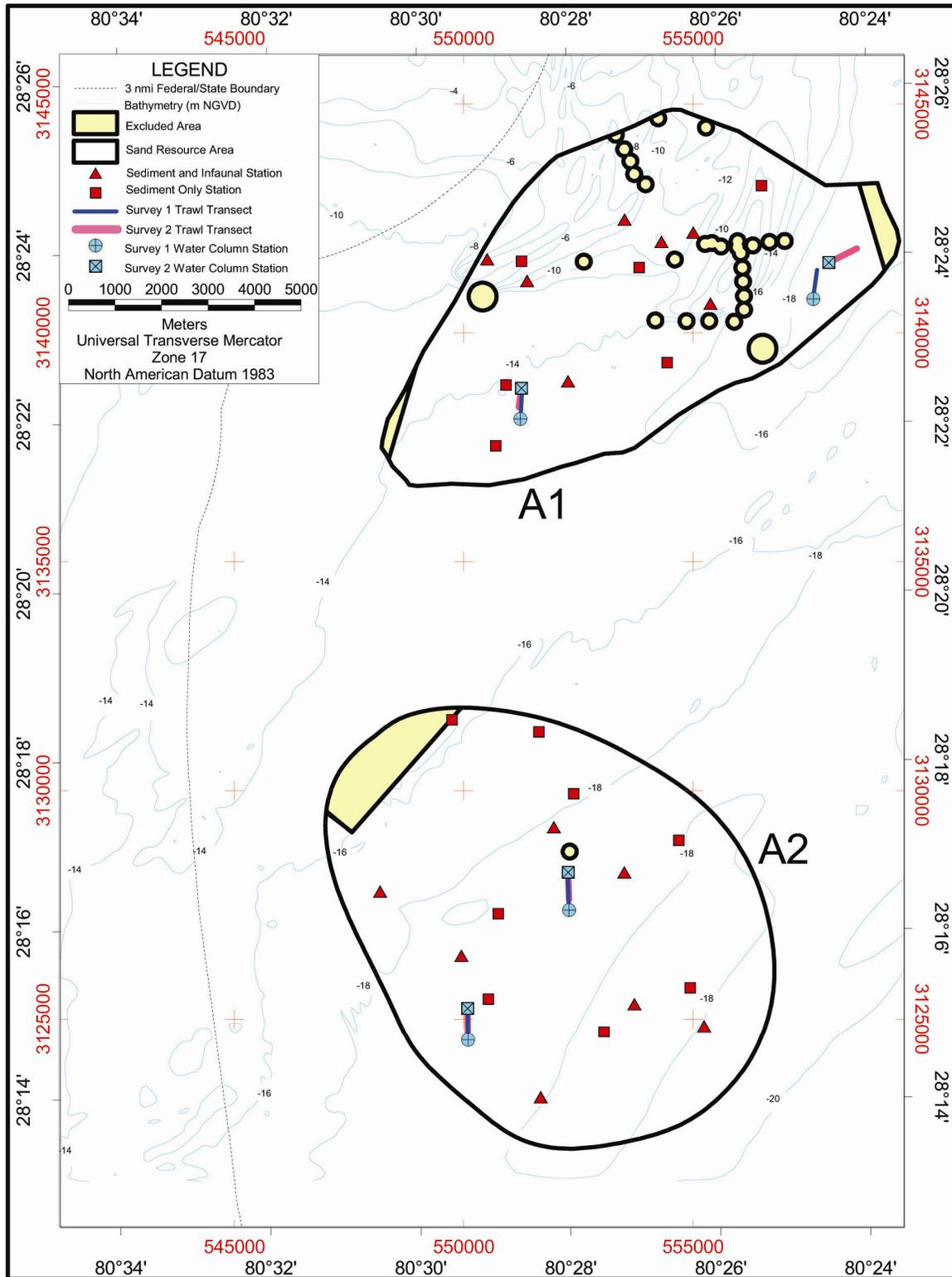


Figure E-15. Sampling stations and transects (sediment, sediment/infaunal, trawls, water column) in Sand Resource Areas A1 and A2.

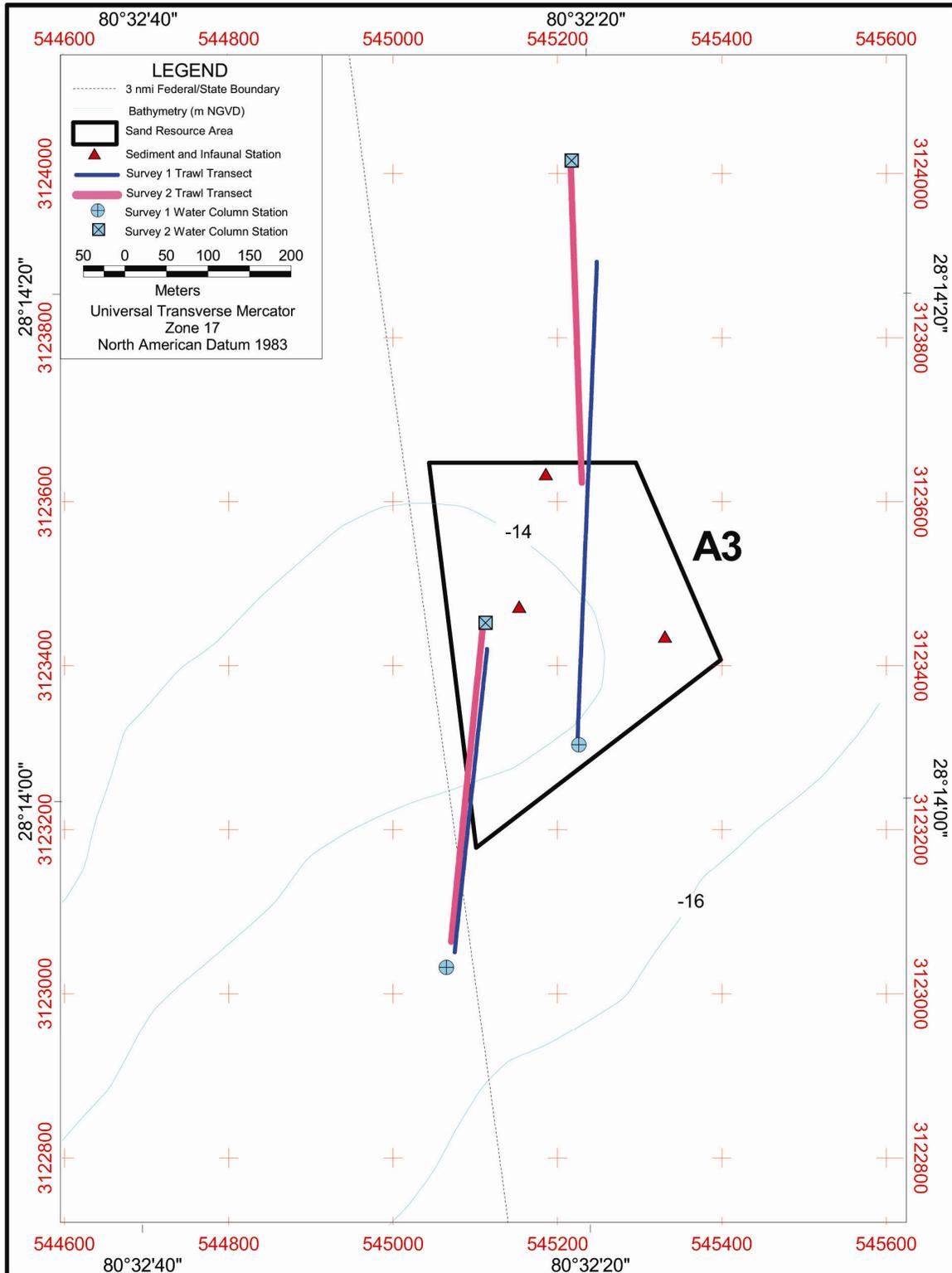


Figure E-16. Sampling stations and transects (sediment, sediment/infaunal, trawls, water column) in Sand Resource Area A3.

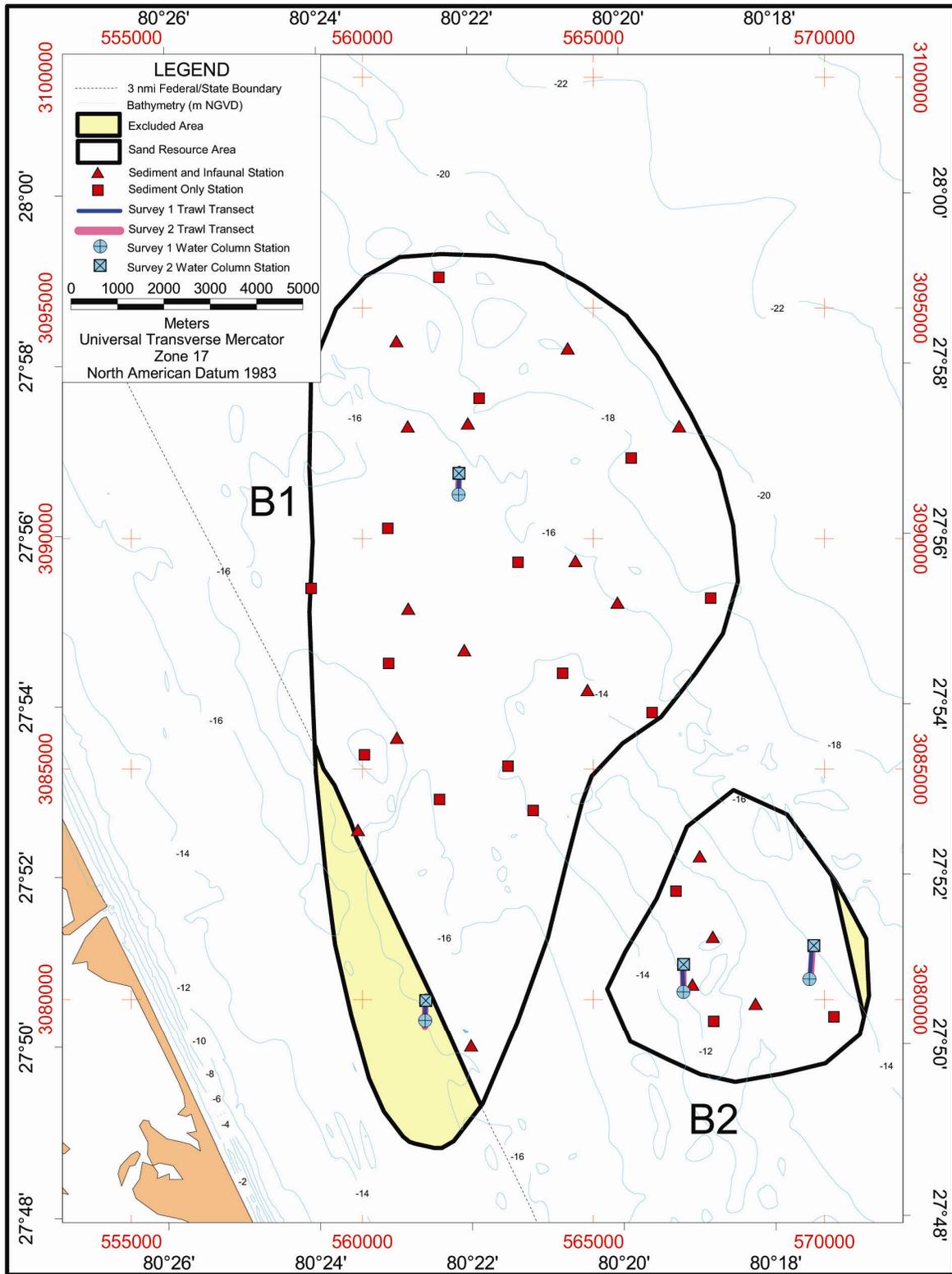


Figure E-17. Sampling stations and transects (sediment, sediment/infaunal, trawls, water column) in Sand Resource Areas B1 and B2.

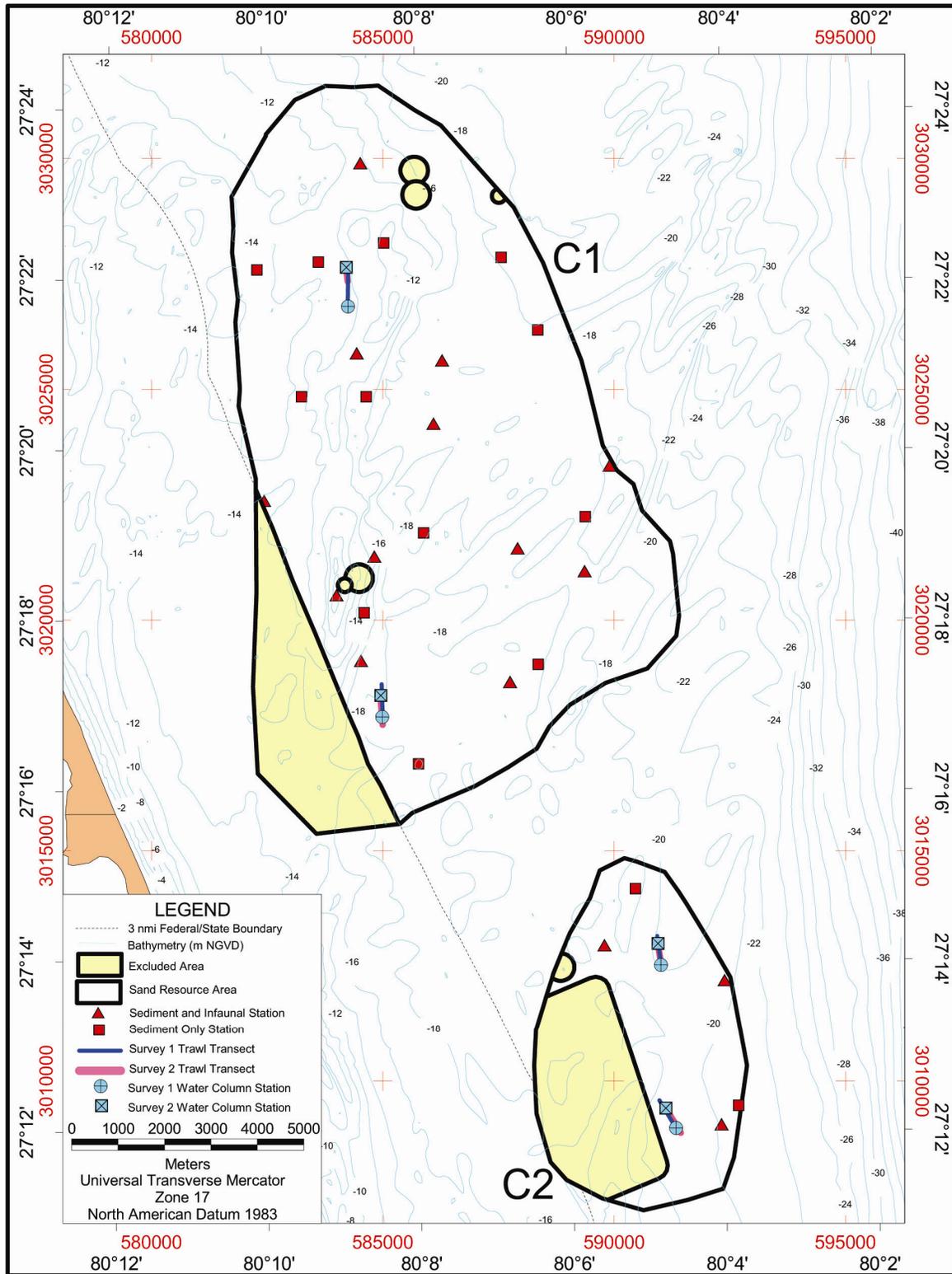


Figure E-18. Sampling stations and transects (sediment, sediment/infaunal, trawls, water column) in Sand Resource Areas C1 and C2.

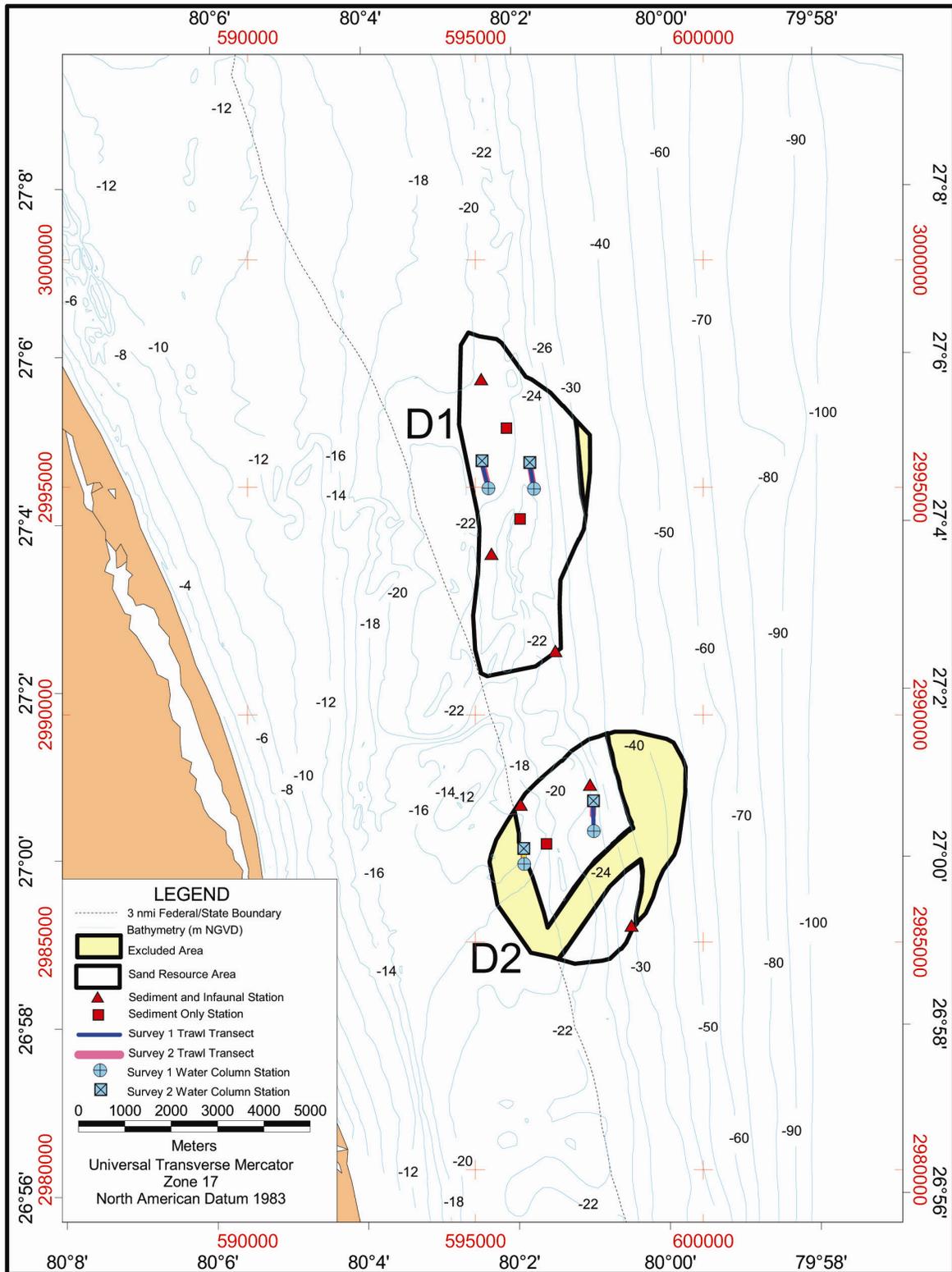


Figure E-19. Sampling stations and transects (sediment, sediment/infaunal, trawls, water column in Sand Resource Areas D1 and D2.

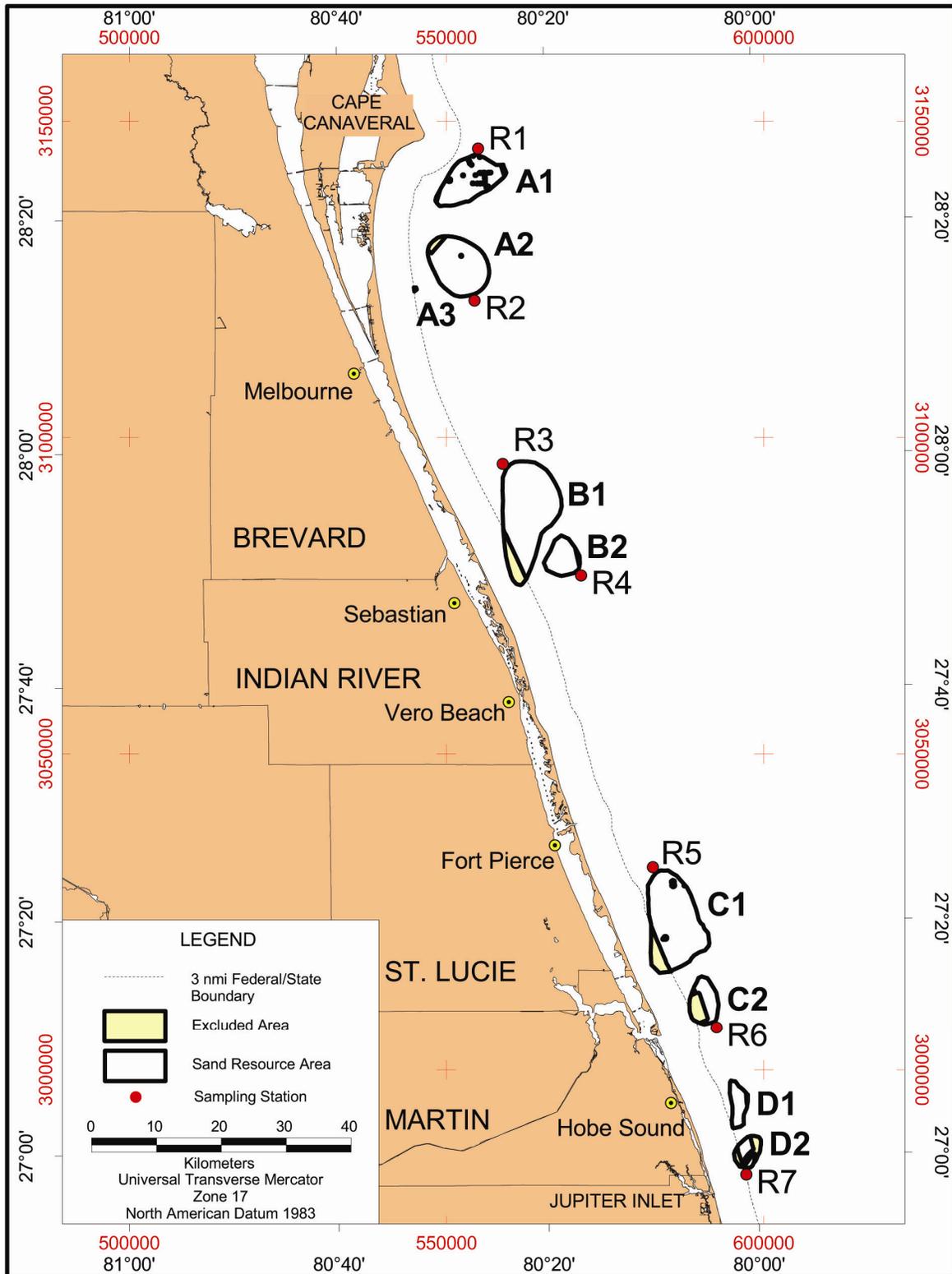


Figure E-20. Adjacent stations approximately 1,000 m north or south of the nine sand resource areas at median water depths.

